Received: 1 March 2021 | Revised: 27 May 2022 | Accepted: 27 May 2022

DOI: 10.1111/jbl.12316

ORIGINAL ARTICLE

WILEY

Implementing supplier integration practices to improve performance: The contingency effects of supply base concentration

Margherita Molinaro[1] | **Pamela Danese**[2] | **Pietro Romano**[1] | **Morgan Swink**[3]

[1]Polytechnic Department of Engineering and Architecture, University of Udine, Udine, Italy

[2]Department of Management and Engineering, University of Padova, Vicenza, Italy

[3]Neeley School of Business, Texas Christian University, Fort Worth, Texas, USA

Correspondence
Margherita Molinaro, Polytechnic Department of Engineering and Architecture, University of Udine, via delle Scienze 206, 33100 Udine, Italy.
Email: molinaro.margherita.1@spes.uniud.it

Abstract

Companies are recently facing increasing supply chain disruptions that may influence their supply base design choices. However, studies investigating how these choices affect the effectiveness of other supplier management practices, such as supplier integration, are scarce. The aim of this paper is to explore the impact of various types of supplier integration on the buyer's efficiency and innovation, as well as the contingency effects of supply base concentration, an important supply base design choice. Drawing upon Social Exchange Theory, we argue that the expected benefits of supplier integration activities to efficiency and innovation are strengthened by supply base concentration. We test our hypotheses using data collected from 324 manufacturing plants. Hierarchical regression results reveal that some supplier integration types improve performance *only* under higher levels of supply base concentration, while the effects of other supplier integration types vary according to the type of performance considered or are not significant at all. In addition, the results suggest that developing technologies to share information with suppliers may be counterproductive in driving efficiency. Besides enriching the supplier integration literature, this research offers guidance for managers who wish to improve efficiency and innovation, while also considering the pros and cons of supply base concentration.

KEYWORDS

efficiency, innovation, supplier integration, supply base concentration, supply base design

INTRODUCTION

A sizable supply chain management literature addresses buyer–supplier relationships and supply base design (Choi & Krause, 2006; Danese, 2013; Lu & Shang, 2017). Venerable managerial paradigms such as Lean Management and Total Quality Management argue that buying firms should establish close relationships with a relatively concentrated base of suppliers to reduce costs and increase supplier commitment (Cousins, 1999). However, recent disruptive events call the above-mentioned practices into question, suggesting that broader and more complex supply bases reduce risks and negative effects of disruptions (Birkie & Trucco, 2020), while also speeding the recovery of buying firms (Wiedmer et al., 2021). Consequently, many companies, such as Nike (see van Hoek, 2020), are revising their supply base design choices.

Supply base design creates the context in which supplier management processes are carried out. Consequently, it affects the ways in which processes such as supplier integration can contribute to the efficiency and innovative capacity of the buying company. Supplier integration is a widely studied, multidimensional concept, indicated by the level of cooperation, information exchange and partnership development that a firm establishes with its suppliers (Schoenherr & Swink, 2015). The literature proposes several different types of supplier integration and related activities, which can be classified into three groups (Leuschner et al., 2013): (a) relational integration, which refers to a strategic connection between the firms characterized by significant commitment and trust; (b) operational integration, which concerns the coordination of daily activities and processes; and (c) information integration, which refers to collaborative communication and information sharing, supported by appropriate technologies.

While research generally supports the proposition that supplier integration positively affects buyer performance, studies also suggest that the effects of supplier integration are contingent on contextual factors (Shou et al., 2018; Wong et al., 2017). As highlighted by the recent literature review of Danese et al. (2020), environmental factors (e.g., demand uncertainty) and internal practices (e.g., risk management) have been widely examined in previous literature as potential contingent factors. In contrast, aspects of supply base design have not received as much attention (Danese et al., 2020). Empirical research has mostly ignored interactions between supply network breadth/concentration and supplier integration, even though supply base rationalization, the reduction of the total number of suppliers actively managed by a buyer (Sarkar & Mohapatra, 2006), is frequently mentioned in the supplier integration literature (Golini & Kalchschmidt, 2015; Lu & Shang, 2017; Vanpoucke et al., 2014). Supply base concentration decisions require managers to evaluate trade-offs between costs and risks associated with concentrated and dispersed supply bases (see Choi & Krause, 2006), yet the effects of reduction on supplier integration effectiveness have not been empirically examined.

Accordingly, this study explores the main and interacting effects of various types of supplier integration and supply base concentration (SBC) on efficiency and innovation. We draw upon Social Exchange Theory (SET) to elaborate our hypotheses. Applied to supply chain relationships, SET suggests that the relational behavior toward partners changes depending on four main social factors: trust, commitment, reciprocity/justice, and power/dependence (Wu et al., 2014). The relevance of this study lies not only in the investigation of an under-explored contingent factor (supply base concentration) but also in the selection of important operational performance dimensions and four types of supplier integration. We distinguish these latter by the goal and type of activities, as well as by their time frame. Relying on the classification proposed by Leuschner et al. (2013), we identify four types of supplier integration: e-information integration (as a form of Leuschner's information integration), operational coordination (reflecting Leuschner's operational integration), and supplier development and supplier involvement in new product development (NPD) (as strategic forms linked to Leuschner's relational integration). These precise dimensions of supplier integration represent the variety and complexity of supplier integration activities, which are not necessarily implemented together by companies and may interact in different ways with contextual variables and other managerial practices. Using this distinction, the present work examines complementary effects of each type of supplier integration and supply base concentration on performance, thus providing deeper insights into the relative benefits of different integration approaches (Leuschner et al., 2013). To our knowledge, this study is unique in simultaneously investigating different types of supplier integration. Prior researchers either use broad, one-dimensional operationalizations of supplier integration (Shou et al., 2018), or focus on a single type of supplier integration (Koufteros et al., 2005). An exception is offered by Zhang et al. (2018), who investigate how internal integration influences the performance effects of three different supplier integration activities (i.e., strategic, process and information integration). However, these authors do not distinguish between the processes in which integration is carried out (e.g., new product development vs production planning) or among the media employed for information exchange.

This study offers two main contributions. First, it extends our understanding of the different types of supplier integration and their relative impacts on a buying organization's efficiency and innovation, stressing the importance of adopting a holistic approach. Second, it theoretically argues and empirically demonstrates that both efficiency and innovation are improved when buying firms implement supplier integration initiatives with more concentrated supply bases.

The structure of the paper is as follows: We first provide a literature review on the supplier integration–performance relationship, with a focus on the role of contingent factors, and develop a set of research hypotheses. We then describe research methodology and results. Finally, we provide a discussion of the research implications and a conclusion section with the main limitations of the study.

LITERATURE REVIEW

The relationship between supplier integration and performance has been widely studied in the literature, with mixed findings (Wiengarten et al., 2016). Previous research applies Contingency Theory to better understand the phenomenon (Danese et al., 2013; Flynn et al., 2010). Contingency theory (Thompson, 1967) states that the effects of a given strategy or tactic are context dependent and that they can be achieved only through an appropriate organizational design. Applying this logic to the supplier integration literature, researchers show that different contingent factors, including both environmental uncontrollable factors and internal practices, shape the link between supplier integration and performance. The recent literature review of Danese et al. (2020) provides an overview of these factors, summarized in Table 1.

As the table indicates, while some factors have been widely examined in the literature (e.g., complexity, uncertainty), aspects of supply base design have not received as much attention (Danese et al., 2020). In particular, no previous studies consider the interactions between supply base concentration and supplier integration, despite the trade-offs that may emerge when a company has to combine decisions on cooperation activities and network design. On one hand, collaborations with fewer suppliers are easier, more efficient and characterized by increased interdependence and collaboration incentives (Ateş et al., 2015; Dong et al., 2020). On the other hand, cooperation with a larger supply base offers advantages for more alternative supply options and provides access to more knowledge sources (Ateş et al., 2015; Sharma et al., 2020; Swink & Zsidisin, 2006). These respective advantages have implications for both efficiency and innovation, yet study of these performance outcomes is quite limited in the supplier integration literature (see Table 1). This represents a problem from a managerial viewpoint because efficiency and innovation are critical competitive

TABLE 1 Overview of contingent factors influencing the supplier integration-performance relationship (adapted from Danese et al., 2020)

Factor types		Contingent factors	Investigated performance dimensions
External, environmental ($n = 7$)		Supply, demand or technological uncertainty	Product innovation and quality (Koufteros et al., 2005) Cost, delivery, flexibility and quality (Wong et al., 2011) Delivery (Boon-itt & Wong, 2011)
		Supply chain complexity	Innovation and flexibility (Caniato & Größler, 2015) Operational performance (Wong et al., 2015)
		Country's rule of law	Cost and innovation (Wiengarten et al., 2016)
		National culture	Operational performance (Wong et al., 2017)
Internal, controllable ($n = 12$)	Internal practices ($n = 9$)	Customer integration	Operational performance (Devaraj et al., 2007;Flynn et al., 2010; Song et al., 2017) Financial performance (Flynn et al., 2010; Song et al., 2017) Efficiency (Danese & Romano, 2011)
		Internal integration	Operational performance (Flynn et al., 2010; Song et al., 2017)
		Involvement of supply chain personnel in innovation activities	Cost, delivery and flexibility (Turkulainen & Swink, 2017)
		Supply chain risk management	Flexibility (Chaudhuri et al., 2018) Operational efficiency and flexibility (Shou et al., 2018)
		Top management support	Supply chain performance (Shee et al., 2018)
		Entrepreneurial orientation	Market responsiveness (Luu, 2017)
		Internal production system	Operational performance (Shou et al., 2018)
	Supply base design ($n = 3$)	International supplier network	Responsiveness (Danese et al., 2013)
		Fast supply network structure	Efficiency, schedule attainment and flexibility (Danese, 2013)
		Global purchasing	Product innovation and time to market (von Haartman & Bengtsson, 2015)

factors in current business contexts. While efficiency is always at the forefront of supply management, innovation has become increasingly important for companies. Because suppliers serve as important sources of innovation, understanding when and how to engage them in innovation has become crucial (Patrucco et al., 2017).

Considering the aforementioned weaknesses in previous literature, this study examines the main and interactive effects of various supplier integration types and supply base concentration on two performance dimensions: efficiency and innovation. In line with previous literature (Danese & Romano, 2011), we define efficiency as the ability of the focal firm to exploit its resources, reduce manufacturing costs, and minimize inventories. In defining innovation, we focus on operational aspects of innovativeness and time-to-market. This choice is linked to the relevance that these components play in current business competitive environments, especially in high-tech sectors (Leal et al., 2017; Oh et al., 2015).

Supplier integration types

Numerous researchers conceptualize supplier integration by emphasizing differences in goals, time-frames, levels of information exchange, media of exchange, and interactions among supply chain functions. While some studies employ broad, one-dimensional operationalizations (Shou et al., 2018), others focus on specific activities that include information sharing (Prajogo & Olhager, 2012), operational coordination (Sanders, 2008), and collaboration in NPD (Koufteros et al., 2005). A well-known classification that encompasses all these conceptualizations of supplier integration is that proposed by Leuschner et al. (2013), who distinguish between relational, operational and information integration activities. We rely on this classification to identify the specific supplier integration constructs to be explored in this paper, as it offers several important distinctions. First, Leuschner et al.'s (2013) distinction between operational and strategic/relational integration activities is widely recognized in the literature. Operational supplier integration concepts address the degree to which the focal company and its suppliers coordinate and synchronize daily activities, including scheduling, order processing, operational planning, and shipment schedules (Flynn et al., 2010; Peng et al., 2013). In contrast, strategic integration concerns activities that are "more long-term and collaborative, including relationship building, joint development activities, and sharing of cost and capability information" (Swink et al., 2007, p. 150). While the former activities are ongoing, the latter tend to be episodic, as they are focused on particular initiatives with specified beginnings and ends, such as changes in the network structure, reaction to quality problems, and development of new products or product lines (Mackelprang et al., 2014). Second, Leuschner et al.'s (2013) concept of information integration, often used in the literature (Liu et al., 2013; Prajogo & Olhager, 2012), distinguishes supplier integration based on the nature of information being processed. This distinction is useful in identifying low levels of integration.

Using these distinctions, we develop four different constructs encompassing the three classes of supplier integration proposed by Leuschner et al. (2013). Two of them, *supplier development* and *supplier involvement in NPD*, represent strategic and more episodic collaborations that focus on developing resource capabilities and product/process designs. In contrast, *operational coordination* reflects more continuous integration and synchronization of production plans and transactions, in line with Leuschner et al.'s (2013) operation integration. Finally, *e-information integration* is linked to information integration and concerns the use of information systems and e-business technologies to share information. In the following section, we describe our hypotheses concerning the effects of these four supplier integration types and efficiency and innovation.

HYPOTHESIS DEVELOPMENT

To develop our hypotheses, we rely on Social Exchange Theory (SET). The SET postulates that buyer–supplier relationships are formed because the two parties offer reciprocal benefits to one another over time (Wu et al., 2014). Four main social factors underlie this theory: trust, commitment, reciprocity/justice and power/dependence (Narasimhan et al., 2009; Wu et al., 2014; Yang et al., 2008). Considering the effects of supplier management and network design decisions on these social factors, we expect not only a positive significant effect of supplier integration activities on efficiency and innovation but also an enhancement of such benefits in contexts characterized by more concentrated supply bases. Below, we develop specific research hypotheses, relying on the literature summarized in Table 2.

Relationships between supplier integration types and performance

Supplier development is defined as collaborative efforts such as training, consulting, and technical support, implemented by a firm to improve its suppliers' capabilities and performance (Krause et al., 2007). Supplier development initiatives can be costly and intensive in both time and

TABLE 2 Relevant literature on the supplier integration–performance relationship

Supplier integration types	Reference papers	Supplier integration sub-types	Research findings: Positively affected performance dimensions	Research findings: Negatively (or not) affected performance dimensions	Research findings: Influencing factors
Supplier development	Krause et al. (2007)	–	Flexibility, quality, delivery	Product cost	
	Li et al. (2007)	Joint action, trust, asset specificity, performance expectation	Operational effectiveness by joint action and trust Market responsiveness by asset specificity	Operational effectiveness by asset specificity and performance expectation Market responsiveness by joint action, trust and performance expectation	
	Wagner (2011)	–	Reliability, time-to-market, production downtimes, customer satisfaction, quality, reliability, innovation (effect maximized by relationship life cycle)		Moderation of relationship life cycle
	Li et al. (2012)	–	Sales, cost, quality, speed, responsiveness		
Supplier involvement in NPD	Ragatz et al. (2002)	Need and alignment, integrative strategies and team processes	Cycle time, cost, quality		
	Petersen et al. (2003)	–	NPD project goals achievements		
	Koufteros et al. (2005)	–	Product innovation when equivocality is low	Quality when equivocality is high	Moderation of equivocality
	Koufteros et al. (2010)	–	Reduction of glitches, timely execution of engineering changes		
	Peng et al. (2013)	–	Plant improvement, innovation capability		
	Perols et al. (2013)	–	Time-to-market (partially mediated effect)		Partial mediation of external technology adoption
	Salvador and Villena (2013)	–	Unit cost of manufacturing (effect maximized by modular design competence and NPD project innovation) Product technical performance with modular design competence	Product technical performance without modular design competence	Moderation of modular design competence and NPD project innovation
	Suurmond et al. (2020)	Early supplier involvement, extensive supplier involvement	NPD speed by early and extensive involvement of suppliers Product quality by extensive involvement of suppliers	Product quality by early involvement of suppliers	

(Continues)

TABLE 2 (Continued)

Supplier integration types	Reference papers	Supplier integration sub-types	Research findings: Positively affected performance dimensions	Research findings: Negatively (or not) affected performance dimensions	Research findings: Influencing factors
Operational coordination	Flynn et al. (2010)	–	Operational performance with customer integration	Operational performance without customer integration	Moderation of customer integration
	Wong et al. (2011)	–	Production flexibility and delivery (effect maximized by environmental uncertainty), product quality and production cost		Moderation of environmental uncertainty
	Prajogo et al. (2016)	–	Competitive performance only with mediation of lean production processes and inbound supply performance	Competitive performance without lean production processes and inbound supply performance	Mediation of lean production processes and inbound supply performance
	Wiengarten et al. (2016)	–	Cost, innovation performance when rule of law is high	Cost, innovation performance when rule of law is low	Moderation of rule of law
E-information integration	da Silveira and Cagliano (2006)	Dyadic information systems, multilateral information systems	Quality, delivery and cost by dyadic systems (i.e., systems which support coordination among a few supply chain partners) Quality and flexibility by multilateral systems (i.e., systems which allow communication with a larger number of partners)	Flexibility by dyadic systems Delivery and cost by multilateral systems	
	Devaraj et al. (2007)	–	Operational performance only with mediation of production information integration	Operational performance without production information integration	Mediation of production information integration
	Sanders (2007)	–	Delivery, quality, cost, speed, new product introduction time (partially mediated effect)		Mediation of inter-organizational collaboration
	Wiengarten et al. (2013)	–	Operational performance		

Note: This overview includes only the papers exploring, with specific constructs, at least one of the four supplier integration activities included in the research; papers using one-dimensional operationalizations (i.e., combining different supplier integration types in the same construct) are thus excluded.

resource (Krause et al., 2007; Li et al., 2007; Su et al., 2018). However, they represent important investments to enhance a buyer's competitive advantage (Li et al., 2012; Wagner, 2011). Product costs are improved through reductions in supplier's scrap, rework and downtimes (Krause et al., 2007), while performance outcomes like quality, flexibility and productivity are strengthened through rich communication between the partners during supplier development activities (Li et al., 2012). Furthermore, when a buying company commits its resources to a certain supplier, the satisfaction of this partner may increase and, according to SET, it may reciprocate its positive feelings by offering its knowledge and ideas (Glavee-Geo, 2019). This accomplishment, combined with enhanced suppliers' capabilities and evolved technologies, produces benefits to strategic projects such as new product launches, positively affecting a buyer's innovation (Krause et al., 2007; Schoenherr & Swink, 2015; Wagner, 2011). Innovation management literature suggests that buyers obtain effective innovation through the collaboration and support of external actors (in particular, suppliers), who provide human, knowledge and technological resources that the buyer may lack (Leonidou et al., 2020; et al., 2021). Following these logical arguments, we hypothesize that:

H1 *Supplier development has a positive effect on the buyer's (a) efficiency and (b) innovation.*

Supplier involvement in NPD means that the buyers' and suppliers' engineers work together, often creating specific NPD teams, to jointly design new products, services or processes (Koufteros et al., 2005). In this context, the partners become highly interdependent since the success of the NPD process depends on the combination of their knowledge, resources, and technologies (Perols et al., 2013). From the SET perspective, such interdependence and continuous interaction among two parties builds strong mutual interests, more effective problem solving, and faster conflict resolution (Servajean-Hilst et al., 2021). These engagements lead to better technical performance of designed products, less design errors and changes, and better fit between components (Koufteros et al., 2010; Petersen et al., 2003; Ragatz et al., 2002; Salvador & Villena, 2013). In these ways, supplier involvement in NPD improves a buyer's efficiency and innovation. Improvements in product structure and quality reduce manufacturing costs and enhance innovativeness, while more efficient processes and shared decisions significantly shorten time-to-market (Koufteros et al., 2010; Petersen et al., 2003; Ragatz et al., 2002; Salvador & Villena, 2013). On the other hand, supplier involvement in NPD also involves significant costs, resource requirements, and challenges that, together with the potential advantages, determine the overall effect of supplier integration on performance (Merminod et al., 2022; Perols et al., 2013; Salvador & Villena, 2013). Considering the extent and variety of the aforementioned benefits, we posit that:

H2 *Supplier involvement in NPD has a positive effect on the buyer's (a) efficiency and (b) innovation.*

Operational coordination concerns the common management of daily activities in which the buyer's supply chain personnel and supplier's operations managers conduct joint operational planning and share information to smooth process execution (Turkulainen & Swink, 2017). The main benefits of this form of integration include more efficient resource allocations and lower inventories through reduction of the bullwhip effect (Danese, 2013). In addition, operational coordination improves a buyer's innovation, as better coordination and more efficient processes shorten time-to-market. Moreover, the interaction between parties during operational coordination enables a learning process that, in the medium term, can help buyers to develop new ideas and enhance their innovativeness (Turkulainen & Swink, 2017), as suggested by the open innovation paradigm (Patrucco et al., 2021). Scholars note that the time and effort required for operational coordination may create rigidities that nullify its potential benefits (Flynn et al., 2010). However, SET suggests that improved mutual understanding and trust developed in this form of integration create a positive atmosphere which directly and positively influences relationship effectiveness (Guo et al., 2021). We thus offer a positive expectation for coordination effects:

H3 *Operational coordination has a positive effect on the buyer's (a) efficiency and (b) innovation.*

E-information integration focuses on information sharing and its related technology. This supplier integration type encompasses interorganizational systems, such as EDI, and other technologies that enable intercompany communication, like the internet (Prajogo & Olhager, 2012). We consider the use of internet-based e-business technologies as means to "acquire, process and transmit information for more effective decision-making" (Wiengarten et al., 2013, p. 26). Researchers highlight the value of Internet-based applications in sharing information and managing supplier relationships (Cassetta et al., 2020; da Silveira & Cagliano, 2006), as well as their numerous advantages compared to classic technologies, such as EDI, including lower transaction costs, wider interoperability, and open-standard settings (da Silveira & Cagliano, 2006; Rabinovich et al., 2003; Sanders, 2007). According to Prajogo and Olhager (2012) and Cassetta et al. (2020), the use of IT and e-business technologies for collaboration is important because it increases the volume and complexity of information that can be quickly exchanged with supply chain partners. Sharing real-time information is essential to increase performance, since it allows partners to improve production schedules, thus reducing inventory requirements and speeding up decision-making, in both operational and innovation-related activities (Chen & Paulraj, 2004; Devaraj et al., 2007). This means that time-to-market can be shortened and innovative ideas can be acquired and processed quickly. Furthermore, by leveraging on e-business technologies, companies can improve the productivity of employees as they acquire more knowledge and learn to perform multiple tasks (Benitez et al., 2018). Accordingly, we hypothesize that:

H4 *E-information integration has a positive effect on the buyer's (a) efficiency and (b) innovation.*

Role of supply base concentration

The previous review highlights that research findings regarding the relationship between supplier integration and performance have been mixed. We hypothesize that the effects of supplier integration activities are contingent upon a supply network design choice: Supply base concentration. We expect that the potential benefits of supplier integration are more likely to be realized when buying firms interact with fewer suppliers. In addition, greater concentration in the supply base limits the risks identified in the literature that may degrade the positive effects of integration. A more concentrated supply base is associated with higher levels of trust, reciprocity and relationship commitment, which, according to SET, increase the stability and quality of collaboration with the focal company (Yang et al., 2008). Similarly, when supply bases are reduced, greater mutual interdependence between the partners results, as fewer ready alternatives are present. Following SET, companies in this situation are more likely to act with reciprocal, instead of individual interests (Narasimhan et al., 2009), thus strengthening the potential benefits of supplier integration activities. Popular sourcing frameworks, such as the Kraljic matrix (Kraljic, 1983), also emphasize the importance of combining supplier integration activities with supply base concentration efforts, especially for strategic items with high economic value and complex procurement conditions. Below, we develop more refined arguments for each supplier integration type.

First, supplier development requires resource and time commitments to support suppliers in improving their competitive capabilities; we assume that greater buyer commitments produce greater levels of supplier improvement (Krause et al., 2007; Su et al., 2018). Given that buying firms have limited resources to invest in supplier development, a reduced supply base, compared to a more enlarged one, allows them to dedicate more resources per supplier. This implies stronger performance improvements for suppliers and, consequently, a stronger effect of supplier development on buyer's performance. SET provides a complementary explanation by suggesting that attitudes and behaviors of one partner toward another are influenced by the expected outcomes of collaboration (Wu et al., 2014). When a party receives a valuable contribution from a supply chain relationship, it develops appropriate responses according to norms of justice (Griffith et al., 2006). Therefore, if a buying firm consolidates purchases and resource investments to a limited number of suppliers, the suppliers likely develop gratitude and impulses for reciprocity toward the buyer and its interests, thus strengthening buyer's performance improvements. On the contrary, if a buyer purchases small quantities from numerous suppliers, commitment levels on both sides may be insufficient to drive significant improvements (Giannakis, 2008). Accordingly, we expect that:

H5 *A concentrated supply base strengthens the positive effect of supplier development on the buyer's (a) efficiency and (b) innovation.*

Scholars highlight the benefits of increased customer–supplier collaboration in NPD process, but also warn about the risks which include the possible (a) explosion of development times (Parker & Brey, 2015), (b) opportunistic supplier behaviors (Salvador & Villena, 2013), and (c) loss of control over valuable knowledge and information (Parker, 2012). These risks, which may degrade the positive effects of NPD collaboration, can be decreased with a reduction of the supply base. As underlined by Parker and Brey (2015), increased management costs, plus possible stretching of times due to more intense alignment and information sharing, can easily nullify efficiency improvements from collaboration in NPD. In a reduced supply base, however, buyers are able to give more management attention to fewer suppliers. In addition, suppliers who participate in NPD are likely to make greater resource commitments given the increases in the scale of each supplier's economic relationship and in the potential share of project success. For example, a single source supplier has stronger vested interests in the success of the NPD project. It therefore is more likely to offer stronger commitments to innovation and to maintaining secrecy of proprietary information. According to the tenets of SET, the higher the commitment, the stronger the common goal for competition against rivalry

(Yang et al., 2008), with a consequent contribution to the positive effects of collaboration.

Interestingly, some authors argue that cooperation with larger numbers of suppliers in NPD activities provides more opportunities to reduce costs and improve innovations through greater access to specialized knowledge and avoidance of lock-in situations (Swink & Zsidisin, 2006). Thus, the literature presents a potential trade-off between the scale efficiencies and greater commitments associated with NPD collaboration with a reduced set of suppliers and the greater knowledge diversity represented in a larger set of suppliers. Following the tenets of SET (i.e., commitment, reciprocity, trust) as our primary theoretical frame, we forward a hypothesis that emphasizes the limits to which the potential of efficiency and innovation improvements can be exploited when buyers must commit scarce resources to many suppliers who participate in NPD. Accordingly, we argue that:

H6 *A concentrated supply base strengthens the positive effect of supplier involvement in NPD on the buyer's (a) efficiency and (b) innovation.*

Operational coordination increases the quality and richness of data shared (Paulraj & Chen, 2005), which in turn creates rich opportunities for process improvement (Liu et al., 2013). Again, following SET, we expect that the trust and interdependence generated by supply base concentration offer the proper motivations for mutual adaption between partners (Wu et al., 2014), which in turn maximizes improvement outcomes driving efficiency and innovation. In contrast, when dependence between the buyer and any of its suppliers is diluted by the number of relationships present in a large supply base, a given supplier may be led by conflicting interests, like gaining more volumes from the buyer and reducing the amount and quality of information shared with the buyer (Lu & Shang, 2017). Similarly, given the lower trust levels present in dispersed supply bases, a buyer may be reluctant to completely rely on its partner's data and information, thus hindering the potential benefits of collaboration. In contrast, when a buyer collaborates with fewer suppliers, transaction costs of communication between partners are lower, relationship-specific protocols are easier to manage, and quick responses expectations are raised (Choi & Krause, 2006; Dong et al., 2020). Accordingly, joint operational planning and scheduling can be executed easier, faster, and with lower costs, maximizing the benefits of supplier integration.

Turkulainen and Swink (2017) suggest that supply managers glean valuable market and technology information from their day-to-day operational interactions with suppliers, thus better supporting innovation. We expect that such learning is more likely across interactions with fewer, more trusted, dedicated partners. The opposite argument could also be made: operational interactions with a larger set of suppliers increase the breadth of scanning that supply managers can conduct and the diversity of information sources they consult, with positive effects on innovativeness. However, since the collection of innovative information is mainly indirect when the core activity of supplier integration is operational coordination, we believe that it is more difficult to catch innovation cues when companies must manage a higher number of suppliers. Thus, we opt for the former argument and posit that:

H7 *A concentrated supply base strengthens the positive effect of operational coordination with suppliers on the buyer's (a) efficiency and (b) innovation.*

The possibility to exchange real-time information of both an operational and strategic (e.g., NPD) nature through e-business technologies enables companies to send continuous updates to partners, which can be beneficial for performance. However, we argue that benefits are increased in reduced supply bases, where the sources of information are fewer and easier to manage. Indeed, e-business technologies can create heavy information processing loads that increase with supply base size. While e-business technologies can provide the basis for so-called mass collaboration through automating and standardizing information processing (Chen et al., 2007), the implementation and maintenance costs greatly increase as the number of connected partners grows (Rabinovich et al., 2003).

Considering all the above aspects, we hypothesize that:

H8 *A concentrated supply base strengthens the positive effect of e-information integration with suppliers on the buyer's (a) efficiency and (b) innovation.*

Figure 1 shows the conceptual model proposed in this study, with the related research hypotheses.

RESEARCH METHODOLOGY

Sample and data collection

Our research study relies on data collected between 2013 and 2018 in the fourth round of the High Performance Manufacturing (HPM) project. This data set is composed of plants located in 15 countries (see Table 3) and belonging to 3 manufacturing sectors (electronics, machinery, and transportation equipment). We deemed these sectors particularly appropriate for our analysis given the relevance of efficiency and innovation in such contexts. As highlighted by Leal et al. (2017), in the transportation equipment and

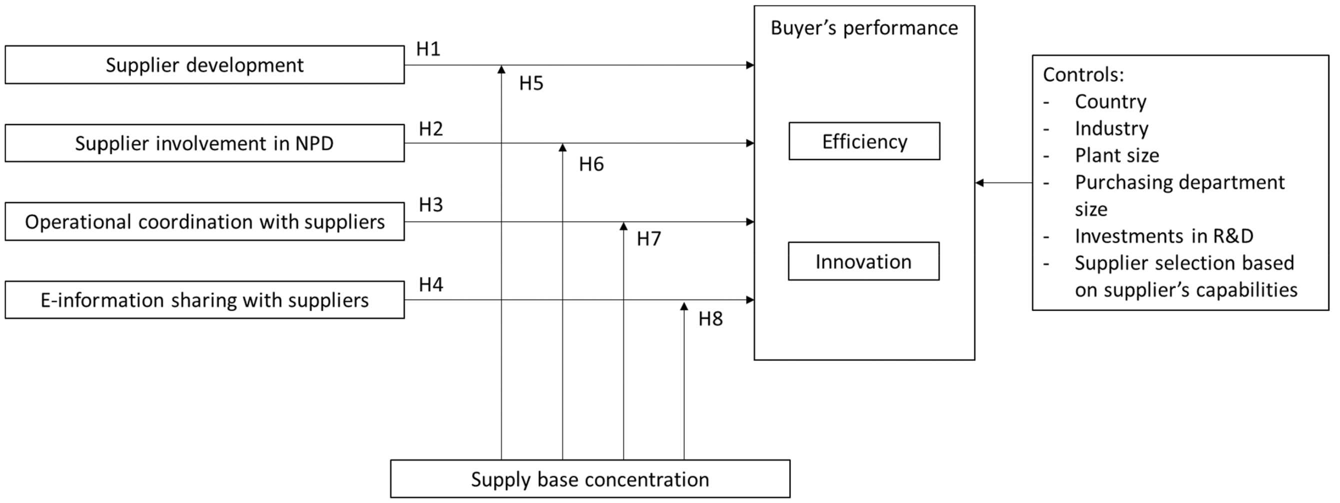

FIGURE 1 Conceptual model

TABLE 3 Distribution of companies per industry and country and average plant size

	Industry			Total number of companies
	Electronics	Machinery	Transportation	
Country				
Brazil	5	7	12	24
Germany	6	12	9	27
Spain	7	7	10	24
Israel	17	5	0	22
Sweden	4	4	1	9
Italy	7	17	5	29
Japan	6	7	9	22
China	10	17	3	30
Korea	8	5	13	26
Finland	6	6	5	17
Taiwan	19	10	1	30
United Kingdom	4	5	4	13
Vietnam	10	7	8	25
US	5	7	3	15
Switzerland	3	6	2	11
Total number of companies	117	122	85	324
Average plant size per industry (total number of personnel)	877	705	949	

automotive sectors, the reduction of time-to-market plays a key role for competitiveness. A key role is also played by the innovativeness of firms, which are required to frequently develop new models, components, and shapes. Similarly, in high-velocity industries such as electronics, the short life cycle of products requires not only an effective new product development process but also efficient management of both production and inventory (Oh et al., 2015). The importance of enhancing operational efficiency is key also in the machinery sector, where companies experience price pressures from low-cost locations because of the intense global competition (Cannas et al., 2019).

The data collection process of HPM was structured in a precise way. In each country, a local team of researchers contacted plants, gathered data and assisted the respondents to guarantee the collection of complete and correct information. To select the potential plants, the local team relied on a master list of manufacturing companies (e.g., Dunn's Industrial

Guide, Jetro data base, etc.) and randomly selected the participants from such list (Schroeder & Flynn, 2002). Only one plant per participating company was included in the sample to avoid the potential impact of unobserved firm-level variations. If the CEO of a contacted plant was willing to be part of the HPM project, the team responsible for data collection sent to the related plant a batch of 12 questionnaires, each focused on a specific topic (i.e., process engineering, environmental affairs, quality management, product development, downstream supply chain management, information system management, human resources management, accounting, plant management, upstream supply chain management, supervision, production control). The target respondents of each questionnaire differed depending on the specific topic addressed in the questions. To raise measurement reliability and avoid common method bias, each participating plant selected two respondents to complete each questionnaire, except for the accounting questionnaire. The average of the individual responses for each item was then taken to perform the plant level analyses. Finally, to increase the rate of response, the local team of researchers administered the questionnaires to the respondents using their local language. In particular, one local team member translated the original English versions into the local language and another local team member back-translated them into English. This process ensured accuracy in translation.

We selected the items used in this research from three of the aforementioned questionnaires: upstream supply chain management, product development and plant management. Target respondents included supply chain managers, product development managers and plant managers or their subordinates (Table 4 provides more respondent details). Respondents provided answers about the supplier integration practices implemented in the plant, the supply network design, and performance achieved.

The HPM dataset includes 330 plants; six were excluded from the study due to incomplete responses on the selected items, leaving a sample of 324 plants used for the analyses. Table 3 provides an overview of these plants.

Measures

This research includes several multi-item constructs, developed from a literature review in the relevant areas. All measurement items use a scale from one to five, indicating complete disagreements and complete agreements to the proposed statements. Table 4 displays the complete list of the measurement scales.

Supplier development includes five items measuring the company's commitment in the provision of assistance and training to its suppliers. Turkulainen et al. (2017) and Lo et al. (2018) use a similar operationalization. Supplier involvement in NPD is assessed using four items that reflect the degree of interactions with suppliers in NPD. Peng et al. (2014) and Garrido-Vega et al. (2015) also use this scale. Operational coordination includes three items that address the level of coordination with suppliers to increase task execution efficiency. Sanders (2008) uses the same scale, though measured from the supplier's perspective. The adoption of e-business technologies to share information with suppliers is measured with three items, adapted from Wu et al. (2003). To assess supply base concentration, we follow Chen and Paulraj (2004) and use a scale with four items measuring the degree of reliance on a small number of suppliers. We evaluate efficiency using six items, adapting the scale from Danese and Bortolotti (2014), Wiengarten et al. (2016), and Alfalla-Luque et al. (2018). We measure innovation performance with two items, as in Sanders Jones and Linderman (2014). To evaluate these two performance dimensions, respondents compared their plant performance with competitors, using a scale from one ('poor') to five ('superior').

Finally, we adopt six control variables: industry, country, firm size, purchasing department size, investments in R&D and supplier selection based on supplier's capabilities. We create two dummy variables to control for industry; the transportation sector serves as the comparison group. To control for country differences, we divide the plants according to location in Asia, America, and Europe, using the latter as comparison group. Plant size is measured using the total number of personnel employed, while the purchasing department size is calculated by dividing the number of people employed in the purchasing department by the total number of personnel employed. We calculate the natural log of both size and purchasing department size to improve skewness of data. Investments in R&D are assessed using the percentage of sales spent in R&D compared to the leading competitors. Finally, we include a supplier selection construct that evaluates the importance given to a supplier's capabilities during the selection process (see Table 4). This scale is included as a control variable because of the important roles that supplier capabilities play in affecting the buyer's performance (Kannan & Tan, 2006). This is particularly true for innovation performance, since technical and innovative capabilities and complementarities of suppliers increase the innovativeness of buyer companies, as well as reduce the risks of delays in design-related tasks (Jajja et al., 2017; Johnsen, 2009).

Reliability and validity

We assess the reliability and validity of the construct measurement items in several ways. First, following the recommendations of Boyer and Verma (2000), we

TABLE 4 Measurement items

Construct	Standardized factor loading	Cronbach's α	CR
Supplier development (DEV)[a]		0.77	0.78
Please indicate your opinion on the following statements, referring to your plant			
We provide our suppliers with sufficient technical assistance	0.56		
We encourage our suppliers to continuously improve their production processes	0.66		
We offer the necessary training to our suppliers	0.68		
We share our vision and supply chain policy with our key suppliers	0.66		
As our suppliers strive to improve their processes, we provide assistance	0.65		
Supplier involvement in NPD (INV)[b]		0.85	0.85
Please indicate your opinion on the following statements related to new product development projects, referring to your plant			
Suppliers are involved early in product design efforts	0.85		
We partner with suppliers for the design of new products	0.79		
Suppliers are frequently consulted during the design of new products	0.73		
Suppliers are an integral part of new product design efforts	0.69		
Operational coordination (OPC)[a]		0.82	0.82
Please indicate the extent of involvement of your plant in the following activities with your primary suppliers			
Sharing operational information	0.75		
Coordination of production planning	0.81		
Utilization of integrated database for information sharing	0.77		
E-information integration (EII)[a]		0.83	0.83
To what extent does your plant use e-business tools to reach the following goals?			
Send suppliers regular updates about new product plans and other new developments (e.g., via email)	0.70		
Provide specific online information about product specifications that our suppliers must meet	0.77		
Share product and inventory planning information with our suppliers	0.89		
Supply base concentration (SBC)[a]		0.68	0.69
Please indicate your opinion on the following statements, referring to your plant			
We rely on a small number of high-quality suppliers	0.61		
We maintain a close relationship with a limited pool of suppliers	0.55		
Our supply base is quite small, compared with our competitors	0.50		
We try to keep our supply base small	0.71		
Efficiency (EFF)[c]		0.85	0.85
Please circle the number that indicates your opinion about how your plant compares to its competitors in its industry, on a global basis			
Unit cost of manufacturing	0.71		
Labor cost	0.73		
Labor productivity	0.68		
Throughput: the rate at which the plant generates money through sales	0.67		

TABLE 4 (Continued)

Construct	Standardized factor loading	Cronbach's α	CR
Inventory: raw materials, work-in-process and finished goods	0.65		
Operating expense: funds spent to generate turnover, including direct labor, indirect labor, rent, utility expenses and depreciation	0.73		
Innovation (INN)[c]		0.72	0.74
Please circle the number that indicates your opinion about how your plant compares to its competitors in its industry, on a global basis			
On time new product launch	0.91		
Product innovativeness	0.61		
Supplier selection[a]		0.79	0.81
How important is each of the following criteria in the selection of key suppliers for this plant?			
Design capability	0.61		
Ideas and suggestions from suppliers	0.55		
Technical skill	0.84		
Technological capabilities	0.87		

[a]Questionnaire: upstream supply chain management. Possible respondents: supply chain manager, purchasing manager, logistics manager.

[b]Questionnaire: product development. Possible respondents: product development manager, product engineer, product designer.

[c]Questionnaire: plant management. Possible respondents: plant manager, president, chief operating officer.

calculate the Interclass Correlation (ICC) index using inputs from both respondents to each questionnaire. The ICC values exceed 0.7 for each item, indicating an acceptable inter-rater agreement and measurement item reliability. Second, we execute a confirmatory factor analysis (CFA). Considering the indications of Hair Jr. et al. (2006), the resulting model fit is good ($\chi^2 = 819.86$; df = 406; χ^2/df = 2.019; RMSEA = 0.055 [0.0495;0.0606]; CFI = 0.951; NFI = 0.91; TLI = 0.94). All the standardized parameter loadings of the measurement items on their respective constructs exceed 0.50 and are statistically significant, thus providing support for convergent validity (see Table 4). Composite reliabilities (CR) of multi-item scales exceed the threshold of 0.70 recommended by Hair Jr. et al. (2006); only the CR value for SBC is slightly below this point, but still above 0.60 and thus acceptable (Nunnally & Bernstein, 1994). Finally, the square root of the average variance extracted (AVE) for each construct scale is larger than the correlation coefficient between that construct and all the other constructs. This demonstrates discriminant validity (Flynn et al., 2010). We also build a CFA model with every possible pair of latent constructs and the correlations between the paired constructs set to 1.0. The results of the comparison based on χ^2 differences between these models and the original model provide additional support for discriminant validity (Bagozzi et al., 1991). Table 5 provides the basic statistics and correlations for the constructs included in the analysis.

RESULTS

Before testing the hypotheses, we execute preliminary tests to check the prerequisites of the estimations. First, tests of normality for all the items reveal acceptable values of skewness and kurtosis; all values are below suggested thresholds of 2 and 7, respectively (Curran et al., 1996). Next, we address common method bias. Besides positioning in different parts of the questionnaire the items related to dependent and independent variables, we perform a CFA that assigns all measurement items to a single construct. The results show a poor model fit ($\chi^2 = 2879.38$; df = 434; χ^2/df = 6.635; RMSEA = 0.132 [0.128; 0.137]; CFI = 0.397; TLI = 0.354), indicating that common method bias is not a serious concern.

We test our hypotheses by running hierarchical regression analysis. We include interaction terms, calculated as products between supply base concentration and the four supplier integration variables, to test hypotheses describing moderation effects. Following the suggestions of Jaccard and Turrisi (2003), we mean-center all independent variables to reduce potential multicollinearity effects.

The analyses consist of three steps. The first regression model includes only the control variables (Model 0 in Tables 6 and 7). Model 1 adds the independent variables to estimate their main effects on performance (Tables 6 and 7). Models 2–5 iteratively enter and remove each interaction term (Models 2, 3, 4 and 5 in Tables 6 and 7). This approach minimizes multicollinearity arising from simultaneous

TABLE 5 Summary statistics and correlations

	Mean	*SD*	1	2	3	4	5	6	7	8	9	10	11
1. Supplier development	3.85	0.62	0.64										
2. Supplier involvement in NPD	3.70	0.74	0.33**	0.77									
3. Operational coordination	2.95	0.86	0.44**	0.18**	0.78								
4. E-information integration	3.01	0.97	0.39**	0.14**	0.60**	0.79							
5. Supply base concentration	3.50	0.67	0.44**	0.14*	0.24**	0.22**	0.60						
6. Efficiency	3.39	0.64	0.23**	0.29**	0.22**	0.08	0.068	0.70					
7. Innovation	3.64	0.75	0.19**	0.20**	0.16**	0.16**	0.15**	0.50**	0.78				
8. Supplier selection	4.13	0.53	0.54**	0.28**	0.27**	0.23**	0.24**	0.22**	0.20**	0.73			
9. Firm size	6.11	1.11	0.18**	0.18**	0.13*	0.11*	−0.08	0.22**	0.05	0.08	1		
10. Purch. dep. Size	−3.79	0.90	−0.03	−0.08	0.00	0.04	0.05	−0.04	−0.04	−0.02	−0.38**	1	
11. Investments in R&D	3.31	0.94	0.10	0.16**	0.22**	0.24**	0.06	0.31**	0.31**	0.16**	−0.01	0.07	1

Note: the square-root of the average variance extracted (AVE) is printed on the diagonal.

**Significant at the 0.01 level (Pearson probabilities).; *Significant at the 0.05 level (Pearson probabilities).

inclusion of multiple interaction terms (Danese et al., 2013). The maximum variance inflation factor (VIF) score for all models is 2.11, well below the recommended threshold. Jaccard and Turrisi (2003) identify two conditions that indicate an interaction effect: significant increase of R^2 when the interaction term is added to the model and statistical significance of the β-coefficient of the interaction term.

The results in Tables 6 and 7 indicate partial support for the set of hypotheses. Regarding the main effects of supplier integration activities, we find that only supplier involvement in NPD has a positive significant effect on efficiency, supporting H2a. Associations of supplier development and operational coordination with efficiency are not significant, while the effect of e-information integration on efficiency is significant but negative, thus rejecting H1a, H3a and H4a. Similarly, only supplier involvement in NPD is significantly and positively associated with innovation (H2b). All the other hypotheses describing the main effects of integration on innovation (i.e., H1b, H3b and H4b) are not supported. Interestingly, the main effect of supply base concentration is also not significant in either the efficiency or the innovation regressions.

Looking to the interaction effect hypotheses, the results indicate that supply base concentration significantly affects the relationships between supplier development and both efficiency (H5a) and innovation (H5b), between supplier involvement in NPD and efficiency (H6a), between operational coordination and both efficiency (H7a) and innovation (H7b), and between e-information integration and efficiency (H8a – marginally significant). The results provide no support for contingency effects of supply base concentration on the relationships between supplier involvement in NPD and innovation (H6b) and between e-information integration and innovation (H8b). Table 8 summarizes these results and associated support for hypotheses.

Following the suggestions of Jaccard and Turrisi (2003), we also calculate the marginal effect of each supplier integration dimension on both efficiency and innovation using Equation (1):

$$\frac{\partial Y}{\partial X} = \beta_1 + \beta_3 Z \tag{1}$$

TABLE 6 Regression analysis results for efficiency (unstandardized coefficients)

	Control variables	Main effects	Interaction effects			
	Model 0	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Constant	2.84**	2.91**	2.84**	2.86**	2.85**	2.88**
Electronics	−0.14	−0.10	−0.12	−0.11	−0.11	−0.10
Machinery	−0.15+	−0.12	−0.13	−0.13	−0.14+	−0.13
Asia	0.38**	0.33**	0.34**	0.33**	0.33**	0.33**
America	0.21*	0.18+	0.18+	0.17	0.16	0.19+
Firm size	0.07*	0.06+	0.07*	0.07*	0.07*	0.07*
Purch. dep. Size	−0.01	0.00	0.01	−0.01	−0.01	0.00
Investments in R&D	0.20**	0.20**	0.19**	0.19**	0.20**	0.20**
Supplier selection	0.20**	0.12+	0.09	0.11	0.09	0.10
DEV		0.07	0.13+	0.08	0.09	0.09
INV		0.10*	0.10*	0.11*	0.09+	0.10*
OPC		0.08	0.07	0.07	0.08	0.07
EII		−0.10*	−0.10*	−0.10*	−0.11**	−0.10*
SBC		0.01	0.00	−0.02	0.02	0.00
DEVxSBC			0.24**			
INVxSBC				0.13*		
OPCxSBC					0.11*	
EIIxSBC						0.09+
R^2	0.25	0.28	0.31	0.29	0.29	0.29
ΔR^2	–	0.03	0.03	0.01	0.01	0.01
F change	12.78**	2.62*	14.64**	4.65*	5.37*	3.64+

$^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$.

TABLE 7 Regression analysis results for innovation (unstandardized coefficients)

	Control variables	Main effects	Interaction effects			
	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	3.58**	3.62**	3.55**	3.58**	3.53**	3.60**
Electronics	−0.17+	−0.17	−0.20+	−0.18+	−0.18+	−0.17
Machinery	−0.27**	−0.23*	−0.24*	−0.24*	−0.26*	−0.24*
Asia	−0.01	−0.03	−0.03	−0.03	−0.04	−0.04
America	0.13	0.13	0.13	0.13	0.11	0.14
Firm size	0.01	0.01	0.02	0.01	0.02	0.01
Purch. dep. Size	−0.04	−0.03	−0.03	−0.04	−0.04	−0.03
Investments in R&D	0.24**	0.22**	0.21**	0.21**	0.22**	0.22**
Supplier selection	0.23**	0.14	0.10	0.13	0.09	0.12
DEV		0.05	0.11	0.06	0.08	0.07
INV		0.10+	0.09	0.11+	0.08	0.09
OPC		−0.02	−0.03	−0.02	−0.02	−0.02
EII		0.02	0.03	0.02	0.01	0.02
SBC		0.09	0.07	0.06	0.09	0.08
DEVxSBC			0.27**			
INVxSBC				0.12		
OPCxSBC					0.18**	
EIIxSBC						0.06
R^2	0.15	0.17	0.20	0.18	0.19	0.17
ΔR^2	0.15	0.02	0.03	0.01	0.02	0.00
F change	6.94**	1.43	11.70**	2.25	8.86**	1.31

$^+p < .10$; $^*p < .05$; $^{**}p < .01$.

where *Y* represents the dependent variable (performance), *X* is the independent variable (supplier integration), and *Z* is the contingent factor (supply base concentration). The significance of the marginal effect depends on the standard error of the right side of Equation 1 that is function of the contingent factor, supply base concentration. Using t-tests, we identified the range of supply base concentration values where the marginal effect is significant at 0.05 level. This information aids interpretation of the impacts of supplier integration activities on efficiency and innovation at different supply base concentration levels (see Figure 2). As suggested by Cohen and Cohen (1983), we plot this impact at two levels: one standard deviation above and below the mean score of supply base concentration ('high SBC' and 'low SBC'), respectively. Panels 1–3 of Figure 2 show that, when SBC is high, the positive effect of each respective type of supplier integration on efficiency and innovation is amplified (i.e., complementary effect). When SBC is low, the benefits of supplier integration are nullified and, in some cases, even nominally negative (i.e., barrier effect). According to Jaccard and Turrisi (2003), this situation can be classified as 'crossover interaction'.

These interesting results generally suggest that increasing levels of supplier integration activities are beneficial when the buying company manages a concentrated supply base. Integration efforts appear to produce little benefit to either efficiency or innovation when the firm manages a larger, less-concentrated, supply base. In fact, increasing operational coordination appears to be harmful to innovation, and increasing e-information integration appears to be harmful to efficiency, when supply bases are less concentrated. These findings stress the importance of ensuring a proper fit between supplier integration regimes and supply base design.

Endogeneity

As highlighted by many authors (Lu et al., 2018; Zaefarian et al., 2017), our estimation of the hypothesized effects may be threatened by endogeneity. Two primary causes of endogeneity include: (a) omitted variables that affect the dependent variable and are also correlated with one or more independent variables, thus creating a bias in the

TABLE 8 Summary of the results

Hypothesis		Results
H1a	DEV → EFF (+)	Not supported (nonsignificant term)
H1b	DEV → INN (+)	Not supported (nonsignificant term)
H2a	INV → EFF (+)	Supported
H2b	INV → INN (+)	Supported
H3a	OPC → EFF (+)	Not supported (nonsignificant term)
H3b	OPC → INN (+)	Not supported (nonsignificant term)
H4a	EII → EFF (+)	Not supported (significant term but negative sign)
H4b	EII → INN (+)	Not supported (nonsignificant term)
H5a	DEV x SBC → EFF (+)	Supported
H5b	DEV x SBC → INN (+)	Supported
H6a	INV x SBC → EFF (+)	Supported
H6b	INV x SBC → INN (+)	Not supported (nonsignificant interaction term)
H7a	OPC x SBC → EFF (+)	Supported
H7b	OPC x SBC → INN (+)	Supported
H8a	EII x SBC → EFF (+)	Supported
H8b	EII x SBC → INN (+)	Not supported (nonsignificant interaction term)

estimated coefficients; (b) simultaneous causality, that occurs when the dependent and one or more independent variables cause each other (Wooldridge, 2002).

We reduce the potential influences of endogeneity in two ways. First, we include an extensive set of control variables to reduce the likelihood of omitted variables bias. Second, as suggested by Lu et al. (2018), we conduct a two-stage least square (2SLS) regression analysis based on the use of proper instrumental variables. In doing this, we focus on the three relationships found to be significant in the previous analysis (i.e., between supplier involvement in NPD and efficiency, between supplier involvement in NPD and innovation, and between e-information integration and efficiency). To select appropriate instrumental variables (reported in Table 9), we apply an iterative procedure starting from a set of theoretically relevant instruments (Lu et al., 2018). We then estimate the 2SLS regression using the variables indicated in Table 9, which vary according to the relationships considered. We use the Wu–Hausman test to check that instrumental variables are not correlated with the error term and the Stock-Yogo test to assess their relevance. As the table shows, the former tests are not significant in all the cases, suggesting exogeneity of the instrumental variables; the latter tests instead present first stage F-statistics that always exceed the suggested thresholds, indicating high quality and relevance of the selected instrumental variables. Based on these results, we conclude that endogeneity is not a concern for our research.

DISCUSSION

This study provides several contributions and novel insights to supplier integration research. With a few exceptions, supply base concentration seems to play a central role in strengthening the benefits of several types of supplier integration, as suggested by SET. Our study is the first to evaluate such a relationship using a large, globally dispersed, sample of companies, though Vanpoucke et al. (2014) and Golini and Kalchschmidt (2015) study similar effects. Vanpoucke et al. (2014) propose a "supplier integrative capabilities" construct reflecting different supplier integration activities; they show that its impacts on cost efficiency and process flexibility are weakened as the number of key suppliers increases. Golini and Kalchschmidt (2015) find that supply management activities, including both operational and strategic supplier integration practices, are associated with lowered inventories only when the number of suppliers is limited. Our study extends these results and provides several original contributions to the supplier integration research by including innovation as an additional dependent variable and by distinguishing the effects of different supplier integration dimensions and grounding our expectations in SET.

Overall, the research findings are partially consistent with the literature and the developed hypotheses, yet with a few interesting surprises. The results suggest that some supplier integration types improve performance *only* under higher levels of supply base concentration, while the effects of other supplier integration types are not significant at all, or their effects vary according to the type of performance considered. Thus, our findings point to a more nuanced understanding of the ways that supplier integration activities contribute to the efficiency and innovation of a buyer firm.

The results confirm the hypothesis for positive effects of supplier involvement in NPD on operational efficiency, supporting the views of Ragatz et al. (2002) and Salvador and Villena (2013). Our research further shows that these positive effects are strengthened when the supply base is more concentrated (see Panel 2a in Figure 2). We interpret this finding to suggest that it is possible through increased dependence and commitment to reduce not only the risks of opportunistic supplier behavior described by Salvador and Villena (2013), but also the management

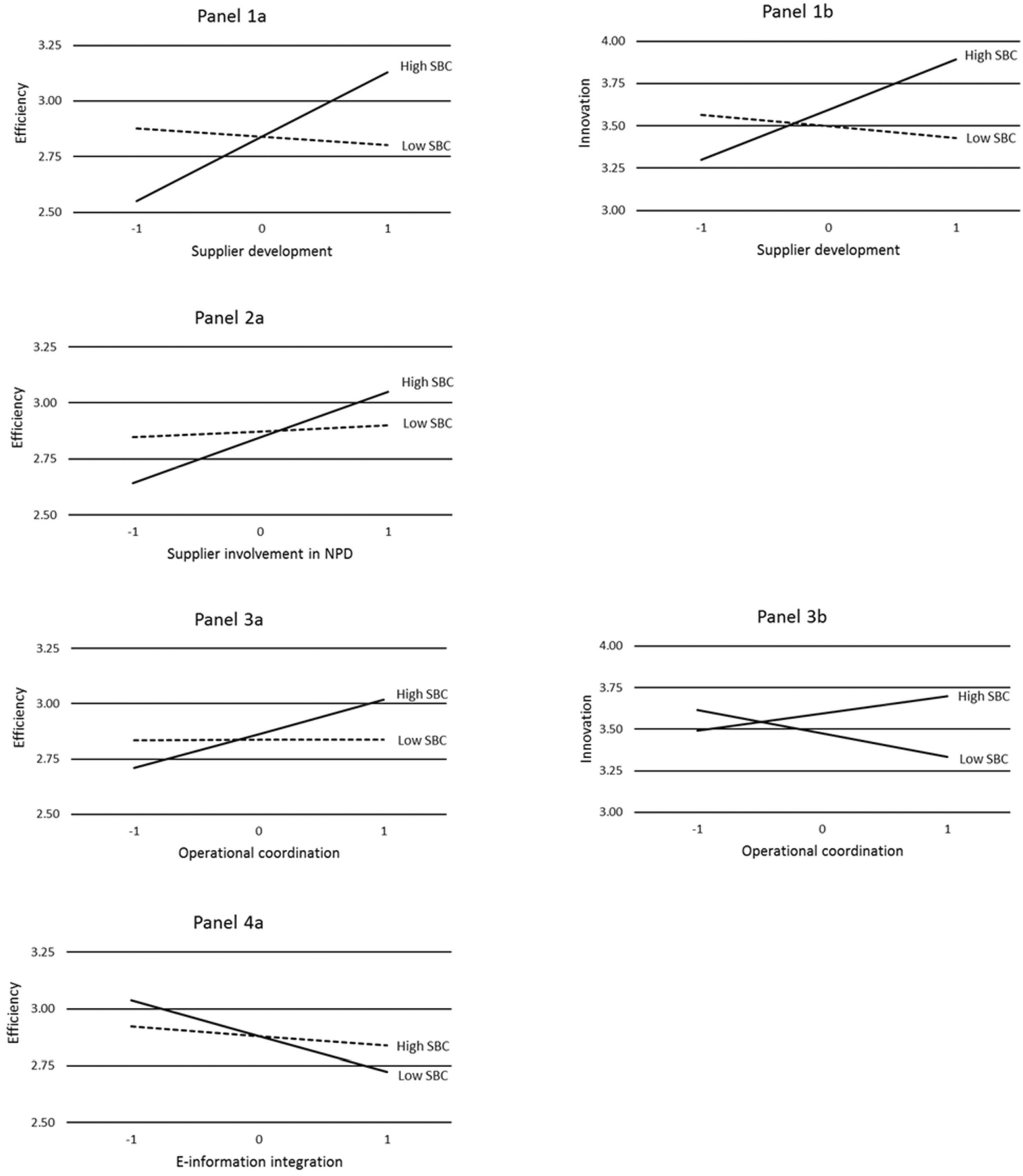

FIGURE 2 Efficiency and innovation slopes at low and high levels of SBC (only significant interactions). Note: Dotted lines indicate that the marginal effect (curve slope) is not significant at 0.05 level

costs required to guarantee collaboration and information sharing with suppliers. This result is coherent with the arguments found in SET; key SET variables such as trust, commitment and reciprocity strengthen the relevance of the relationship and enhance its effectiveness.

For supplier development and operational coordination with suppliers, the results indicate significant positive effects on efficiency *only* when supply bases are more concentrated. These findings are consistent with arguments that efficiency can be improved through supplier

TABLE 9 Endogeneity analysis

Dependent variable	Efficiency	Innovation	Efficiency
Potential endogenous variable	INV	INV	EII
Instrumental variables[a]	Team rewards, Design for quality	Team rewards, Strategic Implications of Supply Chain Management	Attitude toward teamwork, Supply chain applications
Independent variables	DEV, OPC, EII, SBC, all control variables	DEV, OPC, EII, SBC, all control variables	DEV, INV, OPC, SBC, all control variables
Wu–Hausman	1.06 ($p = .30$)	1.69 ($p = .19$)	2.37 ($p = .13$)
Stock-Yogo	63.10 (threshold = 19.93)	21.29 (threshold = 19.93)	20.42 (threshold = 19.93)

[a]see the Appendix: Table A1 for a complete description of the instrumental variables.

development with fewer suppliers because the parties are more interdependent (Koufteros et al., 2007) and their coordination is simplified (Ateş et al., 2015), in line with the SET principles. Examples of supplier development programs implemented in concentrated supply bases are frequent in companies working in the automotive industry, such as Volkswagen, Honda, and Nissan. In a concentrated supply base, there are also fewer interfaces to be managed; thus, as underlined by Choi and Krause (2006), communicating with suppliers and coordinating operational activities with them is cheaper and easier, increasing the returns on efficiency improvement projects. The patterns revealed in Panels 1a and 3a of Figure 2 not only suggest that supplier integration increases efficiency when supply bases are concentrated, but, in absence of such a network structure (i.e., dispersed supply bases), attempts to develop suppliers or coordinate operations are ineffectual (the simple slopes for low SBC are not significantly different from zero). Future research should investigate the effect of supplier integration on efficiency when the supply base concentration is low in greater depth.

An interesting result related to efficiency is offered by e-information integration, as our findings indicate a significant negative main effect. Devaraj et al. (2007) discuss the lack of positive effects of e-business technologies, emphasizing that companies often lack the process maturity needed to leverage such capability. Writers outside the field of supplier integration have noted decreases in productivity, despite the growth of technological investments (Solow, 1987), describing a "productivity paradox" (Kim et al., 2015; Polák, 2017). The mismanagement of technological solutions has been widely discussed. For example, Polák (2017) claims that managers are easily influenced by transitory common beliefs that a certain technology is new and efficient. They thus make inappropriate investments in IT that lead to development of inefficient systems and the creation of slack instead of efficiency. Similarly, recent literature on digital supply chain governance claims that companies may be subject to unexpected adverse effects of digital transformation when it is implemented in inappropriate contexts (Barbieri et al., 2021). In particular, as highlighted by Faruquee et al. (2021), companies should not believe that that the introduction of information technologies is an alternative to the development of trust. Such technologies may facilitate trust among supply chain partners, but they do not replace it. In the context of supplier integration, companies belonging to our sample may have introduced e-business technologies to share information without developing proper organizational capabilities to process the information received, or without building strong interpersonal, trust-based relationships. It may also be that shared information leads to misunderstandings between partners. This possibility illustrates the need to complement information sharing with other collaborative practices. Finally, the effectiveness of such solutions can be limited by technological problems, like the difficulty of integrating e-business systems with existing legacy systems.

Interestingly, increased supply base concentration appears to lessen the negative efficiencies associated with e-information integration (see panel 4a, Figure 2); yet, this effect is only marginally significant. Such an effect is consistent with the notion that e-information integration creates the potential for increased management load, errors, and other inefficiencies that are increased with the number of suppliers attempted to be integrated into the system. The causes may be not only the relatively high costs of implementation of these technologies (Rabinovich et al., 2003) but also the difficulties that companies encounter in receiving, using, and communicating information with many different suppliers. These findings highlight an opportunity for future research to corroborate the results and provide additional information to explain them. Managers should also pay attention to technology-based integration initiatives, carefully considering the potential limitations as well as the benefits of mass collaboration (Chen et al., 2007).

As for innovation, supplier development and operational coordination with suppliers appear to produce positive benefits *only* when supply bases are more concentrated. On one hand, this confirms the logic conveyed by the innovation management literature on the need to rely on external knowledge sources to improve innovation (Leonidou et al., 2020; Patrucco et al., 2021). On the other hand, it warns that these external sources should not be too numerous to avoid losing the important contributions of the SET key principles. More practical explanations can also be applied.

Regarding supplier development activities, we suggest that lowered transactional loads, increased dependence, and deepened commitments resulting from more concentrated supply bases explain why supplier development is more successful in this context. In addition, following the logic of SET, a supplier that is properly supported by the buyer in its performance improvement may be more willing to return the favor, sharing its knowledge and innovative ideas in more concrete ways.

For operational coordination, the findings (see Panel 3b in Figure 2) indicate that the positive relationship with innovation becomes significantly negative when supply bases are large. A trade-off may be at work here. Knowledge gained through operational coordination efforts spills over into innovation efforts (Turkulainen & Swink, 2017). As the number of involved suppliers increases, the amount of feedback and ideas collected during interactions increases as well, but so does the potential to receive misaligned ideas and suggestions concerning new products. As the number of ideas and suggestions grows, it may also be possible for better ideas to get lost in the noise; it becomes more difficult and time consuming for the buyer to manage and internalize knowledge, with the risk of losing related benefits (Dong et al., 2020; Sharma et al., 2020).

A different finding emerges for supplier involvement in NPD, where the positive effect on innovation is not dependent on supply base concentration. The differences in operational and NPD integration effects may be due to the different ways in which the two integration activities improve innovation. We consider the effects of operational coordination on innovation to be less direct, where the buyer typically interfaces with suppliers in separate sessions and must thus manage them and the ideas collected independently. Supplier involvement in NPD likely produces more direct and intentional benefits to innovation. Moreover, the buyer may engage only selected suppliers from the overall supply base to create specific teams dedicated to specific NPD projects and involving representatives only from targeted suppliers. In this case, the data collection and transfer load are lessened, as partners work jointly on a common NPD project. In addition, buyer firms may also improve innovation when they go beyond the "trusted" supplier network to identify innovation opportunities, as suggested by the open innovation perspective (Patrucco et al., 2021). For example, Lewin et al. (2017) describe how Haier was able to introduce six radical product innovations in a span of only 6 years, four of which were proposed by suppliers and developed in collaboration with them. Elia et al. (2020) explain how Philips relies on a virtual brand community ('SPICE') where suppliers and investors can propose potential innovations to the company and discuss their ideas with it. Innovation is thus boosted thanks to the different and complementary knowledge, ideas, and resources provided in these open relationships.

Finally, the results show that the use of e-business technologies with suppliers does not improve innovation, even when supply bases are more concentrated. We can conclude that, although e-information integration can be used to share data on NPD plans and their execution, this does not produce tangible improvements in terms of product innovativeness or on-time new product launch. Probably, direct and face-to-face collaborative activities, like strategic or operational SI, are needed to improve this performance dimension.

Overall, our consideration of moderating influences of supply base concentration on supplier integration impacts confirms the logical arguments grounded in SET, while also identifying boundary conditions concerning the applicability of this theory in the supplier integration literature. Benefits derived from increased trust, commitment, and interdependence do not materialize for all supplier integration activities and performance outcomes, as indicated by the nonsignificant effects highlighted in Table 8. In particular, these benefits seem to be more related to the operational performance dimensions, such as efficiency, than for innovation. For instance, the creation of relational-atmosphere elements underlying SET through supply base concentration does not result into a broader innovation level when suppliers are involved in NPD projects. This level of specificity related to SET applications, according to our knowledge, is not adopted by prior studies addressing performance effects of supplier integration and, as such, represents an important theoretical contribution of this study.

Besides establishing complementarities between supplier integration activities and supply base concentration, our research findings support the importance of using a fine-grained approach to investigate the effects of supplier integration on performance. Indeed, our analysis demonstrates that different types of supplier integration have different effects on different performance outcomes, and that they interact with supply base concentration in different ways. For some supplier integration types, the effect on performance is strengthened by supply base concentration, for others it is enabled (i.e., they affect performance only when combined with concentration activities), and for still others, it is independent from supply base concentration. This understanding may help to resolve some of the contrasting findings found in previous research related to the supplier integration–performance link; by incorporating all the activities into a single construct, the specific characteristics and effects of the individual dimensions are lost.

Managerial implications

The results of this study offer guidance for managers who wish to improve efficiency and innovation, while also considering the pros and cons of supply base concentration. First, we find that different supplier integration activities offer differing levels of influence on efficiency and innovation. While supplier involvement in NPD seems to positively and consistently affect both performance dimensions, all the other integration activities need to be implemented in consideration of supply base choices. In addition, managers should be aware that integration can be costly; developing e-business technologies to share information with suppliers may even be counterproductive in efficiency terms.

Second, our results also show that, when combined with supply base concentration efforts, the majority of supplier integration activities become beneficial for both efficiency and innovation. Therefore, a proper supplier management strategy must include both practices (i.e., supplier integration and supply base concentration) and combine them coherently. This result is particularly important for firms looking for ways to reduce the risks of supply chain disruptions through a reorganization of the supplier base. Indeed, while it is true that a wider supply base may be a good solution to increase supply chain resilience, this choice negatively affects the efficacy of supplier integration practices, making them less effective. Companies that currently rely on few suppliers and obtain positive benefits from collaboration with them must be aware that growth in the supply base could alter trust and relationship parameters established with current suppliers. The choice of relying on additional supply sources could be viewed as a lack of trust. As a result, the risks and disadvantages of investing in supplier integration with a large supply base could emerge, and prior realized benefits of integration may diminish.

Overall, a final implication is that managers should make a choice when designing their supplier network. If they want to leverage supplier integration benefits, they should simultaneously implement supply base concentration practices. Otherwise, if they decide to guarantee continuity of supply by relying on a large supply base, they should lessen supplier integration activities and look for alternative ways to improve efficiency and innovation. The final choice must proceed from a proper evaluation of advantages and disadvantages of each option.

CONCLUSIONS

This research investigates the interaction between supplier integration and supply base concentration and its impact on efficiency and innovation, relying on the Social Exchange Theory. The findings show that consistency between supplier integration and supply base concentration decisions benefits performance. These two supply chain management practices produce complementary effects on efficiency and innovation and, for this reason, must be essential parts of a coherent strategy.

Researchers interested in extending this research should consider the limitations of the current study. First, it considers a limited set of operational performance measures. Companies may implement supplier integration initiatives not only to improve efficiency and innovation but also to be more responsive to customers' requirements or to improve customer service. Future research should thus consider additional performance indicators, including both operational and financial measures.

Other limitations concern the strategic dimensions of supplier integration included in the research. For supplier involvement in NPD, we only considered supplier process integration, a practice in which customers involve suppliers into their internal NPD processes; we neglected another possible form of integration in NPD, supplier product integration, in which suppliers directly assume the responsibility to develop parts or subassemblies (see Koufteros et al., 2005). Future research could address this latter dimension, investigating its interactions with supply base concentration. Similarly, supplier development could be further distinguished into different initiatives. It would be worth assessing if and how supply base concentration influences the effects of specific development initiatives on performance. It may be useful for managers to understand whether some supplier development practices are beneficial without concomitant concentration of the supply base.

This research focused on supply base concentration, but other variables likely exert contingency effects on supplier integration and thus deserve future research attention. In particular, researchers could create a construct of supply base complexity such as that conceptualized by Choi and Krause (2006), considering not only the size of the supply base, but also the relationship among suppliers and their heterogeneity. The collection of such data would be more difficult and require the involvement of suppliers' managers, besides the focal company's ones, but the research would be useful to understand how to properly design the supplier network to maximize supplier integration investments.

Finally, the research setting, which focuses on electronics, machinery, and transportation sectors, could limit the generalizability of the findings. Future research should thus expand the analysis including companies belonging to other industries.

ACKNOWLEDGMENT

Open Access Funding provided by Universita degli Studi di Udine within the CRUI-CARE Agreement.

ORCID

Margherita Molinaro https://orcid.org/0000-0003-2895-5573
Pamela Danese https://orcid.org/0000-0002-2355-575X

REFERENCES

Alfalla-Luque, R., Machuca, J. A., & Marin-Garcia, J. A. (2018). Triple-a and competitive advantage in supply chains: Empirical research in developed countries. *International Journal of Production Economics*, *203*, 48–61.

Ateş, M. A., Wynstra, F., & van Raaij, E. M. (2015). An exploratory analysis of the relationship between purchase category strategies and supply base structure. *Journal of Purchasing and Supply Management*, *21*(3), 204–219.

Bagozzi, R. P., Yi, Y., & Phillips, L. W. (1991). Assessing construct validity in organizational research. *Administrative Science Quarterly*, *36*(3), 421–458.

Barbieri, P., Ellram, L., Formentini, M., & Ries, J. M. (2021). Guest editorial. Emerging research and future pathways in digital supply chain governance. *International Journal of Operations & Production Management*, *41*(7), 1021–1034.

Benitez, J., Chen, Y., Teo, T. S., & Ajamieh, A. (2018). Evolution of the impact of e-business technology on operational competence and firm profitability: A panel data investigation. *Information & Management*, *55*(1), 120–130.

Birkie, S. E., & Trucco, P. (2020). Do not expect others do what you should! Supply chain complexity and mitigation of the ripple effect of disruptions. *International Journal of Logistics Management*, *31*(1), 123–144.

Boon-itt, S., & Wong, C. Y. (2011). The moderating effects of technological and demand uncertainties on the relationship between supply chain integration and customer delivery performance. *International Journal of Physical Distribution of Logistics Management*, *41*(3), 253–276.

Boyer, K. K., & Verma, R. (2000). Multiple raters in survey-based operations management research: A review and tutorial. *Production and Operations Management*, *9*(2), 128–140.

Caniato, F., & Größler, A. (2015). The moderating effect of product complexity on new product development and supply chain management integration. *Production Planning and Control*, *26*(16), 1306–1317.

Cannas, V. G., Gosling, J., Pero, M., & Rossi, T. (2019). Engineering and production decoupling configurations: An empirical study in the machinery industry. *International Journal of Production Economics*, *216*, 173–189.

Cassetta, E., Monarca, U., Dileo, I., Di Berardino, C., & Pini, M. (2020). The relationship between digital technologies and internationalisation. Evidence from Italian SMEs. *Industry and Innovation*, *27*(4), 311–339.

Chaudhuri, A., Boer, H., & Taran, Y. (2018). Supply chain integration, risk management and manufacturing flexibility. *International Journal of Operations and Production Management*, *38*(3), 690–712.

Chen, I. J., & Paulraj, A. (2004). Towards a theory of supply chain management: The constructs and measurements. *Journal of Operations Management*, *22*(2), 119–150.

Chen, M. C., Yang, T., & Li, H. C. (2007). Evaluating the supply chain performance of IT-based inter-enterprise collaboration. *Information & Management*, *44*(6), 524–534.

Choi, T. Y., & Krause, D. R. (2006). The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. *Journal of Operations Management*, *24*(5), 637–652.

Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences*. Lawrence Erlbaum.

Cousins, P. D. (1999). Supply base rationalisation: Myth or reality? *European Journal of Purchasing & Supply Management*, *5*(3–4), 143–155.

Curran, P. J., West, S. G., & Finch, J. F. (1996). The robustness of test statistics to non-normality and specification error in confirmatory factor analysis. *Psychological Methods*, *1*(1), 16–29.

da Silveira, G. J., & Cagliano, R. (2006). The relationship between interorganizational information systems and operations performance. *International Journal of Operations & Production Management*, *26*(3), 232–253.

Danese, P. (2013). Supplier integration and company performance: A configurational view. *Omega*, *41*(6), 1029–1041.

Danese, P., & Bortolotti, T. (2014). Supply chain integration patterns and operational performance: A plant-level survey-based analysis. *International Journal of Production Research*, *52*(23), 7062–7083.

Danese, P., Molinaro, M., & Romano, P. (2020). Investigating fit in supply chain integration: A systematic literature review on context, practices, performance links. *Journal of Purchasing and Supply Management*, *26*(5), 100634.

Danese, P., & Romano, P. (2011). Supply chain integration and efficiency performance: A study on the interactions between customer and supplier integration. *Supply Chain Management: An International Journal*, *16*(4), 220–230.

Danese, P., Romano, P., & Formentini, M. (2013). The impact of supply chain integration on responsiveness: The moderating effect of using an international supplier network. *Transportation Research Part E*, *49*(1), 125–140.

Devaraj, S., Krajewski, L., & Wei, J. C. (2007). Impact of eBusiness technologies on operational performance: The role of production information integration in the supply chain. *Journal of Operations Management*, *25*(6), 1199–1216.

Dong, Y., Skowronski, K., Song, S., Venkataraman, S., & Zou, F. (2020). Supply base innovation and firm financial performance. *Journal of Operations Management*, *66*, 768–796.

Elia, G., Petruzzelli, A. M., & Urbinati, A. (2020). Implementing open innovation through virtual brand communities: A case study analysis in the semiconductor industry. *Technological Forecasting and Social Change*, *155*, 119994.

Faruquee, M., Paulraj, A., & Irawan, C. A. (2021). Strategic supplier relationships and supply chain resilience: Is digital transformation that precludes trust beneficial? *International Journal of Operations & Production Management*, *41*(7), 1192–1219.

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance: A contingency and configuration approach. *Journal of Operations Management*, *28*(1), 58–71.

Garrido-Vega, P., Jimenez, C. H. O., & Morita, M. (2015). Implementation of technology and production strategy practices: Relationship levels in different industries. *International Journal of Production Economics*, *161*, 201–216.

Giannakis, M. (2008). Facilitating learning and knowledge transfer through supplier development. *Supply Chain Management: An International Journal*, *13*(1), 62–72.

Glavee-Geo, R. (2019). Does supplier development lead to supplier satisfaction and relationship continuation? *Journal of Purchasing and Supply Management*, *25*(3), 100537.

Golini, R., & Kalchschmidt, M. (2015). Managing inventories in global sourcing contexts: A contingency perspective. *International Journal of Production Economics*, *165*, 64–78.

Griffith, D. A., Harvey, M. G., & Lusch, R. F. (2006). Social exchange in supply chain relationships: The resulting benefits of procedural and distributive justice. *Journal of Operations Management*, *24*(2), 85–98.

Guo, W., Lu, W., Hao, L., & Gao, X. (2021). Interdependence and information exchange between conflicting parties: The role of interorganizational trust. *IEEE Transactions on Engineering Management*. https://doi.org/10.1109/TEM.2020.3047499

Hair, J. F., Jr., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis*. Prentice-Hall.

Jaccard, J., & Turrisi, R. (2003). *Interaction effect in multiple regression*. Sage.

Jajja, M. S. S., Kannan, V. R., Brah, S. A., & Hassan, S. Z. (2017). Linkages between firm innovation strategy, suppliers, product innovation, and business performance. *International Journal of Operations & Production Management*, *37*(8), 1054–1075.

Johnsen, T. E. (2009). Supplier involvement in new product development and innovation: Taking stock and looking to the future. *Journal of Purchasing and Supply Management*, *15*(3), 187–197.

Kannan, V. R., & Tan, K. C. (2006). Buyer-supplier relationships. *International Journal of Physical Distribution & Logistics Management*, *36*(10), 755–775.

Kim, G., Lin, W. T., & Simpson, N. C. (2015). Evaluating the performance of US manufacturing and service operations in the presence of IT: A Bayesian stochastic production frontier approach. *International Journal of Production Research*, *53*(18), 5500–5523.

Koufteros, X. A., Cheng, T. E., & Lai, K. H. (2007). "Black-box" and "gray-box" supplier integration in product development: Antecedents, consequences and the moderating role of firm size. *Journal of Operations Management*, *25*(4), 847–870.

Koufteros, X. A., Rawski, G. E., & Rupak, R. (2010). Organizational integration for product development: The effects on glitches, on-time execution of engineering change orders, and market success. *Decision Sciences*, *41*(1), 49–80.

Koufteros, X. A., Vonderembse, M., & Jayaram, J. (2005). Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy. *Decision Sciences*, *36*(1), 97–133.

Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review*, *61*(5), 109–117.

Krause, D. R., Handfield, R. B., & Tyler, B. B. (2007). The relationships between supplier development, commitment, social capital accumulation and performance improvement. *Journal of Operations Management*, *25*(2), 528–545.

Leal, R., Barreiros, F. M., Alves, L., Romeiro, F., Vasco, J. C., Santos, M., & Marto, C. (2017). Additive manufacturing tooling for the automotive industry. *The International Journal of Advanced Manufacturing Technology*, *92*(5), 1671–1676.

Leonidou, E., Christofi, M., Vrontis, D., & Thrassou, A. (2020). An integrative framework of stakeholder engagement for innovation management and entrepreneurship development. *Journal of Business Research*, *119*, 245–258.

Leuschner, R., Rogers, D. S., & Charvet, F. F. (2013). A meta-analysis of supply chain integration and firm performance. *Journal of Supply Chain Management*, *49*(2), 34–57.

Lewin, A. Y., Välikangas, L., & Chen, J. (2017). Enabling open innovation: Lessons from Haier. *International Journal of Innovation Studies*, *1*(1), 5–19.

Li, W., Humphreys, P. K., Yeung, A. C., & Cheng, T. C. E. (2007). The impact of specific supplier development efforts on buyer competitive advantage: An empirical model. *International Journal of Production Economics*, *106*(1), 230–247.

Li, W., Humphreys, P. K., Yeung, A. C., & Cheng, T. C. E. (2012). The impact of supplier development on buyer competitive advantage: A path analytic model. *International Journal of Production Economics*, *135*(1), 353–366.

Liu, H., Ke, W., Wei, K. K., & Hua, Z. (2013). Effects of supply chain integration and market orientation on firm performance: Evidence from China. *International Journal of Operations & Production Management*, *33*(3), 322–346.

Lo, S. M., Zhang, S., Wang, Z., & Zhao, X. (2018). The impact of relationship quality and supplier development on green supply chain integration: A mediation and moderation analysis. *Journal of Cleaner Production*, *202*, 524–535.

Lu, G., Ding, X. D., Peng, D. X., & Chuang, H. H. C. (2018). Addressing endogeneity in operations management research: Recent developments, common problems, and directions for future research. *Journal of Operations Management*, *64*, 53–64.

Lu, G., & Shang, G. (2017). Impact of supply base structural complexity on financial performance: Roles of visible and not-so-visible characteristics. *Journal of Operations Management*, *53*, 23–44.

Luu, T. (2017). Market responsiveness: Antecedents and the moderating role of external supply chain integration. *Journal of Business & Industrial Marketing*, *32*(1), 30–45.

Mackelprang, A. W., Robinson, J. L., Bernardes, E., & Webb, G. S. (2014). The relationship between strategic supply chain integration and performance: A meta-analytic evaluation and implications for supply chain management research. *Journal of Business Logistics*, *35*(1), 71–96.

Merminod, V., Le Dain, M. A., & Frank, A. G. (2022). Managing glitches in collaborative product development with suppliers. *Supply Chain Management: An International Journal*, *27*(3), 348–368.

Narasimhan, R., Nair, A., Griffith, D. A., Arlbjørn, J. S., & Bendoly, E. (2009). Lock-in situations in supply chains: A social exchange theoretic study of sourcing arrangements in buyer–supplier relationships. *Journal of Operations Management*, *27*(5), 374–389.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory*. McGraw-Hill.

Oh, J., Lee, S., & Yang, J. (2015). A collaboration model for new product development through the integration of PLM and SCM in the electronics industry. *Computers in Industry*, *73*, 82–92.

Parker, H. (2012). Knowledge acquisition and leakage in inter-firm relationships involving new technology-based firms. *Management Decision*, *50*(9), 1618–1633.

Parker, H., & Brey, Z. (2015). Collaboration costs and new product development performance. *Journal of Business Research*, *68*(7), 1653–1656.

Patrucco, A., Frattini, F., & Di Benedetto, A. (2021). Characteristics of supplier performance measurement systems in collaborative innovation projects: The role of the purchasing department. *Supply Chain Management: An International Journal*, *27*(2), 207–231. https://doi.org/10.1108/SCM-11-2020-0551

Patrucco, A. S., Luzzini, D., & Ronchi, S. (2017). Achieving innovation through supplier collaboration: The role of the purchasing interface. *Business Process Management Journal*, *23*(6), 1463–1754.

Paulraj, A., & Chen, I. J. (2005). Strategic supply management and dyadic quality performance: A path analytical model. *Journal of Supply Chain Management*, *41*(3), 4–18.

Peng, D. X., Heim, G. R., & Mallick, D. N. (2014). Collaborative product development: The effect of project complexity on the use of information technology tools and new product development practices. *Production and Operations Management*, *23*(8), 1421–1438.

Peng, D. X., Verghese, A., Shah, R., & Schroeder, R. G. (2013). The relationships between external integration and plant improvement and innovation capabilities: The moderation effect of product clockspeed. *Journal of Supply Chain Management*, *49*(3), 3–24.

Perols, J., Zimmermann, C., & Kortmann, S. (2013). On the relationship between supplier integration and time-to-market. *Journal of Operations Management*, *31*(3), 153–167.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2003). A model of supplier integration into new product development. *Journal of Product Innovation Management*, *20*(4), 284–299.

Polák, P. (2017). The productivity paradox: A meta-analysis. *Information Economics and Policy*, *38*, 38–54.

Prajogo, D., Oke, A., & Olhager, J. (2016). Supply chain processes: Linking supply logistics integration, supply performance, lean processes and competitive performance. *International Journal of Operations & Production Management*, *36*(2), 220–238.

Prajogo, D., & Olhager, J. (2012). Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. *International Journal of Production Economics*, *135*(1), 514–522.

Rabinovich, E., Bailey, J. P., & Carter, C. R. (2003). A transaction-efficiency analysis of an internet retailing supply chain in the music CD industry. *Decision Sciences*, *34*(1), 131–172.

Ragatz, G. L., Handfield, R. B., & Petersen, K. J. (2002). Benefits associated with supplier integration into new product development under conditions of technology uncertainty. *Journal of Business Research*, *55*(5), 389–400.

Salvador, F., & Villena, V. H. (2013). Supplier integration and NPD outcomes: Conditional moderation effects of modular design competence. *Journal of Supply Chain Management*, *49*(1), 87–113.

Sanders Jones, L., & Linderman, K. (2014). Process management, innovation and efficiency performance: The moderating effect of competitive intensity. *Business Process Management Journal*, *20*(2), 335–358.

Sanders, N. R. (2007). An empirical study of the impact of e-business technologies on organizational collaboration and performance. *Journal of Operations Management*, *25*(6), 1332–1347.

Sanders, N. R. (2008). Pattern of information technology use: The impact on buyer–suppler coordination and performance. *Journal of Operations Management*, *26*(3), 349–367.

Sarkar, A., & Mohapatra, P. K. (2006). Evaluation of supplier capability and performance: A method for supply base reduction. *Journal of Purchasing and Supply Management*, *12*(3), 148–163.

Schoenherr, T., & Swink, M. (2015). The roles of supply chain intelligence and adaptability in new product launch success. *Decision Sciences*, *46*(5), 901–936.

Schroeder, R. G., & Flynn, B. B. (2002). *High performance manufacturing: Global perspectives*. John Wiley & Sons.

Servajean-Hilst, R., Donada, C., & BenMahmoud-Jouini, S. (2021). Vertical innovation partnerships and relational performance: The mediating role of trust, interdependence, and familiarity. *Industrial Marketing Management*, *97*, 84–96.

Sharma, A., Pathak, S., Borah, S. B., & Adhikary, A. (2020). Is it too complex? The curious case of supply network complexity and focal firm innovation. *Journal of Operations Management*, *66*, 839–865.

Shee, H., Miah, S. J., Fairfield, L., & Pujawan, N. (2018). The impact of cloud-enabled process integration on supply chain performance and firm sustainability: The moderating role of top management. *Supply Chain Management: An International Journal*, *23*(6), 500–517.

Shou, Y., Hu, W., Kang, M., Li, Y., & Park, Y. W. (2018). Risk management and firm performance: The moderating role of supplier integration. *Industrial Management & Data System*, *118*(7), 1327–1344.

Solow, R. M. (1987). We'd better watch out. *New York Times Book Review*, *36*, 36.

Song, Y., Cai, J., & Feng, T. (2017). The influence of green supply chain integration on firm performance: A contingency and configuration perspective. *Sustainability*, *9*(5), 763.

Su, H. C., Chen, Y. S., & Kao, T. W. (2018). Enhancing supplier development: An efficiency perspective. *Journal of Business Logistics*, *39*(4), 248–266.

Suurmond, R., Wynstra, F., & Dul, J. (2020). Unraveling the dimensions of supplier involvement and their effects on NPD performance: A meta-analysis. *Journal of Supply Chain Management*, *56*(3), 26–46.

Swink, M., Narasimhan, R., & Wang, C. (2007). Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance. *Journal of Operations Management*, *25*(1), 148–164.

Swink, M., & Zsidisin, G. (2006). On the benefits and risks of focused commitment to suppliers. *International Journal of Production Research*, *44*(20), 4223–4240.

Thompson, J. D. (1967). *Organizations in action*. McGraw-Hill.

Turkulainen, V., Kauppi, K., & Nermes, E. (2017). Institutional explanations: Missing link in operations management? Insights on supplier integration. *International Journal of Operations & Production Management*, *37*(8), 1117–1140.

Turkulainen, V., & Swink, M. L. (2017). Supply chain personnel as knowledge resources for innovation—A contingency view. *Journal of Supply Chain Management*, *53*(3), 41–59.

van Hoek, R. (2020). Research opportunities for a more resilient post-COVID-19 supply chain–closing the gap between research findings and industry practice. *International Journal of Operations & Production Management*, *40*(4), 341–355.

Vanpoucke, E., Vereecke, A., & Wetzels, M. (2014). Developing supplier integration capabilities for sustainable competitive advantage: A dynamic capabilities approach. *Journal of Operations Management*, *32*(7–8), 446–461.

von Haartman, R., & Bengtsson, L. (2015). The impact of global purchasing and supplier integration on product innovation. *International Journal of Operations & Production Management*, *35*(9), 1295–1311.

Wagner, S. M. (2011). Supplier development and the relationship life-cycle. *International Journal of Production Economics*, *129*(2), 277–283.

Wiedmer, R., Rogers, Z. S., Polyviou, M., Mena, C., & Chae, S. (2021). The dark and bright sides of complexity: A dual perspective on supply network resilience. *Journal of Business Logistics*, *42*(3), 336–359. https://doi.org/10.1111/jbl.12264

Wiengarten, F., Humphreys, P., Gimenez, C., & McIvor, R. (2016). Risk, risk management practices, and the success of supply chain integration. *International Journal of Production Economics*, *171*(3), 361–370.

Wiengarten, F., Humphreys, P., McKittrick, A., & Fynes, B. (2013). Investigating the impact of e-business applications on supply chain collaboration in the German automotive industry. *International Journal of Operations & Production Management*, *33*(1), 25–48.

Wong, C. W., Sancha, C., & Thomsen, C. G. (2017). A national culture perspective in the efficacy of supply chain integration practices. *International Journal of Production Economics*, *193*, 554–565.

Wong, C. W. Y., Lai, K., & Bernroider, E. W. N. (2015). The performance of contingencies of supply chain information integration: The roles of product and market complexity. *International Journal of Production Economics*, *165*, 1–11.

Wong, C. Y., Boon-itt, S., & Wong, C. W. Y. (2011). The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance. *Journal of Operations Management*, *29*(6), 604–615.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. MIT Press.

Wu, F., Mahajan, V., & Balasubramanian, S. (2003). An analysis of e-business adoption and its impact on business performance. *Journal of the Academy of Marketing Science*, *31*(4), 425–447.

Wu, L., Chuang, C. H., & Hsu, C. H. (2014). Information sharing and collaborative behaviors in enabling supply chain performance: A social exchange perspective. *International Journal of Production Economics*, *148*, 122–132.

Yang, J., Wang, J., Wong, C. W., & Lai, K. H. (2008). Relational stability and alliance performance in supply chain. *Omega*, *36*(4), 600–608.

Zaefarian, G., Kadile, V., Henneberg, S. C., & Leischnig, A. (2017). Endogeneity bias in marketing research: Problem, causes and remedies. *Industrial Marketing Management*, *65*, 39–46.

Zhang, M., Lettice, F., Chan, H. K., & Nguyen, H. T. (2018). Supplier integration and firm performance: The moderating effects of internal integration and trust. *Production Planning & Control*, *29*(10), 802–813.

AUTHOR BIOGRAPHIES

Margherita Molinaro is Research Fellow and Lecturer at the University of Udine (Italy). She graduated in Management Engineering and holds PhD in Industrial and Information Engineering from the University of Udine. Her research interests include the areas of Industry 4.0, supply chain management and sustainability. She has published in several academic journals, including *International Journal of Production Research* and *Journal of Purchasing and Supply Management*.

Pamela Danese is Full Professor of Operations & Supply Chain Management at University of Padova, Italy. She is coordinator of the EDEN Doctoral Seminar on Research Methodology in Operations Management. She is Associate Editor of International Journal of Operations and Production Management, and a member of the Editorial Review Board of Journal of Operations Management. She was a member of the European Operations Management Association (EurOMA) board and chair of EurOMA communication team. She is Director of the Master in Lean Management of Fondazione CUOA, Italy. Her research interests focus on lean management and supply chain management. She has published in several prestigious journals.

Pietro Romano is Full Professor of Supply Chain Management and New Product Development at the University of Udine (Italy). He graduated in Management and Engineering and completed his PhD in Operations and Supply Chain Management at the University of Padova. He is Director of the Master in Coffee Science and Economics at Illy Academy and of the Executive Master in Operations and Supply Chain Management at CUOA Business School. He is involved in several research projects on lean- and supply chain management-related topics and is author of more than 120 publications.

Morgan Swink is the Eunice and James L. West Chaired Professor of Supply Chain Management, and the Executive Director of the Center for Supply Chain Innovation at Texas Christian University. He is the former Co-Editor in Chief for the Journal of Operations Management, and he continues to serve in consulting and associate editor roles for several top journals. He is a Fellow and past president of the Decision Sciences Institute. Dr. Swink has co-authored two supply chain operations textbooks, one managerial book on supply chain excellence, and more than 90 articles in a variety of academic and managerial journals.

How to cite this article: Molinaro, M., Danese, P., Romano, P., & Swink, M. (2022). Implementing supplier integration practices to improve performance: The contingency effects of supply base concentration. *Journal of Business Logistics*, *00*, 1–26. https://doi.org/10.1111/jbl.12316

APPENDIX

TABLE A1 Instrumental variables description

Instrumental variables	Items
Team rewards[a] (Cronbach's α = 0.93)	Members of new product development teams are rewarded for accomplishing project goals
	When our new product development teams meet project goals, they will be rewarded
	When a new product development project is completed, rewards are received by the team
	Our reward system is aligned with the new product development goals
Design for quality[a] (Cronbach's α = 0.78)	New products are thoroughly reviewed before they are produced and marketed
	Departments work in a coordinated manner in the product development process
	The quality of new products is emphasized, compared with other objectives, such as cost or schedule
	Product specifications and procedures for new products are clear
	Implementation and producibility are considered in the product design process
	Sales, customer service, marketing, and public relations personnel emphasize quality of new products
Strategic Implications of Supply Chain Management[b] (Cronbach's α = 0.71)	We view the reduction of process lead time (cycle time) to reduce in-process inventory as a key to effective supply chain management
	We can determine the appropriate level of total in-process inventory, based on our knowledge of cycle time throughout processes, given demand forecasts
	We understand the effect of quality conformance, process throughput variability and demand variability on delivery and cost performance, and take them into account when new strategic initiatives are being planned
	We consider factors such as delivery lead time, technological significance, quality and cost when we make make-or-buy decisions
	We believe a supply chain's purpose is not only to move products to where they need to be, but is also a tool to enhance key outcomes by gaining advantages over rivals
	Our concept of inventory cost in managing supply chains includes the cost of obsolescence
Attitude toward teamwork[b]	Our supervisors encourage the people who work for them to work as a team
Supply chain applications[c]	The following applications communicate in real time: Supply chain applications with internal application within our organization (such as enterprise resource planning)

[a]Questionnaire: product development. Possible respondents: product development manager, product engineer, product designer.

[b]Questionnaire: plant management. Possible respondents: plant manager, president, chief operating officer.

[c]Questionnaire: information system management. Possible respondents: information system manager, chief information officer.