The rugged landscape of product stewardship: Does it invoke the double-edged effect of knowledge acquisition?

Antony Paulraj
Department of Information Systems, Supply Chain Management and Decision Support, NEOMA Business School, Reims, France
Christopher Rajkumar
Department of Production and Operations Management, Xavier Institute of Management and Entrepreneurship, Bangalore, India
Constantin Blome
School of Management, Lancaster University Leipzig, Leipzig, Germany and
Louvain School of Management, Catholic University of Louvain, Louvain-la-Neuve, Belgium, and
Murtaza Faruquee
Department of Management, University of Sussex, Brighton, UK

Abstract

Purpose – That knowledge acquisition from external sources can play a pivotal role in product design is a well-known fact. However, knowledge acquisition need not play a pivotal role in every context; it is also documented to have a dark side (i.e. negative impacts). Specifically, given that product stewardship, by definition, calls on each party in the product life cycle – including suppliers – to share responsibility for the environmental impact of products, the purpose of this study is to answer the question "whether knowledge acquired from suppliers plays a beneficial role in the context of product stewardship?"

Design/methodology/approach – This study focuses on the effect of knowledge acquisition on product stewardship and its subsequent effect on environmental performance. Given that the effect of knowledge acquisition could be moderated by firm-specific and relational factors, this study also considers the moderating role of knowledge exploitation and supplier opportunism. Using primary data, the hypotheses are tested using two-stage hierarchical ordinary least squares regression models involving valid instruments.

Findings – Though extant research doubts that knowledge acquisition will always be beneficial, this study adheres to the tenets of knowledge-based view and hypothesize that knowledge acquisition is pivotal to product stewardship and its subsequent impact on environmental performance. But the results suggest an intriguing double-edged effect of knowledge acquisition; while its direct effect on product stewardship is nonsignificant, it seemed to have a significant positive moderating effect on the relationship between product stewardship and environmental performance. But whenever knowledge exploitation and supplier opportunism are maintained at ideal levels, this double-edged effect of knowledge acquisition is successfully negated.

Originality/value – While knowledge acquisition is key for new product design, its specific role in the product design that incorporates environmental considerations is still not clear. By proposing that knowledge acquisition could instead have a double-edged effect within the unique context of product stewardship, the study makes an invaluable contribution to the extant literature on knowledge management within supply chain relationships.

Keywords Product stewardship, Knowledge acquisition, Double-edged effect, Knowledge exploitation, Supplier opportunism

Paper type Research paper

Introduction

The knowledge-based view (KBV) showcases the central role that knowledge acquired from external partners could play in the design and development of products (Grant, 1996; Katila and Ahuja, 2002; Laursen and Salter, 2006; Nickerson and Zenger, 2004; Szulanski *et al.*, 2016; Zahra and George, 2002; Zhou and Li, 2012). Simply put, the more the knowledge that can be gained from external partners, the better the design and development of products. While it is irrefutable that knowledge gained from suppliers could be beneficial for firms in incorporating innovative design changes (Ardito and Messeni Petruzzelli, 2017; Flor *et al.*, 2018; Hofman *et al.*, 2020; Liu *et al.*, 2018; Zhang *et al.*, 2018), extant research has been relatively silent when it comes to the effect of knowledge acquisition on product stewardship in particular. This is

The current issue and full text archive of this journal is available on Emerald Insight at: **https://www.emerald.com/insight/1359-8546.htm**

Supply Chain Management: An International Journal
© Emerald Publishing Limited [ISSN 1359-8546]
[DOI 10.1108/SCM-11-2021-0501]

Received 1 November 2021
Revised 22 July 2022
29 November 2022
14 January 2023
Accepted 15 January 2023

interesting as product stewardship could be defined as the integration of input from all external parties involved in each step of the product life cycle (including suppliers) in the product design and development process (Hart, 1995). Different terminologies – eco-design, design for environment, life cycle design, and design for sustainability – have been used to refer to the incorporation of sustainability into product design (Abele *et al.*, 2009).

Product stewardship is a complex process involving different groups and legal entities in that it represents a multipeaked rugged landscape[1] that is very different in comparison to general product design and development (Levinthal and Warglien, 1999; Matos and Hall, 2007). Product stewardship also requires the integration of a diverse set of stakeholders (Hart, 1995; Sharma and Vredenburg, 1998); these stakeholders could have a conflicting set of motivations and/or emphasis on different sustainability issues (Dangelico *et al.*, 2013; Pujari *et al.*, 2003). Specifically, while customers attribute great importance to environmentally sustainable products, their willingness to pay more for such products is debatable (Luchs *et al.*, 2010; White *et al.*, 2019). In other words, the commercial success of product stewardship in several industries is considered a fallacy (Dangelico and Pujari, 2010; White *et al.*, 2019). Firms that still choose to pursue product stewardship must contend with numerous complexities given that product stewardship is a more comprehensive initiative as it takes into consideration the entire life cycle of the product (Hall and Vredenburg, 2005; Hart, 1995; Hart and Dowell, 2011; Matos and Hall, 2007). Apart from involving the application of new approaches to product design, product stewardship efforts must also contend with conflicting interactions among the economic, environmental and social dimensions (Dangelico *et al.*, 2013; Hall and Vredenburg, 2005; Matos and Hall, 2007; Pujari *et al.*, 2003). The conflicting interdependencies between these performance domains create great uncertainty about how even simple design decisions could affect performance in general. Accordingly, product stewardship presents a unique context within which to study the role of knowledge acquisition.

Against this backdrop, we contend that more research is required to understand whether knowledge acquisition could be conducive for product stewardship efforts. The key question is: as is the case with general product development efforts, will knowledge acquisition complement internal knowledge components and assist firms to successfully design products that incorporate sustainability aspects? With greenwashing being widely spread across industries (Blome *et al.*, 2017; Pimonenko *et al.*, 2020), firms might just acquire knowledge from suppliers superficially without engaging, in a detailed manner, with the acquired knowledge, thereby not actually designing environmentally friendly products. Particularly, given the ambiguity of environmental performance standards as well as sustainability accounting standards that cross boundaries from one organization to the next (in our case, the supplier), firms might be getting away with just talking the talk instead of walking the talk (Lee and Hageman, 2018; Pizzetti *et al.*, 2021). This forms the main thesis of our study.

Additionally, we also conjecture that the direct effects of knowledge acquisition on product stewardship could be amplified or attenuated by moderators. First, though sharing of complementary knowledge between partners could be beneficial, there is an increased chance that the partners could end up losing their proprietary knowledge. Therefore, firms' inclination to share as well as assimilate external knowledge could be predicated by their relationship characteristics. Second, once successfully acquired, the benefits derived from externally acquired knowledge are subsequently contingent upon the firms' ability to use it. Accordingly, the effect of knowledge acquisition could also by moderated by other firm-level characteristics. As a guiding framework for identifying a parsimonious set of moderators, we separate the process of knowledge acquisition into two distinguishable parts: (1) "learning the knowledge" and (2) "application of the knowledge"; this conceptualization adheres to the works of Zahra and George (2002) and Law (2014). Specifically, we forward two moderators that could impact these two distinguishable parts of knowledge acquisition. First, since knowledge acquisition is basically a social process (Yli-Renko *et al.*, 2001), we consider supplier opportunism as a key "debilitating" moderator that can present a social dilemma and deter the "learning of knowledge" from external partners, thereby impeding the mobility of such knowledge. Second, since knowledge exploitation capability reflects the presence of processes and routines that could facilitate the successful integration of the acquired knowledge (Zahra and George, 2002), we consider knowledge exploitation as a key "facilitating" moderator that can enhance the "application of the knowledge" acquired from external partners. While the notion of absorptive capacity could be considered to subsume both knowledge acquisition and exploitation capabilities (Roldán Bravo *et al.*, 2018; Roldán Bravo *et al.*, 2020), in this study, we consider them as distinct factors and study their effects on product stewardship.

By pursuing these aspirations, our research makes significant contributions to extant literature as well as the theoretical discourse on knowledge management related to product stewardship. Though the role of knowledge has been broadly touted in literature, there are doubts that have been cast on the ability of knowledge acquisition to be beneficial in all settings (Alcacer and Oxley, 2014; Zanarone *et al.*, 2016). Also, while some firms might be good at acquiring as well as using external knowledge, others might not. Therefore, it is also pertinent for both supply chain researchers and practitioners to understand what firm-level and/or relationship characteristics would assist firms to benefit more from knowledge acquisition. Following this line of thought, we study the effect of knowledge acquisition as well as the role of knowledge exploitation and supplier opportunism in augmenting the productive or destructive effect of knowledge acquisition on product stewardship. Our contention is that the rugged landscape of product stewardship makes these questions salient in this context. Rightly so, our results shed light on an intriguing double-edged effect (i.e. negative) of knowledge acquisition (Alcacer and Oxley, 2014; Rossetti and Choi, 2005; Zanarone *et al.*, 2016). Using the concept of fitness landscape, we showcase that product stewardship presents a unique context within which the very benefits attributed to knowledge acquisition could turn out to be either nonexistent or detrimental. Understanding the double-edged effect of knowledge acquisition on product stewardship has significance beyond the buyer-supplier relationship. Given the growing need for environmental-friendly products, all parties along the entire product life cycle (including suppliers) need to work together to optimize the environmental impact of the product. Therefore, even though we study the specific context of strategic buyer-supplier relationships, our findings have implications for the entire supply chain.

Theoretical background

Product stewardship

Incorporating sustainability aspects into product design signals a proactive posture wherein firms aspire to reduce the negative environmental impacts of their products (Aragón-Correa and Sharma, 2003; Hart, 1995; Sarkis *et al.*, 2010). As such a design approach entails the integration of the "voice of the environment" into product design, Hart (1995) adopts a broader term of product stewardship instead. No matter the terminology, the major objective of product stewardship is to ensure that the firms' products have a minimal impact on the natural environment in addition to meeting the needs of the customer (Hart, 1995; Sarkis *et al.*, 2010). It promotes reuse, recycle, as well as recovery of component materials and parts (Zhu and Sarkis, 2004; Zhu *et al.*, 2008). While products are designed with environmentally friendly materials and components in mind, the incorporation of easy disassembly in the early design stages also facilitates reuse and recycle of products. More importantly, product stewardship involves the application of life cycle analysis to minimize the product's environmental impact throughout its entire useable life (Hart, 1995; Liu *et al.*, 2017; Sarkis, 2001). Hart (1995) originally envisioned life cycle analysis, as part of product stewardship, to focus only on environmental aspects. But when it comes to life cycle analysis, other scholars suggest that it should also consider social aspects (Dreyer *et al.*, 2006; Gauthier, 2005; O'Brien *et al.*, 1996); specifically, social life cycle analysis encompasses social impact on all stakeholders (workers, consumers, local communities, etc.) throughout the life cycle of the product. Given that we focus predominantly on the acquisition of technical knowledge from suppliers, we conceptualize product stewardship to specifically focus only on the environmental aspects.

Product stewardship adheres to the principles of sustainable development in that it aspires "to meeting the needs of the present generation without compromising the ability of the future generation to meet their own needs" (WECD, 1987, p. 43). In other words, our conceptualization of product stewardship subsumes some of the social considerations indirectly, even if not directly. Specifically, the increased attention to reduce environmental impact through reduced consumption, as well as environmental-friendly material, could also benefit the society, at large. Given their scope, product stewardship initiatives are fraught with a high degree of ambiguity, uncertainty as well as complexity (Hall and Vredenburg, 2005; Matos and Hall, 2007). Among others, this could be driven by the adoption of new materials and/or technologies wherein their potential impacts are hard to ascertain. The complex interdependencies among the environmental, social and economics dimensions increase the ambiguity pertaining to the performance impacts of any design decisions; in doing so, it also increases the bounded rationality of the decision-makers. Product stewardship also involves the participation of external stakeholders with diverse needs (Hall and Vredenburg, 2005; Hart, 1995; Sharma and Vredenburg, 1998). Accordingly, using the idea of fitness landscape, Matos and Hall (2007) suggest that product stewardship represents a multipeaked rugged landscape that requires careful coordination between the different performance dimensions as well as the diverse stakeholders.

The concept of fitness landscape has its origin in the literature of biology (Wright, 1931). In the context of organizations, Kauffman (1993) indicates that the topography of a landscape is influenced by two variables: the number of elements that characterize the concept is denoted as "N" and the number of interactions each element is subjected to is denoted as "K". In the case of product stewardship, N denotes the individual indicators that measure the economic and environmental domains. These indicators could span quantitative (e.g. emissions, quality, cost, etc.) and qualitative (e.g. stakeholder input, customer requirements, etc.) aspects (Matos and Hall, 2007). Alternatively, in this context, an interdependency could be related to the choice of new material, which could reduce the environmental impact of the product while simultaneously increasing the cost as well as reducing the ability to maintain high quality. In effect, the lower the number of interdependencies (i.e. K), the smoother the landscape (inverted U-shape with a single peak). Alternatively, the landscape becomes more rugged and multipeaked as the interdependencies increase. In a smooth landscape, the global optimum is related to the single peak; any improvements will eventually lead to global optimum (Levinthal and Warglien, 1999). On the contrary, in multipeaked rugged landscapes, the search for global optimum (or peak) – overall high sustainable development performance – is not that straightforward.

Accordingly, product design that encompasses a simultaneous pursuit of sustainability is not an easy task as it requires a completely different mindset as well as the incorporation of creative product development processes (Aragón-Correa and Sharma, 2003; Sarkis *et al.*, 2010). It also requires a better understanding of the complex interactions between the conflicting objectives spanning the environmental and economic dimensions (Hall and Vredenburg, 2005; Matos and Hall, 2007). More importantly, to contend with and to subsequently smoothen the rugged landscape, product stewardship requires higher-order learning from various supply chain partners; the successful smoothening of the rugged landscape could also result in the development of tacit as well as casually ambiguous organizational capabilities (Hart, 1995; Sharma, 2000; Sharma and Vredenburg, 1998). Given product stewardship practices create the potential for strategic preemption, they could help firms achieve as well as maintain competitive advantage in the long run (Aragón-Correa and Sharma, 2003; Hart, 1995; Hart and Dowell, 2011; Porter and van der Linde, 1995; Sharma and Vredenburg, 1998). Numerous researchers provide sufficient evidence for the fact that product stewardship could lead to superior triple bottom-line performance outcomes (Dangelico *et al.*, 2013; Lee *et al.*, 2016; Pujari *et al.*, 2003; Seuring and Müller, 2008; Zhu and Sarkis, 2004).

The role of knowledge acquisition

Guided by the tenets of the KBV (Grant, 1996; Nickerson and Zenger, 2004), we forward knowledge acquisition as a key determinant of product stewardship as well as its subsequent effect on environmental performance. While deep domain-related knowledge that resides within a firm could be a significant source of sustainability-related product innovations, it also creates a cognitive inertia that could constrain firms' ability to pioneer innovative improvements in their product design (Levinthal and March, 1993; Tripsas and Gavetti, 2000). To overcome this drawback, scholars suggest that firms should rejuvenate their internal knowledge base by actively seeking knowledge components that reside outside their organization (Laursen and Salter, 2006; Zhou and Li, 2012). Termed as knowledge acquisition, this capability signifies the degree to which firms can seek, identify and acquire knowledge generated beyond its boundaries (Zahra and George, 2002). Among others, knowledge acquired from external partners is touted to help firms to improve their capability to design and develop innovative products (Yli-Renko *et al.*, 2001; Zahra and George, 2002; Zhou and Li, 2012).

Alternatively, the knowledge that is acquired from partner firms is not always easily used by the recipient; the effectiveness of knowledge acquisition is often predicated by the ambiguity inherent in the knowledge that is acquired (Grant, 1996; van Wijk *et al.*, 2008). This ambiguity could relate to the knowledge components themselves and/or the effect of the knowledge components (Law, 2014; Simonin, 1999). If the external knowledge components are either abstract or complex, then they might hide from the recipient firms, thereby impeding the learning process. Alternatively, the difficulty in understanding the effect of the knowledge components – i.e. connections between actions and outcomes – might also preclude the learning as well as the applicability of those knowledge components (Law, 2014). These complexities could amplify the double-edged effect of knowledge acquisition, wherein it might prevent the use of knowledge acquired in product development efforts. In addition to the negativity related to knowledge ambiguity, scholars also suggest that while exchanging knowledge, firms are also exposed to the risk of knowledge leakage as well as undesirable learning races (Hamel, 1991; Kale *et al.*, 2000; Li *et al.*, 2008). So, firms are equally compelled to protect their knowledge resources due to the belief that undue appropriation or imitation could be detrimental to their competitive advantage. This signifies another double-edged effect of knowledge acquisition, as it could also expose firms to their partner's potential rent-seeking behavior (Zanarone *et al.*, 2016). Therefore, even if knowledge is successfully acquired, this dark side of knowledge acquisition could present a dilemma for firms as there is no guarantee that the knowledge acquired could be successfully utilized in product design.

Hypothesis development

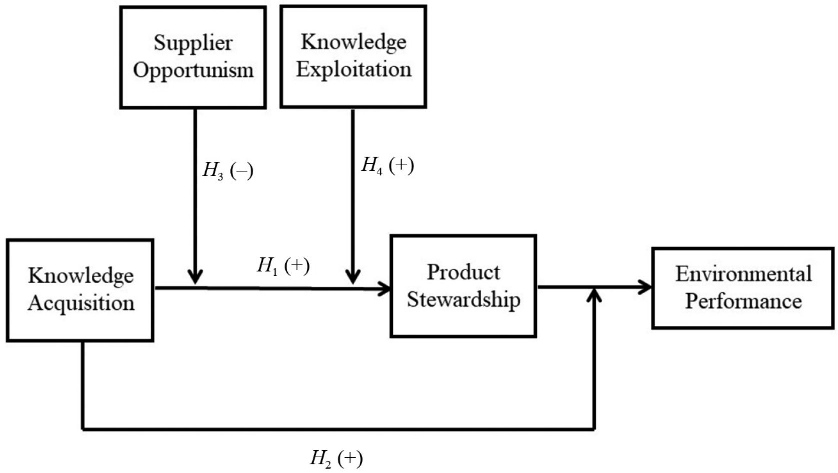
Please refer to Figure 1 for the conceptual model depicting the hypothesized relationships. Though extant research brings out the good and bad sides of knowledge acquisition, in our conceptual model, we adhere to the positives of knowledge acquisition in developing our hypotheses. Specifically, we contend that the ability to acquire knowledge is of paramount importance to the incorporation of sustainability aspects into product design due to the very fact that product stewardship requires a careful coordination across the different conflicting domains (Hart and Dowell, 2011; Pujari *et al.*, 2003). As pointed out earlier, product stewardship represents a rugged landscape wherein the interdependencies between environmental, social and economic decisions are ambiguous and difficult to ascertain. Accordingly, deciphering the benefits of product stewardship could be elusive given that the design decisions are fraught with increased complexity, uncertainty, ambiguity and bounded rationality (Hall and Vredenburg, 2005; Pujari *et al.*, 2003; Simon, 1996).

When it comes to product stewardship, knowledge captured through supply chain relationships could play a significant role (McDougall *et al.*, 2021). Specifically, knowledge acquisition from suppliers could help firms to overcome these challenges as it could increase the number as well as the variety of external knowledge components that they can access (Fleming, 2001). As the knowledge pool increases in terms of number of knowledge components, firms can gain a better understanding of the various aspects and implications of product stewardship. The breadth and depth of the diverse knowledge gained from suppliers could also enable firms to continuously renew and enrich their existing knowledge base (Ardito and Messeni Petruzzelli, 2017; Flor *et al.*, 2018; Zhou and Li, 2012). More specifically, firms could acquire new product-related or process-related knowledge from their suppliers. Within the purview of product stewardship, this could include knowledge pertaining to life cycle assessment, new materials as well as clean technology and remanufacturing, among others (Hart and Dowell, 2011; Matos and Hall, 2007; Mihelcic *et al.*, 2003; Pujari *et al.*, 2003; Sarkis, 2001; Zhu and Sarkis, 2004). Specifically, we conjecture that knowledge acquisition from suppliers can lead to novel recombinations of internal and external knowledge components, thereby enhancing firms' ability to understand as well as incorporate novel sustainability aspects into their product design (Laursen and Salter, 2006; Zhou *et al.*, 2014):

H1. Knowledge acquisition from suppliers will have a positive effect on product stewardship.

Given that superior environmental performance could enhance the firm's image in the eyes of the consumers (Porter and van der Linde, 1995), it is increasingly becoming a mainstream performance concern rather than just a good to have. There is sufficient empirical evidence suggesting that when firms design their products in a sustainable fashion, the products will result in less environmental degradation (Lee *et al.*, 2016; Pujari *et al.*, 2003; Seuring and Müller, 2008; Zhu and Sarkis, 2004). While product stewardship can enhance the environmental performance of the firm, its subsequent performance effects could be significantly higher in the presence of certain contingencies. Specifically, we purport that in addition to increasing the scope of incorporation of sustainability in product design, knowledge acquisition could further serve as a catalyst in enhancing the effect of product stewardship on environmental performance. When it comes to product stewardship, the environmental impact of the product is not about the product itself; it is also about the entire lifecycle of the product including

Figure 1 Conceptual model



its manufacturing process (Dangelico *et al.*, 2013). Also, innovating for sustainable development is often challenging due to the conflicting pressures as well as complex interactions between different performance domains as well as stakeholders. These ambiguities could hinder not only the design decisions themselves but also the ability to ascertain the potential impact such decisions could have on different performance measures. Accordingly, the rugged landscape of product stewardship initiatives requires well-informed cognition pertaining to the numerous interacting parameters as well as their potential outcomes (Hall and Vredenburg, 2005; Matos and Hall, 2007). While transforming this rugged landscape by simplifying the system (i.e. not aspiring for lofty stewardship initiatives in product design) is a tempting alternative, Levinthal and Warglien (1999) propose that the rugged landscape could rather be smoothened through the acquisition of appropriate knowledge. The number and variety of knowledge gained from external partners could help firms to acquire a nuanced cause-and-effect understanding and strengthen their related cognitive structures as well as competencies. As a result, firms could effectively reconfigure their knowledge resources for the smoothening of this rugged landscape (Subramaniam and Youndt, 2005; Yang *et al.*, 2010; Zhou and Li, 2012). Accordingly, we forward the following hypothesis for formal testing:

H2. Knowledge acquisition from suppliers will positively moderate the effect of product stewardship on environmental performance.

While strategic supplier relationships could serve as effective platforms for acquiring valuable as well as complementary knowledge from supply partners, they also pose an inherent dilemma, given there is a chance that firms could end up losing their proprietary knowledge to their partners. Therefore, we focus on the role that supplier opportunism, a fundamental relationship characteristic, could play on the relationship between knowledge acquisition and product stewardship. When it comes to interfirm collaboration, opportunism can have serious consequences no matter the context (Blome *et al.*, 2023; Luo, 2006). It can not only preclude confidence building but also escalate conflicts. Therefore, the presence of opportunism could be considered as detrimental to almost all aspects of interfirm exchanges (Oliveira and Lumineau, 2019). Consequently, opportunistic behavior has also been widely identified as a key deterrent to the sharing of knowledge (Cabrera and Cabrera, 2002; Nickerson and Zenger, 2004). A self-interest seeking supplier could become increasingly protective of their knowledge and would not only deliberately withhold key information but also wilfully provide false information with the intent to mislead the buyer (Nickerson and Zenger, 2004; Simonin, 1999; Wathne and Heide, 2000; Williamson, 1985). Therefore, while firms understand external knowledge could be good for their competitive advantage, they would be cautious in acquiring knowledge from a supplier if they doubt that the supplier might be shirking or cheating (Wang *et al.*, 2010). Any acts of guile or misuse from the supplier could further cast a shadow of doubt about the authenticity of the acquired knowledge. Therefore, in addition to preventing the mobility of knowledge, opportunism could also preclude the application of the knowledge that is successfully acquired. Accordingly, supplier opportunism may emerge as a potential hazard as it can turn on the dark side of knowledge acquisition; in doing so, it could limit the application of the acquired knowledge as the buyer might be uncertain as well as wary about the supplier's rent-seeking behavior as well as malfeasance (Zanarone *et al.*, 2016).

The negative effects of supplier opportunism could be particularly damaging when it comes to the application of sustainability-related knowledge. Specifically, product stewardship initiatives are ambiguous in nature as it is hard for firms to ascertain the potential impact that their design decisions could have on the different conflicting performance measures; this increases the bounded rationality of the related design decisions (Hall and Vredenburg, 2005; Matos and Hall, 2007). Therefore, higher levels of opportunism could exacerbate the complexities, uncertainties and ambiguities that are associated with designing sustainable products. Additionally, as pointed out by Williamson (1985), the detrimental effects of opportunism is even greater when joined with bounded rationality. Therefore, higher levels of opportunism would make it particularly hard for the buying firm to verify the accuracy, appropriateness as well as the value of the sustainability-related knowledge acquired from the supplier. Higher levels of supplier opportunism could also escalate the conflicts while subsequently reducing the confidence among the exchange partners (Wathne and Heide, 2000; Williamson, 1985). Hence, the partners will not be inclined to work together to understand the interdependencies of their knowledge bases as well as the applicability of the knowledge acquired. Accordingly, we forward that supplier opportunism could act as a significant deterrent in not only learning the knowledge but also the effective incorporation of the acquired knowledge in the design of sustainable products (Zanarone *et al.*, 2016). Based on this discourse, we hypothesize:

H3. Supplier opportunism will negatively moderate the effect of knowledge acquisition on product stewardship.

Once firms acquire external knowledge, it is important that this new knowledge is internalized, juxtaposed, and, if needed, combined with existing knowledge to realize the related benefits. The extent of benefits derived from knowledge acquisition could be contingent upon the firms' ability to use as well as exploit this acquired knowledge. Specifically, to realize new opportunities from the acquired knowledge, firms need to possess the ability to solve novel problems (Nickerson and Zenger, 2004). This organizational capability, termed knowledge exploitation, is developed through established processes, routines and structures that facilitate the ongoing dissemination as well as synthesis of firms' knowledge resources (Foss *et al.*, 2013; Zahra and George, 2002). It also mandates the development of coordination devices, such as cross-divisional communication channels, so as to ensure the deployment of knowledge gained from external sources (Foss *et al.*, 2013). Among others, this capability can be honed through local searching as well as experiential refinement of knowledge bases that reside within the organizational boundaries (Baum *et al.*, 2000; Gupta *et al.*, 2006; Li *et al.*, 2010b). In this study, we refrain from the temporal separation of acquisition and exploitation activities (i.e. firms need to acquire knowledge before exploiting it); instead, we envision knowledge exploitation as a complementary, yet stand-alone, capability (Gupta *et al.*, 2006; Katila and Ahuja, 2002; March, 1991; Rosenkopf and Nerkar, 2001).

While we acknowledge that knowledge acquisition could lead to product stewardship, we also contend that this effect will be augmented significantly by the firms' knowledge exploitation capability. Specifically, a well-developed knowledge exploitation capability signifies the presence of appropriate structural and procedural mechanisms that facilitate easy assimilation as well as synthesis of diverse knowledge components. Accordingly, the ability to exploit knowledge can enable firms to not only refine, extend and reuse existing knowledge resources but also create new knowledge components by translating and integrating externally acquired knowledge (Zahra and George, 2002). It could also help firms to gain a much deeper understanding of the acquired knowledge as well as its possible use in catering to the needs of product stewardship, thereby enabling them to combine the diverse knowledge bases effectively as well as creatively. Specifically, we contend that only through such an active integration of these internal and external knowledge bases could firms fully realize the benefits that are offered by both (Zhou and Li, 2012). Against this backdrop, we conjecture that firms can significantly augment the incorporation of sustainability into their product design by combining both knowledge acquisition and exploitation capabilities. Specifically, through the nuanced exploitation of diverse sustainability-related knowledge acquired from suppliers, firms could gain a better understanding of the complexities and ambiguities associated with product stewardship (Levinthal and March, 1993; Li *et al.*, 2010b; March, 1991; Zahra and George, 2002). Based on this discourse, we hypothesize:

H4. Knowledge exploitation capability will positively moderate the effect of knowledge acquisition on product stewardship.

Methodology

Data collection

Given that our study aims to test theory, we follow the positivist paradigm in our research. Our research also assumes that the constructs used in our study are real and not socially constructed (e.g. through interpretation). While different methods to measure such constructs exist, we opted for survey research as we can more closely and rigorously measure the variables of our research study (Roth and Rosenzweig, 2020). Also, survey research is particularly powerful in directly measuring latent constructs that are otherwise difficult to measure. Once we designed the survey instrument, it was pretested using a total of eight supply chain experts (including both practitioners and academicians). The experts were asked to assess the readability, appropriateness as well as the completeness of the survey questions (Dillman, 2007); based on their input, some minor changes were made to the instrument. Except for performance-related questions, most other questions were measured using a five-point Likert scale; the anchors used were "1 = strongly disagree" and "5 = strongly agree." The respondents were asked to answer performance-related questions in response to their direct competitors; they answered these questions based on five-point Likert scale with anchors "1 = much worse" and "5 = much better." The survey included both firm-level and relational-level items; so, we sought respondents that held senior purchasing positions. For the supplier relationship related indicators, we requested the respondents to answer them with respect to the top supplier selected based on dollar amounts and/or importance of materials purchased.

We obtained the sampling frame of US manufacturing firms from the Institute for Supply Management (ISM). The sampling frame consisted of 3,000 members working in industries covered under multiple SIC codes. Since we did not receive the e-mail address for these members from ISM, we adopted a two-step data collection approach. In the first step, we contacted 1,500 randomly selected respondents (from a sampling frame of 3,000 potential respondents) regarding our research study and asked them to mail a consent form if they were willing to participate in the study. Out of these 1,500 survey questionnaires, 30 were returned undelivered. Though

580 respondents returned the consent form, only 305 respondents consented to participate in our study. The other 275 declined to participate in the study; majority of them stated reasons such as company policy or lack of experience. We gave the interested participants the option to complete either a paper version or an electronic version of the survey. The effective sample size was 1,195 (1,500 contacted – 30 undelivered – 275 declined to participate). From the effective sample of 1,195, we received a total of 241 completed surveys resulting in an effective response rate of approximately 20% (241/1195). While we acknowledge that 20% is a low response rate, there have been numerous publications within the operations and supply chain management discipline that have had a response rate much lower than 20% (Ambulkar *et al.*, 2015; Bode *et al.*, 2011; Jansen *et al.*, 2006; Paulraj, 2011; Rexhausen *et al.*, 2012).

To ensure that only key respondents participated in our study, we asked two questions assessing the respondent's: (1) "knowledge relating to the survey questions" and (2) "level of confidence in answering the questions". The two questions were measured using a five-point Likert scale with endpoints of 1 = "not at all" and 5 = "significantly". The average score for these two questions were 3.97 and 4.04, suggesting that the respondents were appropriate to participate in our study. More importantly, majority of our respondents (approximately 65%) held senior positions in their firms (e.g. president, vice president or director). As for the profile of the responding firms, we found that nearly 59% of the respondents worked for firms employing more than 1,000 employees, while approximately 20% of the respondents worked for firms with less than 250 employees. Still, we had an adequate representation of firms across all sizes.

Bias check

As a preliminary step, we address the issues of nonresponse bias and common-method bias. First, nonresponse bias could be minimized by having a higher response rate (Groves and Peytcheva, 2008; Wright and Armstrong, 2008). Though our response rate was only 20%, this was comparable to prior research published in our discipline. Therefore, we assessed potential nonresponse bias by using the wave analysis (Rogelberg and Stanton, 2007), in which the early responses were compared to late responses (Pace, 1939). The responses were split based on their receipt date (early respondent group had 131 responses; late respondent group had 110 responses). We included company size as well as ten indicators that were selected randomly. The group comparison test did not reveal any difference between the two samples. Apart from this statistical testing, we also manually assessed the range of responses received for the ten indicators across the two groups; there were no apparent differences in the range of responses received for these indicators. As an added test, we also adopted the follow-up approach suggested by Rogelberg and Stanton (2007). Specifically, we contacted 200 randomly selected firms from the list of nonresponding firms and collected minimal data related to number of employees and annual sales volume. Comparison of these demographic variables between the 200 nonresponding firms and our sample yielded no significant differences at the 95% confidence level. Finally, we also compared the distribution of industries (Standard Industrial Classification [SIC] codes) across the randomly selected sampling frame (i.e. the 1,500 firms initially contacted), the total consent forms received (i.e. those willing/unwilling to participate) and our final sample. In addition to all industries in the sampling frame being represented in our final sample, the proportion of responses for the different industries in our final sample was consistent with the proportion of industry representation in the sampling frame as well as the list of total consent forms received. These results suggest that nonresponse bias might not be a concern in our study.

We adopted both procedural and methodological approaches recommended by Podsakoff *et al.* (2003) to ensure the absence of common methods bias. The potential for common method bias was minimized through the methodological separation of the nonperformance and performance indicators into separate sections as well as different response formats; this reduces method bias caused by commonalities in the scale endpoints. Verbal labels were provided for the midpoints of the measurement scales with the ambition of minimizing acquiescence bias (Podsakoff *et al.*, 2003). When combined with the length of the survey instrument, there is an increased possibility that these design considerations could ensure that the respondents do not link the nonperformance and performance indicators (Paulraj *et al.*, 2014). As for methodological approaches, we followed Olson *et al.* (2005) and compared our measurement model involving five factors with a measurement model involving a single latent factor (representing the method factor). The fit for the single method factor model (comparative fit index [CFI] = 0.59, non-normed fit index [NNFI] = 0.55, root mean square error of approximation [RMSEA] = 0.25) was found to be considerably worse in comparison to our measurement model (CFI = 0.97, NNFI = 0.97, RMSEA = 0.051). Finally, as suggested by Podsakoff *et al.* (2003), we adopted the single-common-method-factor approach. According to this approach, we first ran a trait-based measurement model (Mod 1). Subsequently, we modified this model by including a method factor to the model and linking all the measurement items to this method factor (Mod 2) as well (Ketokivi and Schroeder, 2004; Podsakoff *et al.*, 2003; Williams *et al.*, 1989). From these two measurement models, we found that the method factor accounted only for 4% of the total variance (Widaman, 1985). In addition, the significance of the paths from the measurement items to their respective trait were similar between Mod 1 and Mod 2. So, we can safely conclude that despite the inclusion of the methods factor, Mod 1 was robust. Collectively these procedural and methodological approaches suggest that common methods bias might not be a concern in our study.

Measures

Knowledge acquisition relates to gaining access to and acquiring preexisting knowledge from collaborating partners. Accordingly, we used five indicators that measure the extent to which valuable technical knowledge and know-how are received from the key supplier. The items were developed based on the studies by Dess *et al.* (2003) and Yli-Renko *et al.* (2001). Supplier opportunism implies whether the supplier tries to mislead, distort, disguise, obfuscate or confuse the buying firm. It occurs when the supplier indulges in inequitable actions that violate promises concerning its required behavior.

Accordingly, we used five items measuring the focal firm's perception of the opportunistic behavior of its supplier (Katsikeas *et al.*, 2009; Lado *et al.*, 2008). Knowledge exploitation is an organizational capability that is oriented toward innovating through the exploitation of firm's existing knowledge components. Accordingly, we used measurement items to capture the firm's capability of using as well as exploiting (1) know-how, patent and new product design, (2) newly introduced advanced technologies, and (3) techniques, equipment and establishment. This four-item scale was adopted from Li *et al.* (2010b). Product stewardship includes the extent to which the design of products focuses on (1) reduction of hazardous material, energy and resource consumption, (2) disassembly, reusability and recyclability, and (3) environmentally-oriented life cycle analysis. The six-item scale was developed based on the studies of Aragón-Correa and Sharma (2003), González-Benito and González-Benito (2005) and Zhu and Sarkis (2004). Environmental performance was operationalized to measure the firm's ability to use reduced energy as well as minimize pollution, waste, environmental accidents and the use of natural resources. While researchers have come up with several scales to measure environmental performance, we developed a six-item scale based on the works of De Giovanni and Vinzi (2012) and Zhu and Sarkis (2004).

We included multiple control variables that might impact product stewardship as well as environmental performance. First, we controlled for the market share held by the company in comparison to its competition (measured using a five-point Likert scale with endpoints "much smaller" and "much larger"); market share could relate to not only the extent of resources available to a firm but also the motivation to engage in environmental sustainability initiatives (Boulding and Staelin, 1993). The level of competition in a product market could also explain the ambition of a firm to engage in sustainability initiatives. Specifically, increasing competition will not only put pressure on a firm but might also motivate them into seeking first-mover advantage related to environmental sustainability (Khilji *et al.*, 2006). Therefore, we also controlled for the level of competition; it was captured using the indicator "In your major product/product line, the intensity of competition is very high", measured using a five-point Likert scale with end-points of "not at all" and "significant."

As pointed out earlier, product stewardship is considered a proactive initiative (Aragón-Correa and Sharma, 2003; Hart, 1995; Sarkis *et al.*, 2010); accordingly, the extent of environmental proclivity within a firm could be a key predictor of product stewardship as well as the ensuing environmental performance. Therefore, we included environmental proclivity measured using a single question, "our organization has a proactive posture to the environmental market"; this Likert-scale question was measured using endpoints of "1 = strongly disagree" and "5 = strongly agree." Finally, the extent of incorporation of sustainability aspects into product design could also be driven strongly by the ability of a firm to integrate perspectives from its customers (Hart, 1995). Therefore, we included the item "we conduct joint planning to anticipate and resolve sustainability-related problems with our key customers" as an additional control variable. This item was measured using a Likert scale with end points of "1 = strongly disagree" and "5 = strongly agree."

Measurement instrument development

The data set was initially assessed for the assumption of multivariate normality using Mardia's test (Mardia, 1970). The Mardia coefficient for our data set was 1.00, which was within the recommended limits of −1.96 and 1.96. We tested the measurement instrument using the confirmatory factor analysis. The results of this analysis is presented in Table 1; this table also includes the items (questions) we used to measure the constructs. As evident from the model fit indices included in Table 1, our data fit the measurement model well (Hu and Bentler, 1999), thereby establishing unidimensionality. The standardized loading values and *t*-values clearly indicated the convergent validity of our measurement items.

We established discriminant validity using the Fornell and Larcker (1981) approach. The correlation values and the square root of AVE values provided in the upper part of Table 2 suggests that our measurement items exhibit discriminant validity. Additionally, we validated this using the heterotrait-monotrait (HTMT) analysis; this approach is considered more reliable in comparison to the Fornell–Larcker criterion (Henseler *et al.*, 2015). To exhibit discriminant validity, the HTMT values should be lower than 0.85. The HTMT values were well below this limit (between 0.045 and 0.452), suggesting that our measurement items exhibit discriminant validity. We used multiple measures to establish the reliability of the measures. Initially, reliability was assessed using coefficient alpha (Nunnally, 1978) and coefficient omega (McDonald, 1999). Given that none of the constructs were found to be tau-equivalent, coefficient omega is considered to yield a consistent estimate of reliability (Deng and Chan, 2017). As given in Table 1, coefficient alpha and omega values were all above 0.80. We also calculated the (1) confidence intervals for alpha and omega using the bootstrapping approach, and (2) robust alpha and omega values that are appropriate for missing data (Zhang and Yuan, 2016); all these values were well above 0.80. Finally, we also used the composite reliability score (Bagozzi and Yi, 1988) to ensure the reliability of the constructs. The composite reliability values were also above 0.80 for all theoretical constructs. In addition, all constructs also had AVEs above 0.50. Overall, these results clearly established the reliability, validity and unidimensionality of our measurement items.

Results

When it comes to product design as well as innovation literature, knowledge acquisition is mostly considered an antecedent to innovation and product design (Dyer and Singh, 1998; Yli-Renko *et al.*, 2001; Zahra and George, 2002). But the reverse relationship could also be plausible given that a firm that is good at designing innovative and sustainable products might be keen on actively acquiring knowledge from suppliers as well. This would make knowledge acquisition endogenous in our hypothesized model (Antonakis *et al.*, 2010). With this in mind, we conducted two-stage hierarchical ordinary least squares (OLS) regressions involving valid instruments to correct for potential endogeneity (Hamilton and Nickerson, 2003). We incorporate two instruments for knowledge

Table 1 Measurement instrument development

Indicator *(Coefficient alpha, coefficient omega, composite reliability, average variance extracted)*	Std. loading
Knowledge acquisition (α = 0.90; Ω = 0.90; CR = 0.91; AVE = 0.66)	
We view this supplier as a source of technical information	0.81
We get valuable amount of information on industry trends from this supplier	0.74
We get valuable technical know-how related to the supplier products	0.89
We obtain a tremendous amount of technical know-how from this supplier	0.84
There is strong willingness to learn successful practices of this supplier	0.77
Supplier opportunism (α = 0.92; Ω = 0.93; CR = 0.92; AVE = 0.70)	
In working with us, this supplier . . .	
exaggerates its needs in order to get what it wants	0.80
is not always sincere if that helps to promote its own objectives	0.88
alters facts to meet its own goals and objectives	0.90
tries to take unfair advantage of us to further its own interests	0.88
breaches formal or informal agreements to its benefit	0.72
Knowledge exploitation (α = 0.87; Ω = 0.87; CR = 0.88; AVE = 0.70)	
Our organization emphasizes the utilization and exploitation of. . .	
know-how, patent, and new product design	0.76
newly introduced advanced technologies	0.85
techniques, equipment and establishment	0.90
Product stewardship (α = 0.87; Ω = 0.87; CR = 0.87; AVE = 0.57)	
When designing products, we pay attention to reduced consumption of material/energy	0.75
When designing products, we pay attention to reuse, recycle and/or recovery of material	0.87
We design our products to use environmentally friendly materials	0.82
We use life cycle analysis to evaluate the environmental impacts of our products	0.76
We design our products with standardized components to facilitate reuse	0.55
We design our products for easy disassembly*	
Environmental performance (α = 0.93; Ω = 0.93; CR = 0.93; AVE = 0.69)	
Reduction in air pollution	0.80
Reduction in waste (water and/or solid)	0.86
Decrease in consumption of hazardous/harmful/toxic materials	0.83
Decrease in frequency for environmental accidents	0.75
Increase in energy saved due to conservation and efficiency improvements	0.84
Decrease in use of natural resources	0.88

Notes: Model fit indices: normed Chi-square = 1.62 ($\leq$2.0); non-normed fit index = 0.97 ($\geq$0.90); comparative fit index = 0.97 ($\geq$0.90); standardized root mean square residual = 0.042 ($\leq$0.08); root mean square error of approximation = 0.051 ($\leq$0.08). *items dropped during instrument development process; ‡All t-values are significant at $p < 0.01$ level

Table 2 Correlation between theoretical constructs

Factors	Mean	SD	KA	OP	KE	PS	EP
Knowledge acquisition (KA)	3.83	0.76	0.81*				
Supplier opportunism (OP)	1.97	0.80	−0.31	0.84			
Knowledge exploitation (KE)	3.66	0.87	0.28	−0.08	0.81		
Product stewardship (PS)	3.47	0.83	0.23	−0.02	0.32	0.84	
Environmental performance (EP)	3.41	0.58	0.13	−0.04	0.15	0.42	0.78
Confidence	4.01	0.85	0.44	−0.59	0.16	0.09	0.12
Supplier innovativeness	3.49	1.06	0.64	−0.15	0.32	0.30	0.18
Environmental proclivity	3.75	0.95	0.19	−0.07	0.35	0.47	0.32
Sustainability planning with customers	3.14	1.04	0.20	0.11	0.17	0.45	0.22
Competition	4.14	0.96	0.14	−0.16	0.15	0.18	0.08
Market Share	3.25	1.12	0.10	0.05	0.06	0.14	0.07

Note: *The values along the diagonal are the square root of the AVE values acquisition; while the appropriateness of the instrument variables is statistically determined, our selection of instruments was also motivated theoretically. First, the level of confidence that a firm has on its supplier's behavior could be considered a key driver of knowledge acquisition (Das and Teng, 1998; Dyer and Singh, 1998; Kale *et al.*, 2000; Li *et al.*, 2010a). Given that the level of confidence in a partner could reflect the embeddedness, trustworthiness, certainty, as well as compatibility in the exchange relationship, it could be a significant predictor to the exchange of knowledge. Therefore, we used the "level of confidence" the firm has on its key supplier as an instrument for knowledge acquisition; we adopted a Likert scale with anchors of "1 = strongly disagree" and "5 = strongly agree" to measure this indicator "the supplier is a company that we have great confidence in." Additionally, firms would be more inclined to acquire knowledge from suppliers that are innovative (Azadegan and Dooley, 2010; Kotabe *et al.*, 2003). Therefore, we used a second instrument related to supplier innovativeness; this indicator, "we achieve our innovation target through joint innovation projects with this supplier," was measured with end points of "1 = not at all" and "5 = significant."

In the first stage, we regressed knowledge acquisition on confidence, supplier innovativeness and all the control variables. Since the Breush–Pagan test was found to be significant, we used robust standard errors to overcome the issues of heteroskedasticity. We found both confidence (b = 0.32; t = 5.24; $p < 0.001$) and supplier innovativeness (b = 0.52; t = 8.02; $p < 0.001$) to be significantly related to knowledge acquisition. Subsequently, in the second stage, we used the predicted scores of knowledge acquisition from the first stage in subsequent models (models M1–M4 and M6 in Table 3) to test our hypotheses. Since both the Breush–Pagan and White tests were found to be nonsignificant in all our models, there were no issues of heteroskedasticity. But given that the standard errors generated in this second stage do not account for the fact that we used the predicted value of knowledge acquisition, the standard errors may be underestimated (Hamilton and Nickerson, 2003). Therefore, we corrected for this issue by using the bootstrapping approach employing 5,000 replications to determine the standard errors and the significance of the coefficients; we have also reported the bias-corrected confidence intervals wherever appropriate.

The descriptive statistics and bivariate correlation values are presented in Table 2. We mean-centered all variables that were used in the creation of interaction terms; this was done with the ambition of reducing nonessential multicollinearity as well as the ill-conditioning in the data (Dalal and Zickar, 2012); the individual variance inflation factor (VIF) values were all below 2. The regression results for the different models evaluated are provided in Table 3. As evident from the results of M1, knowledge acquisition was found to have a marginally significant positive effect on product stewardship (b = 0.12; z = 1.90; $p < 0.10$), thereby not providing support for *H1*. The other three hypotheses tested different interaction effects. *H2* focused on the moderating role of knowledge acquisition on the relationship between product stewardship and environmental performance. As evident from M6 (in Table 3), we found the moderating effect of knowledge acquisition to be statistically significant (M6: b = 0.26; z = 3.28; $p < 0.01$; 95% bias-corrected confidence interval (CI): lower limit (LL) = 0.1359; upper limit (UL) = 0.4944), thereby providing support for *H2*. *H3* and *H4* focused on the moderating role of supplier opportunism and knowledge exploitation on the relationship between knowledge acquisition and product stewardship, respectively. As evident from model M3, we found the moderating effects of supplier opportunism (M3: b = –0.11; z = 1.87; $p < 0.10$) to be not significant. On the other hand, we found the moderating effect of knowledge exploitation (M2: b = 0.16; z = 3.23; $p < 0.01$; 95% bias-corrected CI: LL = 0.1087; UL = 0.4071) to be significant. In summary, while *H4* was supported, *H3* was not supported. Please refer to Appendix 1 for the effect sizes and practical significance of our results.

Additional analysis

We corrected for potential endogeneity by using a two-stage hierarchical OLS estimation approach involving valid instruments (Hamilton and Nickerson, 2003). Even though we took necessary steps to ensure rigor, the OLS estimator could still be considered biased when involving troublesome endogenous variables. Therefore, we assessed the robustness of our results using other estimation approaches. The results of the robustness analysis are presented in Appendix 2. Additionally, to shed further light on the significant as well as nonsignificant moderation effects, we conducted further conditional effects-based analyses; details of these analyses are presented in Appendix 3.

Discussion

Theoretical implications

Our central thesis was that knowledge acquisition is pivotal to product stewardship initiatives as well as its subsequent impact on environmental performance. This premise of ours was based on the tenets of KBV, which advocates the superior role that newly acquired knowledge from external partners could play in enhancing the product design capabilities of the focal firm (Grant, 1996; Laursen and Salter, 2006; Szulanski *et al.*, 2016; Zahra and George, 2002; Zhou and Li, 2012). Specifically, product stewardship requires considerable amount of technical know-how and new knowledge about product components, characteristics and performance impacts (Dangelico *et al.*, 2013; Hart, 1995; Hart and Dowell, 2011; Pujari *et al.*, 2003). Therefore, adhering to the KBV, we conjectured that firms that acquire more knowledge from their supply partners could be in a better position to engage in product stewardship initiatives. But our results turned out to be intriguing in that, while its direct effect on product stewardship is nonsignificant, knowledge acquisition seemed to have a significant positive moderating effect on the relationship between product stewardship and environmental performance. This could, on the one hand, be explained by the fact that knowledge acquisition need not directly influence the willingness to become more sustainable. Accordingly, knowledge acquisition, by itself, might not lead to product stewardship. But, once a firm aspires to become more sustainable and incorporate stewardship in its product design, knowledge acquisition could allow the firm to be effective in product stewardship, thereby improving its effect on environmental performance.

Before delving deeper into the implications of our results, we would like to first highlight the important role that the two

Table 3 Regression results

		Product stewardship			Environmental performance	
Dependent variable	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**
Knowledge acquisition (KA)	0.12^{+}	0.10	0.11	0.10		0.09
	$\eta^2 = 0.017$	$\eta^2 = 0.014$				$\eta^2 = 0.010$
	$\Omega^2 = 0.012$	$\Omega^2 = 0.008$				$\Omega^2 = 0.005$
Supplier opportunism (OP)			0.005	0.001		
Knowledge exploitation (KE)		0.13*		0.12*		
		$\eta^2 = 0.023$				
		$\Omega^2 = 0.018$				
Product stewardship (PS)					0.32**	0.30**
					$\eta^2 = 0.073$	$\eta^2 = 0.071$
				$\Omega^2 = 0.068$	$\Omega^2 = 0.066$	
KA * OP			−0.11^{+}	−0.10^{+}		
			$\eta^2 = 0.018$			
			$\Omega^2 = 0.013$			
KA * KE		0.16**		0.14*		
		$\eta^2 = 0.040$				
		$\Omega^2 = 0.035$				
PS * KA						0.26**
						$\eta^2 = 0.081$
						$\Omega^2 = 0.076$
Environmental proactivity	0.35***	0.33***	0.36***	0.33***	0.13	0.12
Sustainability planning with customers	0.28***	0.29***	0.29***	0.30***	0.05	0.05
Competition intensity	0.10^{+}	0.08	0.12*	0.10^{+}	0.01	−0.02
Market share	0.15*	0.17**	0.14*	0.17**	0.05	0.04
F (*p*-value)	22.64***	19.37***	17.01***	15.21***	8.82***	9.76***
R^2	0.36	0.41	0.38	0.42	0.18	0.26
Sample size	205	204	203	202	207	205

Notes: ****t-values significant at $p \leq 0.001$; **t-values significant at $p \leq 0.01$; *t-values significant at $p \leq 0.05$; $^{+}$t-values significant at $p \leq 0.10$; Significance values were generated bootstrapping for 5,000 replications*

instruments – level of confidence and supplier innovativeness – play when it comes to knowledge acquisition. Specifically, the results from the first stage of our two-stage hierarchical OLS approach suggest that the level of confidence in the supply partner could signal trustworthiness as well as compatibility in the relationship, thereby leading to increased acquisition of knowledge from the partner (Dyer and Singh, 1998). The significant effect of supplier innovativeness on knowledge acquisition further validates our belief that firms would be more inclined to acquire knowledge from suppliers that are more innovative in nature (Azadegan and Dooley, 2010; Kotabe *et al.*, 2003). In the remainder of this section, we focus our attention on the intriguing results surrounding the effect of knowledge acquisition on product stewardship.

Product stewardship is fraught with a high degree of ambiguity and complexity which is driven by the intricate interactions among the diverse performance domains as well as the involvement of a wider range of stakeholders (Hall and Vredenburg, 2005; Hart, 1995; Sharma and Vredenburg, 1998). Accordingly, the acquired knowledge components related to product stewardship might themselves be complex in that they might relate to the application of new material, new technology and/or new approach to product design; accordingly, these knowledge components could suffer from the "liability of newness" (Stinchcombe, 1965) which could hinder the mobility of such knowledge components (Law, 2014). Additionally, the complexities surrounding product stewardship could rather create a façade wherein firms might consider external knowledge components to be either imperfect or inappropriate (Matos and Hall, 2007), thereby wanting neither to understand the performance implications nor apply even the not-so-complex design considerations (Law, 2014; Simonin, 1999). The rugged landscape of product stewardship impedes the understanding of the knowledge components as well as their performance impacts, thereby limiting the applicability of the acquired knowledge. In other words, the rugged landscape of product stewardship amplifies the double-edged effect of knowledge acquisition, wherein knowledge acquisition from supply partners need not necessarily have a significant positive effect on product stewardship.

Alternatively, even if firms are reluctant to incorporate specific design changes based on the new knowledge acquired, they could rather use the learning from external knowledge to understand the potential effects of their internal knowledge components. Specifically, based on the medium to large effect size of the moderation as well as the conditional indirect effects of knowledge acquisition (section on additional analysis) and product stewardship (please refer to Figure A1 in Appendix 3) on environmental performance at different levels of knowledge acquisition, we can safely purport that the new knowledge gained from external partners, when above a threshold, could enable firms to deepen their own thinking and understand the interdependencies between the different performance domains. Accordingly, external knowledge, new or redundant, could assist, indirectly, in deciphering the performance implications of their internal product design decisions. In other words, we forward that even if the acquired knowledge may not lead directly to design changes, it could help firms to find unforeseen combinations of already known, but previously unearthed knowledge elements that reside within the firm (Cohen, 1981; Levinthal and Warglien, 1999). Accordingly, through acquired knowledge firms can potentially enhance the performance impacts of their own product stewardship efforts (Levinthal and Warglien, 1999).

As for the contingent effects, our results suggest that knowledge exploitation plays a pivotal role in the relationship between knowledge acquisition and product stewardship. While knowledge exploitation positively moderates the relationship, opportunism does not negatively moderate the relationship as we had hypothesized. Based on a detailed post hoc analysis, we find knowledge acquisition to have a significant positive effect on product stewardship only at low levels of supplier opportunism (please refer to Panel B of Figure A2 in Appendix 3) and moderate to high levels of knowledge exploitation (please refer to Panel A of Figure A2 in Appendix 3). We also find the combined moderating effects of these contingencies to be significant at the 99% confidence level (please refer to Figure A3 in Appendix 3). Our results, including the practical significance of the moderating effect presented in Appendix 1 (i.e. medium effect size), suggest that through well-established processes, routines and structures (Foss *et al.*, 2013), knowledge exploitation can help firms in understanding the complexities and ambiguities associated with product stewardship (Levinthal and March, 1993; Li *et al.*, 2010b; March, 1991; Zahra and George, 2002). By facilitating the synthesis of external and internal knowledge components, knowledge exploitation capability can also help firms to use the acquired knowledge to smoothen the rugged landscape.

Taking the nonsignificant moderating effect of supplier opportunism and the conditional indirect effect of knowledge acquisition on product stewardship in the presence of supplier opportunism (Figure A2 – Panel B in Appendix 3) together, even at slightly elevated levels of supplier opportunism, knowledge acquisition does not lead to product stewardship. Specifically, if firms suspect a supplier to be opportunistic, there is an increased chance that they will perceive that the supplier might not only withhold knowledge deliberately but also go to the extent of providing false information (Wathne and Heide, 2000). In other words, supplier opportunism seems to act as a significant obstacle to “learning the knowledge” from suppliers, even at slightly lower levels. Additionally, given that opportunistic behavior could also escalate conflicts in relationships (Wathne and Heide, 2000; Williamson, 1985), firms will not be motivated to take the effort to jointly understand the performance effects of the acquired knowledge. Though the negative moderating effect was not significant, the conditional effects of opportunism suggest that it could still have a strong debilitating effect on the application of the knowledge that could be acquired. Even the slightly elevated levels of opportunism, in itself, seem to invoke the dark side of the external knowledge that is acquired (Zanarone *et al.*, 2016), wherein it prevents the firm from using such knowledge in its own internal product design decisions.

When looking at the combined effect of both knowledge exploitation and supplier opportunism, we find that moderate to high levels of knowledge exploitation combined with low to slightly moderate levels of supplier opportunism provides the ideal environment that will facilitate both learning as well as the application of knowledge, thereby maximizing the benefits that could be accrued along the rugged landscape of product stewardship. In other words, when maintained at their ideal levels, these contingencies could negate the double-edged effect of knowledge acquisition wherein firms can synthesize the acquired knowledge successfully. On the contrary, low levels of knowledge exploitation combined with moderate to high levels of supplier opportunism will rather serve as the undesirable breeding ground for the double-edged effect of knowledge acquisition.

Practical implications

Our study offers some key implications for practicing supply chain managers. First, managers should be cognizant about the double-edged nature of knowledge acquisition. While knowledge acquired from suppliers is generally seen as beneficial, the negativities surrounding product stewardship could make it challenging for managers to successfully integrate the knowledge acquired. At the same time, companies that want to take a pro-environment stand and aspire to overcome such challenges should rest assured that knowledge acquisition could be beneficial in not only improving the sustainability-related design aspects of their products but also in improving their environmental performance. More importantly, managers need to understand that they must control the double-edged effect of knowledge acquisition, given that it is pivotal to subsequently smoothening the rugged landscape inherent in product stewardship. For this to work seamlessly, other firm-specific capabilities, as well as appropriate relationship governance mechanisms, are a must. Specifically, in addition to ensuring that the knowledge exploitation capabilities are properly honed, managers also need to adopt appropriate formal and/or informal governance mechanisms that could minimize the level of opportunism in their relationship with key suppliers. If so, they could successfully negate the double-edged effect of knowledge acquisition and subsequently maximize the benefits that could be accrued along the rugged landscape of product stewardship.

Conclusion

Given the importance of environmental sustainability is increasing exponentially, companies could stay ahead of their competition by engaging in product stewardship initiatives. Product stewardship requires diverse input from supply chain partners. Therefore, external knowledge acquired from suppliers may benefit firms in their stewardship efforts and their subsequent impact on environmental performance. With this belief, we study the effect of knowledge acquisition along with two key contingencies – knowledge exploitation and supplier opportunism. Specifically, in addition to selecting these contingencies based on the split process of knowledge sharing between firms, we also considered choosing one facilitating and one debilitating contingency in our theoretical model. Our study offers some interesting findings that could significantly augment the theoretical discourse surrounding the role of knowledge acquisition in product stewardship. Specifically, our study showcases a potential double-edged effect of knowledge acquisition that could be specific to complex contexts such as product stewardship. Additionally, it also shows that specific levels of knowledge exploitation and supplier opportunism could help to negate this double-edged effect. More importantly, the medium to large effect sizes for the moderating role of knowledge acquisition and knowledge exploitation also showcase the practical relevance of our findings.

We now discuss some of our study's limitations that might pave the way for future research opportunities. First, owing to parsimony, we considered only two contingencies in our model; we encourage future research to consider other aspects of knowledge management as well as relationship management and evaluate their role in enhancing or inhibiting the effect of knowledge acquisition within the context of sustainable development. Second, when it comes to product stewardship, we follow Hart (1995) and conceptualize it to include only the environmental considerations; this seemed appropriate as we focused specifically on technical knowledge acquisition. But life cycle assessment of products could include social considerations as well (Gauthier, 2005; O'Brien *et al.*, 1996; Traverso *et al.*, 2012). Additionally, through knowledge acquisition, firms could also learn about novel social practices from their suppliers. Accordingly, we believe that it is important to assess how knowledge acquisition could impact product stewardship after taking social considerations into account. Therefore, we recommend future research to evaluate our research model by broadening the scope of both knowledge acquisition and product stewardship to include social aspects. Third, though product stewardship should cater to the economic, environmental and social aspects of the triple bottom line, given our ambition to focus predominantly on the specific effect of knowledge acquisition on product stewardship, we focused only on environmental performance. But we acknowledge that it will be interesting to see how knowledge acquisition could impact the effect of product stewardship on all three performance domains. So, we recommend future research to take a triple bottom-line approach toward performance measurement (Paulraj and Blome, 2017). Finally, even though we took procedural as well as methodological efforts to minimize common methods bias, data on independent and dependent variables were collected from a single respondent; future research could validate our results using data collected from multiple respondents. Despite these and other potential limitations, we believe that our study makes an invaluable contribution to the literature on knowledge management in general, and product stewardship in particular.

Note

1 For a graphical representation of a multipeaked rugged landscape as opposed to a single-peak smooth landscape, we request readers to refer to Figure 1 of Levinthal and Warglien (1999) and Matos and Hall (2007).

References

Abele, E., Anderl, R. and Birkhofer, H. (2009), *Environmentally-Friendly Product Development: Methods and Tools*, Springer, London.

Alcacer, J. and Oxley, J. (2014), "Learning by supplying", *Strategic Management Journal*, Vol. 35 No. 2, pp. 204-223.

Ambulkar, S., Blackhurst, J. and Grawe, S. (2015), "Firm's resilience to supply chain disruptions: scale development and empirical examination", *Journal of Operations Management*, Vol. 33, pp. 111-122.

Antonakis, J., Bendahan, S., Jacquart, P. and Lalive, R. (2010), "On making causal claims: a review and recommendations", *The Leadership Quarterly*, Vol. 21 No. 6, pp. 1086-1120.

Aragón-Correa, J.A. and Sharma, S. (2003), "A contingent resource-based view of proactive corporate environmental strategy", *Academy of Management Review*, Vol. 28 No. 1, pp. 71-88.

Ardito, L. and Messeni Petruzzelli, A. (2017), "Breadth of external knowledge sourcing and product innovation: the moderating role of strategic human resource practices", *European Management Journal*, Vol. 35 No. 2, pp. 261-272.

Azadegan, A. and Dooley, K.J. (2010), "Supplier innovativeness, organizational learning styles and manufacturer performance: an empirical assessment", *Journal of Operations Management*, Vol. 28 No. 6, pp. 488-505.

Bagozzi, R.P. and Yi, Y. (1988), "On the evaluation of structural equation models", *Journal of the Academy of Marketing Science*, Vol. 16 No. 1, pp. 74-94.

Baum, J.A.C., Li, S.X. and Usher, J.M. (2000), "Making the next move: how experiential and vicarious learning shape the locations of chains' acquisitions", *Administrative Science Quarterly*, Vol. 45 No. 4, pp. 766-801.

Blome, C., Foerstl, K. and Schleper, M.C. (2017), "Antecedents of green supplier championing and greenwashing: an empirical study on leadership and ethical incentives", *Journal of Cleaner Production*, Vol. 152, pp. 339-350.

Blome, C., Paulraj, A., Preuss, L. and Roehrich, J.K. (2023), "Trust and opportunism as paradoxical tension: implications for achieving sustainability in Buyer-Supplier relationships", *Industrial Marketing Management*, Vol. 108, pp. 94-107.

Bode, C., Wagner, S.M., Petersen, K.J. and Ellram, L.M. (2011), "Understanding responses to supply chain disruptions: insights from information processing and resource dependence perspectives", *Academy of Management Journal*, Vol. 54 No. 4, pp. 833-856.

Boulding, W. and Staelin, R. (1993), "A look on the cost side: market share and the competitive environment", *Marketing Science*, Vol. 12 No. 2, pp. 144-166.

Cabrera, A. and Cabrera, E.F. (2002), "Knowledge-sharing dilemmas", *Organization Studies*, Vol. 23 No. 5, pp. 687-710.

Cohen, M.D. (1981), "The power of parallel thinking", *Journal of Economic Behavior and Organization*, Vol. 2 No. 4, pp. 285-306.

Dalal, D.K. and Zickar, M.J. (2012), "Some common myths about centering predictor variables in moderated multiple regression and polynomial regression", *Organizational Research Methods*, Vol. 15 No. 3, pp. 339-362.

Dangelico, R. and Pujari, D. (2010), "Mainstreaming green product innovation: why and how companies integrate environmental sustainability", *Journal of Business Ethics*, Vol. 95 No. 3, pp. 471-486.

Dangelico, R.M., Pontrandolfo, P. and Pujari, D. (2013), "Developing sustainable new products in the textile and upholstered furniture industries: role of external integrative capabilities", *Journal of Product Innovation Management*, Vol. 30 No. 4, pp. 642-658.

Das, T.K. and Teng, B.-S. (1998), "Between trust and control: developing confidence in partner cooperation in alliances", *Academy of Management Review*, Vol. 23 No. 3, pp. 491-512.

De Giovanni, P. and Vinzi, V.E. (2012), "Covariance versus component-based estimations of performance in green supply chain management", *International Journal of Production Economics*, Vol. 135 No. 2, pp. 907-916.

Deng, L. and Chan, W. (2017), "Testing the difference between reliability coefficients alpha and omega", *Educational and Psychological Measurement*, Vol. 77 No. 2, pp. 185-203.

Dess, G.G., Ireland, R.D., Zahra, S.A., Floyd, S.W., Janney, J. J. and Lane, P.J. (2003), "Emerging issues in corporate entrepreneurship", *Journal of Management*, Vol. 29 No. 3, pp. 351-378.

Dillman, D.A. (2007), *Mail and Internet Surveys: The Tailored Design Method*, John Wiley & Sons.

Dreyer, L., Hauschild, M. and Schierbeck, J. (2006), "A framework for social life cycle impact assessment", *International Journal of Life Cycle Assessment*, Vol. 11 No. 2, pp. 88-97.

Dyer, J.H. and Singh, H. (1998), "The relational view: cooperative strategy and sources of interorganizational competitive advantage", *Academy of Management. The Academy of Management Review*, Vol. 23 No. 4, pp. 660-679.

Fleming, L. (2001), "Recombinant uncertainty in technological search", *Management Science*, Vol. 47 No. 1, pp. 117-132.

Flor, M.L., Cooper, S.Y. and Oltra, M.J. (2018), "External knowledge search, absorptive capacity and radical innovation in high-technology firms", *European Management Journal*, Vol. 36 No. 2, pp. 183-194.

Fornell, C. and Larcker, D. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50.

Foss, N.J., Lyngsie, J. and Zahra, S.A. (2013), "The role of external knowledge sources and organizational design in the process of opportunity exploitation", *Strategic Management Journal*, Vol. 34 No. 12, pp. 1453-1471.

Gauthier, C. (2005), "Measuring corporate social and environmental performance: the extended life-cycle assessment", *Journal of Business Ethics*, Vol. 59 No. 1, pp. 199-206.

González-Benito, J. and González-Benito, Ó. (2005), "Environmental proactivity and business performance: an empirical analysis", *Omega*, Vol. 33 No. 1, pp., pp. 1-15.

Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17 No. S2, pp. 109-122.

Groves, R.M. and Peytcheva, E. (2008), "The impact of nonresponse rates on nonresponse bias: a meta-analysis", *Public Opinion Quarterly*, Vol. 72 No. 2, pp. 167-189.

Gupta, A.K., Smith, K.G. and Shalley, C.E. (2006), "The interplay between exploration and exploitation", *The Academy of Management Journal*, Vol. 49 No. 4, pp. 693-706.

Hall, J. and Vredenburg, H. (2005), "Managing stakeholder ambiguity", *MIT Sloan Management Review*, Vol. 47 No. 1, pp. 11-13.

Hamel, G. (1991), "Competition for competence and inter-partner learning within international strategic alliances", *Strategic Management Journal*, Vol. 12, p. 83.

Hamilton, B.H. and Nickerson, J.A. (2003), "Correcting for endogeneity in strategic management research", *Strategic Organization*, Vol. 1 No. 1, pp. 51-78.

Hart, S. (1995), "A natural-resource-based view of the firm", *Academy of Management Review*, Vol. 20 No. 4, pp. 986-1014.

Hart, S.L. and Dowell, G. (2011), "Invited editorial: a natural-resource-based view of the firm: fifteen years after", *Journal of Management*, Vol. 37 No. 5, pp. 1464-1479.

Henseler, J., Ringle, C. and Sarstedt, M. (2015), "A new criterion for assessing discriminant validity in variance-based structural equation modeling", *Journal of the Academy of Marketing Science*, Vol. 43 No. 1, pp. 115-135.

Hofman, P.S., Blome, C., Schleper, M.C. and Subramanian, N. (2020), "Supply chain collaboration and eco-innovations: an institutional perspective from China", *Business Strategy and the Environment*, Vol. 29 No. 6, pp. 2734-2754.

Hu, L.T. and Bentler, P.M. (1999), "Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives", *Structural Equation Modeling: A Multidisciplinary Journal*, Vol. 6 No. 1, pp. 1-55.

Jansen, J.J.P., Van Den Bosch, F.A.J. and Volberda, H.W. (2006), "Exploratory innovation, exploitative innovation, and performance: effects of organizational antecedents and environmental moderators", *Management Science*, Vol. 52 No. 11, pp. 1661-1674.

Kale, P., Singh, H. and Perlmutter, H. (2000), "Learning and protection of proprietary assets in strategic alliances: building relational capital", *Strategic Management Journal*, Vol. 21 No. 3, pp. 217-237.

Katila, R. and Ahuja, G. (2002), "Something old, something new: a longitudinal study of search behavior and new product introduction", *Academy of Management Journal*, Vol. 45 No. 6, pp. 1183-1194.

Katsikeas, C.S., Skarmeas, D. and Bello, D.C. (2009), "Developing SUCCESSFUL TRUST-BASED international exchange relationships", *Journal of International Business Studies*, Vol. 40 No. 1, pp. 132-155.

Kauffman, S.A. (1993), *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, New York, NY.

Ketokivi, M.A. and Schroeder, R.G. (2004), "Perceptual measures of performance: fact or fiction?", *Journal of Operations Management*, Vol. 22 No. 3, pp. 247-264.

Khilji, S.E., Mroczkowski, T. and Bernstein, B. (2006), "From invention to innovation: toward developing an integrated innovation model for biotech firms *", *Journal of Product Innovation Management*, Vol. 23 No. 6, pp. 528-540.

Kotabe, M., Martin, X. and Domoto, H. (2003), "Gaining from vertical partnerships: knowledge transfer, relationship duration, and supplier performance improvement in the U.S. and Japanese automotive industries", *Strategic Management Journal*, Vol. 24 No. 4, pp. 293-316.

Lado, A.A., Dant, R.R. and Tekleab, A.G. (2008), "Trust-opportunism paradox, relationalism, and performance in interfirm relationships: evidence from the retail industry", *Strategic Management Journal*, Vol. 29 No. 4, pp. 401-423.

Laursen, K. and Salter, A. (2006), "Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms", *Strategic Management Journal*, Vol. 27 No. 2, pp. 131-150.

Law, K.K. (2014), "The problem with knowledge ambiguity", *European Management Journal*, Vol. 32 No. 3, pp. 444-450.

Lee, W.E. and Hageman, A.M. (2018), "Talk the talk or walk the walk? An examination of sustainability accounting implementation", *Journal of Business Ethics*, Vol. 152 No. 3, pp. 725-739.

Lee, C.-K., Lee, J.-Y., Choi, Y.-H. and Lee, K.-M. (2016), "Application of the integrated ecodesign method using the GHG emission as a single indicator and its GHG recyclability", *Journal of Cleaner Production*, Vol. 112, pp. 1692-1699.

Levinthal, D.A. and March, J.G. (1993), "The myopia of learning", *Strategic Management Journal*, Vol. 14 No. S2, pp. 95-112.

Levinthal, D.A. and Warglien, M. (1999), "Landscape design: designing for local action in complex worlds", *Organization Science*, Vol. 10 No. 3, pp. 342-357.

Li, J.J., Poppo, L. and Zhou, K.Z. (2010a), "Relational mechanisms, formal contracts, and local knowledge acquisition by international subsidiaries", *Strategic Management Journal*, Vol. 31 No. 4, pp. 349-370.

Li, Y., Zhang, C., Liu, Y. and Li, M. (2010b), "Organizational learning, internal control mechanisms, and indigenous innovation: the evidence from China", *IEEE Transactions on Engineering Management*, Vol. 57 No. 1, pp. 63-77.

Li, D., Eden, L., Hitt, M.A. and Ireland, R.D. (2008), "Friends, acquaintances, or strangers? Partner selection in R&D alliances", *The Academy of Management Journal*, Vol. 51 No. 2, pp. 315-334.

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

Liu, Y., Blome, C., Sanderson, J. and Paulraj, A. (2018), "Supply chain integration capabilities, green design strategy and performance: a comparative study in the auto industry", *Supply Chain Management: An International Journal*, Vol. 23 No. 5, pp. 431-443.

Luchs, M.G., Naylor, R.W., Irwin, J.R. and Raghunathan, R. (2010), "The sustainability liability: potential negative effects of ethicality on product preference", *Journal of Marketing*, Vol. 74 No. 5, pp. 18-31.

Luo, Y. (2006), "Opportunism in Inter-Firm exchanges in emerging markets", *Management and Organization Review*, Vol. 2 No. 1, pp. 121-147.

McDonald, R.P. (1999), *Test Theory: A Unified Treatment*, Lawrence Erlbaum, Mahwah, NJ.

McDougall, N., Wagner, B. and MacBryde, J. (2021), "Leveraging competitiveness from sustainable operations: frameworks to understand the dynamic capabilities needed to realise NRBV supply chain strategies", *Supply Chain Management: An International Journal)*.

March, J.G. (1991), "Exploration and exploitation in organizational learning", *Organization Science*, Vol. 2 No. 1, pp. 71-87.

Mardia, K.V. (1970), "Measures of multivariate skewness and kurtosis with applications", *Biometrika*, Vol. 57 No. 3, pp. 519-530.

Matos, S. and Hall, J. (2007), "Integrating sustainable development in the supply chain: the case of life cycle assessment in oil and gas and agricultural biotechnology", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1083-1102.

Mihelcic, J.R., Crittenden, J.C., Small, M.J., Shonnard, D.R., Hokanson, D.R., Zhang, Q., Chen, H., Sorby, S.A., James, V.U., Sutherland, J.W. and Schnoor, J.L. (2003), "Sustainability science and engineering: the emergence of a new metadiscipline", *Environmental Science & Technology*, Vol. 37 No. 23, p. 5314.

Nickerson, J. and Zenger, T. (2004), "A knowledge-based theory of the firm—the problem-solving perspective", *Organization Science*, Vol. 15 No. 6, pp. 617-632.

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

O'Brien, M., Doig, A. and Clift, R. (1996), "Social and environmental life cycle assessment (SELCA)", *International Journal of Life Cycle Assessment*, Vol. 1 No. 4, pp. 231-237.

Oliveira, N. and Lumineau, F. (2019), "The dark side of interorganizational relationships: an integrative review and research agenda", *Journal of Management*, Vol. 45 No. 1, pp. 231-261.

Olson, E.M., Slater, S.F. and Hult, G.T.M. (2005), "The performance implications of fit among business strategy, marketing organization structure, and strategic behavior", *Journal of Marketing*, Vol. 69 No. 3, pp. 49-65.

Pace, C.R. (1939), "Factors influencing questionnaire returns from former university students", *Journal of Applied Psychology*, Vol. 23 No. 3, pp. 388-397.

Paulraj, A. (2011), "Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability", *Journal of Supply Chain Management*, Vol. 47 No. 1, pp. 19-37.

Paulraj, A. and Blome, C. (2017), "Plurality in environmental supply chain mechanisms", *International Journal of Operations and Production Management*, Vol. 37 No. 8, pp. 1010-1030.

Paulraj, A., Jayaraman, V. and Blome, C. (2014), "Complementarity effect of governance mechanisms on environmental collaboration: does it exist?", *International Journal of Production Research*, Vol. 52 No. 23, pp. 1-18.

Pimonenko, T., Bilan, Y., Horák, J., Starchenko, L. and Gajda, W. (2020), "Green brand of companies and greenwashing under sustainable development goals", *Sustainability*, Vol. 12 No. 4, p. 1679.

Pizzetti, M., Gatti, L. and Seele, P. (2021), "Firms talk, suppliers walk: analyzing the locus of greenwashing in the blame game and introducing 'vicarious greenwashing", *Journal of Business Ethics*, Vol. 170 No. 1, pp. 21-38.

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

Porter, M.E. and van der Linde, C. (1995), "Green and competitive: ending the stalemate", *Harvard Business Review*, Vol. 73 No. 5, p. 120.

Pujari, D., Wright, G. and Peattie, K. (2003), "Green and competitive: influences on environmental new product development performance", *Journal of Business Research*, Vol. 56 No. 8, pp. 657-671.

Rexhausen, D., Pibernik, R. and Kaiser, G. (2012), "Customer-facing supply chain practices—the impact of demand and distribution management on supply chain success", *Journal of Operations Management*, Vol. 30 No. 4, pp. 269-281.

Rogelberg, S.G. and Stanton, J.M. (2007), "Introduction – understanding and dealing with organizational survey nonresponse", *Organizational Research Methods*, Vol. 10 No. 2, pp. 195-209.

Roldán Bravo, M.I., Ruiz-Moreno, A. and Lloréns Montes, F.J. (2018), "Examining desorptive capacity in supply chains: the role of organizational ambidexterity", *International Journal of Operations and Production Management*, Vol. 38 No. 2, pp. 534-553.

Roldán Bravo, M.I., Stevenson, M., Moreno, A.R. and Lloréns Montes, F.J. (2020), "Absorptive and desorptive capacity configurations in supply chains: an inverted U-Shaped relationship", *International Journal of Production Research*, Vol. 58 No. 7, pp. 2036-2053.

Rosenkopf, L. and Nerkar, A. (2001), "Beyond local search: boundary-spanning, exploration, and impact in the optical disk industry", *Strategic Management Journal*, Vol. 22 No. 4, pp. 287-306.

Rossetti, C. and Choi, T. (2005), "On the dark side of strategic sourcing: experiences from the aerospace industry", *The Academy of Management Executive*, Vol. 19 No. 1, pp. 46-60.

Roth, A. and Rosenzweig, E. (2020), "Advancing empirical science in operations management research: a clarion call to action", *Manufacturing and Service Operations Management*, Vol. 22 No. 1, pp. 179-190.

Sarkis, J. (2001), "Manufacturing's role in corporate environmental sustainability – concerns for the new millennium", *International Journal of Operations & Production Management*, Vol. 21 Nos 5/6, pp. 666-686.

Sarkis, J., Gonzalez-Torre, P. and Adenso-Diaz, B. (2010), "Stakeholder pressure and the adoption of environmental practices: the mediating effect of training", *Journal of Operations Management*, Vol. 28 No. 2, pp. 163-176.

Seuring, S. and Müller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.

Sharma, S. (2000), "Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy", *Academy of Management Journal*, Vol. 43 No. 4, pp. 681-697.

Sharma, S. and Vredenburg, H. (1998), "Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities", *Strategic Management Journal*, Vol. 19 No. 8, pp. 729-753.

Simon, H.A. 1996. *The Sciences of the Artificial/Herbert A. Simon*, 3rd ed., MIT Press, Cambridge, Mass.

Simonin, B. (1999), "Ambiguity and the process of knowledge transfer in strategic alliances", *Strategic Management Journal*, Vol. 20 No. 7, p. 595.

Stinchcombe, A.L. (1965), "Social structure and organizations", in J.G. March (Ed.). *Handbook of Organizations*, Rand McNally and Company, Chicago, IL, pp. 142.-193.

Subramaniam, M. and Youndt, M.A. (2005), "The influence of intellectual capital on the types of innovative capabilities", *The Academy of Management Journal*, Vol. 48 No. 3, pp. 450-463.

Szulanski, G., Ringov, D. and Jensen, R. (2016), "Overcoming stickiness: how the timing of knowledge transfer methods affects transfer difficulty", *Organization Science*, Vol. 27 No. 2, pp. 304-322.

Traverso, M., Finkbeiner, M., Jørgensen, A. and Schneider, L. (2012), "Life cycle sustainability dashboard", *Journal of Industrial Ecology*, Vol. 16 No. 5, pp. 680-688.

Tripsas, M. and Gavetti, G. (2000), "Capabilities, cognition, and inertia: evidence from digital imaging", *Strategic Management Journal*, Vol. 21 Nos 10/11, pp. 1147-1161.

van Wijk, R., Jansen, J.J.P. and Lyles, M.A. (2008), "Inter- and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences", *Journal of Management Studies*, Vol. 45 No. 4, pp. 830-853.

Wang, J., Yu, S., Chu, J. and Qi, B. (2010), "A methodology for idea generation in sustainable product design", *Advanced Materials Research*, Vols 129/131, pp. 174-178.

Wathne, K.H. and Heide, J.B. (2000), "Opportunism in interfirm relationships: forms, outcomes, and solutions", *Journal of Marketing*, Vol. 64 No. 4, pp. 36-51.

WECD (1987), *Our Common Future*, Oxford University Press, Oxford.

White, K., Hardisty, D.J. and Habib, R. (2019), "The elusive green consumer", *Harvard Business Review: July-August*.

Widaman, K.F. (1985), "Hierarchically nested covariance structure models for multitrait-multimethod data", *Applied Psychological Measurement*, Vol. 9 No. 1, pp. 1-26.

Williams, L.J., Cote, J.A. and Buckley, M.R. (1989), "Lack of method variance in self-reported affect and perceptions at work: reality or artifact?", *Journal of Applied Psychology*, Vol. 74 No. 3, pp. 462-468.

Williamson, O.E. (1985), *The Economic Institutions of Capitalism*, Free Press, New York, NY.

Wright, M. and Armstrong, J.S. (2008), "The ombudsman: verification of citations: fawlty towers of knowledge?", *Interfaces*, Vol. 38 No. 2, pp. 125-139.

Wright, S. (1931), "Evolution in Mendelian populations", *Genetics*, Vol. 16, pp. 97-159.

Yang, H., Phelps, C. and Steensma, H.K. (2010), "Learning from what others have learned from you: the effects of knowledge spillovers on originating firms", *Academy of Management Journal*, Vol. 53 No. 2, pp. 371-389.

Yli-Renko, H., Autio, E. and Sapienza, H.J. (2001), "Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms," *Strategic Management Journal*, Vol. 22 Nos 6/7, pp. 587-613.

Zahra, S.A. and George, G. (2002), "Absorptive capacity: a review, reconceptualization, and extension", *The Academy of Management Review*, Vol. 27 No. 2, pp. 185-203.

Zanarone, G., Lo, D. and Madsen, T.L. (2016), "The double-edged effect of knowledge acquisition: how contracts safeguard pre-existing resources", *Strategic Management Journal*, Vol. 37 No. 10, pp. 2104-2120.

Zhang, Z. and Yuan, K.-H. (2016), "Robust coefficients alpha and omega and confidence intervals with outlying observations and missing data: methods and software", *Educational and Psychological Measurement*, Vol. 76 No. 3, pp. 387-411.

Zhang, M., Zhao, X. and Lyles, M. (2018), "Effects of absorptive capacity, trust and information systems on product innovation", *International Journal of Operations & Production Management*, Vol. 38 No. 2, pp. 493-512.

Zhou, K.Z. and Li, C.B. (2012), "How knowledge affects radical innovation: knowledge base, market knowledge acquisition, and internal knowledge sharing", *Strategic Management Journal*, Vol. 33 No. 9, pp. 1090-1102.

Zhou, K.Z., Zhang, Q., Sheng, S., Xie, E. and Bao, Y. (2014), "Are relational ties always good for knowledge acquisition? Buyer–supplier exchanges in China", *Journal of Operations Management*, Vol. 32 No. 3, pp. 88-98.

Zhu, Q. and Sarkis, J. (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises", *Journal of Operations Management*, Vol. 22 No. 3, pp. 265-289.

Zhu, Q., Sarkis, J., Cordeiro, J.J. and Lai, K.-H. (2008), "Firm-level correlates of emergent green supply chain management practices in the Chinese context", *Omega*, Vol. 36 No. 4, pp. 577-591.

Appendix 1. Effect sizes and practical significance

In addition to assessing the statistical significance of the effects using the *p*-value, we also examined whether these effects are practically meaningful using the partial eta-squared and omega-squared (Ω^2) estimates of effect sizes (Kiss *et al.*, 2020). Partial eta-squared (η^2) estimate is commonly used in social sciences as a measure of effect size. But given that η^2 estimates might be biased in the case of smaller sample sizes, Field (2013) recommends the usage of Ω^2 estimates instead. Though our sample is large enough to minimize bias, we have reported both these estimates of effect size. Cohen (1988) suggests that η^2 ranges between 0.01 (small effect) and 0.09 (large effect) in social sciences research. Please refer to Table 2 for the effect sizes across the different models. As evident from M2, in the case of product stewardship, the effect size of knowledge acquisition was lower (M2: η^2 = 0.014; Ω^2 = 0.008) in comparison to the effect size of knowledge exploitation (M2: η^2 = 0.023; Ω^2 = 0.018). Though we did not specifically hypothesize the direct effect of product stewardship on environmental performance, it seemed to have a medium to large effect size (M5: η^2 = 0.073; Ω^2 = 0.068). Though nonsignificant, the moderation effect of supplier opportunism also had a small effect size (M3: η^2 = 0.018; Ω^2 = 0.013). The moderation effect of knowledge exploitation had a medium effect size (M2: η^2 = 0.037; Ω^2 = 0.032). The moderation effect of knowledge acquisition had a medium to large effect size (M6: η^2 = 0.081; Ω^2 = 0.076).

Appendix 2. Robustness checks

We included instrumental variables for overcoming potential endogeneity issues; still, our research might also suffer from endogeneity caused by self-selection bias (Rocha *et al.*, 2019). Specifically, though we did not collect dyadic data, we had asked the randomly-selected respondents to select a key supplier to answer questions pertaining to a particular supplier. Therefore, to ensure that our research does not suffer from endogeneity due to self-selection (i.e. nonrandomness), we adopted the Heckman's two-stage approach to test for the robustness of our results (Certo *et al.*, 2016; Hamilton and Nickerson, 2003). In the first stage, we used a probit model to estimate the probability of each observation entering our sample. We defined a selection variable, supplier environmental performance which was based on the indicator "reduction in environmental impacts" that was measured using a five-point Likert scale with anchors "not at all" to "significant". The selection variable was set to 1 if the value was able average for the indicator and zero otherwise. Apart from including all the control variables, we also included the two moderators in the first stage. We used the same instruments that we had included in our main analysis as exclusion criteria; as indicated, these variables were not significantly correlated with the outcome variables in our hypothesized model. From the first stage model, we calculated the inverse Mills ratio that was used as a control variable in the subsequent models predicting product stewardship and environmental performance. The results of hypothesis testing were all consistent with our original results after controlling for the inverse Mill's ratio. In other words, our results were consistent after accounting for the potential endogeneity from self-selection.

We assessed the robustness of our models using the two-stage least squares (2SLS) estimator. The Durbin $\chi 2$ and Wu–Hausman *F*-statistic showed adequate evidence of endogeneity of knowledge acquisition (Antonakis *et al.*, 2010); while these values were nonsignificant for three of the models, they were significant ($p < 0.05$) for two models. So, we cannot ignore the chance that endogeneity could affect our results; alternatively, this also justifies our inclusion of instrumental variables for overcoming the potential endogeneity issues. The results from the 2SLS approach are presented in Appendix 2 – Table A1 below. We first tested for the heteroscedasticity in simultaneous equations using the Pagan and Hall (1983) test. Though the Pagan and Hall statistic was nonsignificant for all models, the model with environmental performance as the dependent variable (Please refer to M5 in Appendix 2 – Table A1) had a significant value for the Breush–Pagan test. Therefore, for M5, we ran the 2SLS command with the robust option to include robust standard errors. We also assessed this model using the generalized method of moments (GMM) estimator as this method is robust in the presence of heteroscedasticity (Please refer to M6 in Appendix 2 – Table A1). The Anderson canonical correlation as well as the Kleibergen–Paap LM statistics for underidentification were found to be significant in all models, indicating that our instruments are valid and relevant. We tested the strength of the instrumental variables in the different models using the first-stage *F*-statistics; the value for Cragg–Donald Wald F-statistic as well as Kleibergen–Paap Wald F-statistic were higher than the critical values for relative bias as well as size distortions provided by Stock and Yogo (2005), thereby indicating that our instrumental variables were strong. Finally, we tested for the overidentifying restrictions using the Hansen–Sargan tests (Antonakis *et al.*, 2010). Both these statistics were found to nonsignificant for all the models, thereby suggesting that our instrumental variables are not correlated with the error term. Overall, the results from the 2SLS estimator were found to be consistent with our two-stage hierarchical OLS estimation approach.

We also tested for the robustness of our results using the 3SLS estimation approach. This estimation approach accommodates the fact that the error terms across the system of equations could be correlated; in doing so, it also accounts for the possible bias due

Table A1 Robustness tests – 2SLS/GMM

	M1 (2SLS)	M2 (2SLS)	M3 (2SLS)	M4 (2SLS)	M5 (2SLS)	M5 (GMM)
Knowledge acquisition (KA)	0.18+	0.17+	0.19+	0.16	0.11	0.11+
Supplier opportunism (OP)			0.01	−0.009		
Knowledge exploitation (KE)		0.09		0.08		
Product stewardship (PS)					0.18**	0.18**
KA * OP			−0.15+	−0.11		
KA * KE		0.26**		0.24*		
PS * KA					0.31***	0.28**
Environmental proactivity	0.32***	0.31***	0.32***	0.31***	0.08+	0.09*
Sustainability planning with customers	0.22***	0.24***	0.23***	0.25***	0.03	0.03
Competition intensity	0.09+	0.06	0.10*	0.07	−0.01	−0.02
Market share	0.11**	0.13**	0.11*	0.12**	0.03	0.02
F (*p*-value)	22.10***	18.13***	16.60***	14.48***	8.21***	7.37***
R^2	0.35	0.37	0.38	0.39	0.14	0.15
Sample size	204	203	202	201	204	204
Underidentification tests						
Anderson canon. corr. LM statistic	89.10***	89.03***	75.17***	77.67***	88.22***	
Kleibergen–Paap rk LM statistic	48.27***	49.86***	46.28***	36.60***	50.14***	
Weak identification tests						
Cragg–Donald Wald *F*-statistic	76.38	37.69	28.45	19.73	36.96	
Kleibergen–Paap rk Wald F statistic	68.37	31.89	26.40	16.61	32.48	
Overidentification tests						
Sargan statistic (*p*-value)	0.78	0.65	0.13	0.46	0.68	
Hansen J statistic (*p*-value)	0.81	0.71	0.29	0.77	0.71	

Notes: ****t*-values significant at $p \leq 0.001$, ***t*-values significant at $p \leq 0.01$, **t*-values significant at $p \leq 0.05$. +*t*-values significant at $p \leq 0.10$

to omitted variables (Zellner and Theil, 1962). Since model M5 suffers from heteroscedasticity, we used the conditional mixed-process framework which allows for the testing of the 3SLS estimator with the inclusion of robust errors (Roodman, 2007). While we have not presented the results of this analysis in a tabular format, model results using the 3SLS approach were also found to be consistent with our two-stage hierarchical OLS estimation approach.

Finally, we also considered alternative instruments for knowledge acquisition to establish the robustness of our results. Specifically, we used the level of interdependence between the partners as the first alternative instrument; this indicator "we both have made a great deal of investments in this relationship" was also measured using endpoints of "1 = strongly disagree" and "5 = strongly agree." As a second alternative instrument, we used the improvements in supplier's innovation performance; this indicator was captured based on the focal firm's perception of the supplier's performance using endpoints of "1 = not at all" and "5 = significant." We conducted a similar two-stage hierarchical OLS regressions involving these alternative instruments. In the first stage, we regressed knowledge acquisition on interdependence, supplier performance and all the control variables. Since the Breush–Pagan test was found to be significant, we used robust standard errors to overcome the issues of heteroskedasticity. We found both interdependence ($b = 0.39$; $t = 4.90$; $p < 0.001$) and supplier performance ($b = 0.23$; $t = 3.29$; $p < 0.01$) to be significantly related to knowledge acquisition. Subsequently, in the second stage, we used the predicted scores of knowledge acquisition from the first stage in subsequent models. The results based on the bootstrapping approach were found to be consistent with our results. Overall, these alternate tests suggest that our results could be considered as robust and not driven by biases and/or specific estimators.

Appendix 3. Conditional effects analyses

We assessed the conditional effects of product stewardship on environmental performance at different levels of knowledge acquisition and knowledge acquisition on product stewardship at different levels of knowledge exploitation and supplier opportunism. We used the bootstrapping approach with 5,000 replications to assess the significance of these conditional effects (Preacher *et al.*, 2007). Additionally, we adopted the Johnson–Neyman technique to isolate the significant regions for the effect of knowledge acquisition on product stewardship and product stewardship on environmental performance (Gardner *et al.*, 2017). Figures A1 and A2 presents the confidence bands for the moderation effects of knowledge acquisition, supplier opportunism and knowledge exploitation.

Though the positive effect of product stewardship on environmental performance increased with an increase in knowledge acquisition (please refer to Figure A1), this effect is significantly positive only when knowledge acquisition is greater than a threshold value (starting when knowledge acquisition was above 3.5384); approximately, for the top 72% values of knowledge acquisition, product stewardship is found to lead to better environmental performance. Additionally, at very low values of knowledge acquisition, product stewardship has a negative effect on environmental performance (bottom 0.50% approximately). In the case of supplier opportunism (Figure A2 – Panel B), only at its low level does knowledge acquisition seem to have a positive effect on product stewardship only (i.e. when supplier opportunism is below 1.7952; lower 38.92% of the values). In the case of knowledge exploitation (Figure A2 – Panel A), knowledge acquisition seemed to have a significant positive effect on product stewardship only when knowledge exploitation was above 3.8031 (i.e. top 44.61%); additionally, knowledge acquisition seemed to have a negative effect for the lower 2.45% values of knowledge exploitation (i.e. for knowledge exploitation values below 1.0844).

The significance regions for the combined effects of the two moderators are presented in Figure A3. The combined effect was significant at the 99% confidence level. Specifically, when both the moderators (knowledge exploitation and supplier opportunism) are present, knowledge acquisition seemed to have a significant effect on product stewardship only when low to moderate levels of supplier opportunism is combined with moderate to high levels of knowledge exploitation capability. This nuanced analysis sheds an interesting insight into the nonsignificant effect of knowledge acquisition on product stewardship (i.e. *H1*). Additionally, given that the effect of knowledge acquisition on product stewardship was marginally significant, we also estimated the conditional indirect effect of knowledge acquisition on environmental performance through product stewardship (as a mediating variable) so as assess the presence of a moderated mediation effect (Preacher *et al.*, 2007). The conditional indirect effect of knowledge acquisition was tested using the bootstrapping method recommended by Preacher *et al.* (2007); the results presented here are based on 5,000 replications. The indirect effect of knowledge acquisition on environmental performance (i.e. through product stewardship) was significant (95% CI: LL = 0.0023; UL = 0.0964). Additionally, the index for moderated mediation represented was also found to be significant (95% CI: LL = 0.0052; UL = 0.1432) (Hayes, 2015; Preacher *et al.*, 2007). Overall, our results suggest that there is a positive conditional indirect effect of knowledge acquisition on environmental performance at moderate to high levels of knowledge acquisition. In other words, these results suggest that the mediation effect of product stewardship could be further moderated by knowledge acquisition (Hayes, 2015; Preacher *et al.*, 2007).

Figure A1 Conditional effect of product stewardship on environmental performance at values of knowledge acquisition

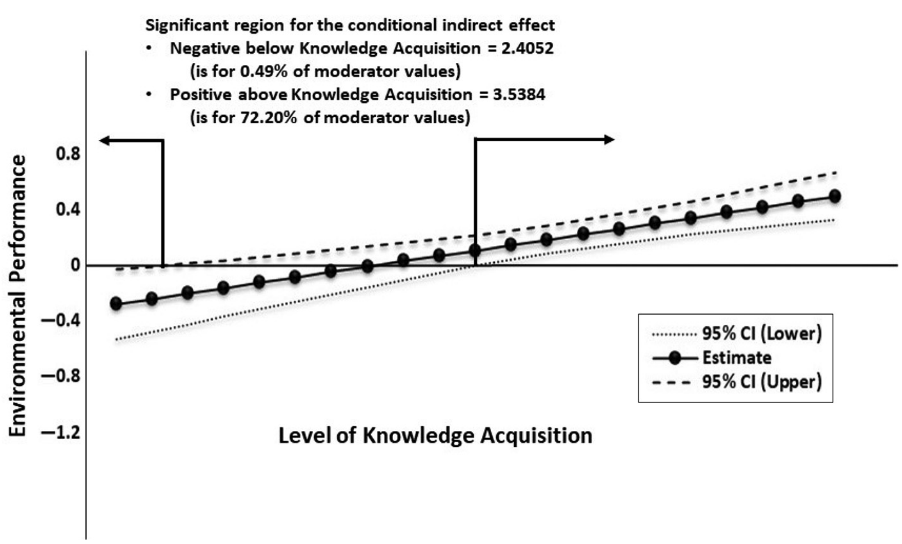
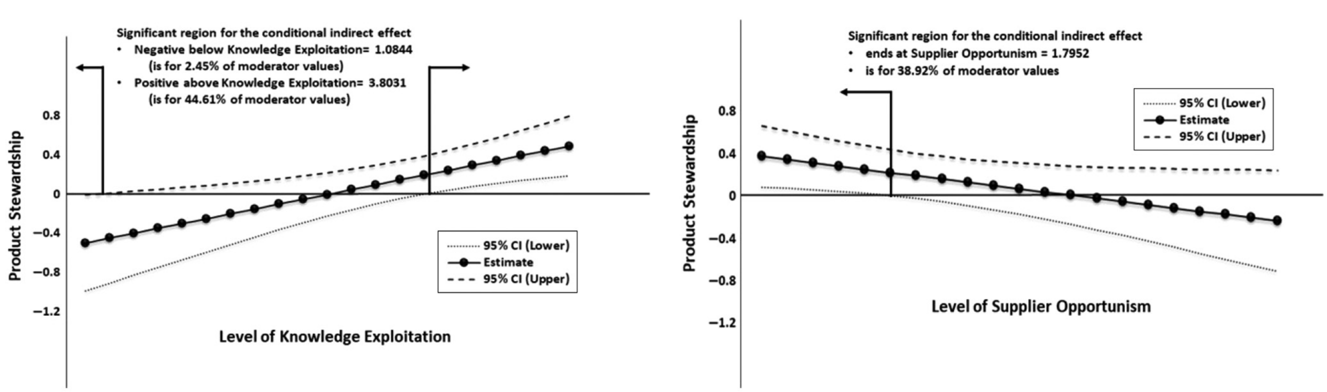
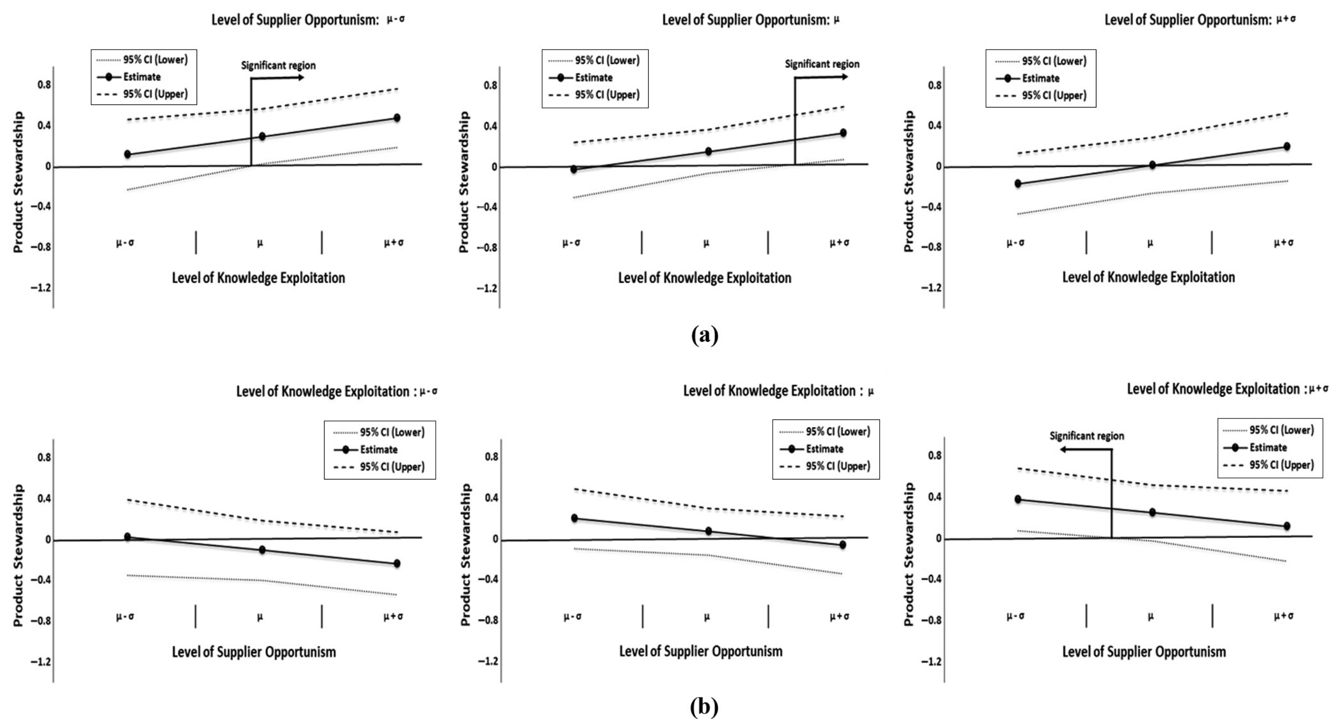


Figure A2 Conditional effect of knowledge acquisition on product stewardship at values of knowledge exploitation and supplier opportunism



(a) (b)

Figure A3 Conditional effect of knowledge acquisition on product stewardship at values of both knowledge exploitation and supplier opportunism



References

Antonakis, J., Bendahan, S., Jacquart, P. and Lalive, R. (2010). "On Making Causal Claims: A Review and Recommendations," *The Leadership Quarterly* Vol. 21 No. 6, pp. 1086–1120.

Certo, S. T., Busenbark, J. R., Woo, H. S. and Semadeni, M. (2016). "Sample Selection Bias and Heckman Models in Strategic Management Research," *Strategic Management Journal* Vol. 37 No. 13, pp. 2639-2657.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences, 2nd ed., Erlbaum, Hillsdale, NJ.

Field, A. P. (2013). Discovering Statistics Using Ibm Spss Statistics, 4th ed., SAGE, London.

Gardner, R. G., Harris, T. B., Li, N., Kirkman, B. L. and Mathieu, J. E. (2017). "Understanding 'It Depends' in Organizational Research," *Organizational Research Methods* Vol. 20 No. 4, pp. 610-638.

Hamilton, B. H. and Nickerson, J. A. (2003). "Correcting for Endogeneity in Strategic Management Research," *Strategic Organization* Vol. 1 No. 1, pp. 51–78.

Hayes, A. F. (2015). "An Index and Test of Linear Moderated Mediation," *Multivariate Behavioral Research* Vol. 50 No. 1, pp. 1–22.

Kiss, A. N., Libaers, D., Barr, P. S., Wang, T. and Zachary, M. A. (2020). "Ceo Cognitive Flexibility, Information Search, and Organizational Ambidexterity," *Strategic Management Journal* (n/a: n/a).

Pagan, A. R. and Hall, A. D. (1983). "Diagnostic Tests as Residual Analysis," *Econometric Reviews* Vol. 2 No. 2, pp. 159–218.

Preacher, K. J., Rucker, D. D. and Hayes, A. F. (2007). "Addressing Moderated Mediation Hypotheses: Theory, Methods, and Prescriptions," *Multivariate Behavioral Research*, Vol. 42 No. 1, pp. 185–227.

Rocha, V., Van Praag, M., Folta, T. B. and Carneiro, A. (2019). "Endogeneity in Strategy-Performance Analysis: An Application to Initial Human Capital Strategy and New Venture Performance," *Organizational Research Methods* Vol. 22 No. 3, pp. 740–764.

Roodman, D. (2007). "Cmp: Stata Module to Implement Conditional (Recursive) Mixed Process Estimator." Boston College Department of Economics.

Stock, J. and Yogo, M. (2005). "Testing for Weak Instruments in Linear Iv Regression.," in Andrews, D. (Ed.), *Identification and Inference for Econometric Models*, NY, NY: Cambridge University Press, pp. 80–108.

Zellner, A. and Theil, H. (1962). "Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Equations," *Econometrica* Vol. 30 No. 1, pp. 54–78.

Corresponding author

Antony Paulraj can be contacted at: antony.paulraj@neoma-bs.fr