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Translating front-end supplier involvement orientation into firm innovation capability: The mediating role of outward-looking organizational practices

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ABSTRACT

In recent years, supplier involvement in the innovation processes of focal firms has evolved from a minor activity into a major element of company strategy. There has been a steady increase in supplier responsibility for development, leading to a shift in the supply base from purely delivering products to providing unmatched expertise from the very beginning. We regard this phenomenon as the motive force behind our study. Our aim is to investigate the consequent effects of orienting towards supplier involvement in the fuzzy front end (FFE), as well as purchasing and supply management (PSM) practices, on a focal firm's innovation capability. We drew on the capability-based transactions theory, which looks at bounded innovation capabilities that are complemented by transactions. Data from 206 automotive firms and structural equation modeling (SEM) show that supplier involvement orientation in the FFE has a stronger positive impact on incremental innovation capability. In addition, we find significant effects regarding several PSM practices. Cooperation with non-value-chain partners supports both radical and incremental innovation. More PSM practices positively affect radical innovation – for example, early purchasing involvement and non-monetary incentives. The results generate advances for the capability-based transactions theory. For scholars, the differences between radical and incremental innovation capabilities are of interest while, for practitioners, the selection of good PSM practices in the FFE is an important concern.

1. Introduction

In today's global competitive environment, firms are being challenged to develop product innovations not only quickly but also economically, whilst simultaneously ensuring greater novelty and customer benefit (Stephan et al., 2019). In particular, the automotive industry has been undergoing a major upheaval in recent years due to digital transformation (Llopis-Albert et al., 2021; Sommer et al., 2021). Digitalization has brought about changes in automotive companies' business models (Riasanow et al., 2017) and has affected products, services, and product development processes (Sommer et al., 2021). The changes include platforms for mobility service or used car retailing, virtual car showrooms, robo-taxis, automotive hardware/software architecture design, and simulation-based, prototype-free development (Riasanow et al., 2017; Winkelhake, 2025). The need for innovation in new

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technological fields, such as e-mobility and autonomous driving, exerts pressure on firms and opens doors for new competitors, such as Tesla, BYD (Build Your Dreams), Waymo, and Cruise of General Motor (Möller et al., 2019). The new manufacturers driving radical innovation use an early approach to the automotive industry characterized by vertical integration, internal control of components, internal R&D, and a limited number of suppliers (MacDuffie, 2018). On the other hand, original equipment manufacturers (OEMs) act as system integrators. Given this innovation pressure, the use of external knowledge sources for new product development (NPD) – in particular, hardware and software expertise – has become increasingly important for automotive incumbents (MacDuffie, 2018; Homfeldt et al., 2019).

Product development outsourcing, cooperation, and the search for external ideas are by no means new trends in the automotive industry (Geleilate et al., 2021), having been discussed in innovation management since the 1990s (Rothwell, 1992; Matthyssens and Van den Bulte, 1994; Niosi, 1999). Resources, knowledge, and capabilities are essential for firms and are the reasons they strive for external relations (Paswan and Panda, 2020). Recently, Nascimento and Zawislak (2023) explained that the cooperation of firms, given the boundedness or underdevelopment of technological and/or non-technological innovation capabilities, makes it necessary to complement these capabilities with external sources. Basically, the theory of capability-based transactions concerns two drivers – technology and business – and identifies four different types of innovation capabilities: technology development driving product innovation, operations driving process innovation, management driving managerial innovation, and transaction driving commercial innovation (Nascimento et al., 2024). Moreira et al. (2024, p. 325) identified cooperation, as well as "creativity, idea management, and innovation strategy" as the main dimensions of innovation capabilities.

With respect to potential partners, suppliers are listed as one of "[t]he most prominent partners for cooperation in the innovation process" (Weber and Heidenreich, 2018, p. 336). Nascimento et al. (2025) have shown that cooperative transactions have a greater impact on technological innovation capabilities (technology development and operations), while commercial transactions have a greater impact on non-technological innovation capabilities (management and transaction). Technical capabilities, in terms of keeping up to date with the latest developments in technology, enable suppliers to create technological innovation (LaBahn and Krapfel, 2000; Lawson et al., 2015; Pulles et al., 2014). Research has identified product development and manufacturing capabilities as key innovation capabilities, including the supplier's proficiency in defining production and material requirements and in specifying and fabricating components or sub-systems (Dowlatshahi, 1998; Koufteros et al., 2006; Suurmond et al., 2020). Furthermore, because they commonly maintain business relations with several focal firms, suppliers gather knowledge about the practices used in these firms, which they implicitly incorporate into their own development activities (Un and Asakawa, 2015). Due to a shift in both development tasks and knowledge from focal firms to suppliers (Geleilate et al., 2021), it is not surprising that firms have begun to expend increasing efforts on the effective management of supplier involvement in the fuzzy front end (FFE). Early supplier involvement and the use of supplier involvement practices are associated with an increase in innovative ideas and concepts (Suurmond et al., 2020). Here, we regard "FFE supplier involvement" as a cooperative interorganizational relationship aimed at strengthening technology development capability. We are interested in new and established routines concerning FFE supplier involvement and their relationship to the firm's radical and incremental innovation capability.

However, the impact of early supplier involvement as a general organizational practice on NPD performance is seen as having only a small significant direct effect on NPD speed (Suurmond et al., 2020). On the other hand, early supplier involvement is one of several strategic orientations that companies employ to facilitate innovation (Kumar et al., 2012). Strategic orientations can be viewed as alternative guiding principles with one or more orientations prevailing along the product development process (Hakala, 2011; Cheng and Huizingh, 2014). Deeply rooted in a firm's organizational routines (Gatignon and Xuereb, 1997; Cheng, 2020), these routines provide the framework for innovation activities (Cheng and Huizingh, 2014). In addition, the literature describes several activities relating to the interface between the focal firm and its suppliers that are termed purchasing and supply management (PSM) practices (Narasimhan and Das, 2001).

Furthermore, we consider the innovation type – radical or incremental – because the role of suppliers in generating these specific types has been investigated only sparsely (Wowak et al., 2016). Eling and Herstatt (2017) have called for further research into the underlying mechanisms between FFE activities and the generation of both radical and incremental innovation. In particular, the literature proposes that constitutive organizational components differ depending on the innovation type (Slater et al., 2014).

In our research, we aim to address the organizational level (Koufteros et al., 2012; Yeniyurt, et al., 2014) and corresponding routines, activities, and capabilities. The literature has conceptualized organizational practices as mediators that translate a firm's orientation into firm performance (Alani et al., 2019). We use survey data from 206 German automotive firms, structural equation modeling (SEM), and the theory of capability-based transactions (Nascimento and Zawislak, 2023). Our aim is to promote a better understanding of "how external knowledge accessed through interfirm transactions can influence […] innovation capabilities" (Nascimento and Zawislak, 2023, p. 1). Therefore, we investigate both the direct and indirect effects of supplier involvement orientation in the FFE on PSM practices and a firm's innovation capability. We propose the following research questions that guide our research: *(1) How is supplier involvement orientation in the FFE related to PSM practices? (2) What effect does supplier involvement orientation in the FFE have on a firm's radical and incremental innovation capability? (3) Which of the PSM practices that are subject to a firm's influence can mediate this relationship?*

We consider that innovation capability differs depending on the type of innovation (Esrig-Tena et al., 2021; Chen et al., 2020). In addition, we include more than the two to three PSM practices that are typically investigated in empirical studies (Foerstl et al., 2013). We include emerging PSM practices – for example, cooperating with new suppliers, such as startups (Aslesen and Freel, 2012; Knight et al., 2022) – to widen the knowledge base (Rodriguez et al., 2017). Besides, we include well-established methods to encourage supplier participation, knowledge sharing, and knowledge sourcing, such as advanced, method-based search practices for supplier ideas (Schiele, 2010), incentivizing suppliers (Pihlajamaa et al., 2019), and early involvement of purchasing (Picaud-Bello et al.,

2019).

In essence, our study contributes to the literature on early supplier integration and the theory of capability-based transactions and strategic orientation (Hakala, 2011; Lavie, 2006). Since the FFE phase has been recognized as crucial to the success of innovation projects (Kock et al., 2015), we aim to provide a better understanding of the governing factors through which supplier involvement orientation in the FFE contributes to a focal firm's ability to generate innovation. We advance the theory of capability-based transactions by considering the difference between radical and incremental technological innovation, which was not addressed by Nascimento and Zawislak (2023). Our results point to universally important PSM practices in the case of cooperation with non-value-chain partners. However, some constitutive organizational components differ depending on the innovation type, and radical innovation capability is affected more than incremental innovation capability.

We first begin with a review of strategic orientation and the potential knowledge and capabilities of suppliers. Relying on the theory of capability-based transactions, we discuss PSM practices for supplier involvement in the FFE as mediators. Accordingly, we have developed and tested a model that answers the research questions. Addressing these questions is important because it extends knowledge of the factors – specifically, PSM practices – that operate differently for radical and incremental innovation.

2. Theory and hypotheses development

Supplier involvement, purchasing and supply chain management, and their corresponding practices have been linked to the firm's resources (Barney, 2012; Zimmermann and Foerstl, 2014; Foerstl et al., 2016; Zimmermann et al., 2020). Since we focus on external supplier knowledge-based resources, the implementation of organizational (dynamic) capabilities to combine internal and external knowledge for innovation is important (Teece et al., 1997). To acquire knowledge, firms can employ different knowledge sourcing strategies (Lin and Wu, 2010), such as cooperation with suppliers. The term "cooperation" is defined as "the joint determination of common goals" in interorganizational relationships (Castañer and Oliveira, 2020, p. 988). The external resources can complement the focal firm's resources both positively and negatively (Lavie, 2006). The theory of capability-based transactions (Nascimento and Zawislak, 2023) describes external resources as complementary to the focal firm's technological development capability. Innovation capabilities can be bounded (missing or underdeveloped) due to the high costs of information, technically knowledgeable and experienced personnel, financial resources, and the development of routines (Nascimento and Zawislak, 2023). Therefore, bounded capabilities are characterized by the "*absence and underdevelopment of their elements*" (Nascimento and Zawislak, 2023, p. 3, italics in the original). The new, well-funded entrants in the automotive industry, such as Tesla (Perkins and Murmann, 2018), exploit internal innovation capabilities – especially for radical innovation – and make use of a small number of suppliers, who often play a peripheral role (MacDuffie, 2018). In contrast, automotive incumbents rely on product development outsourcing as a strategic choice in a competitive, fast-moving market environment (Parry and Roehrich, 2009). The boundedness of their innovation capabilities can be seen as the underlying reason for cooperation with other companies – for example, the development of supply chain relations. The establishment of strategies such as FFE supplier involvement is associated with improved innovation performance, which is derived from innovation capabilities (Nascimento and Zawislak, 2023).

The acquisition of external knowledge requires firms to invest in new management approaches, routines, practices, and structures (Bogers et al., 2019; Pihlajamaa, 2021). According to Barney (2012), heterogeneous PSM practices – both internal and external – are important and strategically relevant. For example, external PSM practices support cooperation and resource sharing across firm boundaries (Zimmermann and Foerstl, 2014). Capabilities consist of bundles of resources, such as specialist knowledge of individuals and organizational practices (Amit and Schoemaker, 1993; Foerstl et al., 2016). Short-term imitability is costly because PSM practices are firm-specific, have common key elements that develop over time, and are relation-specific (Mesquita et al., 2008; Dyer and Hatch, 2006).

Research argues for a dependence between strategic orientations, activities, and the environment – or environmental changes – resulting in corresponding patterns (Hakala, 2011). According to Gatignon and Xuereb (1997), a strong strategic orientation involves anticipating corresponding activities. Therefore, we concentrate on both new and established PSM practices that the literature has linked to innovation. Of the two main types of PSM practices (Day and Lichtenstein, 2006), internal PSM practices involve strategic alignment practices and cross-functional integration practices with other firm functions, as well as enabling practices such as "employee performance measurement, skill development practices, and information technology installation" (Zimmermann and Foerstl, 2014, p. 39). Several supplier involvement studies have investigated internal PSM mechanisms, such as social integration mechanisms as mediators (Hsu et al., 2009; Koufteros et al., 2012; Johnson and Filippini, 2013). Supplier integration mechanisms have most often been linked to new product performance (Lau, 2014) but not to innovation capability. PSM practices were scarcely investigated, with the exception of purchasing (Luzzini et al., 2015; Zhang et al. 2017). Regarding internal PSM practices, purchasing has been described as "(n)atural interface/coordinator of the supply base" (Luzzini et al., 2015, p. 110). It plays an active role as a "gatekeeper between the supplier base and the rest of the buyer organization" (Calvi et al., 2020, p. 302). Concerning integration into NPD, *early purchasing involvement* increasingly encompasses the development of specific procedures for idea and knowledge sourcing, supplier selection, and supplier relationship management practices (Calvi et al., 2020).

External supplier-facing practices can be categorized as either activities carried out by the buyer firm (non-relational practices) or as joint activities involving a network of buyers and suppliers (relational practices) (Day and Lichtenstein, 2006; Zimmermann and Foerstl, 2014; Foerstl et al., 2016). Non-relational practices rely on the efforts of the buyer firm and encompass practices such as supplier evaluation, selection, incentives, and development (Terpend et al., 2008; Melander and Tell, 2014). Relational practices refer to mutual efforts and corresponding practices such as joint product development and knowledge sharing (Foerstl et al., 2016).

Two established non-relational external-facing PSM practices used to increase innovation performance are supplier incentives and

search practices for supplier ideas. For reasons of resource and knowledge protection, suppliers – having already invested "much effort, risk-taking, and capital" (Pihlajamaa, 2021, p. 11) – may only be willing to provide incrementally innovative and rather familiar ideas, but not radically innovative ones (Lau et al., 2010). Incentives for sharing ideas and knowledge can be used to counteract suppliers' reluctance to engage in FFE and motivate them to provide valuable input. *Search practices for supplier ideas* are proactive innovation strategies that relate to sensing capabilities in terms of "(s)ystematic routines for identifying and exploiting external innovation opportunities" (Pihlajamaa, 2021, p. 5). They can be classified as coordination mechanisms, supporting the sharing and transfer of knowledge (Pihlajamaa, 2018).

Finally, relational external-facing PSM practices concern joint product development with external partners. For *cooperation,* firms make use of not only the existing supply base but also brand new ones (Calvi et al., 2020) – for example*, non-value-chain partners* are used to facilitate the exchange of new and complementary knowledge (Aslesen and Freel, 2012). Non-value-chain partners are firms and institutions that are not involved in – or are confined to the later stages of – the focal firm's innovation processes, or that are only loosely connected to the business and the final product (Choi and Krause, 2006; Ahn et al., 2018). This includes, for example, startups and technology companies with digital technology expertise (Júnior et al., 2019).

2.1. The link between supplier involvement orientation in the FFE and innovation capability

The earlier that suppliers become involved in the focal firm's NPD process, the closer the contextual knowledge distance between both parties (Un and Asakawa, 2015). If suppliers are involved in NPD from the outset, complementary capabilities can be combined right at the start of the process. Thus, common goals can be better developed (Un et al., 2010), which will facilitate the transfer and integration of knowledge (Un and Asakawa, 2015). Hence, if a focal firm can foster supplier involvement in the FFE, it can exploit suppliers' knowledge early on – well before concept decisions are made – and, therefore, increase the likelihood of identifying a broad spectrum of both radical and incremental product ideas that are not available to the focal firm (Homfeldt et al., 2019). In addition, early supplier involvement in NPD is associated with a closer buyer–supplier relationship (Parker et al., 2008), enhancing supplier commitment to the focal firm (LaBahn and Krapfel, 2000). Consequently, suppliers can better react to particular market needs (Grimpe and Sofka, 2016), increasing supplier flexibility and promoting openness to adaptation when circumstances change (Heide and Miner, 1992). When involved in the FFE, suppliers can provide their technical knowledge to evaluate the feasibility of new product ideas at the earliest juncture (Crawford and Di Benedetto, 2005).

Research indicates that external integration, such as supplier involvement, requires specific internal capabilities (Luzzini et al., 2015). Open innovation research has highlighted the role of dynamic capabilities as organizational processes and the need for organizational transformations (Bogers et al., 2019; Teece, 2020). The acquisition of external sources relies on the organizational processes of sensing, absorbing, and transforming external knowledge, as well as cooperating with other partners (Pihlajamaa, 2021). Dynamic capabilities have been closely related to innovation capabilities (Lawson and Samson, 2001). Daronco et al. (2023, p. 240) define innovation capabilities as "a set of distinct and interrelated organizational characteristics and traits ('antecedents') that constitute its propensity to innovate." In particular, they result from different organizational (best) practices that are combined and further developed over time (Boly et al., 2014).

The literature has viewed innovation capabilities as a single dimension representing a particular innovation type, such as radical or incremental innovation, but also as a multi-dimensional construct (Yusof et al., 2023). The main difference between the two innovation types is the use of knowledge (Wang and Chen, 2013). Incremental innovation capability builds on current knowledge and refers to the ability to deliver minor changes and customer benefits to existing products and services. Radical innovation capability draws on new knowledge, arising from the transformation of existing knowledge, and enables firms to produce major transformations in terms of fundamental changes and major customer benefits (Subramaniam and Youndt, 2005, Menguc et al., 2014; Escrig-Tena et al., 2021).

The literature has shown inconsistent results on how the two types operate in relation to supplier involvement and whether they draw on different organizational routines and knowledge. Subramaniam and Youndt (2005) found that a firm's social capital in terms of employee interrelationships positively affects both radical and incremental innovation capability. Supplier involvement (in design) strengthened NPD performance in firms that possess high incremental or radical innovation capability (Menguc et al., 2014). However, quality management as a strategic orientation increased incremental innovation capability, but not radical innovation capability (Escrig-Tena et al., 2021). The former was related to innovation process formalization, and the latter to practices supporting creativity. This is in line with Slater et al. (2014, p. 554) who argued that, regarding radical and incremental innovation capabilities and their development, there is a difference "in both intensity and flavour" in their functioning and operation of different organizational components, such as senior leadership, organizational culture or organizational characteristics.

Accordingly, several studies have proposed that suppliers introduce the focal firm to more innovative and creative product ideas (Suurmond et al., 2020). Sjoerdsma and van Weele (2015, p. 194) stress the value of supplier input concerning "ideas on how to improve product quality, improve manufacturability or ideas that contribute to the performance of the NPD process overall". Incremental innovations – in particular, radical innovations – offer competitive advantage when it comes to "rapidly evolving customer needs in high-velocity environments" (Slater et al., 2014, p. 552). From a strategic point of view, a company develops requirements for the innovation process as a whole to engage in both radical and incremental innovation (Leskovar-Spacapan and Bastic, 2007). Companies that follow supplier involvement adopt patterns that rely on suppliers "to help them achieve and sustain innovation" (Kumar et al., 2012, p. 142). Therefore, we hypothesize:

H1. a, b: Supplier involvement orientation in the FFE is positively related to a focal firm's a) radical innovation capability, and b)

incremental innovation capability.

2.2. The mediating role of PSM practices

A strong supplier involvement orientation in the FFE correlates with patterns of appropriate activities (Gatignon and Xuereb, 1997; Hakala, 2011). In terms of the external knowledge search from suppliers (pointing to the importance of network resources (Lavie, 2006), we suggest that established *search practices* are necessary if the focal firm is to develop effective and continuous cooperation linkages and knowledge flows (Martini et al., 2017). Idea search practices are of particular importance in the FFE, taking different forms, such as technology scouting and web-based approaches (Koen et al., 2001). Depending on the supply base (e.g., established or new suppliers) and the maturity of innovation (e.g., ready-to-use innovations or ideas and concepts), different organizing models and scouting activities are suitable for the purchasing function (Calvi et al., 2020). This means that the more a firm is engaged in supplier involvement in the FFE, the more it will make use of different idea search practices. We, therefore, propose the following:

H2a. : Supplier involvement orientation in the FFE is positively related to a focal firm's idea search practices for suppliers.

Knudsen and Srikanth (2014, p. 410) describe the search process as a balance between the "exploration of new domains and exploitation of known domains". Hence, the results of the search process can encompass various ideas from incremental innovations to new inventions that have yet to be developed and introduced into the market (Hagedoorn and Cloodt, 2003). Idea search practices provide a framework for scanning the environment "to provoke and identify fresh ideas" (Calvi et al., 2020, p. 306) and to identify responses to specific problems. They facilitate the processes of internal and external knowledge exchange, required to develop different types of innovation. Accordingly, search practices complement formalized mechanisms through which firms steer the continuous generation of ideas and innovation in their operating businesses (Bodas Freitas and Fontana, 2018; Martini et al., 2017). By extending the knowledge base and the combined knowledge thus garnered, they promote incremental innovation especially, as several studies have confirmed (Shi et al., 2020). Furthermore, search practices can help to translate and transfer environmental trends into practices and routines (Martini et al., 2017). Established mechanisms and searching for supplier ideas using distinct practices that fit specific incremental and radical innovative requirements helps to synchronize external input with internal needs. This "reflective reframing" is crucial in the context of major uncertainty –as with the FFE – to align subsequent activities for successful innovation capability (Bodas Freitas and Fontana, 2018; Grodal et al., 2015). Therefore, we hypothesize the following:

H2. b, c: Supplier idea search practices are positively related to a focal firm's b) radical innovation capability, and c) incremental innovation capability.

Although focal firms often rely on the knowledge of a small number of known key suppliers that often operate in the same industry (Chen and Paulraj, 2004; Paulraj et al., 2008), we argue that, especially in the FFE of NPD when ideas are generated and the foundation for products is laid, firms are increasingly aware that accessing heterogeneous knowledge from a varied supply base is necessary to provide a fertile ground for innovation (Gao et al., 2015). Research studies point to potential benefits for the focal firm when cooperating with complementary *(non-value chain) partners*, such as access to resources in terms of information, market, and technological knowledge (Pérez et al., 2012), changed perspectives, and "fresh" and highly innovative ideas (Calvi et al., 2020). Consequently, firms increasingly rely on young technology partners to keep pace with the newest technology (Pérez et al., 2012). In addition, according to Kurpjuweit et al. (2020, p. 3), firms recognize that startups are "excellent problem solvers and product developers". To exploit the potential of startups, firms are making use of startup supplier programs (Kurpjuweit and Wagner, 2020). We assume that, if a firm is heavily engaged in supplier involvement in the FFE, these programs and the potential benefits from having complementary partners are well known. Therefore, we propose the following:

H3a. : Supplier involvement orientation in the FFE is positively related to a focal firm's cooperation with non-value-chain partners.

A firm's ability to innovate is closely linked to its capacity to think differently – namely, looking at things from different perspectives and combining previously unrelated knowledge-based resources into something novel (Fleming et al., 2007). Thus, a major element in innovation capability is whether a firm can access heterogeneous and varied knowledge bases that are available in non-value-chain partners. Accessing suppliers from different industries enables the focal firm to tap into and combine dissimilar knowledge elements (Gassmann et al., 2010). This practice has been described as a fundamental cognitive process for producing novel insights (Rodan and Galunic, 2004). Using heterogeneous knowledge sources in the early stages of NPD also gives firms access to new problem-solving heuristics. Accordingly, this represents a challenge to firms' current cognitive structures and views on cause-and-effect relations, which is likely to facilitate the generation of varied novel solutions (Fleming, 2001; Phelps, 2010). Furthermore, by accessing a varied supply base in the FFE, the focal firm is exposed to diverse expertise and perspectives in different fields. It can, then, apply, modify, and experiment with solutions in diverse domains, with consequent enhancement of its innovation capability (Gao et al., 2015; Hargadon and Sutton, 1997). In general, research has established a clear link between a diverse knowledge base and radical innovation (Du, 2021). Drawing on external knowledge, Phelps (2010) established a positive linear relationship between radical innovation and diverse supply networks. On incremental innovation, Du (2021, p. 92) points to the positive effects of "combination efficiency of multidisciplinary knowledge and the reorganization potential of different knowledge" and of good market links concerning solutions to improve existing products and services. Hence, we propose the following hypotheses:

H3. b, c: Cooperation with non-value-chain partners is positively related to a focal firm's b) radical innovation capability, and c) incremental innovation capability.

Transferring supplier knowledge is central to an open collaborative buyer–supplier relationship. However, in the particular case of the FFE when a critical knowledge exchange request for protection is made to prevent leakage to competitors and a consequent loss of competitiveness (Wagner, 2012), suppliers may be deterred from providing substantially innovative ideas to the focal firm in order to protect their knowledge and skills (Lau et al., 2010). Focal firms may choose to offer *incentives* to counteract this reluctance and galvanize hesitant suppliers. Terpend and Krause (2015) showed that incentivizing supply chain partners is an effective way to improve innovation. In the context of buyer–supplier cooperation, incentives can range from monetary to non-monetary inducements (LaBahn and Krapfel, 2000). Similar to a focal firm's cooperation with non-value-chain partners, we assume the deeper that firms are involved in supplier involvement in the FFE, the more they are aware of the positive effects of incentives and the more likely they are to make use of monetary and non-monetary inducements. Hence, we hypothesize:

H4. a, b: Supplier involvement orientation in the FFE is positively related to a focal firm's a) monetary, and b) non-monetary supplier incentives.

At the individual level, research has shown that non-monetary rewards are positively related to intrinsic motivation and have the potential to increase innovation performance in due course (Markova and Ford, 2011). Monetary or extrinsic incentives also have a positive impact on innovation performance in terms of patenting activities (Shapiro et al., 2017). Focal firms that offer incentives in the early stages of NPD make attractive customers for suppliers because they signal a willingness to apportion rewards, such as performance bonuses, shares, or one-time payments generated through cooperation with the supplier (LaBahn and Krapfel, 2000). In turn, this communicates fairness (Terpend and Krause, 2015), which is an important driver in maintaining successful cooperation (Jap, 2001). Regarding monetary incentives, Sumo et al. (2016) found a positive effect on radical innovation, rewarding the supplier's innovative activities. Non-monetary incentives include access to the knowledge base and property rights of the focal firm, and opportunities for innovation and self-development (Henke and Zhang, 2010; LaBahn and Krapfel, 2000). Furthermore, a focal firm may offer preferential access to its development needs from very early on in the NPD process for innovative suppliers. Early disclosure of the development roadmap by the focal firm will help the supplier to align its development capabilities. In line with Homfeldt et al. (2019), we assume that suppliers align their idea-generation activities with the focal firm's needs, contributing knowledge and innovation ideas to the cooperation. However, the level of innovativeness is lower because of trust issues (Lau et al., 2010) and the lack of non-monetary compensation incentives. Hence, we propose the following hypotheses:

H4c. Non-monetary supplier incentives are positively related to a focal firm's incremental innovation capability.

H4d. Monetary supplier incentives are positively related to a focal firm's radical innovation capability.

Research on procurement's key role in a firm's innovation capability has only become important in recent years (Legenvre and Gualandris, 2018; Mikkelsen and Johnsen, 2019). However, firms have increasingly recognized procurement's strategic role, which often accounts for more than 50% of companies' expenditures (Luzzini et al., 2015). Today, a purchasing department's competitive priorities go beyond acquiring parts or reducing costs to increasingly include strategic topics, such as contributing to the focal firm's innovation performance by employing scouting practices (Luzzini et al., 2012). Thus, scholars and practitioners are paying greater attention to innovation-oriented supply chains, where procurement plays a key role in the early phases of the innovation process compared to cost-oriented supply chains (Homfeldt et al., 2017). Therefore, we present the following hypothesis:

H5a. : Supplier involvement orientation in the FFE is positively related to a focal firm's early purchasing involvement.

A high level of purchasing knowledge in the FFE, such as extensive expertise in the supply market, is an essential condition because purchasing has access to a variety of suppliers as sources of radical and incremental innovation ideas (Schiele, 2010). Because procurement is concerned with the acquisition of components and is the interface between the firm and its supply base, it plays a key role in identifying diverse ideas in the supply base at an early stage, advertising those ideas internally and, finally, circulating them throughout the company (Hartmann et al., 2012; Homfeldt et al., 2017). Furthermore, purchasing professionals possess the technical knowledge and understanding of the firms' products because they usually serve as the means to transmit internal innovation demands. While monitoring the supply base, purchasers can interpret any changes and consequences for their own product base (Carr and Smeltzer, 2000). Integrating this knowledge into the uncertain and dynamic FFE is decisive in creating the alignment needed for a

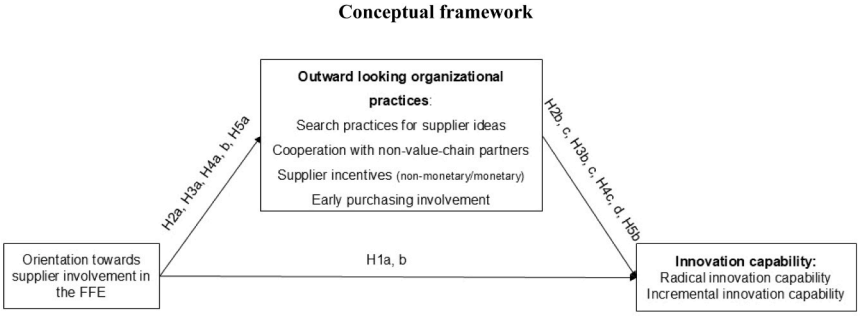

Fig. 1. Conceptual framework.

successful, balanced innovation portfolio (Mikkelsen and Johnsen, 2019). Finally, although radical innovations are often more costly compared with incremental innovation, and despite procurement's responsibility for ensuring the commercial viability of focal firms, procurement's economic knowledge in the early phase of NPD can be particularly helpful in making radical innovation more affordable (Homfeldt et al., 2017). Based on these arguments, we postulate the following:

H5b. : Early purchasing involvement is positively related to a focal firm's radical innovation capability.

Fig. 1 depicts the framework and the hypothesized relationships.

3. Methodology

3.1. Data and sample

To test our hypotheses, we conducted a self-administered Internet-based survey among German automotive companies. We used representative sampling to achieve a random but representative sample of automotive firms involving suppliers in NPD. Our sampling frame consisted of automotive firms listed in the German Association of the Automotive Industry (VDA). The VDA is the most representative association of the automotive industry in Germany and includes about 600 small to large companies that are involved in automotive production. We excluded those companies that did not pursue their own product development (e.g., pure technical service providers), producing a sample of 517 firms. In line with probability sampling, every firm within the representative target group was selected for the survey.

Our study targeted key informants (Montabon et al., 2018). Specifically, we addressed senior managers who were likely to have an overarching, boundary-spanning view of their firms' development process and supplier cooperation activities. The informants had job titles such as head of product (pre-)development, business line director, and head of corporate innovation management (Al-Zu'bi and Tsinopoulos, 2012). To check key informant quality, the respondents were asked a single-item confidence question about their level of knowledge on all the issues under investigation (1 = very limited knowledge, 7 = very substantial knowledge). The mean score of 5.7 provided confidence that the respondents were knowledgeable, and it compared favorably with the levels of knowledge indicated in similar studies in this field (e.g., Schoenherr and Wagner, 2016).

The initial mailing began in mid-August 2019 and was followed by two subsequent mailings at intervals of two to three weeks until mid-October. We were able to generate 223 firm responses, of which two containing missing data were discarded. The resulting 221 usable responses represent an effective response rate of approximately 42%.

The survey contained a question on whether the respective firm involved suppliers in the NPD process at all, regardless of the exact manner and timing. Overall, 206 firms indicated that they involve suppliers in NPD, which represents a rate of 93.2%. We checked whether our sample firms and the firms that did not involve suppliers in NPD differed on firm characteristics (firm size expressed in logarithms, firm age expressed in logarithms, whether the firm was part of a group, whether the firm manufactured complete vehicles, environmental turbulence, and competitive intensity). We found significant differences only in environmental turbulence ($p = 0.043$). The other five variables did not differ significantly between the sample firms and the firms not included in the sample ($p > 0.05$). Based on these findings, we are confident that our sample is unlikely to be affected by selection bias.

The sample is characterized by a heterogeneous set of firms covering a broad range of firm sizes and manufacturer groups (Table 1). The average number of years the respondents had worked in the firm was 13.3 years (std. dev. = 9.3 years). These data provide further evidence of a high level of key informant quality (Montabon et al., 2018).

To determine the presence of non-response bias, we applied two techniques. First, because late respondents are expected to be similar to non-respondents (Armstrong and Overton, 1977), we checked whether early (initial email) and late (reminder email) respondents differed with respect to all the variables included in our models. The results of the *t*-tests and chi-square tests showed no

Table 1
Sample firm characteristics.

	Overall (*N* = 206)
Manufacturer groups	
Whole vehicles	19 (9.2%)
System parts and modules	110 (53.4%)
Composite components	45 (21.9%)
Single components	27 (13.1%)
Materials	5 (2.4%)
Firm sizes	
1–250	23 (11.2%)
251–1000	43 (20.9%)
1001–5000	53 (25.7%)
5001–10,000	28 (13.6%)
> 10,000	59 (28.6%)
Group affiliation	
Part of a group	129 (62.6%)
Independent firm	77 (37.4%)
Firm age (average years)	79.6

statistical significance between the two groups ($p > 0.05$). Second, we compared responding firms with non-responding firms from the initial sample in terms of firm size and firm age. Of the 296 non-responding firms, we were able to collect firm size information for 175 firms and firm age information for 267 firms. Again, we found no statistically significant differences between these two groups ($p > 0.05$). Overall, the results indicate that non-response bias does not pose a significant threat to the validity of this study.

3.2. Survey instrument and measures

Based on an extensive review of the innovation and supplier integration literature, we identified relevant operationalized scale

Table 2
Measurement scales.

Scales	Principal component factor loadings
Radical innovation capability (α = 0.76; CR = 0.85; AVE = 0.58) (Subramaniam and Youndt, 2005; Menguc et al., 2014)	
Innovations that fundamentally change existing products.	0.80
Innovations that make existing products obsolete.	0.72
Innovations that significantly increase the benefits for our customers.	0.83
Innovations that require different ways of learning from customers.	0.69
Incremental innovation capability (α = 0.74; CR = 0.86; AVE = 0.67) (Subramaniam and Youndt, 2005; Menguc et al., 2014)	
Innovations that reinforce our existing product lines.	0.78
Innovations that reinforce our existing expertise in existing products.	—
Innovations that reinforce how we currently compete.	0.84
Innovations that slightly increase the benefit for our customers.	0.82
Orientation towards supplier involvement in the FFE (α = 0.74; CR = 0.84; AVE = 0.56) (Wagner, 2012)	
We involve suppliers in the generation of new product ideas.	0.79
Ideas of our suppliers are used in the specifications of new products.	0.79
We involve suppliers in the evaluation of new product ideas.	0.71
We involve suppliers in the development of concepts for new products.	0.71
Search practices for supplier ideas (α = 0.87; CR = 0.90; AVE = 0.65) (Spanjol et al., 2011; Homfeldt et al., 2017; Schiele, 2010)	
We search very actively for new product ideas from our suppliers.	0.78
We monitor our suppliers consistently for new product ideas.	0.77
We have established mechanisms for searching for new product ideas from our suppliers.	0.86
We use methods and tools to search for new product ideas from our suppliers (e.g., innovation workshops or competitions with suppliers).	0.84
We have instruments in place where suppliers can proactively provide their ideas (e.g., web-based innovation portal, regular innovation meetings).	0.79
Cooperation with non-value-chain partners (α = 0.70; CR = 0.83; AVE = 0.62) (Choi and Krause, 2006)	
The number of suppliers we involve in the early stages of our NPD process is high.	—
We involve suppliers in the early stages of our NPD process that operate in other markets than we do (i.e., cross-industry partners, e.g., aerospace industry).	0.71
We involve non-established partners in the early stages of our NPD process (e.g., start-ups as potentially new suppliers).	0.89
We foster cooperation with non-direct suppliers in the early stages of our NPD process (e.g., Tier 2, Tier 3 suppliers).	0.75
Supplier incentives (non-monetary) (α = 0.80; CR = 0.88; AVE = 0.64) (LaBahn and Krapfel, 2000; Terpend and Krause, 2015)	
We reward our most innovative suppliers (e.g., supplier awards).	0.75
For innovative suppliers, we offer favored access to our development/procurement needs at an early stage.	0.87
For innovative supplier ideas, we offer exclusive development/sourcing commitment at an early stage.	0.87
We allow our suppliers to benefit from generated industrial property rights when it comes to a joint development of suppliers' ideas.	0.70
Supplier incentives (monetary) (α = 0.91; CR = 0.96; AVE = 0.92) (LaBahn and Krapfel, 2000; Terpend and Krause, 2015)	
For innovative supplier ideas, we share investment costs when it comes to a joint development.	—
For innovative supplier ideas, we are willing to pay a higher price than prevailing market prices.	0.96
For innovative supplier ideas, we are flexible regarding price adjustments to the suppliers' supply agreements.	0.96
Early purchasing involvement (α = 0.91; CR = 0.94; AVE = 0.79) (McGinnis and Vallopra, 1999)	
Purchasing plays a major role in the early stages of our NPD process.	0.85
Purchasing consistently provides input in the early stages of our NPD process.	0.91
Purchasing plays an important role in identifying suppliers who offer innovative ideas that are important to NPD.	0.89
Purchasing plays an important role in cross-functional teams in the early stages of our NPD process.	0.90
Environmental turbulence (α = 0.74; CR = 0.84; AVE = 0.57) (Jaworski and Kohli, 1993)	
Our customers' product preferences change quite a bit over time.	0.80
Our customers tend to look for new products all the time.	0.80
New customers tend to have product-related needs that are different from those of existing customers.	—
The technology in the product categories in which we operate is changing rapidly.	0.76
Technological changes provide big opportunities in the product categories in which we operate.	—
Technological developments in our product categories are rather minor.[R]	0.64
Competitive intensity	
Competition in the product categories in which we operate is very high.	—
Our competitors are relatively strong.	—

Scales in italics signify an item dropped during the scale purification process.
R = reverse-scored item; α = Cronbach's alpha; CR = composite reliability; AVE = average variance extracted.

items for the constructs previously selected (Table 2). To fit with the specific context, we adapted the wording or added certain items. The drafted survey was discussed and pre-tested with 10 practitioners, covering expertise from both manufacturers of complete vehicles and manufacturers of components/modules. They were asked to comment on the content, design, clarity, and scaling. Several minor changes were made as a result of this feedback. All variables were measured at the firm level. Unless otherwise stated, the items were presented using 5-point Likert scales (1 = strongly disagree/does not apply at all, 5 = strongly agree/applies fully) and formulated as reflective indicators.

Dependent variables. Radical innovation capability and incremental innovation capability were each measured using an item scale adapted from Subramaniam and Youndt (2005) and Menguc et al. (2014). We measured incremental innovation capability on a four-item scale assessing a firm's ability to reinforce existing product lines, product expertise, competitive position, and slightly increase customer benefit. We captured radical innovation capability using a four-item scale to assess a firm's competency in generating innovations that fundamentally change existing products or make them obsolete, deliver a major benefit to customers, and require the implementation of new routines that enable employees to explore new ways of learning from customers. The respondents were asked to rate their firm's ability to generate the above innovation types relative to their principal competitors (1 = much worse than the competition, 5 = much better than the competition).

Independent variable. *S*upplier involvement orientation in the FFE is defined as the key conditions (general management principles) envisioning and directing the involvement of suppliers in the focal firm's NPD activities before the actual development phase – for example, idea generation and idea evaluation. Our scale adapts measurement items developed by Wagner (2012) describing supplier integration in the FFE, which are formulated as strategic management principles.

Mediator variables. To infer causality, the respondents were asked to explicitly refer their answers to the early phase of their firm's NPD process prior to the actual development phase. The item scales for the PSM practices are based on established and partly new items (see Table 2).

Control variables. We included several control variables in our models to eliminate undesirable sources of variance in the hypothesis-testing procedure. First, we controlled for firm size, measured as the number of employees (expressed in logarithms), because larger firms have greater resources to fund innovation and establish more powerful R&D centers (Lau et al., 2010). Second, we controlled for the age of the firm – measured as the number of years that have elapsed since foundation (expressed in logarithms) – to mitigate the effects of a firm being long established in its product categories, which may affect its innovation capability (Al-Zu'bi and Tsinopoulos, 2012). Third, our models control whether the firm belongs to a group or is independent because this may influence a firm's innovation portfolio. For instance, firms that are part of a group were found to have a greater propensity to innovate incrementally (Cassiman and Veugelers, 2006). We measured this using a dichotomous variable that equals 1 if the firm is part of a group and 0 otherwise (Bodas Freitas and Fontana, 2018). Fourth, we controlled for any constant and unmeasured differences across these manufacturing groups by including dummy variables in our analysis (manufacturer of whole vehicle, systems and modules, composite components, single components, or materials). Finally, given that a firm's environment may influence how active a firm is in its innovation capabilities, we included the firm's environmental turbulence (captured by market turbulence and technological turbulence) and competitive intensity in our models as controls (Menguc et al., 2014).

3.3. Measurement validity and reliability

We made several efforts to check the uni-dimensionality, reliability, and validity of each multi-item measure employed. We first conducted exploratory factor analyses using the principal component method to check how the items loaded onto the hypothesized factors. We reviewed each construct and deleted items where necessary to ensure measurement quality. Throughout this process, we performed confirmatory factor analysis to check for additional necessary adjustments. The results were satisfactory in that they exceed the evaluation criteria threshold (Farrell and Rudd, 2009).

Based on a confirmatory factor analysis, the established nine-factor measurement model achieved a satisfactory fit with a chi-square of 691.095 (df = 459, $p < 0.01$) and 1.51 chi squares per degree of freedom (Bentler and Bonett, 1980). Confirmatory factor analysis was conducted using the software package Lavaan in R (Rosseel, 2012). The measurement model's fit indices confirmatory fit index (CFI) = 0.92, Tucker–Lewis index (TLI) = 0.90, standardized root mean square residual (SRMR) = 0.063, root mean square area of approximation (RMSEA) = 0.050 are all indicative of acceptable model fit (Hu and Bentler, 1999). In addition, the RMSEA confidence interval is 0.042–0.057, representing a good degree of precision (Byrne, 2001).

Overall, we conclude that the measurement model adequately fits the data. Having established the validity and reliability of the reflective scales, we used unweighted scale averages as latent variable scores in the hypothesis-testing procedure.

3.4. Common method bias

Following prior recommendations (Podsakoff et al., 2003), we inserted various measures to counteract the potential problem of common method bias. We formally tested for the presence of common method bias in our data. First, we conducted Harman's single-factor approach (Podsakoff and Organ, 1986). We entered *all* rating-scale items into an unrotated exploratory factor analysis. The analysis yielded multiple factors with eigenvalues greater than 1.0 rather than a single factor. Furthermore, the largest factor did not account for a majority of the variance (about 20%), suggesting that common method bias is unlikely to be a problem. To further exclude this possibility, we applied the correlational marker technique (Lindell and Whitney, 2001). Here, we used the respondent's tenure as a correlational marker (cf. Krishnan et al., 2006, see also Williams et al., 2010 for the use of demographic marker variables) because it is theoretically unrelated to the dimensions under investigation. As a more conservative estimate, we used the

second-smallest positive correlation (r = 0.019) between the marker variable and one of the other variables to determine common method-based adjusted correlations (Lindell and Whitney, 2001; Malhotra et al., 2006). We compared the zero-order correlations among all dependent, independent, and mediator variables before and after partialing out the marker variable. Significant zero-order correlations remained significant – except for supplier incentives (monetary) and supplier ideas search practices, where the *p* value changed from 0.097 to 0.157 – and did not change in magnitude by more than 0.02. In sum, both tests indicate that common method bias does not pose a significant threat to the validity of our results.

4. Results

We used hierarchical regression analysis and PROCESS model 4 (parallel mediation) to test our hypotheses (Hayes, 2012). No problematic levels of multi-collinearity could be identified (Table 3). The correlations were within acceptable ranges ($|r| < 0.60$), and the variance inflation factors (maximum = 1.87) for the variables in all the reported models were substantially below the commonly suggested threshold (Cohen et al., 2003).

We first started with the baseline model containing only the control variables for the two dependent variables radical innovation capability (Table 4) and incremental innovation capability (Table 5).

Then, we examined the relationship between supplier involvement orientation in the FFE and our dependent variables. As illustrated in the direct effects model, supplier involvement orientation in the FFE is positively and significantly related to a focal firm's radical innovation capability and incremental innovation capability, with incremental innovation exhibiting a stronger effect. The models show significant F values and increasing R^2 after including our independent variable for radical innovation capability ($\Delta R^2 = 0.0273$, $p = 0.0136$) and incremental innovation capability ($\Delta R^2 = 0.0.0359$, $p = 0.0041$). This confirms Hypothesis 1a and Hypothesis 1b.

To assess the hypothesized mediation effects, we followed the common four-step procedure suggested by Baron and Kenny (1986). The first step entailed analysis of the direct and significant effects of supplier involvement orientation in the FFE on radical and incremental innovation capability. In the second step, supplier involvement orientation in the FFE needs to be significantly associated with the mediator variables, as shown for all PSM practices (Figs. 2 and 3). Overall, we find support for Hypotheses 2a, 3a, 4a, 4b, and 5a.

Third, the mediator variable needs to be significantly related to the dependent variables. Fourth, the significant relationship between supplier involvement orientation in the FFE and radical and incremental innovation capability needs to become insignificant (complete mediation) or needs to be reduced (partial mediation) when a potential mediator is included in the regression model. For search practices for supplier ideas, we found no mediation effect on incremental innovation capability ($b = 0.0369$, $p = 0.5703$, $SE = 0.0648$, 95% CI: −0.0908; 0.1647) and radical innovation capability ($b = -0.1031$, $p = 0.1111$, $SE = 0.0644$, 95% CI: −0.2301; 0.0240). Hence, Hypotheses 2b and 2c are not supported. Consistent with Hypotheses 3b and 3c, cooperation with non-value-chain partners in the early stages mediates the relationship between supplier involvement orientation in the FFE and both a firm's radical innovation capability ($b = 0.2824$, $p = 0.0000$, $SE = 0.0605$, 95% CI: 0.1630, 0.4017) and its incremental innovation capability ($b = 0.1203$, $p = 0.0496$, $SE = 0.0609$, 95% CI: 0.002, 0.2404).

Furthermore, in contrast to Hypothesis 4c, we find that non-monetary incentives mediate the relationship between supplier involvement orientation in the FFE and a firm's radical innovation capability ($b = 0.1157$, $p = 0.0427$, $SE = 0.0567$, 95% CI: 0.0039, 0.2275) but not incremental innovation capability ($b = 0.0896$, $p = 0.1178$, $SE = 0.0570$, 95% CI: −0.229, 0.2021). No mediation effects were found for monetary incentives and radical innovation capability ($b = -0.0634$, $p = 0.1916$, $SE = 0.0484$, 95% CI: −0.1569, 0.320) as proposed in Hypothesis 4d.

Finally, and in line with Hypothesis 5b, early purchasing involvement completely mediates the relationship between supplier involvement orientation in the FFE and a focal firm's radical innovation capability ($b = 0.1333$, $p = 0.035$, $SE = 0.0451$, 95% CI: 0.0444, 0.2222).

The direct effect of supplier involvement orientation in the FFE is reduced and becomes insignificant when including the mediators for both radical innovation capability and incremental capability. However, the total effects remain significant.

A series of Sobel tests were conducted as an additional analysis using the SPSS macro (Preacher and Hayes, 2004). For each significant mediator effect regarding radical innovation capability reported above, both the test and the bootstrap results revealed a significant reduction in the relationship between our independent and dependent variables, at $p < 0.01$. On incremental innovation capability, the Sobel test and the bootstrapping results revealed a significant effect of search practices for supplier ideas ($p = 0.0182$, $SE = 0.0250$, $Z = 2.3607$, 95% CI: 0.0100, 0.1081). Cooperation with non-value-chain partners had the second highest Z value (1.87119), but the values in the confidence interval were not on the same side of zero (95% CI: −0.0015, 0.0633).

For robustness testing, we replicated the regression models in R and ran robust regression there to check for outliers. The results matched the results of the OLS regressions of the PROCESS model (see Table 6). Under the linearity assumption, we examined the scatter plot of each relationship and found no issues. The same holds for the robust options in PROCESS regarding heteroscedasticity and normality.

5. Discussion and implications

The current study has examined suppliers' involvement in the FFE phase of focal firms, in which new product ideas are generated and evaluated. We aimed to fill several research gaps that Mendoza-Silva (2021) identified in a systematic research review on innovation capability. First, we addressed the relationship between a firm's strategy and its impact on innovation capability. Second,

Table 3
Descriptive statistics, bivariate correlations, and average variances extracted.

		Mean (Std.)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Radical innovation capability	3.46 (0.59)	*0.58*	0.29	0.03	0.02	0.12	0.04	0.01	0.05	0.00	0.01	0.00	0.00	0.09
2	Incremental innovation capability	3.66 (0.58)	0.54***	*0.67*	0.03	0.05	0.05	0.03	0.00	0.04	0.00	0.01	0.00	0.00	0.08
3	Supplier involvement in the FFE	3.27 (0.66)	0.17*	0.18**	*0.56*	0.12	0.04	0.08	0.02	0.10	0.00	0.00	0.00	0.00	0.00
4	Search practices for supplier ideas	2.74 (0.78)	0.15*	0.23**	0.35***	*0.65*	0.18	0.25	0.01	0.10	0.09	0.04	0.03	0.02	0.00
5	Cooperation with non-value-chain partners	2.38 (0.72)	0.34***	0.22**	0.19**	0.42***	*0.62*	0.07	0.07	0.01	0.05	0.00	0.00	0.02	0.02
6	Supplier incentives (non-monetary)	2.50 (0.89)	0.19**	0.18*	0.29***	0.50***	0.26***	*0.64*	0.14	0.05	0.14	0.01	0.04	0.03	0.00
7	Supplier incentives (monetary)	2.72 (0.88)	0.10	0.02	0.15*	0.12^{+}	0.26***	0.38***	*0.92*	0.01	0.00	0.00	0.00	0.04	0.01
8	Early purchasing involvement	3.24 (0.92)	0.22**	0.19**	0.31***	0.32***	0.07	0.23**	0.11	*0.79*	0.01	0.00	0.00	0.00	0.00
9	Firm size[a]	3.56 (0.92)	0.01	-0.03	-0.03	0.30***	0.22**	0.38***	-0.002	-0.08	–	0.06	0.14	0.02	0.01
10	Firm age[a]	1.81 (0.31)	0.07	0.11	0.01	0.20**	0.03	0.09	-0.04	0.03	0.24**	–	0.01	0.00	0.00
11	Part of a group	0.63 (0.49)	0.02	-0.01	-0.002	0.16*	0.05	0.21**	-0.003	-0.03	0.37**	0.12^{+}	–	0.00	0.00
12	Environmental turbulence	3.34 (0.79)	0.04	-0.04	0.04	0.14*	0.14*	0.17*	0.21**	0.05	0.15*	-0.02	0.05	*0.57*	0.01
13	Competitive intensity	4.03 (0.79)	-0.30***	-0.28***	0.01	-0.01	-0.15*	-0.002	-0.09	-0.01	0.12	0.06	0.01	0.12^{+}	–

$N = 206$.
Pearson correlation coefficients are below the diagonal, diagonal values in italics represent average variances extracted (where appropriate), and squared correlations are above the diagonal.
Significance levels: $+ p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
[a] Expressed in logarithms.

Table 4
Results of hierarchical regression analysis (DV = radical innovation capability, PROCESS model 4).

	Coefficient (SE) *Baseline model*	Coefficient (SE) *Direct effects model*	Lower 95% CI	Upper 95% CI	Coefficient (SE) *Parallel mediation model*
Constant	**3.8740*** (0.3661)**	**3.3701*** (0.4142)**	2.5532	4.1869	**2.8026***** (0.4131)
Firm size[a]	0.0095 (0.0501)	0.0191 (0.0496)	-0.0786	0.1169	-0.0375 (0.0511)
Firm age[a]	0.1842 (0.1363)	0.1799 (0.1346)	-0.0855	0.4453	0.2123 (0.1283)
Part of a group	-0.0008 (0.0894)	-0.0023 (0.0882)	-0.1763	0.1717	0.0039 (0.0829)
Whole vehicles[b]	-0.1950 (0.1436)	-0.2057 (0.1418)	-0.4854	0.0739	**-0.3089*** (0.1343)
Composite components[b]	-0.0361 (0.1048)	-0.0097 (0.1040)	-0.2148	0.1953	0.0428 (0.0980)
Single components[b]	-0.0947 (0.1277)	-0.0678 (0.1265)	-0.3173	0.1817	-0.0919 (0.1191)
Materials[b]	0.0387 (0.2677)	-0.0334 (0.2658)	-0.5576	0.4908	0.1132 (0.2576)
Environmental turbulence	0.0566 (0.0544)	0.0511 (0.0537)	-0.0548	0.1571	0.0243 (0.0516)
Competitive intensity	**-0.2309*** (0.0520)**	**-0.2319*** (0.0513)**	-0.3330	-0.1307	**-0.1800*** (0.0491)**
Supplier involvement orientation in the FFE		**0.1509* (0.0606)**	0.0313	0.2706	0.0432 (0.0643)
R^2, adj. R^2	0.1129, 0.0721	0.1402, 0.0096			0.2698, 0.2121
F, p	2.7707, 0.0045	3.1792, 0.0008			4.6797, 0.000
R^2 change (p)		0.0273 (0.0136)			
F change		6.1950			
Indirect effects model					
Total mediated effect		**0.1078 (0.0370)**	0.0434	0.1881	
Search practices for supplier ideas		-0.0439 (0.0266)	-0.1003	0.0061	-0.1031 (0.0644)
Cooperation with non-value-chain partners		**0.0590 (0.0228)**	0.0202	0.1117	**0.2824*** (0.0605)**
Incentives (non-monetary)		0.0466 (0.0296)	-0.0030	0.1127	**0.1157* (0.0567)**
Incentives (monetary)		-0.0125 (0.0121)	-0.0431	0.0053	-0.0634 (0.0484)
Early purchasing involvement		**0.0585 (0.0212)**	0.0212	0.1045	**0.1333** (0.0451)**

$N = 206$.
Unstandardized regression coefficients with standard errors in parentheses are reported.
Significance levels: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
[a] Expressed in logarithms.
[b] With manufacturer group "system parts and modules" as reference category.

Table 5
Results of hierarchical regression analysis (DV = incremental innovation capability, PROCESmodel 4).

	Coefficient (SE) *Baseline model*	Coefficient (SE) *Direct effects model*	Lower 95% CI	Upper 95% CI	Coefficient (SE) *Parallel mediation model*
Constant	**4.2044*** (0.3516)**	**3.6428*** (0.3956)**	-0.3312	-0.1380	**3.4881*** (0.4156)**
Firm size[a]	-0.0181 (0.0481)	-0.0073 (0.0473)	-0.1007	0.0860	-0.0611 (0.0514)
Firm age[a]	**0.2755* (0.1309)**	**0.2707* (0.1285)**	0.0173	0.5242	**0.2502 + (0.1291)**
Part of a group	-0.0258 (0.0858)	-0.0275 (0.0843)	-0.1937	0.1387	-0.0378 (0.0834)
Whole vehicles[b]	0.2607 + (0.1379)	0.2488 + (0.1354)	-0.0184	0.5159	0.1757 (0.1351)
Composite components[b]	0.0318 (0.1006)	0.0612 (0.0993)	-0.1346	0.2571	0.1006 (0.0986)
Single components[b]	-0.0954 (0.1227)	-0.0655 (0.1208)	-0.3038	0.1729	-0.0528 (0.1198)
Materials[b]	**-0.4430 + (0.2571)**	**-0.5233* (0.2539)**	-1.0240	-0.0226	-0.3617 (0.2592)
Environmental turbulence	-0.0099 (0.0522)	-0.0160 (0.0513)	-0.1172	0.0852	-0.0259 (0.0519)
Competitive intensity	**-0.2336*** (0.0499)**	**-0.2346*** (0.0490)**	-0.3312	-0.1380	**-0.2064*** (0.0494)**
Supplier involvement orientation in the FFE		**0.1682* (0.0579)**	0.0540	0.2825	0.0835 (0.0647)
R^2, adj. R^2	0.1337, 0.0939	0.1696, 0.1270			0.2175, 0.1557
F, p	3.3598, 0.0008	3.9817, 0.000			3.5211, 0.0000
R^2 change (p)		0.0359 (0.0041)			
F change		8.4320			
Indirect effects model					
Total mediated effect		0.0847 (0.0332)	0.0255	0.1569	
Search practices for supplier ideas		0.0157 (0.0260)	-0.0366	0.0676	0.0369 (0.0648)
Cooperation with non-value-chain partners		0.0251 (0.0153)	0.0021	0.0614	**0.1203* (0.0609)**
Incentives (non-monetary)		0.0361 (0.0224)	-0.0030	0.0861	0.0896 (0.0570)
Incentives (monetary)		-0.0139 (0.0132)	-0.0465	0.0058	-0.0706 (0.0487)
Early purchasing involvement		0.0217 (0.0201)	-0.0116	0.0669	0.0493 (0.0454)

$N = 206$.
Unstandardized regression coefficients with standard errors in parentheses are reported.
Significance levels: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
[a] Expressed in logarithms.
[b] With manufacturer group "system parts and modules" as reference category.

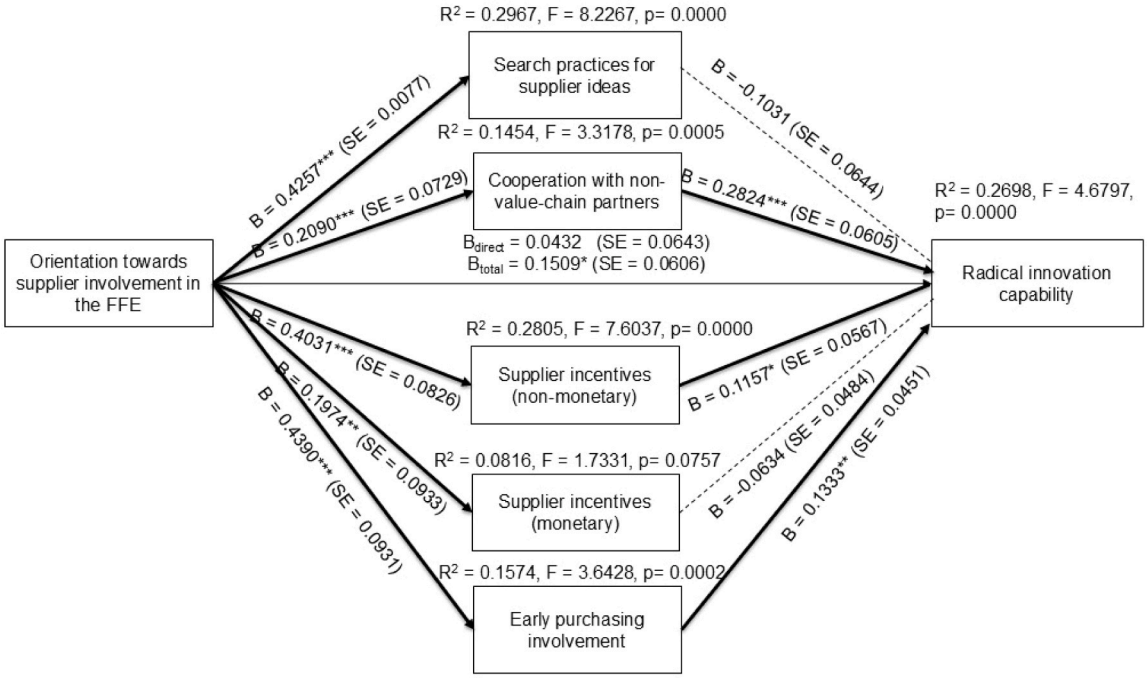

Fig. 2. Parallel mediation model (DV: radical innovation capability). Significance levels: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

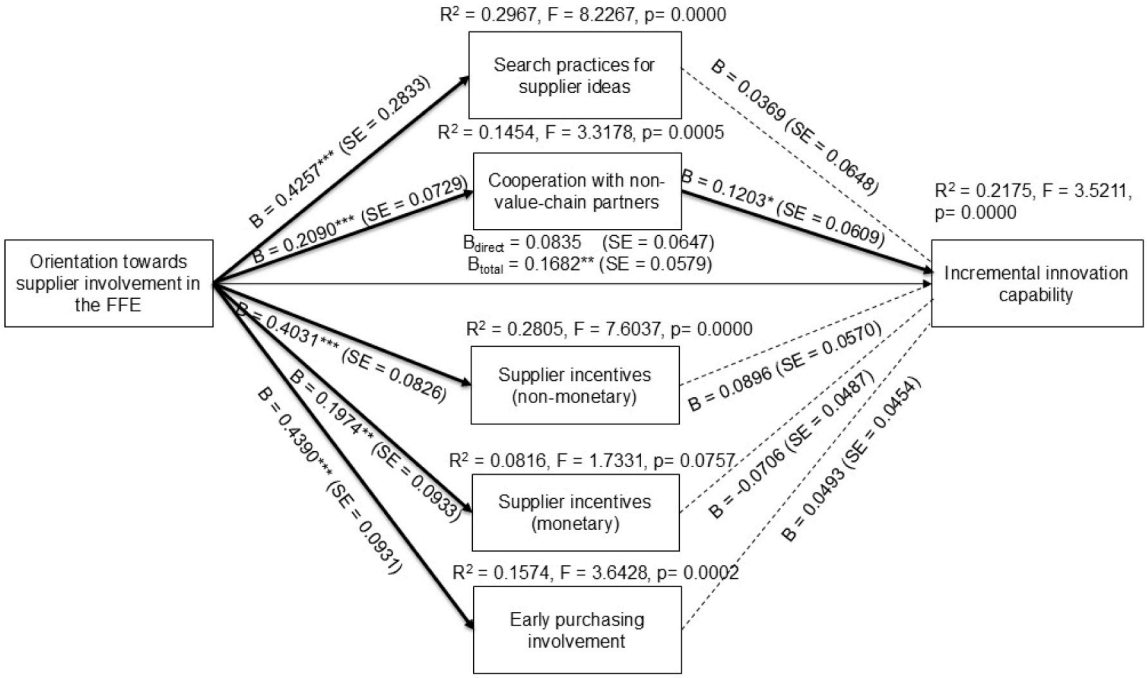

Fig. 3. Parallel mediation model (DV: incremental innovation capability). Significance levels: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

we determined the PSM practices that influence, as processes, the two distinct types of innovation capability: radical and incremental innovation capability. Third, we examined PSM practices as mediation processes between a firm's strategic orientation and the two distinct types of innovation capability.

According to Zimmermann et al. (2020, p. 1), the integration of new features and dependent variables can help to better understand

Table 6
Results of robust regression analysis.

	Model 1	Model 2a	Model 2b
	Supplier involvement in the FFE (mean, std. error, t-value)	Radical innovation capability (mean, std. error, t-value)	Incremental innovation capability (mean, std. error, t-value)
Constant		3.459, 0.039, 89.502	3.652, 0.040, 92.069
Search practices for supplier ideas	0.443***, 0.081, 5.474	-0.096, 0.064, −1.494	0.054, 0.066, 0.829
Cooperation with non-value-chain partners	0.215**, 0.076, 2.819	0.275***, 0.061, 4.485	0.125*, 0.063, 1.976
Supplier incentives (non-monetary)	0.401***, 0.094, 4.246	0.111*, 0.055, 2.022	0.068, 0.056, 1.215
Supplier incentives (monetary)	0.229*, 0.095, 2.402	-0.038,0.049,-0.780	-0.050, 0.050, −0.998
Early purchasing involvement	0.507***, 0.096, 5.282	0.140**, 0.045, 3.136	0.090 + , 0.046, 1.957

$N = 206$.
Model 1: Supplier involvement in the FFE is the independent variable, model 2a, b: radical/incremental innovation capability is the dependent variable
Significance levels: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

"the link between innovation and supply chain". The focal automotive manufacturers and the supply chain have increasingly faced digital transformation in the last decade (Barata, 2021). The adoption of digital technologies in the automotive industry requires the transformation of strategies for OEMs (Sommer et al., 2021), which is reflected in the transformation of organizational practices and innovation capabilities (Rocha et al., 2022). Taking a relational approach as system integrators (MacDuffie, 2018) has a major impact on new product development and front-end supplier involvement.

First, our results show that supplier involvement orientation in the FFE has a positive impact on both the radical and the incremental innovation capabilities of a focal firm, with incremental innovation exhibiting a stronger effect in the direct effects model. This result is in line with the literature arguing that supplier cooperation is generally beneficial for innovation because it enables the firm to gather additional knowledge and explore a broader range of possible solutions to specific problems and application contexts (Bodas Freitas and Fontana, 2018). However, because there is evidence that not all innovation efforts with suppliers are successful – particularly when it comes to the identification of truly innovative solutions (e.g., Gassmann et al., 2010; Song and Thieme, 2009) – our study underscores the importance of embracing supplier knowledge from the beginning. The earlier that suppliers are involved in the focal firm's NPD process, the closer the contextual knowledge distance between both parties. This, in turn, facilitates the transfer and integration of knowledge (Un et al., 2010; Un and Asakawa, 2015). The parallel mediation model revealed higher R^2 values for radical innovation capability demonstrating that it is worthwhile to involve suppliers in the FFE to obtain radical innovative ideas, if using the right organizational practices. Homfeldt et al. (2019) have shown that ideas coming from established suppliers tend to be incrementally innovative and easier to implement, whereas ideas from new partners, such as start-ups, tend to be radical when collected in an idea competition.

Second, while three organizational practices are significant for radical innovation capability, only one is significant for incremental innovation capability. In addition, search practices have a negative but not significant direction in relation to radical innovation capability (Slater et al., 2014). The effect is positive and even significant in the Sobel test for incremental innovation. It was argued – but not supported – that search practices for supplier ideas mediate the relationship between supplier involvement orientation in the FFE and a focal firm's radical and incremental innovation capability. Although additional research on this theme is needed to validate, our results are generally in line with the findings of Bodas Freitas and Fontana (2018). They show that formalizing NPD does not necessarily improve radical innovation performance – particularly in the context of high uncertainty and in the absence of established industry knowledge – as is the case when generating radical innovation.

The mediating effect of cooperation with non-value-chain partners was confirmed. This cooperation in the early stages of NPD is an underlying mechanism through which supplier involvement orientation in the FFE contributes to a focal firm's radical and incremental innovation capabilities. Although some scholars argue for decreasing innovation outcomes when two different suppliers are involved (Choi and Krause, 2006), we show that, in the FFE of NPD when the foundation is laid for new products, accessing heterogeneous knowledge resources is necessary to provide a fertile ground for innovation (Gao et al., 2015; Gassmann et al., 2010; Homfeldt et al., 2019).

In terms of the use of incentives, only non-monetary incentives have a mediating impact between supplier involvement orientation in the FFE and a firm's radical innovation capability. Surprisingly, there is no mediation effect at all from monetary incentives. Rather, the result suggests that successful cooperation between a focal firm and its suppliers requires – at least, in the knowledge-critical early stages of NPD – the establishment of incentives that reflect a relationship based on social outcomes.

Finally, our findings show that early purchasing involvement mediates the relationship between supplier involvement orientation in the FFE and a focal firm's radical capability but not its incremental innovation capability. This confirms how procurement transitions from being merely a buying department to playing a key role in the innovation process because purchasers provide valuable internal knowledge capabilities, such as technical and market knowledge (Homfeldt et al., 2017; Legenvre and Gualandris, 2018).

5.1. Contributions to theory

Our study contributes to the theory of innovation capabilities (Nascimento and Zawislak, 2023; Nascimento et al., 2025). While the innovation capabilities model distinguishes four innovation capabilities related to technological and non-technological innovation, we shed new light on the development capability and product innovation. Specifically, we improve information about the relationship between cooperation with suppliers in the FFE and the focal firm's innovation capabilities. The theory of capability-based transactions emphasizes the boundedness or complementarity of innovation capabilities, proposing that innovation capabilities and transaction types are intertwined. Firms can compensate for these missing or underdeveloped innovation capabilities by cooperating with suppliers in the FFE. We found that, consistent with the theory of capability-based transactions, cooperation with suppliers in the FFE increases the bounded innovation capability through internal organizational and relational routines. Specifically, we relied on several PSM practices from the literature and new processes (Paswan and Panda, 2020; Nascimento and Zawislak, 2023) as relevant activity patterns that constitute innovation capabilities.

Regarding advances from this research on the theory of capability-based transactions, we detailed and adapted product development capabilities to the context of FFE supplier involvement, relying on several constructs rather than a single measurement scale with different items. In addition, the difference between radical and incremental technological innovation was not addressed by Nascimento and Zawislak (2023). In a recent paper, Nascimento et al. (2025) used earnings from new products and increased productivity as operationalization of technological innovation. Therefore, we identified activity patterns for product development capabilities in relation to radical and incremental innovation, extending the analysis beyond simple impact effects. The crucial effect of a relational supplier-facing PSM practice – cooperation with non-value-chain partners – on both radical and incremental innovation confirms the general importance of this cooperative interorganizational relationship practice. A similar finding for firm performance (Foerstl et al., 2016) points to universally important PSM practices.

While organizations share certain common practices that sustain both radical and incremental innovation – such as cooperation with non-value partners – there are also significant differences. We found support for the proposition of Slater et al. (2014, p. 554) that organizational practices related to them differ "in both intensity and flavour". Achieving radical innovation capability requires that several, specific organizational practices are fully operational, compared to those needed for incremental innovation.

Finally, we deepened the understanding of innovation capabilities by including strategic orientation as an antecedent of activities. Our study demonstrates a clear link between strategic orientation, activities, and innovation capability.

5.2. Implications for managerial practice

By adopting a favorable strategic orientation and integrating suppliers early, focal firms can acquire, create, and share unique knowledge-based resources throughout the FFE phase of the NPD process. This, in turn, enhances the focal firm's innovation capability. Considering the positive effects in terms of both radical and incremental innovation, firms should not only rely on the voice of their customers for idea generation and evaluation but also invest in the integration of suppliers into the FFE phase of NPD.

Supplier involvement in the FFE is a worthwhile, strategic approach but it is by no means straightforward (Laursen and Andersen, 2016). Knowledge accumulated over time on supplier involvement in the well-formalized development phase cannot be readily transferred to the FFE because its context is more unstructured and dynamic (Schoenherr and Wagner, 2016). In particular, there are specific organizational practices that need to be considered and implemented by the focal firm (Schoenherr and Wagner, 2016; Wagner, 2012). The significant effects between our mediator variables and the different types of innovation capability that we found might provide helpful guidance here. Cooperation with non-value-chain partners fosters both incremental and, to a large extent, radical innovation capability. Early purchasing involvement and non-monetary supplier incentives also support radical innovation capability. Search practices offer some benefit to incremental innovation capability. Incremental innovation capability seems to increase with firm age, pointing to greater experience with operations and functions.

6. Limitations and future research

Despite its theoretical and managerial contributions, our study is not without limitations. Nevertheless, these limitations point to potential avenues for future research. First, our study relies solely on data collected from firms in the German automotive industry. Although we consider the German automotive industry suitable to examine supplier involvement in firms' NPD processes and representative of other complex and technology-driven industry sectors, we recognize the limitation that this places on the generalizability of our results. German automotive companies are not the best representatives regarding cooperation with non-value-chain partners in the early stages of NPD. About 10% of the respondents agreed to involve suppliers operating in other markets ($n = 19$, 9.2%), non-established partners such as startups (20, 9.7%), or non-direct partners (28, 13.6%). Most often, the last two were involved simultaneously ($n = 12$, 6.4%). Hence, we call for replication of our study across other industries and countries to validate our findings.

Second, this study adopts a single respondent strategy that may potentially produce common method bias. Although the statistical tests suggest that common method bias is not a cause for concern in our study, future work could use multiple data sources for further validation (i.e., use multiple informants or objective data for outcome variables). While we aimed to reach knowledgeable respondents and conceptualized all constructs as monadic (Flynn et al., 2018), we cannot rule out that, due to the size of the firm, some respondents lacked appropriate insight into all PSM practices.

Third, although our model and its dependencies give promising indications, causality is merely implied because our data does not

allow for testing of causal effects over time. Future studies could overcome this limitation by adopting longitudinal data collection.

Fourth, although we have provided a better understanding of the underlying mechanisms through which supplier involvement orientation in the FFE contributes to a focal firm's innovation capability, further research should be conducted on the micro-processes behind these mechanisms. Qualitative research methods could be used to gain a deeper understanding and generate practical advice on how, for instance, search instruments are established in firms and how the purchasing department is organized in terms of innovation scouting. Further organizational practices used in the FFE and across the innovation process (Homfeldt et al., 2017; Flankegård et al., 2021) could be investigated. FFE supplier involvement and product development-related organizational practices might also influence non-technological innovation (Nascimento et al., 2025).

Fifth, our study did not capture information on the characteristics of buyer–supplier cooperation – for example, cooperation duration. Research demonstrates that the extent of partner-specific experience affects collaborative performance, in particular (Bodas Freitas and Fontana, 2018). Similarly, the mediator effects may differ between, for instance, long-term cooperation and first-time cooperation.

Finally, we did not consider other strategic orientations that might exist simultaneously, such as customer integration and its interdependence or influence on PSM activities (Hakala, 2011; Eslami and Melander, 2019; Ataburo et al., 2022). Nor did we investigate whether supplier-facing practices are antecedents of internal PSM practices (Foerstl et al., 2016). We did not take structural aspects such as cross-functional integration and structural empowerment into account (Wu et al., 2024).

7. Conclusion

Our results show that supplier involvement orientation in the FFE has a positive impact on both a focal firm's radical innovation capability and its incremental innovation capability. However, the effect is stronger with incremental innovation. In addition, we find significant effects regarding several mediator variables, such as search practices for supplier ideas, cooperation with non-value-chain partners, monetary and non-monetary incentives, and early purchasing involvement. Interestingly, these effects differ for both types of innovation capability. In particular, they have a positive impact on radical innovation capability, thus providing valuable insights for scholars and practitioners. The study provides an impetus for investigating other organizational practices used across the stages of the innovation process and for different innovation types.

CRediT authorship contribution statement

Felix Homfeldt: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alexandra Rese:** Writing – review & editing, Methodology, Investigation, Formal analysis.

Data availability

The data that supports the findings of this study are available on request from the authors.

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