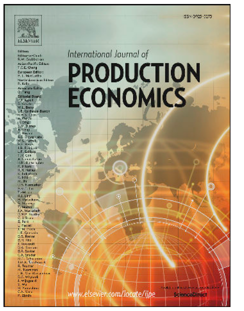

Buyer-led environmental supplier development: Can suppliers really help it?

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Buyer-led environmental supplier development: can suppliers really help it?

Abstract

The importance of supplier development programs to enhance supply chain environmental capabilities has often been posited. However, the literature is limited in identifying and explaining the factors that may influence or mediate the effectiveness of such programs. This paper examines the role of environmental supplier development programs led by the buying organization on supplier environmental practices, while testing the mediating effects of the supplier in the forms of resource allocation and collaboration with the buyer. The relationships are tested based on survey data from 267 supplier organizations in the UK using Partial Least Squares (PLS). The results indicate that supplier development in the form of setting requirements and audits has a wide, positive impact on all supplier environmental activities, while environmental supplier development in the form of direct projects only affects supplier environmental activities in logistics and transport. The results for the mediation effects tested are varied: while supplier collaboration is important to enhance the supplier logistics and transport activities, supplier resource allocation proves to be mediating the impact of environmental supplier development on the supplier energy efficiency and logistics and transport activities. The research sheds new light on the effectiveness of supplier development and environmental programs. The findings indicate that buying organizations should make explicit reference to the way they define supplier collaboration and resource allocation for their environmental plans and environmental supplier development programs to be effective.

Keywords: Environmental supplier development, material management, energy efficiency, logistics, resource allocation, buyer-supplier collaboration

1. Introduction and Background

Moving toward an environmentally-friendly supply chain largely depends on sourcing and supply management decisions and actions. Among them, supplier management, evaluation, and development have essential roles to play (Fu et al. 2012). The literature review on supplier environmental management, conducted in this research, points out various studies on the role of supply management in green supply (Agi and Nishant 2017; Bowen et al. 2001; Ferretti et al. 2007), environmental supplier development (Bai and Sarkis 2019; Liu et al. 2018), the effects of buyer's social responsibility requirements on supplier development activities (Carter 2005; Lu et al. 2012), buyer-supplier joint environmental development (Bowen et al. 2006; Chan et al. 2013; Foerstl et al. 2015) and the links between logistical integration and environmental collaboration (Evangelista et al. 2017; Miao et al. 2012; Vachon and Klassen 2006). Notwithstanding the ample literature on environmental supply chain management, the research on buyer-led environmental supplier development and deploying environmental knowledge and practices in supply chains is still nascent.

Enhancement of the environmental knowledge and practices of a supplier, in the context of its links with its buyer(s), may be initiated in various ways. Studies by Chiarini (2017), Hoejmose and Adrien-Kirby (2012), Rao (2002), and Zhu et al. (2017) underline the buyer's requirements or pressures as major drivers for the supplier's environmental practices. Supplier environmental assessment and monitoring are also seen as an extension of 'greening' the internal production processes (Zhu et al. 2013). Besides, Holt and Ghobadian (2009), Tate et al. (2012), and Zhu et al. (2005) address the impact of buyer-led environmental supplier development projects, in the forms of training, knowledge and technology sharing, buyer-supported research and development, and product development schemes, on supplier environmental activities. Suppliers can encourage the expansion of environmental practices too. Liu et al. (2019) and Zhu et al. (2005) show how the supplier's knowledge base, for example advancements in environmentally-friendly products and processes, motivates environmental knowledge and practices development. Finally, buyer-supplier collaboration is found stimulus to initiation and success of environmental supplier development (Chan et al. 2013, Yadlapalli et al. 2018, Zhu et al. 2005).

Table 1 summarizes the main themes and major motives for supplier environmental management. While the extant literature advances the knowledge on supply base environmental development, the mechanisms used by buying organizations to urge or influence their suppliers to enhance environmental knowledge and activities, and the factors influencing the effectiveness of the buyer's environmental plans, are still mostly missing in the literature. In view of that, this paper focuses on the impacts of byer-led environmental supplier development programs on the supplier's environmental activities and the role of suppliers to support those programs. Moreover, as shown in Table 1, the literature mainly looks at the environmental supplier development from the buyer's standpoint. Tate et al. (2012) underline that there is limited research on how suppliers view buyer-imposed environmental development programs. Therefore, the supplier's perspective and concerns should be considered in environmental development programs too, and this research focuses on the supplier's view to the environmental knowledge and practices. Accordingly, this research is going to fill those gaps by answering the following research questions:

(*i*) Do buyer-led environmental supplier development programs positively affect supplier environmental activities (and which programs and activities specifically)? If so, then

(*ii*) Are those effects mediated by supplier resources and collaborations?

The increasing attention to environmental activities at enterprise and national levels (Eurostat 2017), and the expanding benefits of supplier development programmes (Dalvi and Kant 2015; Li et al. 2007) re-emphasize the importance of investigating the impact of different supplier development programs on supplier environmental activities (i.e. the first research question). Moreover, since supplier development programs are typically cost/resource intensive, it is highly crucial to study the factors which may affect their success and mediate their impacts on the expected results (i.e. the second research question). The research questions are also in line with the calls, raised for further research on the ways organizations manage their environmental activities with their suppliers and customers (Journeault 2016; Theyel 2006), and testing theories around environmental supply management (Hoejmose et al. 2012).

Table 1: Major themes in the literature, related to environmental supplier development.

Theme: / Reference:	Supplier Initiated	Buyer's Requirements or pressures	Environmental monitoring/ audit	Environmental Development Projects (directed by buyer)	Buyer-Supplier Environmental Collaboration	Supplier /Buyer View
Chan et al. (2013)					Buyer-supplier coordination has environmental impacts	-
Chiarini (2017)		Compliance with environmental regulations is core for the supplier environ-mental evaluation				Buyer
Cole and Aitken (2019)			Supplier development to be merged into or implemented before supplier selection			Buyer
Gavronski et al. (2011)			Green manufacturing affects supplier audit			Buyer
Hoejmose and Adrien-Kirby (2012)		Buyer pressures direct supplier toward more environmentally friendly operations				-
Holt and Ghobadian (2009)			Supplier mentoring, assessment, education, and dissemination of best practice are core for green supply chain management			Buyer
Liu et al. (2019)	Supplier's knowledge base encourages the adoption of environ-mental practices					Supplier
Mollenkopf et al. (2010)		An increasing pressure by buyers pushes suppliers toward more environmental actions				Buyer
Zhu et al. (2008)	Green supply chain management is affected by both buyer and supplier pressure					Buyer
Oruezabala and Rico (2012)		The buyer's environmental requirements, set based on quantitative green criteria, are compelling for suppliers. However, the efficiency of sustainable procurement depends on the capacity of both parties				Buyer
Rao (2002)		Supplier environmental management in forms urging suppliers to take environmental action, supplier selection based on environmental criteria, and training suppliers (through workshops and seminars), affect the supply chain environmental performance				Buyer
Tate et al. (2012)		Supplier accountability for environmental performance, environmental supplier development, environment-based supplier selection, and buyer-supplier data-sharing and collaboration have key roles in supply management				Buyer
Yadlapalli et al. (2018)			Supplier Development in the form of assessment improves the supplier's environ-mental performance		Supplier collaboration improves the supplier's environ-mental performance	Supplier
Zhang et al. (2017)		Supplier development in the form of audits as well as training positively affect the supplier social responsibility				Buyer
Zhu et al. (2005)	Supplier's advances in environmentally-friendly products/ processes motivate green supplier management		Environmental audit of suppliers and demanding ISO14001 certification promote green supply manage-ment activities		Environmental cooperation and partnership with suppliers facilitate green supply management	Buyer
Zhu et al. (2013)			Suppliers environ-mental monitoring is core for green procu-rement management			Buyer
Zhu et al. (2017)		Green supply management may include 1st & 2nd tier suppliers environmental audit, ISO 14001 certification for suppliers, and supplier selection based on environmental criteria				Buyer

This paper makes compelling contributions to green supply chain and environmental supplier development literature. First, this research makes a distinguished view to environmental supplier development by focusing on the supplier's perspective. Given that environmental development programs are typically initiated by the buyer, previous studies have mainly taken the buyer's viewpoint to them. The current research, however, approaches the supplier, and delve into its view to the buyer-led environmental development programs. Moreover, the current paper sheds light on what/where the supplier can contribute to the buyer-led environmental programs, with a specific focus on the supplier's resources and collaboration, as the mediators of the development programs' effects on supplier environmental activities. By embedding the role of mediators to the buyer-led supplier development programs, the supplier's environmental targets and their sensitivity to the mediating factors are measured swiftly and more accurately. This, in a broader perspective, establishes a foundation to examine a set of antecedents that influence the supply chain sustainability. Overall, this research sets the stage in extending the environmental supply management toward a more holistic profile of the supplier's as well as buyer's views, decisions and actions.

Further elaboration and justification of the research questions, the relevant theories, and the hypotheses built upon them are provided in the next section. The hypotheses are tested using the partial least squares (PLS) method, and based on empirical data, as explained in sections 3. The hypotheses test results are presented and discussed in section 4. Finally, the conclusions and recommendations for future research are provided in section 5.

2. Theory and Hypotheses Development

An organization's plans to enhance its environmental performance largely depend on internal and external resources and capabilities (Blome et al. 2014a). Taking the supply chain as the main source of external capabilities and with a particular focus on the relationships among supplier development programs and supplier environmental activities, this section explains the relevance of Resource Based View (RBV), Natural Resource Based View (NRBV), and Knowledge Based View (KBV) as the theoretical lenses of this research. Accordingly, the theoretical framework of this paper, consisting of the research hypotheses, is formalized.

2.1 Theoretical ground

The focal point of this research on environmental supplier development, are explained and analyzed by the Resource-Based View (RBV), as a grounding organizational theory (Sarkis et al. 2011), and two of its associated theories: Natural Resource-Based View (NRBV) (Hart and Dowell 2011) and Knowledge-Based View (KBV) (Grant, 1996). The relevance and contribution of suppliers to the organization's environmental practices are justified by RBV and NRBV, and the crucial role of supplier development programs can be exposed by KBV, as follows.

Hart and Dowell (2011) underline that organizations can achieve competitive advantages through maintenance and use of natural resources. Hence, environmental knowledge and practices are recognized to be contributing to the organization's competitive advantages (Orlitzky et al., 2011). They are also consistent with RBV's definition of resources in being rare, difficult to imitate or substitute, imperfectly mobile and heterogeneously distributed across competing firms (Grant, 1992). Built upon RBV, NRBV has a particular emphasis on natural resources, and recognises the significance of environmental knowledge and practices at the organization and supply chain levels. The NRBV's strategies (i.e. pollution prevention, product stewardship and sustainable development) need to engage external stakeholders, mainly suppliers, to preserve the required natural resources (Hart and Dowell 2011).

The fact that natural resources are not limited to physical assets, and appreciating the value of environmental knowledge, as an intangible asset for environmental development, motivate this research to take KBV as another theoretical anchor. KBV, built upon RBV, views knowledge as the organization's resource, which is valuable and is not easy to imitate (Osterloh and Frey, 2000). Taking KBV in the context of environmental management, environmental practices significantly depend on the organization's and its supply chains' abilities to acquire and use of environmental knowledge (Blome et al. 2014a). To contribute to the organization's environmental practices, its suppliers should be equipped with and enhance their environmental knowledge. This can be largely supported by means of environmental supplier development programs (i.e. transferring the environmental knowledge from the buyer to the supplier). This paper's view to KBV and supplier development is also in line with Handfield et al. (2005) and Seuring (2011), who discuss that to achieve and maintain environmentally-based competitive advantages, the organization needs to carefully monitor its suppliers' environmental knowledge and practices, and also support the suppliers to enhance them.

In addition to the points above, the buyer-supplier collaboration, associated with the environmental supplier development programs, turns out to be a valuable capability itself, which is compatible with RBV/NRBV – i.e. uncommon and inimitable (Wong et al., 2012). Therefore it needs to be considered in studying the impact of environmental supplier development programs. Moreover, looking at environmental supplier development programs from the supplier's perspective indicates that the supplier can enhance its environmentally-focused resources (e.g. processes, knowledge, or assets), which are typically valuable, inimitable, rare, and non-substitutable in competitive markets (Rao Tummala et al., 2006). With this attitude to environmental development programs and consistent with RBV/NRBV, the supplier may find them good mediums to improve its competitive advantages, and be ready to contribute to it.

2.2 Supplier Development and Supplier Environmental Activities

Due to the scale and scope of environmental issues, organizations pursuing environmental plans need to involve their external links and develop resources across their supply chains (Handfield et al. 2005; Tseng and Hung 2014; Zhu et al. 2010). Supplier development is recognized as a useful tool to promote and expand environmental knowledge and practices of the organization's suppliers (Bai and Sarkis, 2019). This enhances the organization's resources toward environmental capabilities (e.g. via knowledge transfer, technology diffusion, and capacity building) and meet its environmental targets (Chen and Chang 2013).

The literature primarily introduces two main approaches to supplier development programs: audit/certification and direct development project (Krause et al. 2000; Li et al. 2007; Modi and Mabert 2007), both well-recognized and widely used by other studies (e.g. Lee 2015; Li et al. 2017). In view of that, the two environmental supplier development constructs of this research are defined as follows:

- ESD_{ra}: Buyer-led environmental supplier development, in the form of setting environmental requirements and audits.
- ESD_{dp}: Environmental supplier development in the form of direct development projects, run or supported by the buyer.

Supplier development through setting environmental requirements and audit tries to ensure that the supply base is aware of the buyer's expectations and to meet its requirements. Given that purchased products widely contribute to the buyer's environmental performance (Fang et al. 2007), the buying organization needs to monitor its suppliers' environmental activities and make sure they are in line with its environmental objectives. This can be operationalized via setting environmental requirements for suppliers, and assessing them by audit/certification programs such as ISO 14001 (Boiral and Henri, 2012; de Oliveira Neves et al. 2017). During the audit/certification process, the audit team identifies the suppliers' non-compliance(s) and recommends improvement actions (McGovern and Hicks 2006).

Recognizing that the supplier's environmental performance is a valuable resource, which contributes to the organization's competitive advantage, RBV/NRBV require the buying organization to carefully monitor its suppliers' environmental activities (Zhu et al., 2013). Suppliers are crucial sources of environmental innovative ideas as well as risks, and the use of environmental criteria in appraising them helps the buying organization to identify future opportunities and threats (Handfield et al., 2002).

From the supplier's perspective, as NRBV suggests, the supplier needs to adjust its resources and capabilities in order to improve the environmental impacts of its operations and meet the buyer's environmental requirements. Meanwhile, by working on the buyer's environmental requirements and receiving its support through audit/certification schemes, suppliers enhance their relevant resources (e.g. processes, knowledge, or assets), that provide them with competitive advantages (Rao Tummala et al., 2006). With this attitude to environmental development, suppliers may find the buyers' environmental requirements and audits to be opportunities, rather than challenges (Paulraj, 2009). Given the above theoretical grounds, the first hypothesis can be stated as:

Hypothesis 1 (H1): Buyer-led environmental supplier development, in the form of environmental requirements and audits (ESD_{ra}), supports the supplier's environmental activities (SEA).

Acknowledging the relevance and significance of Hypothesis 1, the literature indicates that imposing environmental requirements is not the only way to enhance supplier environmental activities (Agi and Nishant, 2017; Plaza-Úbeda et al., 2009). Environmental performance may sometimes need improvements in technologies, processes and management systems (Büyüközkan and Karabulut, 2018), to which direct supplier development projects (i.e. the second approach to supplier development, mentioned above) can contribute substantially. Environmental supplier development in the form of direct development projects (ESD_{dp}), run or supported by the buyer, are theoretically consistent with KBV. They predominantly include proactive knowledge transfer in various areas of product, process and resource development (Bai and Sarkis 2019; Modi and Mabert 2007). This supports integration with suppliers, and encourages renewing and improving the supplier's environmental capabilities (Vachon and Klassen, 2007), which subsequently improves the suppliers' environmental performance and make them more responsive to the changing environmental needs of the buying organization (Lee and Klassen, 2008). The effect of direct environmental supplier development programs can be viewed from the supplier's perspective as well. To be environmentally competitive in the market, a supplier need to maintain its environmental-relevant resources and capabilities. Direct supplier development programs can provide valuable environmental knowledge to the supplier, which are not widely and easily available, and can provide the supplier with a competitive advantage to meet the markets' and stakeholders' environmental requirements. Accordingly, the second hypothesis can be stated as:

Hypothesis 2 (H2): Environmental supplier development in the form of direct development projects (ESD_{dp}), run or supported by the buyer, boosts the supplier's environmental activities (SEA).

While the extant literature supports the theoretical basis of Hypotheses 1 and 2 in general, further investigation of the relevant academic journals reveals the gaps in addressing their details specifically (e.g. what/how "particular supplier environmental activities" are supported to a greater extent). There are quite a few studies which focus on the impact of buyer-led environmental supplier development programs on the suppliers' environmental activities explicitly (i.e. addressing what programs affect which activities). Carter (2005), Min and Galle (1997), Simpson et al. (2007), and Walker and Brammer (2009) address the buyers' environmental requirements, by focusing on waste elimination, pollution reduction, and resource management. They do not, however, identify the impacts of those requirements on the supplier's specific environmental activities. Chiarini (2017) emphasizes the suppliers' environmental activities, in response to the buyers' requirements, including material, emission, waste, transport, and compliance management, but the buyers' specific requirements are not addressed. A few particular direct supplier development projects, such as environmental training and education (e.g. the case of General Motors trying to improve the energy-efficiency of its suppliers; Lippman 2001), collaborative supplier development projects toward waste elimination (Handfield et al. 2005), and including carbon management plans in supplier development schemes (Dou et al. 2015), are traceable in the literature. But, there is very limited study, if any, on the links between the specific supplier development programs and particular supplier environmental activities. To the best of the authors' knowledge, the literature is nascent in finding the effects of supplier development schemes on supplier environmental activities in detail. Furthermore, the NRVB and KBV theoretical links of this research will be stronger by detailed deductions on the impact of environmental supplier development on the supplier's specific environmental activities.

To address the above-mentioned gaps in the literature and to find more about supplier development impacts on supplier environmental activities in detail, this research breaks down Hypotheses 1 and 2 to assess the impacts on specific supplier environmental activities. The literature has introduced a wide and quite disjointed list of environmental activities. While some focus on broader practices such as environmental commitment, plans and policies (Lannelongue et al. 2015; Paulraj 2009), environmental management systems (Lo et al. 2012), audit schemes and life cycle assessment (Chiarini 2014), environmental awareness programs (Rao 2006), compliance with laws (Chiarini 2017), and public disclosure of environmental records (Zhu and Geng 2006), others address more focused tasks such as waste elimination (Li et al. 2017; Sroufe 2003), emission reduction (Li et al. 2017; Zhu and Geng 2006), water management (Li et al. 2017), energy consumption and renewable energies (Kurapatskie and Darnall 2013), packaging material, hazardous material (Zhu et al. 2010), transport and logistics (Walker and Brammer 2009), and product recyclability (Bos-Brouwers 2010; Carter 2005). This research extracts a thorough list of environmental practices and their cases from the literature and puts them into major categories of environmental activities. In addition to the references above, more comprehensive environmental activities categories, introduced and validated by Holt and Ghobadian (2009), Kumar et al. (2015) and Rao et al. (2009) as well as recent systematic reviews by Büyüközkan and Karabulut (2018) and Smart et al. (2017) are taken into consideration. To conclude the main groups of environmental activities, in order to formulate the broken-down versions of H1 and H2, the Q-sort method (Nahm et al. 2002) is employed (details are provided in section 3), through which six practitioners and six academics reviewed the environmental activities in multiple iterations and came up with three main constructs for supplier environmental activities as follows:

- SEA_{ee}: Supplier environmental activities in terms of energy efficiency management in manufacturing and warehouse operations as well as general lighting and heating.
- SEA_{mm}: Supplier environmental activities in terms of material management, including the use of environment friendly production and packaging material, controlling hazardous material and emissions, minimizing waste, handling disposals, and product life-cycle analysis.

- SEA_{lt},: Supplier environmental activities in terms of logistics and transport decisions (e.g. transport modes or logistics facility location), planning (e.g. delivery route planning), and infrastructures (e.g. logistics facilities, equipment and vehicles).

The supplier's energy efficiency, material management, and logistics and transport are generally emphasized and motivated by ESD_{ra} programs. ISO14001 audits, for example, have specific sections to assess those areas (Boiral and Henri 2012, de Oliveira Neves et al. 2017). To assure its environmentally friendly production, the buying organization need to monitor its purchased products, and ESD_{ra} is a useful mechanism to detect existing/potential cases of hazardous material, toxic pollution, non-recyclable packaging, harmful material, and waste of material (Carter 2005). Acknowledging the importance of material management in the buyer' assessments, the supplying organization tries to monitor its consuming and producing materials and the relevant processes around them. ESD_{ra} process and its outcomes may involve a number of recommendations, corrective actions, and preventive actions to improve the material management, which promote further material management activities of the supplier. Therefore, *H1* can have a sub-hypothesis on material management as follows:

H1a: Buyer-led environmental supplier development, in the form of environmental requirements and audits (ESD_{ra}) supports the supplier's material management activities (SEA_{mm}).

ESD_{ra} can additionally monitor the energy efficiency of the supplier, helping the buying organization trace the supplier's energy footprint. Finding energy efficiency a vital performance factor for the buyer organization, the supplier will be more determined to improve its energy consumption and management (Li et al. 2017). In view of that, *H1* can specifically address the supplier's energy efficiency activities:

H1b: Buyer-led environmental supplier development, in the form of environmental requirements and audits (ESD_{ra}) supports the supplier's energy efficiency activities (SEA_{ee}).

Over and above how the purchased items are made, in terms of material and energy, the buying organization may monitor how they are moved and delivered. Auditing the environmental aspects of the supplier's logistics and transport operations tries to fulfil this expectation of the buyer and its green procurement initiative (Russo 2009). The implications for the supplier may range from revised route planning to more frequent vehicle checks to assure less pollution and to improve the environmental impacts of its logistics and transport operations - to meet the buyer's environmental assessment criteria (Berlin et al. 2008). In view of that, *H1* can specifically test that:

H1c: Buyer-led environmental supplier development, in the form of environmental requirements and audits (ESD_{ra}) supports the supplier's logistics and transport environmental management activities (SEA_{lt}).

H1a-c emphasize the environmental capacities and capabilities that are developed in the supplier, and provide sustainable competitive advantages for both supplier and buyer (e.g. less cost of energy, more recyclable products, less carbon footprint, and enhanced reputation), all valuable resources which are rare and inimitable - quite compatible with and supported by NRBV.

Similar to *H1*, ESD_{dp} in *H2* may have different impacts on different supplier environmental activities. Supplier environmental activities in terms of material management can be largely supported by supplier development projects on product and process design - initiated by the buying organization to involve suppliers in design projects (Agarwal et al. 2018). Acquiring the knowledge and capability of product/process design and learning about the buyer's expectations in terms of products and material specifications promote the supplier's material management activities and capabilities. Therefore, H2 can more specifically state that:

H2a: Environmental supplier development in the form of direct development projects (ESD_{dp}), run or supported by the buyer, boosts the supplier's material management activities (SEA_{mm}).

Expanding the supplier's environmental activities on energy efficiency are usually in need of innovation and technical support, and buyers can run or take the lead in knowledge transfer projects in this field (Bos□Brouwers 2010). The projects may be extended to technology transfer (e.g. more energy efficient machineries), or joint supplier-buyer energy-efficient process design. Accordingly, *H2* can address the supplier's environmental activities in terms of energy as:

H2b: Environmental supplier development in the form of direct development projects (ESD_{dp}), run or supported by the buyer, boosts the supplier's energy efficiency management activities (SEA_{ee}).

The supplier's attempts to improve the environmental impacts of its logistics and transport may need knowledge/technology transfer (e.g. more intelligent transport and route planning systems) or financial investment (e.g. for new vehicles or modern logistics equipment), which can be supported by the buying organization and its direct supplier development projects. In view of that, H2 can have the third sub-hypothesis as:

H2c: Environmental supplier development in the form of direct development projects (ESD_{dp}), run or supported by the buyer, boosts the supplier's logistics and transport environmental management activities (SEA_{lt}).

As it is evident in *H2a-c*, ESD_{dp} mainly includes knowledge transfer in the environmental supplier development direct projects, which leads to development of valuable and rare resource for suppliers. Hence, in line with what has been already discussed on *H2*, the KBV theory supports the vital role of ESD_{dp} in the supplier's activities in terms of material management, energy efficiency, and logistics and transport.

2.3 Mediating factors

As Hart and Dowell (2011) emphasize, the NRBV needs the organizations, involved in environmental development programs, to commit and allocate adequate resources. In buyer-led environmental supplier development programs, the buying organization is originally committed to the program. The literature, as summarized in Table 1, has dominantly studied the environmental supplier development programs from the buyer's perspective. However, Wong et al. (2012) underline that environmental development programs need partner firms to be engaged and collaborating too. This is consistent with corporate sustainability research (Brown et al. 2010), and the impacts of external and internal motives for suppliers to support their environmental developments (Graham and Bertels 2008). Considering the contribution of sustainability to the firm's market value (Lo and Sheu 2007), the supplier may see immediate as well as long terms results from ESD_{ra} and ESD_{dp} in its environmental performance. These external motives may trigger further internal motives for the supplier to allocate resources to the environmental development programs and collaborate with the buyer organization, who originally initiated such program(s). In view of this, the current research focuses on supplier resource allocation (SRA), and buyer-supplier collaboration (BSC), as two mediating constructs, and test if they mediate the impact of environmental supplier development on the buying organization's environmental activities. These two mediating research constructs are defined as:

- SRA: Supplier resource allocation, in terms of environmental records, and financial/ information/human resources, to the buyer-led environmental supplier development program.

- BSC: Supplier collaboration with the buyer, in the forms of information sharing, joint efforts/decisions/plans, and mutual understanding and achievement of environmental objectives.

Further theoretical ground of the role of SRA and BSC is discussed as follows.

SRA in the environmental supplier development program can be viewed as a natural response of the supplier to the development program to support it. It can be also the result of the buying organization demand and the requirement of the environmental development program. Motived by either or both, SRA is consistent with NRBV to enhance the supplier's environmental knowledge, resources and capabilities, and eventually support its environmental activities (Simpson et al. 2007). All environmental activities on material management, energy efficiency, and logistics and transport may largely benefit from financial, information and human resource allocations - although not at the same level. Empirical evidence shows that supplier development encourages supplier commitment (Ghijsen et al. 2010) and appropriate resource allocation (by suppliers) for development programs and relationships with buyers (Pulles et al. 2016). Moreover, supplier commitment, in general, and resource allocation to the supplier development program, in particular, are crucial for proper supplier development activities and success of the program (Agi and Nishant 2017; Handfield et al. 2000). In view of these, the role of SRA can be seen in the middle of the link between ESD and SEA – i.e. a mediating factor, which is influenced by ESD on one hand and influences SEA on the other. This is hypothesized as:

Hypothesis3(H3): Supplier resource allocation (SRA) mediates the impact of buyer-led environmental supplier development, in the form of environmental requirements and audits *(ESD_{ra})* on:

H3a: the supplier's material management activities (SEA_{mm})

H3b: the supplier's energy efficiency management activities (SEA_{ee})

H3c: the supplier's logistics and transport environmental management activities (SEA_{lt})

Hypothesis 4 (H4): Supplier resource allocation (SRA) mediates the impact of environmental supplier development in the form of direct development projects (ESD_{dp}) on:

H4a: the supplier's material management activities (SEA_{mm})

H4b: the supplier's energy efficiency management activities (SEA_{ee})

H4c: the supplier's logistics and transport environmental management activities (SEA_{lt})

BSC may include joint activities by the buyer and supplier toward developing environmental solutions (Rao 2002; Vachon and Klassen 2006). Building upon the NRBV, the significance of external collaboration for environmental development schemes has been widely underlined by the literature. Foerstl et al. (2015) highlight that effective deployment of the buyer's environmental practices across the supply chain needs collaboration with suppliers. Bowen et al. (2006) and Wang et al. (2018) show how supplier environmental issues and development need mutual cooperation of the supplier and the buyer. Consistent with NRBV, Blome et al. (2014b) show that supplier collaboration can build a good platform for knowledge exchange, and when pursued jointly with the supplier development, in the form of environmental assessment, can lead to improved environmental capabilities. Bowen et al. (2001) and Hoejmose and Adrien-Kirby (2012) point out that environmental capabilities are developed jointly with suppliers. Material management and energy efficiency development projects, in particular, are mostly engaged in innovation and knowledge transfer initiative which cannot be simply dictated by the buyer, and highly demand supplier collaboration. Similarly, environmental activities on logistics and transport are mainly defined in the interface of buyer and supplier, and therefore need a proper collaboration (e.g. sharing the delivery schedules or route planning algorithm).

Some empirical studies show how major buyers (e.g. the case of BMW in von Ahsen 2006) encourage collaboration on environmental development practices. Demanded by environmental supplier development schemes, BSC supports people/processes interactions, and facilitates the adoption and implementation of environmental activities by the supplier (Theyel 2006). Therefore, BSC can be viewed as a mediating factor that is affected by the ESD on the one hand and positively influences SEA on the other. This can be formulated in hypotheses 5 and 6 as:

Hypothesis 5 (H5): Supplier collaboration with the buyer (BSC) mediates the impact of buyer-led environmental supplier development, in the form of environmental requirements and audits *(ESD_{ra})* on:

H5a: the supplier's material management activities (SEA_{mm})

H5b: the supplier's energy efficiency management activities (SEA_{ee})

H5c: the supplier's logistics and transport environmental management activities (SEA_{lt})

Hypothesis 6 (H6): Supplier collaboration with the buyer (BSC) mediates the impact of environmental supplier development in the form of direct development projects (ESD_{dp}) on:

H6a: the supplier's material management activities (SEA_{mm})

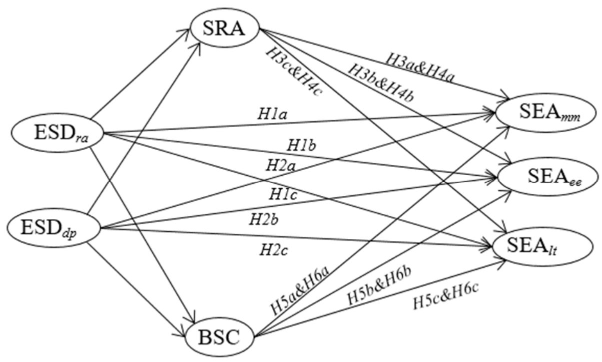
H6b: the supplier's energy efficiency management activities (SEA_{ee})

H6c: the supplier's logistics and transport environmental management activities (SEA_{lt})

Based on H1-H6, Figure 1 provides a structural model of the research hypotheses. Besides, there are three control variables considered in the structural model:

- Business sector: manufacturing and service.
- Firm size (based on the number of employees): micro and small (<50 employees), medium (50-249 employees), large (>=250 employees).
- ISO14001 certification (i.e. being certified for environmental management system. ISO14001).

The literature (e.g. Gonzalez-Benito and Gonzalez-Benito 2006, Lai and Wong 2012) indicates that size, business type and adopting environmental management system may have influences on the organizations environmental activities. Therefore, the control variable effects on the endogenous constructs of this research (i.e. SEA_{ee}, SEA_{mm}, and SEA_{lt}) are tested in this research.



List of Acronyms

BSC	Buyer-Supplier Collaboration
ESD_{dp}	Supplier environmental development in the form of direct development projects
ESD_{ra}	Buyer-led supplier environmental development, in the form of environmental requirements and audits
SEA_{ee}	Supplier's energy efficiency activities
SEA_{lt}	Supplier's logistics and transport environmental management activities
SEA_{mm}	supplier's material management activities
SRA	Supplier Resource Allocation

Figure 1: Research framework and hypotheses.

3. Research Design

The research hypotheses developed in section 2, are tested using survey empirical data. Details of the hypotheses' constructs operationalization, their measurement instruments, as well as the justification for the choice of survey method, data collection medium, and data analysis methods are outlined in the following sub-sections.

3.1 Operationalization of the research constructs

The research exogenous constructs (ESD_{ra} and ESD_{dp}), endogenous constructs (SEA_{mm}, SEA_{ee}, and SEA_{lt}), and mediators (BSC and SRA) are typically latent variables and represented by a number of measured items. Given this, BSC uses the well-developed measured items of Vachon and Klassen (2006), as listed in Appendix 1. For SRA, various measures, introduced by De Vita et al. (2011), Mithas et al. (2008), and Pulles et al. (2016), have been reviewed. Among them, allocation of financial, human, and information/knowledge resources has been found in common and relevant. They are well-formalized by Lee (2008) and thereby employed by the current research (see Appendix 1).

For ESD_{ra}, ESD_{dp}, SEA_{mm}, SEA_{ee} and SEA_{dp}, various relevant measures have been identified in the literature. After the initial review and scale purification, the Q-sort method (Nahm et al. 2002) has been used to finalize and validate the constructs' measured items. Following the Q-sort procedure, through a multiple-iteration process and using two different expert judges (from academia and practice) in each stage, the initial list of 39 items has been condensed to 22 reflective items, agreed upon by judges, to be allocated to the five constructs above (note: in cases of conflict, where the judges cannot reach an agreement, the items are dropped or merged and the new items are tested again). Validity and reliability of the final list have been tested against Moore and Benbasat's (1991) "Hit Ratio" and Cohen's (1960) "Kappa Ratio" thresholds, >90% and >80% respectively. The research constructs/validated measured items and the references, which they are initially adapted from, are provided in Appendix 1.

3.2 Data collection

This research uses the cross-sectional survey method to collect the required data for items' measurements and hypotheses tests. The survey is extensively recognized as an effective research strategy for the explanatory, theory testing (Forza 2016), which is the case in this study, where the theories around environmental supplier development, supplier environmental activities and their relationships are articulated, and the aim is to test those relationships with/without the presence of the mediators.

The data collection instrument is designed as a web-based questionnaire (Fleming and Bowden 2009). The questionnaire allocates each question to a measured item using a five-point Likert scale (ranging from 1= strongly agree to 5=strongly disagree). The questionnaire is in English, and suitable for the target respondents. In addition to the earlier validity/reliability tests of the measured items, the structure and wording of the questionnaire have been approved by two academics and one proofreader.

The questionnaire has been distributed to a sample frame of 1329 suppliers of the public sector in the UK, reflecting a wide range of environmental efforts pursued by various sectors. The UK public sector has a key role in promoting sustainable development within the country and internationally (Walker and Brammer 2009). It addresses sustainability through a wide range of procurement initiatives, e.g. instructing suppliers to reduce their energy or fuel consumption, phasing out hazardous materials in procured products and services, and requiring a minimum recycled content for purchased items.

The unit of study is the individual firm, in its capacity as a supplier. The target respondents in the firms are senior or middle managers in the areas of sustainability, environmental issues, operations, production, customer relationship, purchasing, or strategic management. One completed questionnaire is needed from each firm. After three rounds of contact, 285 questionnaires have been collected; 18 returned questionnaires were dropped due to multiple missing values. Those with one, two or three non-response questions were kept, and dealt with later by the case-wise replacement technique (Tsikriktsis 2005). Therefore 267 usable responses are achieved (i.e. response rate = 20%), which is comparable with similar studies (e.g. Agarwal et al. 2018: sample size = 66; Lee et al. 2018: sample size=197; Nath and Ramanathan 2016: sample size: 76). The sample size meets the recommended rule of thumb by Hair et al. (2017), and is capable of explaining medium to small population effects very well – according to G*Power3.1.9.2 power analysis (Faul et al. 2008): for $f^2 = 0.06$, $n = 267$, $\alpha = 0.05 \Rightarrow 1\text{-}\beta = 0.91$; for $f^2 = 0.15$, $n = 267$, $\alpha = 0.05 \Rightarrow 1\text{-}\beta = 0.99$. The sample profile is provided in Appendix 2. Less than half of the respondents are in various types of manufacturing business and about a third of them are in the service. In terms of size, ten percent are large organization, and small/micro and medium businesses contribute to around a third of responses each. The sample profile also reveals that a small number of the firms have ISO14001 certification. Finally, the extrapolation method (Armstrong and Overton 1977) is followed to test non-response bias. The results of the *t*-test indicate no significant difference (at p=0.05 level) between random samples of 30 taken from the first and last waves of responses, indicating no non-response bias.

3.3 Validity/Reliability Tests and Data Analysis Methods

The Partial Least Squares (PLS) method and SmartPLS 3.0 software (Ringle et al. 2015) are used to analyze the data. The capacity and suitability of PLS for structural hypothesis testing and predictive analysis with medium sample size (similarly to this research) have been widely recognized for years and re-emphasized in the recent literature (Akter et al. 2017). In particular, this research preferred PLS over Covariance-Based methods, such as LISREL, due to the sample size of the useable data (i.e. 267) which is considered medium to low, the complexity of the model and constructs and the possible uncertainties about the normality of their data, and finally the strong prediction capacity of PLS which fits very well with this research (Hair et al. 2017).

In the first step of data analysis, using the confirmatory factor analysis (CFA), convergent validity, discriminant validity, unidimensionality, and reliability of the constructs are tested. Any measured item with a factor loading below 0.7 is removed. Two measured items are dropped at this stage (see Appendix 1). This rigorous test ensures that only the very strong measured items remain in the scales. All remaining measured items have significant (at $p<0.001$) and high factor loadings (>0.7). The levels of average variance extracted (AVE) of the final constructs are also higher than the 0.50 level recommended by Fornell and Larcker (1981). Discriminant validity is examined by comparing AVE and squared correlations for pairs of constructs, and AVE is much higher, as required by Fornell and Larcker (1981). Further, the unidimensionality is assessed by estimation of the cross loadings among the measured items. For all pairs of constructs, all measured items for each pair of constructs are expected to be loaded clearly and strongly on their expected construct, without exception and with a good margin of difference between loadings. The reliability of the constructs is assessed by the levels of Cronbach's α (>0.70), as recommended by Nunnally (1978). Finally, the goodness of the theoretical model is assessed by reviewing the combined effects of relevant exogenous constructs on each endogenous construct and measuring the coefficients of determination (R^2), which indicate the predictiveness of endogenous constructs (Chin 1998). The outputs of the PLS analysis show that R^2s in this research are more than 0.1, which meets Falk and Miller's (1992) acceptable level for R^2, and is compatible with the outcomes of the hypotheses tests. Details of the validity and reliability tests are provided in Table 2.

Table 2: Constructs loadings†, intercorrelations††, cross-loadings†††, AVE and reliabilities.

Constructs→ ↓ Measured Items↓	ESD_{ra}	ESD_{dp}	BSC	SRA	SEA_{ee}	SEA_{lt}	SEA_{mm}	AVE	R^2	Composite Reliability	Cronbach's Alpha
ESD_{ra}		*0.05*	*0.24*	*0.24*	*0.23*	*0.15*	*0.17*	0.89		0.97	0.96
$ESD_{ra}1$	**0.95** (148.01)	0.04	0.21	0.21	0.20	0.15	0.17				
$ESD_{ra}2$	**0.93** (70.31)	0.00	0.22	0.25	0.21	0.14	0.17				
$ESD_{ra}3$	**0.93** (105.95)	0.08	0.23	0.19	0.22	0.13	0.16				
$ESD_{ra}4$	**0.95** (152.12)	0.07	0.23	0.25	0.22	0.13	0.13				
ESD_{dp}			*0.16*	*0.19*	*0.09*	*0.14*	*0.05*	0.78		0.95	0.93
$ESD_{dp}1$	0.08	**0.87** (42.10)	0.11	0.17	0.11	0.11	0.08				
$ESD_{dp}2$	0.02	**0.92** (74.50)	0.14	0.16	0.02	0.13	0.04				
$ESD_{dp}3$	0.02	**0.89** (48.32)	0.15	0.19	0.02	0.11	0.05				
$ESD_{dp}4$	0.06	**0.92** (74.49)	0.16	0.18	0.10	0.14	0.04				
$ESD_{dp}5$	0.03	**0.80** (18.33)	0.13	0.13	0.12	0.12	0.02				
BSC				*0.35*	*0.06*	*0.38*	*0.01*	0.69		0.92	0.89
BSC1	0.22	0.12	**0.89** (61.29)	0.31	0.06	0.37	0.00				
BSC2	0.21	0.15	**0.92** (89.35)	0.37	0.06	0.34	0.02				
BSC3	0.13	0.10	**0.70** (10.78)	0.18	0.02	0.23	0.04				
BSC4	0.23	0.11	**0.90** (66.90)	0.33	0.05	0.34	0.01				
BSC5	0.19	0.17	**0.77** (20.36)	0.24	0.04	0.31	0.04				
SRA					*0.23*	*0.49*	*0.05*	0.82		0.95	0.92
SRA2	0.18	0.18	0.28	**0.94** (107.88)	0.13	0.12	0.03				
SRA3	0.19	0.17	0.33	**0.93** (103.70))	0.14	0.43	0.06				
SRA4	0.17	0.17	0.33	**0.94** (108.74)	0.16	0.49	0.03				
SRA5	0.30	0.17	0.31	**0.80** (32.09)	0.36	0.41	0.04				
SEA_{ee}						*0.02*	*0.15*	0.87	0.13	0.95	0.92
$SEA_{ee}1$	0.13	0.10	0.08	0.22	**0.91** (50.66)	0.04	0.13				
$SEA_{ee}2$	0.26	0.06	0.02	0.20	**0.94** (121.03)	0.01	0.14				
$SEA_{ee}3$	0.24	0.09	0.06	0.22	**0.94** (100.10)	0.01	0.14				
SEA_{lt}							*0.03*	0.92	0.29	0.97	0.96
$SEA_{lt}1$	0.12	0.15	0.40	0.47	0.00	**0.96** (211.87)	0.03				
$SEA_{lt}2$	0.13	0.16	0.40	0.46	0.01	**0.97** (216.05)	0.01				
$SEA_{lt}3$	0.17	0.10	0.31	0.47	0.04	**0.95** (80.49)	0.04				
SEA_{mm}	*0.17*	*0.05*	*0.01*	*0.07*	*0.15*	*0.03*	*1*	0.82	0.10	0.97	0.96
$SEA_{mm}1$	0.16	0.10	0.03	0.06	0.16	0.05	**0.93** (40.77)				
$SEA_{mm}2$	0.12	0.08	0.01	0.00	0.09	0.02	**0.93** (43.66)				
$SEA_{mm}3$	0.18	0.03	0.04	0.10	0.16	0.00	**0.89** (29.64)				
$SEA_{mm}4$	0.15	0.04	0.01	0.02	0.14	0.01	**0.93** (79.53)				
$SEA_{mm}5$	0.16	0.08	0.05	0.03	0.12	0.02	**0.93** (46.19)				
$SEA_{mm}6$	0.13	0.01	0.03	0.04	0.12	0.05	**0.83** (39.15)				

† Loadings are in light shade cells in **bold** with *t*-values in brackets. †† Constructs Correlations are in dark shade cells, in *italic*
††† All other numbers in the left hand-side of the table.

In addition to the key tests above, since the survey data are collected once from single respondents using a self-administered questionnaire, common method bias should be considered. Following Podsakoff et al. (2003) recommendations, necessary actions are taken in the survey design to minimize the method bias risk. Statistical tests (Liang et al. 2007, Podsakoff et al. 2003) are conducted to analyze how much of the measured items' variances is associated with the method factor alongside their assigned constructs. The results ascertain the negligible share of the method factor in explaining the measured items variances – average loadings for principal constructs are 0.89 vs. 0.001 for the method factor (details are available from the authors). Besides, all loadings on substantive constructs are very significant (at $p<0.001$ level), while none of them is significant for the method factor. Thus, the data analysis of this research should not be affected by the common method bias. Overall, a set of valid, reliable constructs is expected to be subsequently used to test the hypotheses in the next step.

In the second step, the research hypotheses are tested by estimating the paths' coefficients of the structural model in Figure 1. Using the variance-based approach of PLS, the paths' coefficients and their significance are calculated via the bootstrapping method. The paths' significance is calculated by a two-tailed test, where t-values of 3.29 or more (i.e. $p<0.001$, significant at 0.1%), between 2.58 and 3.29 (i.e. $p<0.01$, significant at 1%), between 1.96 and 2.58 (i.e. $p<0.05$, significant at 0.5%), and between 1.65 and 1.96 (i.e. $p<0.1$, significant at 10%) are identified as extremely significant, very significant, significant and almost significant respectively.

To test the mediating effects (i.e. H3-H6), the advanced and widely recommended method of Nitzl (2016) is used. The method tests the indirect effect. If it is significant and if the direct effect is not significant, then the full mediation is proved. If both indirect and direct effects are significant, then the partial mediation exists. Since the structural model of this research has more than one mediation, further investigation and calculations are made to find the indirect effect of each mediator, as Cepeda et al. (2017) recommended for multiple mediation assessment – further details are provided in the next section.

The business sectors, firm size, and ISO14001 certification, as defined in section 2, are taken as control variables of the model, and their effects are tested on the endogenous constructs of this research (i.e. SEA_{ee}, SEA_{mm}, and SEA_{lt}). Further details of them are provided in Appendix 2.

4. Findings and Discussions

4.1 Hypotheses test results

To illustrate the results clearly and in detail, the research structural model, featured earlier in Figure 1, is broken down in Table 3, where the direct and indirect effects and their t-values are provided. The results, in summary, show that the hypothesis groups H1 and H2 are supported (with an exception of H2a) directly or via the SRA and BSC mediators, which means that ESD_{ra} and ESD_{dp} boost SEA_{mm}, SEA_{ee}, and SEA_{lt} (except $ESD_{dp} \rightarrow SEA_{mm}$). To elaborate these, the results, presented in Table 3, are explained one by one and row by row as follows:

- $ESD_{ra} \rightarrow SEA_{mm}$, including the direct effect along with indirect effects, $ESD_{ra} \rightarrow SRA \rightarrow SEA_{mm}$ and $ESD_{ra} \rightarrow BSC \rightarrow SEA_{mm}$ (i.e. H1a, H3a, H5a): The direct effect is significant at 1% but the total indirect effect is not significant. Further investigation (column 4 and 6 of the table) shows that $SRA \rightarrow SEA_{mm}$, $ESD_{ra} \rightarrow BSC$, and $BSC \rightarrow SEA_{mm}$ are not significant. Therefore, it can be concluded that the impact of ESD_{ra} on SEA_{mm} is directly significant and it is not mediated by the mediators of this research (i.e. H1a: Supported directly only, H3a: Not supported, H5a: Not supported).

- ESD_{ra}→SEA_{ee}, including the direct effect along with indirect effects, ESD_{ra}→SRA→SEA_{ee} and ESD_{ra}→BSC→SEA_{ee} (i.e. H1b, H3b, H5b): The direct effect is significant at 1% but the indirect effect is not significant. Further investigation (column 4 and 6 of the table) shows that the effect of BSC is not significant, but ESD_{ra}→SRA, and SRA→SEA_{ee} are both significant. This can be an indication that although the total indirect effect via both SRA and BSC (column 3) is not significant, the indirect effect is significant via SRA only. Following Cepeda et al. (2017) advanced calculation for multiple mediation, this research has found the total indirect effect via SRA significant at 1% (details of the calculations are available with authors upon request). Additionally, Variance Account For (VAF) has been calculated as 21.27% which shows the mediating effect of SRA in the relationship between ESD_{ra} and SEA_{ee}. Therefore, it can be concluded that the impact of ESD_{ra} on SEA_{ee} is mediated by SRA (i.e. H1b: Supported, H3b: Supported, H5b: Not supported).

- ESD_{ra}→SEA_{lt}, including the direct effect along with indirect effects, ESD_{ra}→SRA→SEA_{lt} and ESD_{ra}→BSC→SEA_{lt} (i.e. H1c, H3c, H5c): The direct effect is not significant, but the total indirect effect is significant at 0.1%. This shows that the impact of ESD_{ra} on SEA_{lt} is totally mediated by SRA and BSC (i.e. H1c: Supported totally via supported H3c and H5c). Additionally, the calculated VAF shows the shares of 58.52% and 35.11% of SRA and BSC, respectively, in the relationship between ESD_{ra} and SEA_{lt}.

- ESD_{dp}→SEA_{mm}, including the direct effect along with indirect effects, ESD_{dp}→SRA→SEA_{mm} and ESD_{dp}→BSC→SEA_{mm} (i.e. H2a, H4a, H6a): The direct effect is not significant, and the total indirect effect is not significant either. The stand-alone relationship between ESD_{dp} and SEA_{mm} is tested separately and not found significant either. Hence, it can be concluded that the impact of ESD_{dp} on SEA_{mm} is not significant, directly or via the mediators. (i.e. H2a, H4a and H6a are not supported).

- ESD_{dp}→SEA_{ee}, including the direct effect along with indirect effects, ESD_{dp}→SRA→SEA_{ee} and ESD_{dp}→BSC→SEA_{ee} (i.e. H2b, H4b, H6b): The direct effect and total indirect effect are not significant. Further investigation (column 4 and 6 of the table) shows that ESD_{dp}→SRA, and SRA→SEA_{ee} are both significant. This can be an indication that although the total indirect effect via both SRA and BSC (column 3) is not significant, the indirect effect is significant via SRA only. Following Carrión et al. (2017) method the total indirect effect via SRA is found significant at 1%. VAF here is calculated as 48.29%, which shows the mediating effect of SRA in the relationship between ESD_{dp} and SEA_{ee}. Therefore, it can be concluded that the impact of ESD_{dp} on SEA_{ee} is mediated by SRA (i.e. H2b: Supported via H4b, and H6b: Not supported).

- ESD_{dp}→SEA_{lt}, including the direct effect along with indirect effect, ESD_{dp}→SRA→SEA_{lt} and ESD_{dp}→BSC→SEA_{lt} (i.e. H2c, H4c, H6c): The direct effect is not significant, but the total indirect effect is significant at 1%. This shows that the impact of ESD_{dp} on SEA_{lt} is totally mediated by SRA and BSC (i.e. H2c: Supported totally via supported H4c and H6c). The calculated VAF shows the shares of 52.17% and 26.09% of SRA and BSC, respectively, in the relationship between ESD_{dp} and SEA_{lt}.

- Control variable effects are found not significant at 5%. See Figure 2 for details.

The paths significance of the structural model and the control effects are illustrated separately in Figure 2.

Table 3. Hypotheses tests results; direct and indirect effects.

Path	Direct Effect	Total Indirect Effect (via both SRA and BSC)	Indirect via SRA: Individual paths	Indirect via SRA: Total effect via SRA	Indirect via BSC: Individual paths	Indirect via BSC: Total effect via BSC	Notes
$ESD_{ra} \rightarrow SEA_{mm}$	0.17 *(2.84)***	0.01 *(0.36)*	$ESD_{ra} \rightarrow SRA \rightarrow SEA_{mm}$ 0.23 0.01 *(3.67)**** *(0.17)*		$ESD_{ra} \rightarrow BSC \rightarrow SEA_{mm}$ 0.23 -0.04 *(3.98)**** *(0.64)*		Direct effect only. H1a: Supported directly only. H3a: Not supported. H5a: Not supported.
$ESD_{ra} \rightarrow SEA_{ee}$	0.20 *(3.13)***	0.03 *(1.27)*	$ESD_{ra} \rightarrow SRA \rightarrow SEA_{ee}$ 0.23 0.20 *(3.67)**** *(2.99)***	0.046 *(significant at 1%)* VAF[†] = 21.27%	$ESD_{ra} \rightarrow BSC \rightarrow SEA_{ee}$ 0.23 -0.07 *(3.98)**** *(1.05)*	-0.016 *(not significant at 1% and 5%)*	Partial mediation, via SRA only. H1b: Supported, directly and via SRA H3b: Supported H5b: Not supported
$ESD_{ra} \rightarrow SEA_{lt}$	0.01 *(0.17)*	0.15 *(4.44)****	$ESD_{ra} \rightarrow SRA \rightarrow SEA_{lt}$ 0.23 0.40 *(3.67)**** *(7.59)****	VAF= 58.52%	$ESD_{ra} \rightarrow BSC \rightarrow SEA_{lt}$ 0.23 0.24 *(3.98)**** *(4.26)****	VAF= 35.11%	Full mediation via both BSC and SRA. H1c: Supported but totally via both mediators H3c: Supported H5c: Supported
$ESD_{dp} \rightarrow SEA_{mm}$	0.05 *(0.68)*	0.01 *(0.28)*	$ESD_{dp} \rightarrow SRA \rightarrow SEA_{mm}$ 0.18 0.01 *(3.07)*** *(0.17)*		$ESD_{dp} \rightarrow BSC \rightarrow SEA_{mm}$ 0.15 0.05 *(2.55)** *(0.64)*		No effect. H2a: Not supported. H4a: Not supported. H6a: Not supported.
$ESD_{dp} \rightarrow SEA_{ee}$	0.05 *(0.77)*	0.03 *(1.38)*	$ESD_{dp} \rightarrow SRA \rightarrow SEA_{ee}$ 0.18 0.20 *(3.07)*** *(2.99)***	0.037 *(significant at 1%)* VAF = 48.29%	$ESD_{dp} \rightarrow BSC \rightarrow SEA_{ee}$ 0.15 -0.07 *(2.55)** *(1.05)*	-0.011 *(not significant at 1% and 5%)*	Full mediation, but only via SRA. H2b: Supported, but via SRA H4b: Supported H6b: Not supported
$ESD_{dp} \rightarrow SEA_{lt}$	0.03 *(0.47)*	0.11 *(3.27)***	$ESD_{dp} \rightarrow SRA \rightarrow SEA_{lt}$ 0.18 0.40 *(3.07)*** *(7.59)***	VAF= 52.17%	$ESD_{dp} \rightarrow BSC \rightarrow SEA_{lt}$ 0.15 0.24 *(2.55)** *(4.26)****	VAF= 26.09%	Full mediation via both BSC and SRA. H2c: Supported but totally via both mediators H4c: Supported H6c: Supported

* Significant at 5%   ** Significant at 1%   *** Significant at 0.1%   † Variance Accounted for

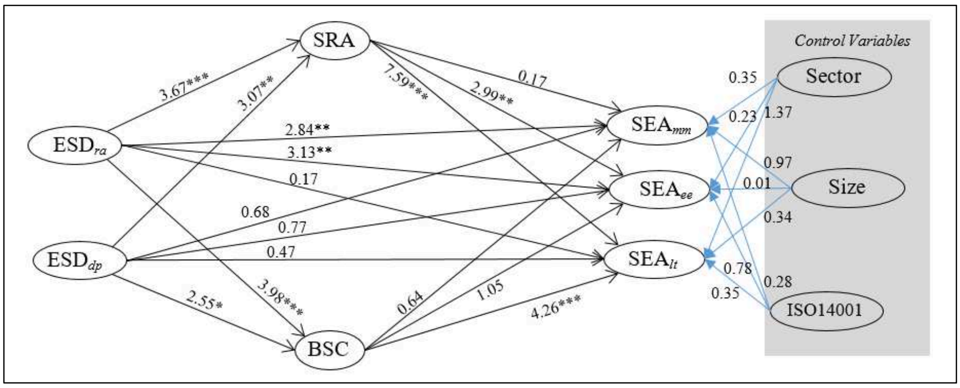


Figure 2: Paths significance and control effects.

4.2 Reflections and discussions

This research has sought to investigate the role of buyers in supplier environmental schemes, and for this purpose, it has formulated and tested hypotheses associated with environmental supplier development, activities, collaboration, and resource allocation.

Among the environmental supplier development constructs, ESD$_{ra}$ demonstrates significant impacts on all supplier environmental activities (SEA$_{mm}$, SEA$_{ee}$, SEA$_{lt}$), but ESD$_{dp}$ only has a detectable impact on SEA$_{ee}$ and SEA$_{lt}$. The results mainly support the theoretical views of this paper, and participating suppliers in the survey found the buyer to be positively influential in their environmental activities. They do not, nevertheless, notify direct involvement of the buyer in SEA$_{mm}$ very effective. With no major contradiction with the theories around ESD$_{dp}$ (discussed in section 2), it can be intuitively explained that although buyer involvement in the supplier's environmental activities is important (Bai and Sarkis 2019), in the case of internally-oriented environmental activities, such as material management, there exist many other influencing factors, in addition to the buyer. Internal environmental activities are typically motivated by and sensitive to various innovative, technological, financial, legal, and behavioral capacities and requirements (Blum-Kusterer and Hussain 2001; Muduli et al. 2013). With this in view, in the case of externally-oriented environmental activities, such as logistics and energy management, the buyer influence in both forms of ESD$_{ra}$ and ESD$_{dp}$ are found to be significant, which is in line with the discussion above. This is also in line with Vachon and Klassen (2006) who show a positive link between logistical integration and environmental collaboration. Moreover, the environmental requirements and audits (ESD$_{ra}$) seem harsher (or more disciplined) ways of instructing suppliers toward environmental activities, as lack of compliance may lead to more serious consequences for them.

The supported effects of ESD$_{ra}$ and ESD$_{dp}$ on supplier environmental activities are mostly proved to be mediated by BSC and SRA. Consistent with the earlier theoretical discussions, the results reveal that ESD$_{ra}$ and ESD$_{dp}$ effects on SEA$_{lt}$ are actually realized through adequate SRA and BSC, indicating that buyers' environmental requirements as well as development projects motivate the supplier resource and relationship commitments, which in turn support SEA$_{lt}$., This is compatible with the recent literature, which recognizes resource allocation and collaboration as major influencing factors on logistics environmental capabilities (Graham and McAdam 2016). The effects of ESD$_{ra}$ and ESD$_{dp}$ on SEA$_{ee}$ are also found to be mediated by SRA, reconfirming how much energy efficiency improvements are sensitive to SRA (as noted by Simpson and Power 2005). Yet to deploy an energy efficient supply, the buying organization should urge the supplier to allocate proper financial, information and human resources first. Despite SRA, BSC cannot prove a pivotal mediating role in the $ESD_{ra}$$\rightarrow$$SEA_{ee}$ and $ESD_{dp}$$\rightarrow$$SEA_{ee}$ relationships. This implies that energy efficiency activities are largely inspired by internal plans and resource commitments, and various other factors, such as technology (Vachon 2007), ethical motivation (Paulraj 2009) and legislative compliance (Bansal and Roth 2000), than just collaboration with buyers. Similarly, the insignificant effect of SRA and BSC on SEA_{mm}, which drops their mediating role in the $ESD_{ra}$$\rightarrow$$SEA_{mm}$ and $ESD_{dp}$$\rightarrow$$SEA_{mm}$ can be explained by the SEA_{mm} impressionability to various other factors such as the nature of the production process or service delivery. This result then underlines the significant direct effect of ESD_{ra} on SEA_{mm}.

Further comparison and contrast of the impacts of the environmental supplier development and their mediators on supplier environmental activities can be done through the importance-performance map analysis (IPMA), which extends the results of PLS structural assessment by taking the importance of each construct into account. Following Hair et al. (2018) procedure for IPMA, Figure 3 illustrates the importance of the exogenous constructs for SEA_{mm}, SEA_{ee} and SEA_{lt}. The three plots of Figure 3 show that ESD_{ra}, ESD_{dp}, SRA, and BSC all have good (average) latent variable scores (i.e. performance, reflected on *y* axis). The exogenous constructs' importance is considerably higher for SEA_{lt} (0.2-0.5), among them, SRA and then BSC has much important role in supplier environmental activities in terms of logistics and transport. For supplier environmental activities in the area of energy efficiency, the important role of SRA is coupled with ESD_{ra}, and the two other factors, BSC and ESD_{ra}, show minor importance. Finally, as it was expected from the hypotheses test results, only ESD_{ra} has some low to medium level of importance for supplier environmental activities in terms of material management.

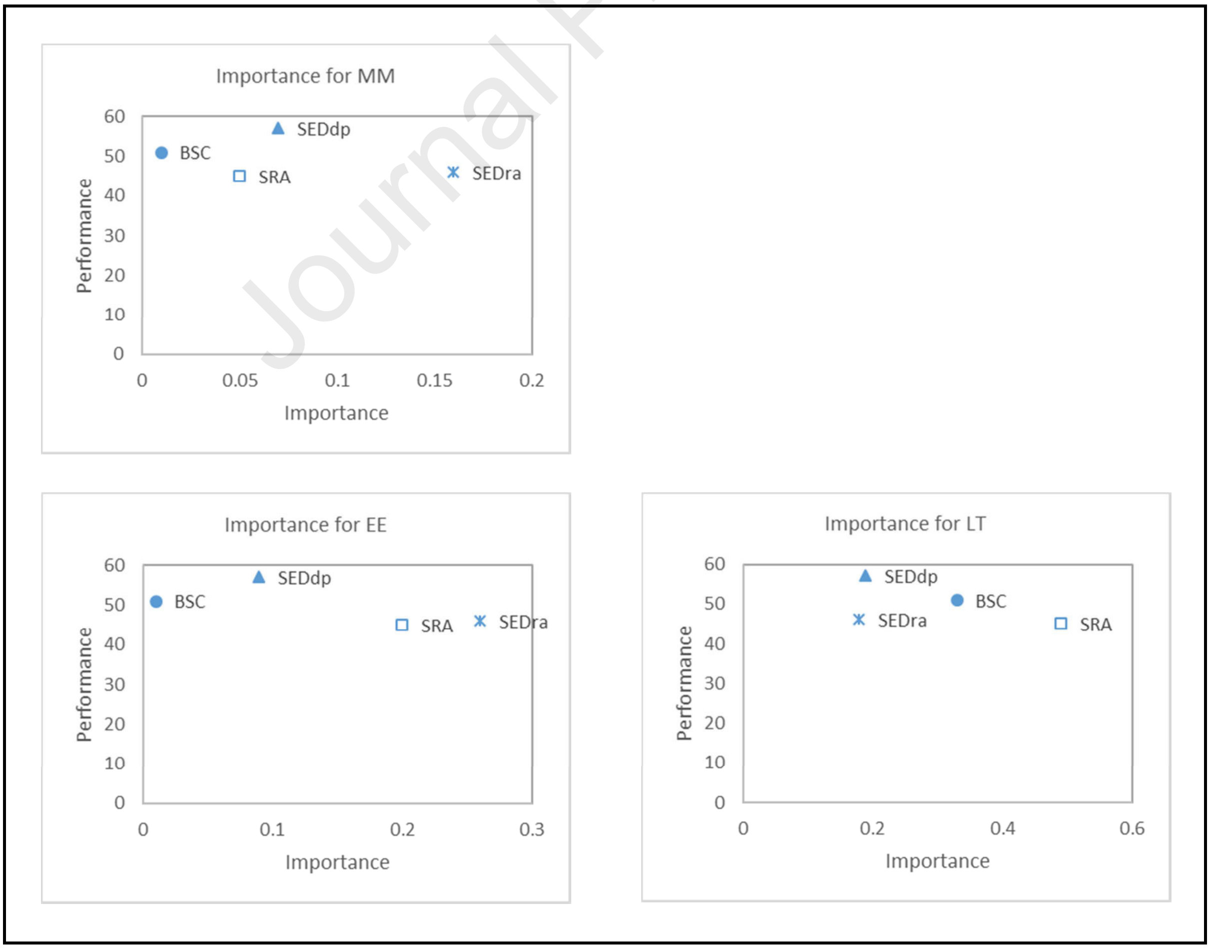


Figure 3: Importance-Performance analysis and comparison.

5. Conclusions

The empirical study of this paper, through a cross-sectional survey of supplier organizations, derives a good profile of the links among different types of buyer-led environmental supplier development approaches, their expected outcomes, and key mediating factors from the supplier's viewpoint. This research advances environmental management and supplier development literature by revealing that the buying organization and its environmental supplier development (ESD) programs can promote major supplier environmental activities (SEAs) in terms of material management, energy efficiency and logistics and transport. The impact is not, however, uniform for all ESDs and SEAs. Environmental supplier development, in the form of environmental requirements and audits (ESD_{ra}) has a positive and significant impact on all SEAs. But, the impact of environmental supplier development in the form of direct development project (ESD_{dp}) is limited to the supplier's energy efficiency (SEA_{ee}) and logistics and transport (SEA_{lt}) management activities.

The relationships among ESD and SEA constructs are found to be more complex than what the extant literature suggests. Whilst the environmental management literature recognizes the overall impact of the business customer on supplier environmental decisions and actions, this paper underscores the pivotal role of mediators (supplier resource allocation: SRA; and buyer-supplier collaboration: BSC). The paper further advances theories around environmental supply chain management by revealing that the effects of ESD_{ra} and ESD_{dp} on SEA_{lt} are not direct, but totally via SRA and BSA. Similarly, it has been shown that ESD_{ra} and ESD_{dp} promotes SEA_{ee} via SRA.

These findings contribute to the environmental supplier development research by measuring the impacts of ESD_{ra} and ESD_{dp} on SEAs and proving the critical roles of SRA and BSC in those impacts. The outcomes of this research clearly show that not all types of supplier development necessarily lead to better environmental activities and performance by the supplier. Therefore, it is crucial for the buying organization to distinguish between its environmental supplier development programs in terms of setting requirements and audit (ESD_{ra}) and direct development project (ESD_{dp}), and their separate impacts on various supplier environmental activities in terms of energy efficiency (SEA_{ee}), material management (SEA_{mm}), and logistics and transport (SEA_{lt}). Supplier resource allocation (SRA) and buyer-supplier collaboration (BSC), which are typically recognized as critical factors in supply chain decisions and activities, are found with significant mediating effects in this research too. Their roles, however, are not the same for all supplier development types and supplier environmental activities. This warns scholars not to make resource allocation and buyer-supplier collaboration imperative in all environmental supplier development schemes. The authors trust that such an enquiry is vital to enhance supply chain environmental development knowledge and leadership.

The theoretical findings of this paper provide a number of key insights which are useful for practitioners too. First, environmental projects, directly run by the buyer, may not be very effective for more internally-oriented environmental activities such as material management (SEA_{mm}). So, buyers may be better off if they organize their supply base environmental development programs via setting environmental requirements and audits than direct intervention. Second, logistics and transport, which are put in the category of externally-oriented environmental activities, need further intervention of the buying organizations, as they are positively influenced by both ESD_{ra} and ESD_{dp}. Third, environmental supplier development schemes need to make explicit reference to the way they define collaborations with suppliers (BSC) and their expectations from suppliers regarding resource allocation (SRA) for the environmental programs. BSC and SRA are acknowledged governance mechanisms in supplier development practices. Done well, they not only facilitate supply base environmental development, but also ensure the effectiveness of supply chain environmental activities. In fact, the supplier's decisions and actions, as focused on by this research, are crucial for the success of the environmental development programs. Particular environmental developments on energy efficiency and logistics and transport significantly need collaboration and resource allocation by the supplier. Recognizing the importance of environmental developments and their contribution to competitive advantages, may motivates the supplier to invest in environmental resources and relationships proactively, rather than just responding to the buyer's demand. This enhanced supplier's view to environmental development can then be extended to the "supplier's suppliers" and practically lead to what is wished for as environmental friendly supply chain in theory.

This research has addressed the relevant theoretical grounds and used a robust methodology. However, it has a number of limitations and gaps which can be considered in future research. Environmental development in the two forms of audits and direct projects might have impacts on each other, which were not the focus of this paper. Future studies may investigate how the outcomes of an environmental audit can support direct supplier development project(s), and also how earlier direct supplier development project(s) can affect future environmental audits.

The results of this paper mainly reflect the supplier's view to collaboration and resource allocation to environmental development programs. Other supply-side influencing factors are needed to be explored and studied. Relevance of the results to one country would require further research with more diverse and bigger sample frames. This can uphold the results of this research, which emerged from a comparatively small-medium sample size.

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References

Agarwal A, Giraud-Carrier FC, Li Y. 2018. A mediation model of green supply chain management adoption: the role of internal impetus. *International Journal of Production Economics* 205: 342-358.

Agi MA, Nishant R. 2017. Understanding influential factors on implementing green supply chain management practices: an interpretive structural modelling analysis. *Journal of Environmental Management* 188: 351-363.

Akter S, FossoWamba S, Dewan S. 2017. Why PLS-SEM is suitable for complex modelling? an empirical illustration in big data analytics quality. *Production Planning & Control* 28(11-12): 1011-1021.

Armstrong J, Overton T. 1977. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research* 14(3): 396–402.

Bai C, Sarkis J. 2019. Green supplier development: a review and analysis. In Handbook on the Sustainable Supply Chain. Edward Elgar Publishing.

Bansal P, Roth K. 2000. Why companies go green: a model of ecological responsiveness. *Academy of Management Journal* 43(4): 717–736.

Blome C, Hollos D, Paulraj A. 2014a. Green procurement and green supplier development: antecedents and effects on supplier performance. *International Journal of Production Research* 52(1): 32-49.

Blome C, Oaulraj A, Schuetz K. 2014b. Supply chain collaboration and sustainability: a profile deviation analysis. *International Journal of Operations & Production Management* 34(5), 639-663.
Blum-Kusterer M, Hussain SS. 2001. Innovation and corporate sustainability: an investigation into the process of change in the pharmaceuticals industry. *Business Strategy and the Environment* 10(5): 300-316.
Boiral O, Henri JF. 2012. Modelling the impact of ISO 14001 on environmental performance: a comparative approach. *Journal of Environmental Management* 99: 84-97.
Bos-Brouwers HEJ. 2010. Corporate sustainability and innovation in SMEs: evidence of themes and activities in practice. *Business Strategy and the Environment* 19(7): 417-435.
Bowen FE, Cousins PD, Lamming RC, Farukt AC. 2001. The role of supply management capabilities in green supply. *Production and Operations Management* 10(2): 174–189.
Bowen FE, Cousins P, Lamming R, Faruk A. 2006. Horses for courses: explaining the gap between the theory and practice of green supply. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London. 41-61.
Brown DL, Vetterlein A, Roemer-Mahler A. 2010. Theorizing transnational corporations as social actors: an analysis of corporate motivations. *Business and Politics* 12(1): 1-37.
Büyüközkan, G., Karabulut, Y. 2018. Sustainability performance evaluation: literature review and future directions. *Journal of Environmental Management* 217: 253-267.
Cepeda, G. C., Nitzl, C., Roldán, J. L. 2017. Mediation analyses in partial least squares structural equation modeling: Guidelines and empirical examples. In *Partial least squares path modeling* (pp. 173-195) by Laten H., Noonan, R., Springer.
Carter CR. 2005. Purchasing social responsibility and firm performance. *International Journal of Physical Distribution & Logistics Management* 35(3): 177-194.
Chan CK, Lee YCE, Campbell JF. 2013. Environmental performance - Impacts of vendor–buyer coordination. *International Journal of Production Economics* 145(2): 683-695.
Chen YS, Chang CH. 2013. The determinants of green product development performance: green dynamic capabilities, green transformational leadership, and green creativity. *Journal of Business Ethics* 116: 107–119.
Chiarini A. 2014. Strategies for developing an environmentally sustainable supply chain: differences between manufacturing and service sectors, *Business Strategy and the Environment* 23(7): 493–504.
Chiarini A. 2017. Environmental policies for evaluating suppliers' performance based on GRI indicators. *Business Strategy and the Environment* 26(1): 98-111.
Chin WW. 1998. The partial least squares approach for structural equation modeling. In *Modern Methods for Business Research*, Marcoulides GA (ed). Lawrence Erlbaum: London.
Chiou TY, Chan HK, Lettice F, Chung SH. 2011. The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation Research Part E: Logistics and Transportation Review* 47(6): 822–836.
Clifford Defee C, Williams B, Randall W S, Thomas R. 2010. An inventory of theory in logistics and SCM research. *The International Journal of Logistics Management*, 21(3), 404-489.
Cohen J. 1960. A coefficient of agreement for nominal scales. *Educational and Psychological Measurement* 20(1): 37–46.
Cole R, Aitken J. 2019. Selecting suppliers for socially sustainable supply chain management: post-exchange supplier development activities as pre-selection requirements. *Production Planning & Control*, 30(14), 1184-1202.

Dalvi, MV, Kant R. 2015. Benefits, criteria and activities of supplier development: a categorical literature review. *Asia Pacific Journal of Marketing and Logistics* 27(4): 653-675.

de Oliveira Neves F, Salgado EG, Beijo LA. 2017. Analysis of the environmental management system based on ISO 14001 on the American continent. *Journal of Environmental Management* 199: 251-262.

De Vita G, Tekaya A, Wang CL. 2011. The many faces of asset specificity: a critical review of key theoretical perspectives. *International Journal of Management Reviews* 13(4): 329-348.

Dou Y, Zhu Q, Sarkis J. 2015. Integrating strategic carbon management into formal evaluation of environmental supplier development programs. *Business Strategy and the Environment* 24(8): 873–891.

Eisenhardt KM, Santos FM. 2002. Knowledge-based view: a new theory of strategy? In: Pettigrew, A., Thomas, H., Whittington, R. (Eds.), *Handbook of Strategy and Management*. Sage, London

Eurostat 2017. Government expenditure on environmental protection. Eurostat Statistics Explained, available at: https://ec.europa.eu/eurostat/, accessed on 01/04/2019.

Evangelista P, Colicchia C, Creazza A. 2017. Is environmental sustainability a strategic priority for logistics service providers? *Journal of Environmental Management* 198: 353-362.

Falk RF, Miller NB. 1992. A Primer for Soft Modeling, University of Akron Press, Ohio.

Fang Y, Cote RP, Qin R. 2007. Industrial sustainability in China: practice and prospects for eco-industrial development. *Journal of Environmental Management* 83(3): 315-328.

Faul F, Erdfelder E, Lang AG, Buchner A. 2008. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavioral Research Methods* 39(2): 175–191.

Ferretti I, Zanoni S, Zavanella L, Diana A. 2007. Greening the aluminum supply chain. *International Journal of Production Economics* 108(1-2): 236-245.

Fleming CM, Bowden, M. 2009. Web-based surveys as an alternative to traditional mail methods. *Journal of environmental management* 90(1): 284-292.

Foerstl K, Azadegan A, Leppelt T, Hartmann E. 2015. Drivers of supplier sustainability: Moving beyond compliance to commitment. *Journal of Supply Chain Management* 51(1): 67-92.

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

Forza, C. 2016. Surveys. In *Research Methods for Operations Management*, Karlsson C (ed). Routledge: London. 95-180.

Fu X, Zhu Q, Sarkis J. 2012. Evaluating green supplier development programs at a telecommunications systems provider. *International Journal of Production Economics* 140(1): 357-367.

Gavronski I, Klassen RD, Vachon S, do Nascimento LFM. 2011. A resource-based view of green supply management. *Transportation Research Part E: Logistics & Transportation Review*, 47(6), 872-885.

Ghijsen PW, Semeijn J, Ernstson S. 2010. Supplier satisfaction and commitment: the role of influence strategies and supplier development. *Journal of Purchasing and Supply Management* 16(1): 17-26.

González-Benito J, González-Benito O. 2006. A review of determinant factors of environmental proactivity. *Business Strategy and the Environment* 15(2): 87–102.

Graham R, Bertels S. 2008. Achieving sustainable value: sustainability portfolio assessment. *Greener Management International* 54: 57-67.

Graham S, McAdam R. 2016. The effects of pollution prevention on performance. *International Journal of Operations & Production Management* 36(10): 1333-1358.

Grant RM. 1992. Contemporary strategy analysis: concepts, techniques, applications, Basil Blackwell, Cambridge, MA.

Grant RM. 1996. Toward a knowledge□based theory of the firm. *Strategic Management Journal* 17(S2): 109-122.

Hair Jr JF, Hult GTM, Ringle C, Sarstedt M. 2017. A primer on partial least squares structural equation modeling (PLS-SEM), Sage Publications, London.

Hair Jr JF, Sarstedt M., Ringle C, Gudergan SP. 2018. Advanced issues in partial least squares structural equation modeling, Sage Publications, London.

Handfield R, Walton SV, Sroufe R, Melnyk SA. 2002. Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process. *European Journal of Operational Research* 141(1): 70-87.

Handfield R, Sroufe R, Walton S. 2005. Integrating environmental management and supply chain strategies. *Business Strategy and the Environment* 14(1): 1-19.

Handfield RB, Krause DR, Scannell TV, Monczka RM. 2000. Avoid the pitfalls in supplier development, *Sloan Management Review* 41(2): 37-49.

Hart SL, Dowell G. 2011. A natural-resource-based view of the firm: fifteen years after. *Journal of Management* 37(5): 1464-1479 .

Hoejmose SU, Adrien-Kirby AJ. 2012. Socially and environmentally responsible procurement: a literature review and future research agenda of a managerial issue in the 21st century. *Journal of Purchasing and Supply Management* 18(4): 232–242.

Holt D, Ghobadian A. 2009. An empirical study of green amongst UK manufacturers. *Journal of Manufacturing Technology Management* 20(7): 933–956.

Journeault M. 2016. The Integrated Scorecard in support of corporate sustainability strategies. *Journal of Environmental Management*, 182: 214-229.

Krause DR, Scannell TV, Calantone RJ. 2000. A structural analysis of the effectiveness of buying firms' strategies to improve supplier performance. *Decision Sciences* 31(1): 33-55.

Kumar V, Holt D, Ghobadian A, Garza-Reyes JA. 2015. Developing green supply chain management taxonomy-based decision support system. *International Journal of Production Research* 53(21): 6372-6389.

Kurapatskie B, Darnall N. 2013. Which corporate sustainability activities are associated with greater financial payoffs? *Business Strategy and the Environment* 22(1): 49–61.

Lai KH, Wong CW 2012. Green logistics management and performance: some empirical evidence from Chinese manufacturing exporters. *Omega* 40(3): 267-282.

Lannelongue G, Gonzalez-Benito J, Gonzalez-Benito O. 2015. Input, output, and environmental management productivity: effects on firm performance. *Business Strategy and the Environment* 24 (3): 145–158.

Lee SY. 2008. Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An International Journal* 13(3): 185-198.

Lee SY. 2015. The effects of green supply chain management on the supplier's performance through social capital accumulation. *Supply Chain Management: An International Journal* 20(1): 42-55.

Lee SY, Klassen RD. 2008) Drivers and enablers that foster environmental management capabilities in small□and medium□sized suppliers in supply chains. *Production and Operations management* 17(6): 573-586.

Lee VH, Ooi KB, Chong AYL, Lin B. 2015. A structural analysis of greening the supplier, environmental performance and competitive advantage. *Production Planning & Control* 26(2): 116-130.

Lee VH, Ooi KB, Chong, AYL, Sohal A. 2018. The effects of supply chain management on technological innovation: The mediating role of guanxi. *International Journal of Production Economics*, 205, 15-29.

Li S, Ngniatedema T, Chen F. 2017. Understanding the impact of green initiatives and green performance on financial performance in the US. *Business Strategy and the Environment* 26(6): 776–790.

Li W, Humphreys PK, Yeung AC, Cheng TE. 2007. The impact of specific supplier development efforts on buyer competitive advantage: an empirical model. *International Journal of Production Economics*, 106(1), 230-247.

Liang H, Saraf N, Hu Q, Xue Y. 2007. Assimilation of enterprise systems: the effect of institutional pressures and the mediating role of top management. *MIS Quarterly* 31(1): 59-87.

Lippman S. 2001. Supply chain environmental management. *Environmental Quality Management* Winter: 11-14.

Liu L, Zhang M, Hendry LC, Bu M, Wang S. 2018. Supplier development practices for sustainability: a multi-stakeholder perspective. *Business Strategy and the Environment* 27(1): 100-116.

Liu L, Zhang M, Ye W. 2019. The adoption of sustainable practices: a supplier's perspective. *Journal of Environmental Management* 232, 692-701.

Lo S, Sheu H. 2007. Is corporate sustainability a value-increasing strategy for business? *Corporate Governance* 15(2): 345-358.

Lo CKY, Yeung ACL, Cheng TCE. 2012. The impact of environmental management systems on financial performance in fashion and textiles industries. *International Journal of Production Economics* 135(2): 561–567.

Lu RX, Lee, PK, Cheng TCE. 2012. Socially responsible supplier development: Construct development and measurement validation. *International Journal of Production Economics*, 140(1), 160-167.

McGovern T, Hicks C. 2006. Specifications and supplier development in the UK electrical transmission and distribution equipment industry, *International Journal of Production Economics* 104(1): 164-178.

Miao Z, Cai S, Xu D. 2012. Exploring the antecedents of logistics social responsibility: A focus on Chinese firms. *International Journal of Production Economics* 140(1): 18-27.

Min H, Galle WP. 1997. Green purchasing strategies: trends and implications. *Journal of Supply Chain Management* 33(3): 10-17.

Mithas S, Jones JL, Mitchell W. 2008. Buyer intention to use internet-enabled reverse auctions: the role of asset specificity, product specialization, and non-contractibility. *MIS quarterly* 32(4): 705-724.

Modi SB, Mabert VA. 2007. Supplier development: improving supplier performance through knowledge transfer. *Journal of Operations Management* 25(1): 42-64.

Moore GC, Benbasat I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information System Research* 2(3): 192–222.

Muduli K, Govindan K, Barve A, Kannan D, Geng Y. 2013. Role of behavioural factors in green supply chain management implementation in Indian mining industries. *Resources, Conservation and Recycling* 76: 50-60.

Nahm A, Solis-Galvan LE, Rao SS, Ragu-Nathan TS. 2002. The Q-sort method: assessing reliability and construct validity of questionnaire items at a pretesting stage. *Journal of Modern Applied Statistical Methods* 1(1): 114–125.

Nath P, Ramanathan R. 2016. Environmental management practices, environmental technology portfolio, and environmental commitment: A content analytic approach for UK manufacturing firms. *International Journal of Production Economics* 171: 427-437.

Nitzl, C., Roldán, J. L., and Cepeda Carrión, G. 2016. Mediation analysis in partial least squares path modeling: helping researchers discuss more sophisticated models. *Industrial Management & Data Systems* 119 (9): 1849-1864.

Nunnally J. 1978. Psychometric Theory, McGraw-Hill, New York.

Orlitzky M, Siegel D, Waldman D. 2011. Strategic corporate social responsibility and environmental sustainability. *Business and Society* 50: 6–27.

Osterloh M, Frey BS. 2000. Motivation, knowledge transfer, and organizational forms. *Organization Science*, 11(5): 538-550.

Paulraj A. 2009. Environmental motivations: a classification scheme and its impact on environmental strategies and practices. *Business Strategy and the Environment* 18(7): 453–468.

Plaza-Úbeda JA, Burgos-Jiménez J, Vazquez DA, Liston-Heyes C. 2009. The 'win-win' paradigm and stakeholder integration. *Business Strategy and the Environment* 18(8): 487–499.

Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology* 88(5): 879-903.

Pulles NJ, Veldman J, Schiele H. 2016. Winning the competition for supplier resources: the role of preferential resource allocation from suppliers. *International Journal of Operations & Production Management* 36(11): 1458-1481.

Rao P. 2002. Greening the supply chain: a new initiative in South East Asia. *International Journal of Operations & Production Management* 22(6): 632-55.

Rao P. 2006. Greening of suppliers/in-bound logistics in the South East Asian context. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London.

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

Rao P, Singh AK, La O'Castillo O, Intal PS, Sajid A. 2009. A metric for corporate environmental indicators … for small and medium enterprises in the Philippines. *Business Strategy and the Environment* 18(1): 14–31.

Rao Tummala VM, Phillips CL, Johnson M. 2006. Assessing supply chain management success factors: a case study. *Supply Chain Management: An International Journal* 11(2): 179-192.

Rigdon EE, Sarstedt M, Ringle CM 2017. On comparing results from CB-SEM and PLS-SEM: five perspectives and five recommendations. *Marketing ZFP* 39(3): 4-16.

Ringle CM, Wende S, Becker, JM. 2015. *SmartPLS 3.0*. www.smartpls.de.

Rucker DD, Preacher KJ, Tormala ZL, Petty RE. 2011. Mediation analysis in social psychology: current practices and new recommendations, *Social and Personality Psychology Compass* 5(6): 359–371.

Russo MV. 2009. Explaining the impact of ISO 14001 on emission performance: a dynamic capabilities perspective on process and learning. *Business Strategy and the Environment* 18(5): 307-319.

Salimian H, Rashidirad M, Soltani E. 2017. A contingency view on the impact of supplier development on design and conformance quality performance. *Production Planning & Control* 28(4): 310-320.

Sarkis J, Zhu Q, Lai KH 2011. An organizational theoretic review of green supply chain management literature. International Journal of Production Economics, 130(1): 1-15.

Seuring S. 2011. Supply chain management for sustainable products–insights from research applying mixed methodologies. *Business Strategy and the Environment*, 20(7): 471-484.

Simpson D, Power D, Samson D. 2007. Greening the automotive supply chain: a relationship perspective, *International Journal of Operations & Production Management* 27(1): 28-48.

Simpson DF, Power DJ. 2005. Use the supply relationship to develop lean and green suppliers. *Supply Chain Management: An international Journal* 10(1): 60-68.

Smart P, Hemel S, Lettice F, Adams R, Evans S. 2017. Pre-paradigmatic status of industrial sustainability: a systematic review. *International Journal of Operations & Production Management* 37(10): 1425-1450.

Sroufe R. 2006. A framework for strategic environmental sourcing. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London.

Tate WL, Ellram LM, Dooley KJ. 2012. Environmental purchasing and supplier management (EPSM): theory and practice. *Journal of Purchasing and Supply Management* 18(3): 173–188.

Theyel G. 2006. Customer and supplier relations for environmental performance. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London.

Tseng SC, Hung SW. 2014. A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management. *Journal of Environmental Management* 133: 315-322.

Tsikriktsis N. 2005. A review of techniques for treating missing data in OM survey research. *Journal of Operations Management* 24(1): 53-62.

Vachon S, Klassen RD. 2006. Extending green practices across the supply chain. *International Journal of Operations & Production Management* 26(7): 795-821.

Vachon S, Klassen RD. 2007. Supply chain management and environmental technologies: the role of integration. *International Journal of Production Research* 45(2): 401-423.

Vachon S. 2007. Green supply chain practices and the selection of environmental technologies. *International Journal of Production Research* 45(18-19): 4357-4379.

von Ahsen A. 2006. Environmental management in automotive supply chains: an empirical analysis. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London.

Walker H, Brammer S. 2009. Sustainable procurement in the United Kingdom public sector. *Supply Chain Management: An International Journal* 14(2): 128-37.

Wang G, Feng T, Zhao X, Song Y. 2018. The influence of supplier trust and relationship commitment on green supplier integration. *Sustainable Development* 26(6), 879–889.

Wong CW. 2013. Leveraging environmental information integration to enable environmental management capability and performance. *Journal of Supply Chain Management* 49(2): 114-136.

Wong CW, Lai K, Shang KC, Lu CS, Leung TKP. 2012. Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. *International Journal of Production Economics* 140(1), 283-294.

Yadlapalli A, Rahman S, Gunasekaran A. 2018. Socially responsible governance mechanisms for manufacturing firms in apparel supply chains. *International Journal of Production Economics* 196, 135-149.

Zhang M, Pawar KS, Bhardwaj S. 2017. Improving supply chain social responsibility through supplier development. *Production Planning & Control*, 28(6-8), 500-511.

Zhu Q, Geng Y. 2006. Green purchasing in Chinese large and medium-sized state-owned enterprises. In *Greening the Supply Chain*, Sarkis J (ed). Springer: London.

Zhu Q, Geng Y, Lai KH 2010. Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management* 91(6): 1324-1331.

Zhu Q, Geng Y, Sarkis J. 2013. Motivating green public procurement in China: an individual level perspective. *Journal of Environmental Management* 126: 85-95.

Zhu Q, Sarkis J, Geng Y. 2005. Green supply chain management in China: pressures, practices and performance. *International Journal of Operations & Production Management* 25(5): 449-468.

Zhu Q, Qu Y, Geng Y, Fujita T. 2017. A comparison of regulatory awareness and green supply chain management practices among Chinese and Japanese manufacturers. *Business Strategy and the Environment* 26(1): 18–30.

Zhu Q, Geng Y, Fujita T, Hashimoto S. 2010. Green supply chain management in leading manufacturers: case studies in Japanese large companies. *Management Research Review* 33(4): 380-392.

Zhu, Q, Sarkis J, Cordeiro JJ, Lai, KH. 2008. Firm-level correlates of emergent green supply chain management practices in the Chinese context. *Omega* 36(4): 577-591.

Appendix 1. Measured items as presented in the questionnaire*.

Construct and Measure Items (questions)	Adapted from**
ESD_{ra}: Buyer-led environmental supplier development, in the form of setting environmental requirements and audits	
ESD_{ra}1: Our main buyer(s) urges us to take environmental actions.	[6,8]
ESD_{ra}2: Our company is evaluated and selected by our main buyer(s) based on environmental criteria.	[2,4,6,8,9]
ESD_{ra}3: Our main buyer(s) send its/their auditors to appraise our environmental performance and compliance.	[2,4,6,8,9]
ESD_{ra}4: Our main buyer(s) asks us to commit to waste reduction goals (e.g. to use recyclable pallet system).	[1]
ESD_{ra}5: Our main buyer(s) expects us to take back our packaging or pallet systems we use to supply goods. †	[3]
ESD_{dp}: Environmental supplier development in the form of direct development projects, run or supported by the buyer	
ESD_{dp}1: Our main buyer(s) exchanges information with us to improve environmental performance (information integration)	[8,12,14]
ESD_{dp}2: Our main buyer(s) holds environmental awareness seminars for its/their suppliers (i.e. educating suppliers through written material, workshops or seminars).	[2,4,6,8]
ESD_{dp}3: Our main buyer(s) guides/helps us to establish our own environmental programs.	[6,8,9]
ESD_{dp}4: Our main buyer(s) bring its/their suppliers (including us) together to share their environmental know-how and problems	[6,8,11]
ESD_{dp}5: Our main buyer(s) arranges funds to help us for our environment programs	[6,8,11]
BSC: Buyer-Supplier Collaboration	
BSC1: We have a mutual understanding of environmental issues with our main buyer(s).	[12]
BSC2: We and our main buyer(s) have joint efforts on managing environmental issues.	[12]
BSC3: We have joint environmental decisions and planning with our main buyer(s).	[12]
BSC4: We and our main buyer(s) have a high level of environment information sharing.	[12]
BSC5: We achieve our environmental goals collectively with our main buyer(s).	[12]
SRA: Supplier Resource Allocation	
SRA1: Our manager is aware of the importance of resource allocation for environmental issues. †	[5]
SRA2: We invest in environmental records.	[5]
SRA3: Our firm has financial reserves to invest in advanced technologies, including environmental solutions.	[5]
SRA4: Our firm has human resources to deal with emerging environmental issues in its industry	[5]
SRA5: Our firm has information and know-how relating to emerging environmental issues in its industry.	[5]
SEA_{ee}: Supplier Environmental Activities in terms of Energy Efficiency	
SEA_{ee}1: We have energy efficient systems in our manufacturing/service operations.	[3]
SEA_{ee}2: Energy efficiency measures are adopted for lighting and heating.	[3]
SEA_{ee}3: We have energy efficient systems in operations in our warehouses.	[3]
SEA_{lt}: Supplier Environmental Activities in terms Logistics and Transport	
SEA_{lt}1: We consider environmental matters generally in our transport decisions.	[3]
SEA_{lt}2: We plan the routes of our vehicles in order to reduce environmental impact.	[3]
SEA_{lt}3: We have invested in vehicles that are designed to have reduced environmental impacts.	[3]
SEA_{mm}: Supplier Environmental Activities in terms of Material Management	
SEA_{mm}1: We manage our hazardous material, toxic pollution and hazardous emissions.	[10,15]
SEA_{mm}2: We use environment friendly material in production.	[7]
SEA_{mm}3: We use environment friendly product packaging (i.e. use of recycled materials for packaging and waste minimization of packaging materials).	[10,13,15]
SEA_{mm}4: We optimize our processes to reduce solid waste.	[3,15]
SEA_{mm}5: We actively manage the disposal of packaging wastes, papers, cartridges, etc.	[3]
SEA_{mm}6: We use life-cycle analysis	[1,13]

[1]Carter (2005);[2]Chiou et al. (2011);[3]Holt and Ghobadian (2009); [4]Lee et al. (2015); [5]Lee (2008);[6]Rao (2002); [7]Rao (2006); [8]Rao and Holt (2005);[9]Russo (2009); [10] Salimian et al. (2017); [11] Sroufe (2006);[12]Vachon and Klassen (2006);[13]Walker and Brammer (2009);[14]Wong (2013);[15]Zhu et al. (2010)

* A number of questions refer to the "main buyer(s)" of the responding organization. When the organization has more than one main buyer with different environmental development plans, which may make it confusing to find a single answer for the relevant questions to them, the respondents are asked to consider only one of those buyers, the one which is more active in environmental supplier development, and has more financial transaction with the supplier. Note: the pilot study has not raised any concern about these question, which can be a good indication that the confusing cases should very rare if any.

** In the current research, wherever a reference provides well-established and widely accepted measured items, only one references is used. Otherwise, the measured items are adapted from numerous references.

† This measured item is dropped in validity test

Appendix 2. Sample Profile (N=267)

Business Sector*	Count
Manufacturing	121
Service	77
Not specified	69
Firm Size (number of employees)	
Micro & Small (<50 employees)	91
Medium (50-249 employees)	82
Large (≥250 employees)	29
Not-specified	65
ISO 14001 Certified	
Yes	34
No	117
Not-specified	116

* These are based on International Standard Industrial Classification (ISIC): codes C10-C32 for manufacturing, and codes F, H, J, K and M for various services.