The impact of global sourcing in new product development processes

Mustafa İncekara

Department of Business Administration,
The Faculty of Economics and Administrative Sciences,
Pamukkale University,
Denizli, Turkey
Email: mincekara@pau.edu.tr

Abstract: This study investigates which product characteristics and sourcing location conditions (global or local) support efficient supplier integration in New Product Development (NPD) processes. A research model is suggested to analyse the relationship between procurement product characteristics, buyer–supplier project organisation and NPD results. Moreover, the moderating impact of the geographical sourcing location on the causal relationships in the model is assessed. Data from 209 research-intensive firms in German-speaking countries were used to test the research hypotheses using structural equation modelling. The findings propose that the complexity and importance of the product procured are crucial to the form of project organisation between the parties. Buyers and suppliers tend to collaborate to a greater extent when the complexity and importance of the procurement object are high. Collaborative project organisation influences the result of NPD, and this relationship is more effective when a local supplier is involved in the process.

Keywords: global sourcing; supplier involvement; NPD; new product development; product complexity; product importance; grey box; black box; structural equation modelling; PLS-MGA; MICOM.

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Biographical notes: Mustafa İncekara is an Assistant Professor in the Chair of Production Management and Marketing at Pamukkale University. He received his Doctoral degree from the Graduate School of Excellence advanced Manufacturing Engineering (GsaME), University of Stuttgart. His research interests include global sourcing, supplier involvement in new product development and resource efficiency practices by SMEs. His works have been published in specialised conference proceedings, journals and books.

1 Introduction

Supplier involvement in development processes has been noted as a possible source of competitive advantage (Ellen, 2013; Luzzini et al., 2015). Firms seek to involve suppliers in their New Product Development (NPD) activities and rely on suppliers' contributions to the development project to gain access to the positive effects of supplier involvement.

Suppliers can deliver information about technological transformation and the innovative applications of new products (Li et al., 2018). Access to new technology, reduced development time, minimised costs, better product quality and improved performance are some of the rewards of this integration (İncekara, 2018; Ragatz et al., 2002; Petersen et al., 2003; Song and Di Benedetto, 2008; Van Echtelt et al., 2008; Mikkelsen and Johnsen, 2019; Melander and Tell, 2014).

The main subject of an interactive collaboration between supplier and buyer in an NPD project is the exchange of services, products or complex systems (Baptista, 2014). The characteristics of interactive NPD processes vary significantly with the characteristics of the product. Therefore, the management of product characteristics can be considered an important strategic task. Some studies have analysed the supply characteristics in product development, and the internationalisation of product development has garnered substantial interest from management and engineering design viewpoints (Søndergaard et al., 2016). However, no studies have addressed the relationship between product characteristics and the extent of supplier integration in development activities in the context of sourcing location (Metcalf and Frear, 1993; Cannon and Perreault, 1999; Baptista, 2014; Caniato and Größler, 2015; Eckstein et al., 2015). Notably, globalisation has increased opportunities to enter new markets and save costs. This trend has led to a research focus on geographical sourcing practices (Giunipero et al., 2019). The benefits of global sourcing (for example, new market access and cost savings) have led researchers to determine the success factors of global sourcing (Steinle and Schiele, 2008).

Furthermore, it is unclear how individual firms benefit from global sourcing (Vos et al., 2016). Risks due to geographical and cultural distance (for example, issues in product quality inspections and total cost increases) have been identified in the global sourcing literature (e.g., Peeters et al., 2015). However, little is known about how global sourcing influences decision-making procedures in NPD (Ha-Brookshire, 2015). Another crucial perspective within the traditional sourcing activities is local sourcing. Local suppliers are crucial to achieving strategic objectives, especially those related to cost savings, manufacturing flexibility, delivery operations and development of knowledge and competence (Giunipero et al., 2019).

Geographic sourcing location, local or global, can also affect supplier involvement in supplier–buyer collaboration. Yet, most supplier integration models do not analyse the effect of the sourcing locations to the relationship between product characteristics and management of the supplier–buyer collaboration. Improved knowledge of the relationship between supply characteristics and cooperative project organisation, and their dependence on the sourcing location, could increase managerial understanding of inter-organisational collaboration in NPD. Thus, this research aims to explore the relationships among product characteristics (complexity and importance) and NPD performance via the role of sourcing location.

The present research examines two important topics in supplier integration in NPD: First, related to the supply characteristics, how should the supplier be involved in buyers' NPD projects to improve performance in the NPD process? Second, is there a difference between the management of different product characteristics and the cooperative cooperation between supplier and buyer related to suppliers' geographic locations?

The rest of the paper is structured as follows: Section 2 formulates the hypotheses and describes the research model. Section 3 describes the research methodology, data collection and measures. The results are outlined in Section 4 and discussed in Section 5. Finally, Section 6 offers conclusions.

2 Theoretical framework, research model and hypotheses

This section first outlines how the Resource-Based View (RBV) of firms can explain supplier integration in NPD. It then describes supplier–buyer project organisation in NPD, which, along with RBV, is important to understand the hypotheses developed in this work. This discussion includes an outline of the expected associations between supplier resources in terms of importance to the supplier–buyer relationship; highlights the effects of supplier–buyer collaboration on NPD performance; and furthermore, outlines how geographical sourcing location may moderate the supplier–buyer relationship in the baseline model.

2.1 Theoretical framework

The theoretical framework of this paper is based on the RBV of firms, which implies that the possession of rare, unique, and irreplaceable resources leads to competitive advantage and superior performance (Barney, 1991; Peteraf, 1993). This type of resource is usually owned by the company but can be obtained from suppliers. Such resources can be physical assets or the knowledge and skills of the people who work for the company. However, to obtain competitive advantage, a company must not only acquire exceptional resources, but also convert these resources into benefits such as cost savings, reduced lead time, or innovative products (Day and Wensley, 1988). These competitive advantages add value, leading customers to accept paying a premium price for such a product (Song et al., 2011).

NPD is a process important for competitive advantage and is an antecedent of firm success (Song and Parry, 1999; Song et al., 2011). However, NPD processes are often unclear. It is common that some information regarding the necessary activities, decision variables, and their interrelationships to complete the project is unknown at the beginning of the NPD process (González-Moreno et al., 2018).

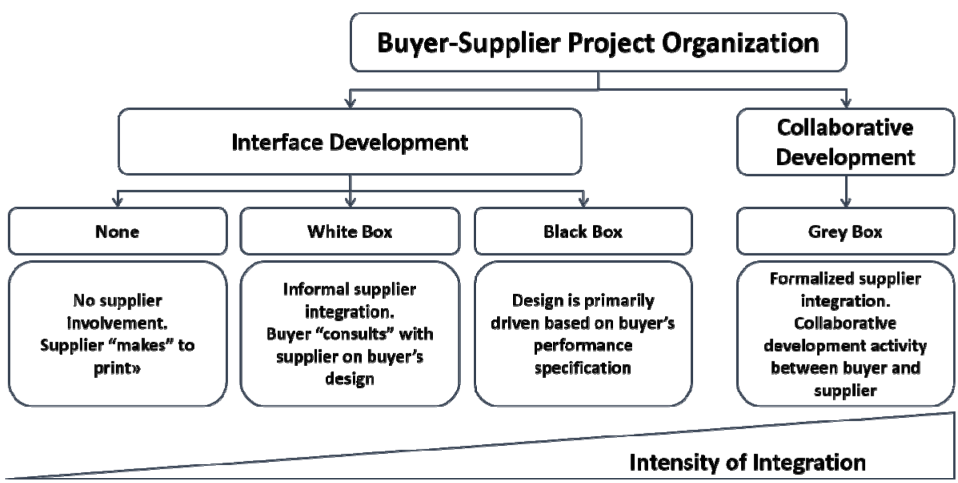
Forming a successful supplier–buyer relationship in NPD is essential to achieve a competitive advantage, as it provides the buyer with advantages unavailable from conventional transactional relationships (Sjoerdsma and Van Weele, 2015). Successful management of supplier innovation capability makes it more likely that the buyer's NPD performance will increase (Lawson et al., 2009). Proactive management of the buyer's relationship with the supplier is vital if it is to take advantage of this possibility and enhance NPD performance (Walter, 2003). Following the RBV framework, firms can become more successful if they manage and gain access to suppliers' resources that are scarce, cannot be substituted, are immobile, hard to imitate and offer competitive advantage (Hunt et al., 2002). Consequently, suppliers' resources and the buyer's skill in utilising these resources to attain its targets are important factors in competitive and NPD strategy (Sjoerdsma and Van Weele, 2015).

2.2 *Cooperative project organisation and research model*

The most common form of collaboration between companies is that between suppliers and buyers in NPD (Kern, 2005). Appropriate design of supplier integration in NPD processes can lead to competitive advantage (Wagner, 2001; Arnold, 2007). Therefore, it is important to use appropriate project structures to support interaction between the buyer and supplier during implementation of joint product development. The form buyer–supplier project organisation takes is an important factor determining the contribution of suppliers to buyers' NPD processes (Groher, 2003). Cooperative project organisation between supplier and buyer can be differentiated in terms of interface development and collaborative development activities.

Figure 1 describes the main differences between the various forms of project organisation between buyer and supplier. The intensity of integration increases steadily from interfaced development to collaborative development. The features of project organisation are represented along this continuum. The main difference in these aspects of project development organisation lies in how activities are processed between the supplier and the buyer. Interfaced developments, such as the None, white box and black box development approaches, are characterised by separating the processes and activities undertaken by the buyer and supplier within project development, whereas in collaborative development (grey box), the buyer and supplier conduct activities together (İncekara and Koçak, 2017; Arnold et al., 2010).

Figure 1 Project organisation between buyer and supplier



Source: (Petersen et al., 2005)

The first level of the interface development, "None," means no supplier involvement. The supplier delivers the finished product to the buyer's specifications without adding extra value. In white box integration, the supplier is consulted in design-related activities. Black box integration gives suppliers a high level of development responsibility, and they tailor parts to the customer's specifications (İncekara, 2018). Grey box is a formal integration of suppliers within collaborative development activities; suppliers have the same development responsibilities as the buyer (Eggers, 2016; Petersen et al., 2005).

This may entail sharing technical expertise and information during collaborative decision processes (Handfield and Lawson, 2007; Kleber et al., 2019). Furthermore, development actions such as collaborative design, prototype development and product testing are shared between the supplier and buyer (Handfield and Nichols, 2002).

In a grey box development approach, neither the buyer nor supplier has the knowledge or ability to complete the design process alone, and so must work together to design and develop the component (Le Dain and Merminod, 2014). Supplier integration begins at the start of the product/component development process and includes feedback from suppliers during the definition phase of the functional requirements (Koufteros and Vonderembse, 2005). Such projects entail comprehensive and intensive construction work. In this context, co-development requires joint decision-making in the form of knowledge, evaluation, information exchange, mutual understanding, problem-solving (translating knowledge) and a recursive cycle (changing knowledge) (Le Dain and Merminod, 2014).

From the start (concept design), the collaborators must confront great insecurity concerning the process and considerable uncertainty over how the tasks are apportioned (Harbi et al., 2002). Suppliers involved in joint development are technical specialists who bring specific expertise to development projects; they must have an essential level of technical knowledge related to NPD activities (Eggers, 2016). The sharing of strategic information, such as technology roadmaps, is essential. Co-development and experience-sharing occurs between the buyer and supplier, leading to investment in the supplier's development (Johnsen et al., 2014). Ragatz et al. (1997) proposed a structure to encourage action based on risk- and reward-sharing and joint performance measurement agreements. To ensure stable and active cooperation, both sides must be ready for such an agreement (Eggers, 2016). For instance, based on the intensity of the supplier's involvement, the buyer secures access and use rights to the results of the collaboration (Groher, 2003). A long-term strategic partnership between supplier and buyer is essential for grey box development. However, depending on the task and sector, the duration varies. For example, the involvement of suppliers in the automotive industry in design review typically lasts between 3 years and 5 years, while if the supplier is an integral part of the design process, a customised collaboration partnership can evolve into a lifetime relationship (Burnes and Dale, 1998).

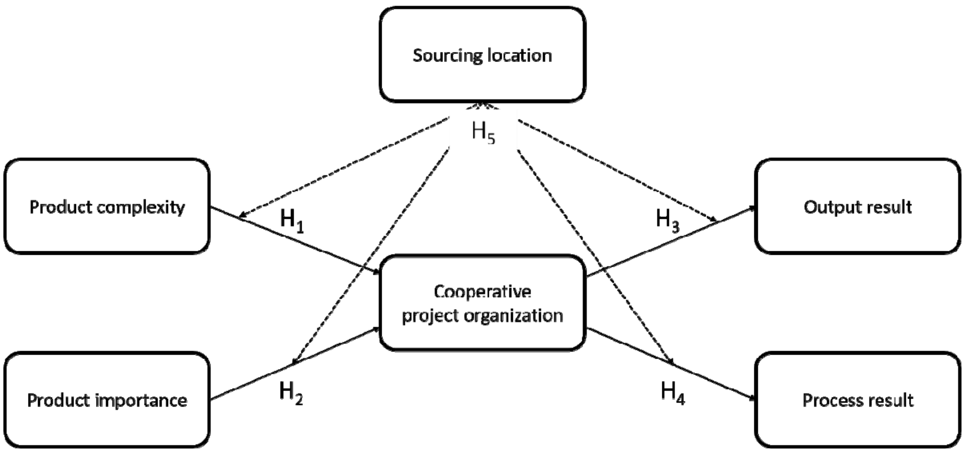
Suppliers can have minor or significant development responsibility in the black box and grey box approaches. However, the other two cooperation models assign them only limited responsibility for product development activities (Eggers, 2016; Petersen et al., 2005).

Planned collaboration between buyer and supplier leads to the choice of a suitable form of project organisation. The buyer must analyse which NPD processes can be assigned to suppliers and use that determination to select an appropriate degree of cooperation, which may take the form of interfacial or collaborative development, determining the intensity of the supplier's involvement in NPD. The project organisation depends on the complexity and importance of the supplier's product in the NPD process, as well as the location from which the relevant component is sourced, as analysed in the following sections.

2.3 Hypotheses development

Figure 2 shows the conceptual model addressing the study of a buyer–supplier relationship engaged in a project to develop a new product. Supplier integration is conceptualised as cooperative project organisation, and its positive influence on the resulting supplier integration is analysed. The antecedents of cooperative project organisation are the complexity and importance of a product. The greater the importance and complexity of the product, the more collaborative the implementation of the project organisation. The hypotheses considered were tested in depth in terms of the effect of a local or global sourcing location.

Figure 2 Conceptual research model



2.3.1 Product complexity and cooperative project organisation

The success of supplier integration within an NPD project is largely determined by the complexity of the product. Product complexity is determined by factors such as product diversity, the variety of components making up the product, product heterogeneity, the degree of product novelty and interaction between the individual parts or technologies used (Thakur-Wernz et al., 2020; Milgate, 2001; Müller, 2004; Vachon and Klassen, 2002; Sommer et al., 2009; Jacobs and Swink, 2011). In a complex product, many individual complex parts are involved; such products require profound and extensive coordination in a supplier–buyer relationship (Thakur-Wernz et al., 2020; Baur, 1991), which necessitates an adjustment process between suppliers and the buyer (Hallén et al., 1994). Through interaction, the inter-organisational relationship generates a closer dependence between supplier and manufacturer; this leads to processes of adaptation between the parts and reinforces the established dependence of the buyer on the product and its supplier (İncekara, 2018). This interdependency implies high customer loyalty, as it is difficult to procure alternative products for complex needs. In such cases, an orientation toward cooperative development of new products is useful, in particular because there is an increased need for information concerning quality specifications.

Hence, high product complexity tends to lead to collaborative project organisation within an intensive buyer–supplier relationship. The liaison between the buyers and the suppliers thus remains manageable and is stabilised. As a result, product complexity is expected to be positively related to cooperative project organisation:

Hypothesis 1: The higher the product complexity, the greater the extent of cooperation in buyer–supplier project organisation.

2.3.2 Importance of the product and cooperative project organisation

The intended objectives of the buyer are closely related to the characteristics of the desired component, and thus to the buyer and supplier's competences in terms of innovation and manufacturing (Müller, 2004). In addition, the component purchased plays an important role in attaining desired goals in terms of product quality, image, or differentiating aspects as specifically intended by the buyer through its use in NPD (Müller, 2004).

Basically, a product's importance determines the degree to which the companies involved (both purchasing and selling) connect the purchased product input/sales output to their objectives (Baptista, 2014). The importance of a purchased object is determined by the degree of fulfilment attained by the company in terms of its specific objectives achieved using the product (Metcalf et al., 1992). The buyer assesses the importance of an object in terms of financial indicators, such as value and scope of the reference amount, as well as an assessment of the intended targets in terms of the procurement objectives. Moreover, there is a direct association between the importance of a product and the intensity of information exchange between buyer and supplier (Metcalf and Frear, 1993).

A high degree of cooperative buyer–supplier collaboration is characterised by intensive, collaborative interactions between buyers and suppliers, as shown in the grey box shown in Figure 2. Collaboration involves certain services during development (Arnold et al., 2010). One characteristic of this type of buyer–supplier relationship is the early integration of suppliers in the NPD process, with the buyer and supplier agreeing to a formal joint development endeavour. These agreements include sharing of technology and information regarding design decisions. In general, buyers prefer suppliers they have already worked with or that are well-known in the market, and aim to build long-term partnerships that gradually improve the product. The development of NPD with lower product importance to the buyer is probably based on the existing skills of buyers and suppliers, with lower risks for both parties. One reason for this is that a buyer's knowledge and experience working with suppliers can help reduce transaction costs. Firms prefer a less intensive collaboration with their supplier if they want to prevent the risk of critical information transfer and protect their core competencies. This applies to innovative projects with a high risk of losing knowledge. Interface development agreements, such as the black box development also allow companies to outsource some R&D tasks without sharing information on the whole project (Arnold et al., 2010). Firms aim to manage all facets of specification and design. Thus, to develop a new product, buyers must decide for themselves what kind of responsibilities they are delegating to their suppliers to protect their core competencies. Therefore:

Hypothesis 2: The greater the importance of the product, the lower the degree of cooperative buyer–supplier project organisation.

2.3.3 Cooperative project organisation and new product development success

Several authors have investigated the impact of suppliers on NPD (e.g., Johnsen, 2009; Arnold et al., 2010). Researchers have examined the impact of increased supplier involvement on output related factors such as customer satisfaction, developing new competencies, and other aspects of output-related measures (Johnsen, 2009; Hoegl and Wagner, 2005; Ragatz et al., 2002).

Because of high technological uncertainty in NPD, the focus is increasingly on the supplier to provide the consumer with pure knowledge of technology. Supplier involvement enables buyers to access the latest technology, increasing the buyer's scope, and increasing flexibility (Berkenhagen and Vrbica, 2007; Arnold, 2010). Thus, supplier integration is a critical step when developing innovative technologies with improved product performance (Ragatz et al., 2002; Song et al., 2011). Supplier performance also plays a role in meeting the differentiating factors desired by the buyer (Müller, 2004), leading to competitive advantage. The intensity of suppliers' involvement in the development of a new product (e.g., grey box) leads to overall product improvement in a manner directly connected to suppliers' competencies regarding its design and architecture (Suurmond et al., 2020). Hence, an overall better product outcome requires deeper supplier integration in the decision-making process (Bodas-Freitas and Fontana, 2018):

Hypothesis 3: The greater the degree of buyer–supplier cooperation in project organisation, the greater the success of the NPD process.

Furthermore, suppliers have specialisations in producing components or subsystems for buyer's product, and pay special attention to component design accuracy (Suurmond et al., 2020). If the supplier acts on behalf of the purchasing company during component development (e.g., black box engineering) or part of a buyer's design team during joint development (grey box), the buyer can significantly reduce the labour hours, development time and costs involved in NPD (Clark, 1989; Eppinger et al., 1994). The design of components and determination of production requirements requires detailed knowledge of the components and extensive supplier involvement (LaBahn and Krapfel, 2000; Koufteros et al., 2007; Suurmond at al. 2020). Collaborating with suppliers by sharing design tasks necessitates fewer engineering and development and resources (Clark, 1989) and makes concurrent engineering possible during the NPD process (Eppinger et al., 1994; Gerwin and Barrowman, 2002).

By involving suppliers in the NPD process through the distribution of development tasks, companies can increase their flexibility and thus reduce their exposure to risk (Bidault et al., 1998; Nishiguchi, 1994). By integrating suppliers in NPD, new products can be brought to market more quickly (Gupta and Souder, 1998). Faster market entry leads to a significant reduction in market risks. In addition, vertical cooperation has a positive effect on the cost and quality of product innovation (Kessler, 2000; McGinnis and Vallopra, 1999). Therefore, the supplier contributes to the process-related characteristics of the whole project:

Hypothesis 4: The greater the degree of cooperative buyer–supplier project organisation, the greater the process-related achievement of NPD.

2.3.4 Moderating effect of sourcing location: local vs. global sourcing

Investigation of the integration of suppliers in NPD processes reveals that most supplier integration frameworks do not differentiate between local and global sources. However, the supplier's location can also influence its involvement in NPD. International sources offer technology that buyers cannot find in the local market, or are perhaps not locally available at the necessary quality (Gunasekaran et al., 2015; Swamidass, 1993; Bozarth et al., 1998). Cost efficiency is another important consideration in global sourcing activities (Carter and Narasimhan, 1990; Fraering and Prasad, 1999; Nassimbeni, 2006). These elements increase the importance of the globally sourced product.

However, international suppliers may represent a higher risk for companies due to their distance from the buyer. Distance can lead to volatile lead times because many different transportation modes are necessary. Suppliers from developing countries may also have lower knowledge and possibly insufficient infrastructure for necessary NPD processes (Meixell and Gargeya, 2005). In addition, cultural and linguistic differences, unstable political environments in sourcing countries, and additional costs, such as those related to transportation and exchange rate fluctuations, can undermine the positive effects of global sourcing (Nassimbeni, 2006; Horn et al., 2013; Fawcett et al., 1993; Swamidass and Kotabe, 1993; Fraering and Prasad, 1999; Dornier et al., 2008). These negative impacts must be addressed by the buyer and increase the complexity of globally sourced products, though their severity depends on the relative importance and complexity of the product. However, no research to date has examined the moderating role of geographical source on the impact of supplier involvement in NPD and the performance outcomes of NPD processes. Hypotheses 1–4 form the basis for the following empirical study. The framework must allow for the moderating effect of the sourcing location in the cause and effect relationship in innovation processes in each of the research questions presented. Thus, the effect of sourcing location is incorporated within the research model as a moderating variable. Based on the discussion of this section, the following hypothesis is proposed:

Hypothesis 5: The relationships in hypotheses H_1–H_4 of the research model are significantly different based on local and global sourcing location.

3 Methodology

The aim of this study was to explain the cause and effect relationship between individual variables. An exploratory methodology, multivariate analysis, was chosen for the empirical analysis. Research questions are answered on the basis of Partial Least-Squares (PLS) structural equation modelling (Hair et al., 2011). This approach allows the simultaneous examination of several variables, and thus the analysis of complex issues. This mathematical/statistical method is implemented within SmartPLS (Ringle et al., 2015), which combines factor and regression analysis to allow cause and effect relationships to be identified (Hair et al., 2012).

3.1 Unit of analysis

The focus of this study is on bilateral cooperation between the buyer and supplier during NPD. Specifically, in bilateral cooperation the supplier should contribute to product development. In this study, only bilateral integration projects were investigated, and only complete projects were considered to allow analysis of the actual success of the project. Each project considered must have generated evaluable data, and have been completed within the five previous years, since a project completed too long ago might no longer be anchored in the minds of those involved (Rink, 2008).

3.2 Data collection and descriptive statistics

To identify sampling elements (suitable persons), Germany's market leading business network internet platform, XING, which has twice the users of LinkedIn in German-speaking countries, was used. A detailed filter was configured in XING to identify contact persons of buying firms working on NPD projects in innovative industries. In the next step, the persons identified were contacted via the integrated mailing system of the networking platform. In this way, 2764 potentially suitable projects and the associated leaders were identified and contacted. In all, 209 persons took part in a web-based survey, representing a response rate of 7.6% for this sample, higher than the average response rate (2%) for B2B (DMA, 2012).

The survey was undertaken over a period of six months, from January to June 2011. The participants were contacted personally through the mail function of XING. Quantitative data were collected using a standardised questionnaire, based on an NPD project where the buyers integrated a supplier into a NPD process. The present study is based on a cross-sector primary survey. The focus of the investigation is the integration of the supplier into innovative product development projects, with consideration of buyers' geographical sourcing strategy. The sample is described in terms of respondents' position in the buying firm, firm's industry affiliation, number of employees, annual turnover, and R&D expenses. Table 1 provides an overview of the main attributes of the analysed firms.

Table 1 Descriptive statistics

Sales volume (millions €)	*Freq.*	*%*	*R&D intensity*	*Freq.*	*%*	*Number of employees*	*Freq.*	*%*
<1	9	4.3	<1%	9	4.3	<10	10	4.8
1–10	19	9.1	1–2%	23	11	10–50	12	5.7
11–50	27	12.9	3–4%	43	20.6	51–250	32	15.3
51–250	47	22.5	5–6%	32	15.3	251–500	23	11
251–500	20	9.6	7–8%	32	15.3	501–1000	20	9.6
501–1,000	15	7.2	9–10%	27	12.9	1001–5000	38	18.2
1001–5000	29	13.9	11–12%	11	5.3	5001–10,000	13	6.2
>5000	43	20.6	>12%	32	15.3	>10,000	61	29.2
Total	209	100	Total	209	100	Total	209	100
Respondent position	*Freq.*	*%*	*Industry*	*Freq.*	*%*	*Sourcing strategy*	*Freq.*	*%*
Purchasing employee	24	11.5	Chemistry/ Pharma	17	8.1	Local	64	30.6
Head of purchasing	54	25.8	Information technology	14	6.7	Global	140	67
R&D employee	9	4.3	Electrical engineering	31	14.8	Other	5	2.4
Head of R&D	31	14.8	Mech. engineering	33	15.8	Total	209	100

Table 1 Descriptive statistics (continued)

Respondent position	*Freq.*	*%*	*Industry*	*Freq.*	*%*	*Sourcing strategy*	*Freq.*	*%*
Project managers	36	17.2	Automotive	54	25.8			
Executive department	4	1.9	Technical/R&D service	9	4.3			
CEO	15	7.2	Other	51	24.4			
Other	36	17.2	Total	209	100			
Total	209	100						

Examining buyers by number of employees, approximately 26% are micro, small, and medium enterprises (<250 employees), and more than half (53.6%) are large companies (>1000 employees). The remainder have 251–1000 employees. Approximately a quarter (25.8%) of the analysed firms belong to the automotive sector, with 4.3% part of the technical/R&D service sector. The remaining firms (69.9%) belong to different sectors. Slightly more than a quarter (26.3%) of firms reported an annual sales volume of <50 M EUR; 39.3% 50–1000 M EUR; and 34.5% >1000 M EUR. About a third (35.9%) spend less than 5% of their budget on R&D activities, while 43.5% spend 5–10% and 20.6% >10% on these activities. The respondents of the survey hold a variety of positions. A little over a third belong to purchasing departments (37.3%) and nearly a fifth (19.1%) to R&D departments, while nearly half (43.6%) belong to various departments. About a third (30.6%) of the buyers reported employing local sourcing strategies during NPD, while about two-thirds (67%) focused on a global sourcing strategy, including overseas suppliers in their NPD process.

3.3 Measurement model assessment and discriminant validity

All measurements were operationalised as seven-point Likert-type item scales. The measurements of project object complexity were adopted from Wertz (2000); Werner (1997) and Müller (2004). The project object importance scale was based on the studies of Werner (1997) and Müller (2004), while the scales for project organisation were developed as described by John (2010) and Eisele (2006). The scales for supplier integration were adapted from Petersen et al. (2005); Rink (2008); and Neubauer (2008).

We assessed the measurement model to explain how the items describe the construct. Hence, individual item reliability, internal consistency reliability, convergent validity and discriminant validity were applied to analyse the measurement model (Hulland, 1999). To ensure individual item reliability, the loadings of the indicators need to be above 0.7 (Hulland, 1999). (Hair et al., 2017). To assess internal consistency reliability, we used Cronbach's α and Composite Reliability (CR). According to Nunnally (1978) and Bagozzi and Yi (1988), the threshold value for Cronbach's α is 0.7, while a value of 0.6 is appropriate for explorative research (Hair et al., 2013). To achieve a satisfactory level of CR, the estimates should be above 0.7 (Hair et al., 2017). To examine the convergent validity of the items we estimated Average Variance Extracted (AVE), using the recommended level of 0.5 (Hair et al., 2017).

Discriminant validity was tested by applying the Fornell–Larcker criterion (Fornell and Larcker, 1981). It is recommended that the square root for every construct of the

AVE should be higher than the relationship between the other respective constructs (Chin, 1998).

Because of low factor loadings, items with factor loadings below 0.7 were eliminated from the measurement model. The loadings of the items on their corresponding constructs vary between 0.701 and 0.880 (see Table 2), which shows a satisfactory level of reliability for the individual items. The CA and CR values of all measurements exceed the threshold of 0.7. The AVE values of all measurements range from 0.540 to 0.717, above the acceptable limit of 0.5. The square roots of all AVE values are higher than the correlation value of the constructs (see Table 3), and thus the discriminant validity test is affirmed. In conclusion, the measurement model provides satisfactory conditions regarding individual item reliability, convergent validity, and discriminant validity.

Table 2 Results of measurement model

Construct items		*Loading*	*t-value*	*CA*	*CR*	*AVE*
Product Importance (PI)						
	Compared to other supplier parts,					
PI_1	the considered supplier part must be of high quality.	0.85	20.32	0.80	0.87	0.63
PI_2	the considered supplier part must be correct in terms of numbers.	0.77	11.12			
PI_3	the delivery of the considered supplier part must be carried out precisely in time.	0.83	17.99			
PI_4	the considered supplier is important for the functionality of the new product development.	0.71	11.04			
Product Complexity (PC)						
PC_1	The supplier part under consideration has a high number of components.	0.74	4.38	0.72	0.82	0.54
PC_2	The components of the considered supplier part depend strongly on each other in their function.	0.70	3.54			
PC_3	The components of the relevant supplier part are very different in terms of their technology.	0.71	3.88			
PC_4	The supplier part under review includes new technologies that tend to be at the beginning of the technology life cycle.	0.79	4.25			
Cooperative Project Organisation (CPO)						
CPO_1	There was an open discussion atmosphere in cooperation with the supplier.	0.79	17.44	0.92	0.94	0.72
CPO_2	We were assured that all information from the supplier was correct.	0.85	37.48			
CPO_3	Overall, there was a trusting relationship with the supplier.	0.88	35.67			
CPO_4	In case of unexpected problems, the necessary resources were mobilised from both sides.	0.80	21.14			
CPO_5	Overall, there was a willingness on both sides to meet the commitments made.	0.87	34.34			
CPO_6	Conflicts were resolved quickly and constructively by both sides.	0.88	44.95			

Table 2 Results of measurement model (continued)

Construct items		*Loading*	*t-value*	*CA*	*CR*	*AVE*
Output Result (OR)						
	To what extent does the new product meet your company's goals in terms of					
OR_1	the competitive advantage achieved.	0.81	15.75	0.85	0.90	0.68
OR_2	customer satisfaction with the product.	0.86	36.90			
OR_3	the gain of competence through the innovation project.	0.82	21.60			
OR_4	the image gain through innovation.	0.81	17.40			
Process Result (PR)						
	To what extent does the new product meet your company's goals in terms of					
PR_1	the competitive advantage achieved.	0.82	29.85	0.82	0.87	0.58
PR_2	the target cost per piece.	0.71	13.80			
PR_3	the implementation of planned development requirements.	0.81	21.28			
PR_4	the implementation of planned production requirements.	0.76	14.38			
PR_5	the planned phases of the innovation process.	0.72	12.30			

Notes: CA=Cronbach's alpha; CR= Composite reliability; AVE= Average variance extracted

Table 3 Discriminant validity test (Fornell–Larcker Criterion)

	Output result	*Process result*	*Product complexity*	*Product importance*	*Cooperative project organisation*
Output result	**0.826**				
Process result	0.725	**0.764**			
Product complexity	0.192	0.180	**0.735**		
Product importance	0.285	0.304	0.246	**0.791**	
Cooperative project organisation	0.463	0.510	0.192	0.429	**0.847**

Notes: Statistics under the diagonal show correlation between each construct; statistics on the diagonal are the squared AVE.

3.4 Common method variance

Common Method Variance (CMV) is "variance that is attributable to the measurement method rather than to the constructs the measures represent" (Podsakoff et al., 2003, p.879). In the paper, both ex-ante and ex-post methods were applied to assess the CMV (Chang et al., 2020; Podsakoff et al., 2003). In the ex-ante method survey, design instruments were applied. Expert groups from both academia and industry reviewed the questions before deployment of the survey. This ensured that short and straightforward items with clear and concise wordings were used. Respondents were also assured that there are no right or wrong answers and that their anonymity was guaranteed. The participants were not conscious of our research model (Podsakoff et al., 2003).

Two statistical methods were applied in the ex-post analysis. According to the recommendations of Podsakoff et al. (2003), Harman's single factor test determines whether there was a common method bias. This assessment was executed on individual-level data. The estimation has shown that common method bias does not cause a significant risk to the accuracy of the study. Harman's single-factor test reveals that 22.7% of the variance (below the threshold of 50%) is explained by a single variable. Furthermore, a full collinearity test was applied according to the method of Kock (2015). This method estimates the inner factor Variance Inflation Factor (VIF). The scores revealed measures between 1.049 and 2.308, below the recommended threshold of 3.3 (Diamantopoulos and Siguaw, 2006). Overall, these results indicated that CMV does not represent a significant issue in this study.

3.5 Structural model assessment

According to the structural model assessment procedure described by Hair et al. (2017, Chapter 6), we evaluate the structural model for collinearity concerns by analysing the VIF scores of all predictor variables. VIF scores for all constructs are below 1.064 and, therefore, under the threshold of 3.3. Therefore, we can assume that collinearity is not an issue in our research model.

The next step was analysis of the R^2-value, which measures the explanatory power of the model and characterises the extent of variance in the endogenous construct explained by all related exogenous constructs; R^2-values of 0.25, 0.50 and 0.75 can be considered weak, moderate and substantial (Hair et al., 2019). The R^2-values results of this study show that product complexity and product importance have relatively low explanatory power in terms of cooperative project organisation, and that project organisation has a low predictor effect on the result of integration in terms of output and process-related results.

In addition to examining the R^2, we estimated the effect size, f^2, to determine how R^2-values alter if a construct is excluded from the research model (Hair et al., 2017) using Cohen's (1988) classification of f^2 effect sizes (weak: 0.02; moderate: 0.15; strong: 0.35). The effect size for product complexity (f^2 = 0.01) on cooperative project organisation is weak, whereas the effect size for product importance on cooperative project organisation (f^2=0.192) is moderate. The effect sizes for cooperative project organisation on output results (f^2=0.272) and process results (f^2=0.352) are moderate and strong.

We tested the predictive relevance of the structural model (see Table 4). For this purpose, we first applied the Stone–Geisser Q^2 coefficient, calculated by applying the blindfolding method. The results revealed that all Q^2-values of cross-validated construct redundancy were above the sufficient level of 0 (Hair et al., 2012).

Table 4 R^2 and Q^2 values for the structural model

	R^2	Q^2
Cooperative project organisation	0.192	0.127
Output result	0.214	0.133
Process result	0.260	0.136

Second, we used the PLSpredict method of Shmueli et al. (2016), which applies training and holdout samples to establish the out-of-sample predictive quality of results. We analysed the out-of-sample predictive quality of the research model for the constructs' cooperative project organisation, output and process results. The Q^2-value of all indicators is positive (see Table 5). Additional analysis of the output of PLSpredict involved a comparative assessment focusing on whether the PLS estimations or Linear Model (LM) estimations produced higher prediction errors (Shmueli et al., 2019). If the forecast error distribution is highly non-symmetric, researchers should use the Mean Absolute Error (MAE). However, in most cases, Root Mean Squared Error (RMSE) is more appropriate as a prediction statistic (Shmueli et al., 2019).

Table 5 PLSpredict assessment

Construct		*PLS-SEM*			*Linear model benchmark*		
		$Q^2_{predict}$	*RMSE*	*MAE*	*RMSE*	*MAE*	$Q^2_{predict}$
Cooperative project organisation	COP_1	0.071	1.138	0.845	1.171	0.872	0.015
	COP_2	0.095	1.257	0.979	1.296	1.000	0.037
	COP_3	0.107	0.981	0.718	1.008	0.743	0.056
	COP_4	0.101	1.080	0.822	1.106	0.845	0.057
	COP_5	0.134	1.024	0.717	1.054	0.741	0.083
	COP_6	0.089	1.189	0.919	1.234	0.941	0.019

Furthermore, the RMSE is typically preferred for business-related research for purposes of comparison (Hair et al., 2019). Shmueli et al. (2019) proposed that if all indicators in Partial Least Squares-Structural Equation Modelling (PLS-SEM) have lower MAE or RMSE values than the LM analysis, the model possesses high-predictive power. Medium predictive power exists, when the PLS-SEM assessment produce lower prediction errors (RMSE or MAE) for the majority or same number compared to the LM. If the minority of the indicators in the PLS-SEM evaluation yields lower prediction errors in terms of RMSE or MAE than LM, this shows a low it has low-predictive power. If None of the indicators in the PLS-SEM has lower MAE or RMSE statistics than LM, the model has no predictive power.

When interpreting PLSpredict outcomes, the emphasis should be on the model's primary endogenous construct and not across all endogenous constructs (Hair et al., 2020); in this study, this means the focus should be on cooperative project organisation. We assess both RMSE and MAE, and we can conclude the values of RMSE and MAE for each item in PLS-SEM are lower than the LM values (see Table 5), and therefore the model has high predictive power (Shmueli et al., 2019).

4 Analysis and results

4.1 Assessment of hypotheses

To assess the research hypotheses, we first estimated the path coefficients between the related constructs. In a second step, we conducted a test of the significance of the path coefficients in the structural model through the bootstrapping resampling procedure (5000 subsamples). The results of the PLS-SEM show that all hypotheses are supported.

Hypothesis 1 states that product complexity has a positive effect on project organisation between the supplier and buyer. This hypothesis is not supported ($\beta = 0.092$; $p > 0.1$) – though the analysis also does not confirm a negative relationship between product importance and cooperative project organisation. However, the importance of the product is significantly and positively related to project organisation ($\beta = 0.406$; $p < 0.001$). The PLS model also supports Hypotheses 3 and 4. Cooperative project organisation has a positive and significant effect on the output- and process-related results of NPD ($\beta = 0.463$, $p < 0.001$ and $\beta = 0.510$, $p < 0.001$, respectively).

Table 6 Path coefficients of the structural model

Hypothesis	*Relationship*	*Path coefficient β*	*t-value*	*Significant*
H1	Product complexity → Cooperative project organisation	0.092	1.176	n.s.
H2	Product importance → Cooperative project organisation	0.406	4.647	****
H3	Cooperative project organisation → Output result	0.463	6.624	****
H4	Cooperative project organisation → Process result	0.510	8.577	****

Notes: Significance test (two-tailed): n.s. = non-significant; **** $p < 0.001$

A post-hoc power analysis was executed applying G*Power (Faul et al., 2007). A two-tailed *t*-test with a multiple linear regression, including a fixed model, and a single regression coefficient was used to compute statistical power. The average effect size ($f^2 = 0.229$), probability of alpha error (0.05), number of respondents ($n = 209$), and number of predictors ($n = 5$) led to a calculated power of 0.99, above the established threshold of 0.8 (Benitez et al., 2020).

4.2 Multi-group analysis

To analyse the moderating effect of the geographic location, we investigate whether the observed path coefficients of each relationship in the research model differ in terms of the supplier's location: local (German-speaking countries) or global (non-German-speaking countries). We assessed the research model for group differences related to the location of the supplier, compared the path coefficients of the groups, and applied a multi-group analysis (PLS-MGA) to analyse the importance of group differences.

Before the multi-group analysis, the measurement invariance of composites (MICOM) method was employed to examine the measurement invariance. According to the results, the partial measurement invariance was validated, which is the prerequisite for interpreting and evaluating the group-specific variations of MGA results. Henseler et al. (2016) recommend assessing MICOM before establishing MGA when applying SEM to ensure the validation of multiple group analysis. MICOM is a three-step procedure including (1) configural invariance evaluation, (2) the assessment of compositional invariance and (3) an analysis of equal means and variance. In the first step, the configural invariance necessity is assured by both models by applying identical data set, indicators, and algorithm settings. In the second step, compositional invariance was assessed through a permutation method at a 5% significance level. The findings of the permutation show that the initial correlation values range from 0.919 to 0.999, all above the 5.0% test level to confirm compositional invariance (see Table 7). In the third step, full measurement invariance necessitates the equivalence of composite mean statistics and variances among the two groups. Outcomes from the permutation method suggest uniformity of composite mean statistics was established for all the constructs in the model except product complexity (Henseler et al. 2016).

The results also reveal equivalence of variances for all the constructs in the model except for cooperative project organisation. Hence, full measurement invariance was not established for the models. However, the establishment of the first two steps verified partial measurement invariance and permitted the assessment of the differences in the path coefficients between local sourcing and global sourcing by applying PLS-MGA (Henseler et al., 2016; Hair et al., 2017).

After determining measurement invariance between the two geographical sourcing locations, the relevant path coefficients were compared using PLS-MGA. The goal was to determine the differences in the research model regarding different groups of supplier locations. Table 8 provides estimates of the path coefficients for each group and the probability that these parameters differ between the two groups. The results show that the positive effect of product complexity on project organisation is not significant for a local and global supplier.

Furthermore, the results of PLS-MGA analysis show there is no significant difference between global and local supplier (local: $\beta = 0.184$, $p > 0.1$; global: $\beta = 0.052$, $p > 0.05$; MGA $p = 0.562$). The positive relationship between product importance and cooperative project organisation is stronger for global suppliers than for local suppliers, but there are no significant differences between the two groups (local: $\beta = 0.381$, $p < 0.001$; global: $\beta = 0.429$, $p < 0.001$; MGA p-value = 0.766).

The results reveal that both sourcing locations (local and global) support the buyer in engaging to a greater extent in cooperative project organisation to achieve output-related objectives. Furthermore, PLS-MGA analysis reveals that a local supplier contributes more to output-related NPD outcomes than a global supplier (local: $\beta = 0.636$, $p < 0.001$; global: $\beta = 0.310$, $p < 0.001$; MGA p-value = 0.005).

The positive hypothesised path between the cooperative project organisation and process-related outcomes is considerably stronger for local than for global suppliers. There is also a significant difference between the two groups (local: $\beta = 0.645$, $p < 0.001$; global: $\beta = 0.417$, $p < 0.001$; MGA p-value = 0.034).

These findings illustrate that the relationship between product complexity, product importance, and cooperative project organisation cannot be differentiated based on the geographical location of the supplier. However, the path coefficient concerning the relationship between the cooperative project organisation between supplier and buyer, and the output and process-related outcome of the NPD, is significantly higher for local than for global suppliers.

Table 7 Measurement invariance of composites

Constructs	*STEP 1*	*STEP 2*			*STEP 3*							
	Configural invariance	*Compositional invariance (Correlation = 1)*		*Partial measurement invariance*	*Equal mean assessment*				*Equal variance assessment*			
		C = 1	*5% quantile*		*Difference*	*Confidence interval*		*Equal*	*Differences*	*Confidence interval*		*Equal*
Output result	YES	0.997	0.975	Yes	–0.202	–0.300	0.288	Yes	0.714	–0.738	0.723	Yes
Process result	YES	0.997	0.977	Yes	–0.177	–0.294	0.290	Yes	0.540	–0.573	0.591	Yes
Product complexity	YES	0.919	0.207	Yes	–0.314	–0.308	0.288	No	0.313	–0.544	0.500	Yes
Product importance	YES	0.991	0.933	Yes	–0.105	–0.294	0.283	Yes	0.629	–0.914	0.888	Yes
Cooperative project organisation	YES	0.999	0.997	Yes	–0.090	–0.307	0.299	Yes	0.690	–0.724	0.668	No

Table 8 Path coefficients and multi-group results for sourcing location (local-global)

Hypothesis		PLS-MGA between local and global sourcing location							
		Local			*Global*			*Multi-group comparison*	
		Path coefficient β	*t-value*	*p-value*	*Path coefficient β*	*t-Value*	*p-value*	*Path coefficient difference*	*p-value*
H1	PC à CPO	0.184	1.053	0.292	0.052	0.395	0.693	0.132	0.562
H2	PI à CPO	0.381	2.193	0.028	0.429	5.539	<0.001	-0.049	0.766
H3	CPO à OR	0.636	6.724	<0.001	0.310	4.812	<0.001	0.325	0.005
H4	CPO à PR	0.645	7.526	<0.001	0.417	6.866	<0.001	0.228	0.034

Note: *P*-values are from a two-tailed significance test

5 Discussion

5.1 Theoretical implications

This study contributes to the field of international and supply chain management by investigating the significant role of product characteristics on the buyer–supplier relationship in the NPD process. To our knowledge, this research is the first large-scale empirical study to examine the moderating role of sourcing location on the linkages between product characteristics, buyer–supplier relationship, and NPD performance. Our study's main impact to the literature on supplier integration in NPD is in refining scholars' understanding of the relative effects of alternative sourcing location choices on NPD performance. This analysis of the effects and importance of product complexity in NPD and the role of geographical sourcing location offers new insights regarding how to best establish supplier–buyer cooperation for optimal NPD results. We offer three major insights:

First, the findings of this study highlight the relevance of product importance for supplier–buyer cooperation in NPD activities. Product importance is identified as the key driver of more intensive collaboration between buyer and supplier. The findings show that the more important the product is for the success of NPD, the higher the scope of the cooperative project organisation, causing a collaborative project organisation, such as a grey box, to be preferable. Since the supplier part is essential to the entire project, its optimal use is achieved through more intensive cooperation.

Second, product complexity plays no role in the extent of a buyer–supplier collaboration. It is difficult for buyers to identify which suppliers (and geographical locations) can be involved in their NPD process without too high a risk of losing valuable intellectual property. In times of technological change and volatile markets, it is the buyer's task to both increase flexibility and minimise risk. Interface development with suppliers may give the buyer the flexibility to benefit from the supplier's technological competence and to incorporate of technical improvements into the NPD process for product innovation (Arnold, 2010). Cooperation, in the form of interface development (such as black box development), thus can maintain the flexibility of the buyer in NPD projects with a high level of product complexity. In contrast to Thakur-Wernz et al. (2020), we found no positive impact on NPD performance of any location sourcing choice based on project complexity.

Third, Le Dain and Merminod (2014) analysed the positive effect of grey box collaborative development to NPD outcome without considering how to involve suppliers in NPD based on the supplier's the geographic location. The effect of global sourcing on performance remains debatable (Golini and Kalchschmidt, 2011). However, analysis of the results in Table 8 illustrates the relationship between the intensity of supplier involvement and sourcing location on NPD performance. These results indicate that higher product importance leads to higher collaboration between a local supplier and buyer, and that NPD performance is significantly higher for local than for global suppliers. These findings suggest that geographical proximity is an important factor affecting the supplier–buyer relationship and NPD success.

5.2 Managerial implications

This paper also reveals managerial insights regarding to what extent buyers should involve suppliers in NPD activities. Our findings illustrate that if a product's importance is high, its supplier should be more collaboratively involved in NPD organisation. When the procurement of a product is essential for the project, its optimal application is achieved through intensive cooperation. Based on our findings, cooperative project organisation significantly affects the success of the buying firm's NPD performance. However, for the success of supplier involvement in NPD, the intensity of supplier–buyer collaboration must be differentiated by sourcing location.

Cooperative project organisation in product development is more effective when a local supplier is involved. Local, established supplier–buyer relationships are built on trust and shared experiences in previous product development projects. Basically, if previous successful collaboration experiences have occurred with a supplier, buyers should involve that supplier in future NPD projects at a deeper level. Furthermore, the empirical results indicate that local suppliers can be key for successful NPDs, since geographical proximity stimulates closer collaboration and communication – for example, through regular personal meetings. This communication contributes to more successful collaboration in joint development activities. Local sourcing is an essential aspect of greater supplier–buyer cooperation. If a new product is developed in cooperation with a supplier, the supplier must be in regular contact with the buyer. Geographical proximity is a decisive factor in arranging personal meetings, so representatives of both firms can interact frequently. Local suppliers are also more likely to have similar cultural backgrounds, which may be important in helping supplier and buyer understand each other. A lower extent of cooperative project organisation implies less-frequent meetings, and may be more appropriate for global sourcing strategies.

5.3 Limitations and further research

This research project was subject to certain limitations, which may be modified or addressed in further investigations. First, the data in this study was gathered solely from buyers. Dyadic data, with feedback on the same topic from both supplier and buyer, is recommended to examine the role of product characteristics on the cooperative relationship. A second limitation is that data were collected from a single respondent for each buyer. We encourage future studies to use multiple respondents from each firm to improve the validity of our results. In addition, the research model could consider other moderating variables.

The results may vary in the different environments of various industries. Gathering information for a purchase decision under consideration depends on many factors, which may vary by industry. In addition, the number of potential suppliers and buyers is different based on the country and market and may influence the transparency of the sector, and by extension, the degree of ease in obtaining relevant information from suppliers for NPD. Therefore, further research may focus on different industries and countries to develop a more detailed explanation of how to effectively integrate suppliers in the NPD processes of different industries and countries.

6 Conclusion

Supplier integration in NPD has been examined by several researchers (e.g., Johnsen, 2009). Although there is a body of literature on supplier integration, the research on product characteristics remains scarce. This limited body of research has assessed the relations among project object complexity and importance, project organisation between buyer and supplier, and success in supplier integration. This study added to this body of work by examining the effects of product characteristics – such as complexity and importance – on supplier integration. This was accomplished by assessing the form of cooperative project organisation used in the NPD process. A framework was introduced to analyse the relationship between product complexity and importance in relation to the cooperative project organisation. Furthermore, this study connected and compares sourcing location with the theoretical research model using PLS-MGA. Our findings indicate that companies should assess the properties of their products and the location of their supplier when deciding the degree of buyer–supplier collaboration appropriate in an NPD process.

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