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The impact of networking with knowledge-intensive professional service firms on speed to market and product innovativeness

Abstract

During the new product development (NPD) process, exploitation and exploration are important, especially for small manufacturing firms (SMFs). However, limited resources and a lack of internal knowledge capacity have forced SMFs to work with knowledge-intensive professional service firms (KIPSFs). This study investigates the impact of SMFs' networks with KIPSFs on the performance of NPD. Using data from 164 SMFs in the northwest of England, this study reveals a linear relationship between a network for exploitation and product innovativeness, and a curvilinear relationship between a network for exploration and speed to market. A curvilinear relationship was also found between networks for ambidexterity and product innovativeness and speed to market. These results lead to several practical implications for networking strategy as each network supports different innovation activities and produces different outcomes.

Keywords: Ambidexterity, Exploitation, Exploration, Network, New Product Development, Speed to Market

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1. Introduction

It is well documented that small firms are constrained by access to resources and capabilities, limiting their capacity to innovate (Marlin & Geiger, 2015). Specifically, small manufacturing firms (SMFs) typically seek support from professional service firms to reduce development time and increase innovativeness during the new product development (NPD) process. Because professional service firms tend to have greater knowledge intensity than manufacturing firms (Wong & He, 2005), sourcing knowledge from such firms implies lower resource commitments with higher returns in knowledge, technical capabilities and outcomes (Moeen & Mitchell, 2020).

However, a gap in the literature remains about the contribution of professional service firms to SMFs' innovation activities (Ciriaci & Palma, 2016). Much of the work has examined how SMFs innovate, but the role of professional service firms has been overlooked (for an exception, see Seclen & Barrutia, 2018). Firms are exposed to various professional service firms with which they can collaborate during the NPD process. Nevertheless, there is a lack of understanding of (i) the characteristics of the network with professional service firms that underpin SMFs' innovation activities and (ii) the network's impact on supporting exploitation, exploration and ambidexterity. While exploitation extends current knowledge and seeks greater efficiency and improvement to enable incremental innovation, exploration entails the development of new knowledge, experimentation and novelty for more radical innovation (Atuahene-Gima, 2005). Ambidexterity refers to the capability of SMFs to perform simultaneous exploitation and exploration. Exploitation and exploration are inherently contradictory and require trade-offs in one to accomplish the other. Hence, ambidexterity is highly challenging for firms with limited resources, posing considerable managerial problems

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(Dezi et al., 2019; Lavie, Stettner, & Tushman, 2010) and requires firms to manage tensions and succeed in simultaneously accomplishing both activities.

To date, however, researchers have not studied how SMFs select suitable partners for conducting either exploitation or exploration while securing returns by balancing both activities, that is, engaging in ambidexterity (Dai et al., 2017; Tushman & O'Reilly, 1996). Indeed, while theory suggests trade-offs between exploitation and exploration – expressed as a direct curvilinear (inverted U-shaped) relationship between the two – their relationship with firms' innovation performance has neither been conceptualised nor tested in previous studies. Hence, we lack understanding of the relationship between various innovation networks (exploitation, exploration, ambidexterity) and innovation performance. This is unfortunate, as the original elaborations on ambidexterity (March, 1991) depicted an inverted U-shaped relationship between exploitation and exploration, resulting in lower firm performance as one was favoured at the expense of the other. Thus, it remains unclear how networks impact performance during NPD.

Using data collected from 164 SMFs in the northwest of England, this study investigates the relationships between SMFs and a specific type of professional service firm defined as knowledge-intensive professional service firms (KIPSFs). KIPSFs are unique innovation partners as their activities consist of the accumulation, creation or dissemination of highly specialised knowledge to develop knowledge-based, customised service or product solutions (Bettencourt et al., 2002). Given these characteristics of KIPSFs, this study considers services that link directly to SMFs' exploitation and exploration activities during NPD (technical consultancy, intellectual property advice, R&D, market research, engineering and testing services) but excludes general services (bookkeeping, marketing, administration, general legal matters). We collected data through interactive workshops and interviews where

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respondents were asked to draw their complete network maps, articulate their relationships and describe their networking, innovation activities and the firm's performance. The process was repeated over two years to capture the dynamic interaction between SMFs and their KIPSFs.

Our study makes several contributions to existing literature. First, this study benefits from extending Resource-Based View (RBV) theory by integrating Social Network Theory (SNT). While combining RBV and SNT is not new, this study shows that the application of both theories in the context of network and innovation is rather complex. For instance, our study found that SMFs engaging in exploitative activities with KIPSF partners improve their product innovativeness by every addition of a partner to their network. In contrast, our analyses also reveal a different performance effect from networks dedicated to exploration. The performance increases only up to a threshold, revealing a curvilinear (inverted U-shaped) relationship between network and speed to market. The second contribution of this study lies in enriching literature on organisational ambidexterity and innovation. This study argues that small firms can perform ambidextrous innovation activities by receiving helps from KIPSFs. Interestingly, this study shows how developing partnership with KIPSFs to perform both exploitation and exploration will only improve performance up to a threshold level, forming a curvilinear (inverted U-shaped) relationship. To date, these relationships have been tested only at the firm level without considering the network effects. Third, we bring forth how service firms play critical roles in the process of new product development. More specifically, this study highlights that KIPSFs are both highly innovative firms and important facilitators in the innovation process that help clients to innovate and participate in knowledge exchange activities (Tether, Li, & Mina, 2012). As empirical studies on KIPSFs are relatively few, this study contributes to our understanding of the role of KIPSFs as a 'source of innovation' and a 'bridge for innovation' (Yam et al., 2011).

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This study also makes practical contributions relevant for SMFs' networking strategy. Our findings suggest ways that SMFs with limited resources can tap into the knowledge base of KIPSF partners to improve their innovation performance. However, the benefits of such collaborations depend on the type of innovation activity sought (exploitation, exploration or ambidexterity) and whether one seeks to improve product innovativeness, speed to market, or both. Specifically, we unpack the network configurations that effectively support the NPD process. By filling this research gap, our study is relevant for SMFs that wish to maximise value from their network with KIPSFs and to design an effective networking strategy that fosters the contribution of KIPSFs to the NPD process.

2. Theoretical background

A key assumption driving our theory development is that the interaction between SMFs and KIPSFs can be explained by RBV (Barney, 1991; Penrose, 1959) that recipient firms (SMFs) seek to acquire knowledge-based resources for innovation activities (Cohen & Levinthal, 1990). With limited resources, an SMF's success in developing innovation during NPD depends on its knowledge network of KIPSFs, often defined as commercial firms offering services encompassing high intellectual and knowledge value-added (Bettencourt et al., 2002; Lee & Miozzo, 2019). KIPSFs offer a broad range of traditional services from legal counsel to engineering and design activities, among others (Kim & Lui, 2015; Miles et al., 1995). Hence, KIPSFs are an important category of partners to which SMFs can turn in pursuit of knowledge-based resources for innovation.

During NPD, firms' innovation activities are shaped by a strategic balance between exploration and exploitation of knowledge (March, 1991). Exploitation is defined as activities involving the access to and use of knowledge the firm already has, and exploration is the addition of new knowledge and the development of new competencies (Wadhwa & Kotha,

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2006). Knowledge can originate inside the organisation, or may be acquired externally through interactions and building relationships with KIPSFs (Dyer & Singh, 1998). KIPSFs are widely recognised as drivers of client innovation (Gann & Salter, 2000), based on their accumulation of experience and knowledge after working with diverse clients (Salter & Gann, 2003), which makes them attractive partners for NPD projects (Colombo, Dell'Era, & Frattini, 2015). Hence, SMFs with limited resources could benefit vastly from building networks with KIPSFs.

2.1 Networks for exploitation, exploration and ambidexterity during NPD

To examine the networks between and SMFs and KIPSFs, this study draws on Social Network Theory (SNT). The theory suggest that network configuration in the form of network size, network strength and network density plays critical roles in accessing partners' knowledge-based resources for exploration and exploitation (Gulati, 1995). *Network size* is measured by the number of relationships (Burt, 1997), which represents the accumulation of resources from network partners to perform innovation activities (Baer et al., 2015). The bigger the size of network, the more opportunities are open to access partners' expertise and skills. *Network strength* is defined by the strength or weakness of ties between network partners (Granovetter, 1983), which the literature has shown is likely to influence whether firms perform exploitation or exploration (Stadler et al., 2014). High network strength (strong ties) involves trust, commitment and willingness to support each other (Burt, 1992), where low network strength (weak ties) involves providing information or access to resources with low investment of time and effort (Uzzi, 1997). *Network density* represents the extent to which network ties are interconnected. In low network density, contacts are not well connected (Burt, 1992), but such a network may act as a broker between separate network clusters (Hanaki et al., 2007) in which firms receive more diverse information (Burt, 2005; Mizruchi & Stearns, 2001). In high network density, contacts are well connected, offering firms faster, more accurate and more

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reliable information, increased absorptive capacity, transparency and trust, comfort, legitimacy and joint-problem solving (Uzzi, 1996).

In the following section, network configuration for each network activities during NPD are discussed. For each innovation activities, we argue that SMFs develop a unique network configuration with their KIPSFs partners in terms of network size, network strength and network density. *Exploitation* is generally associated with deepening the organisation's knowledge in a given field by refining existing knowledge (Koryak et al., 2018; Levinthal & March, 1993) and improving existing competencies, technologies, processes and products (March, 1991). In performing exploitation during NPD, SMFs need to understand the benefits of knowledge sourced from networks (den Hamer & Frenken, 2021). But, due to limited time and resources, SMFs can only develop a network that focuses on the quality of the relationship (Ozkan-Canbolat & Beraha, 2016). Such networks tend to be characterised by fewer contacts, a high level of network strength (strong ties) and a level of network density. As exploitation requires a refined understanding of the existing technology or product (Wagner, 2013), SMFs may strategically select a few 'trustable' KIPSFs. Such strong ties are a precursor of effective knowledge exchange (Arranz, Arroyabe, & Fernandez de Arroyabe, 2020; Brattström, Faems, & Mähring, 2019; Koza & Lewin, 1998) and are suitable for the transfer of complex, highly technical and tacit knowledge (Dhanaraj & Parkhe, 2006; Ozkan-Canbolat & Beraha, 2016). In a high network density, KIPSFs are familiar with each other's expertise, skills and resources, making the transfer of knowledge to SMFs more effective (den Hamer & Frenken, 2021). Moreover, such network configurations reduce the likelihood of errors and the cost of knowledge search, which are critical during NPD.

By contrast, performing *exploration* requires a different type of network that aims to foster variety in experience (Levinthal & March, 1993; McGrath, 2001) with which firms

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broaden their existing knowledge base for innovation (Katila & Ahuja, 2002; Sidhu, Commandeur, & Volberda, 2007). Thus, exploration is discretionary and geared towards goals beyond the firm’s current product (Adner & Levinthal, 2008). Here, firms use entirely new mechanisms of search and selection (Ozer & Zhang, 2019) to look for idiosyncratic information, knowledge and resources with which to initiate novel ideas, which in turn are integrated into the NPD process (Arranz et al., 2020). Hence, SMFs reach out to many KIPSF partners (Faems, Van Looy, & Debackere, 2005) to help them find relevant information, knowledge and resources. Consequently, such networks may be characterised by a low level of network strength (weak ties) and a level of network density. Having weak ties with KIPSFs, SMFs benefit from the diversity of expertise, skills and information and the brokerage opportunities between clusters in the network (den Hamer & Frenken, 2021; Kwon et al., 2020; Burt, 2019). A low network density permits SMFs to act as ‘brokers’ and will profit from new commercial opportunities and access to new resources. Those benefits are critical for exploration activities during NPD.

For most firms, the strategic choices of exploitation and exploration are equally crucial in NPD (Branzei & Vertinsky, 2006; Koryak et al., 2018). Here, firms would benefit from ambidexterity (Duncan, 1976; Junni et al., 2013; Simsek, 2009; Tushman & O'Reilly, 1996), which allows to build competitive advantage and superiority using both exploitation and exploration (Andriopoulos & Lewis, 2009; Birkinshaw et al., 2016; Hoang & Rothaermel, 2010). However, limited resources – including the time and effort required – may prevent SMFs from developing both network configurations (exploitation and exploration) simultaneously. Moreover, taking advantage of different network configurations requires different strategies and approaches (Burt, 2019). Alternatively, SMFs may perform both exploitation and exploration with selected KIPSFs that can support both exploitation and

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exploration (Arranz et al., 2020). For example, SMFs can seek support from engineering service firms to explore new opportunities from additive manufacturing technology while exploiting current technology for product improvement (Giudici, Reinmoeller, & Ravasi, 2018).

As a consequence of developing network with few KIPSFs partners, network for ambidexterity is characterised as a high level of network strength (strong ties) and a high level of network density. Developing such network in this context makes sense for several reasons. First, the need for investing in search costs, as is usually needed for exploration (March, 1991), can be reduced as firms know their partners' knowledge base well. Furthermore, KIPSF partners can help to develop SMFs' core competencies, capture new customer-specific information and identify new opportunities (Kohtamäki & Partanen, 2016). In other words, partnerships with few KIPSFs allow exploitation to coexist with exploration (Benner & Tushman, 2003). Second, SMFs can test and select options effectively without needing further confirmation as the requisite expertise resides within the network. SMFs can perform both exploitation and exploration faster, effective and efficient. However, SMFs must ensure that the network partners offers both deep knowledge for potential exploitation and diverse knowledge for exploration (Pina & Tether, 2016). Figure 1 illustrates network configuration for each innovation activity.

Figure 1. Illustrated example of SMF's network configuration for performing exploitation, exploration and ambidexterity

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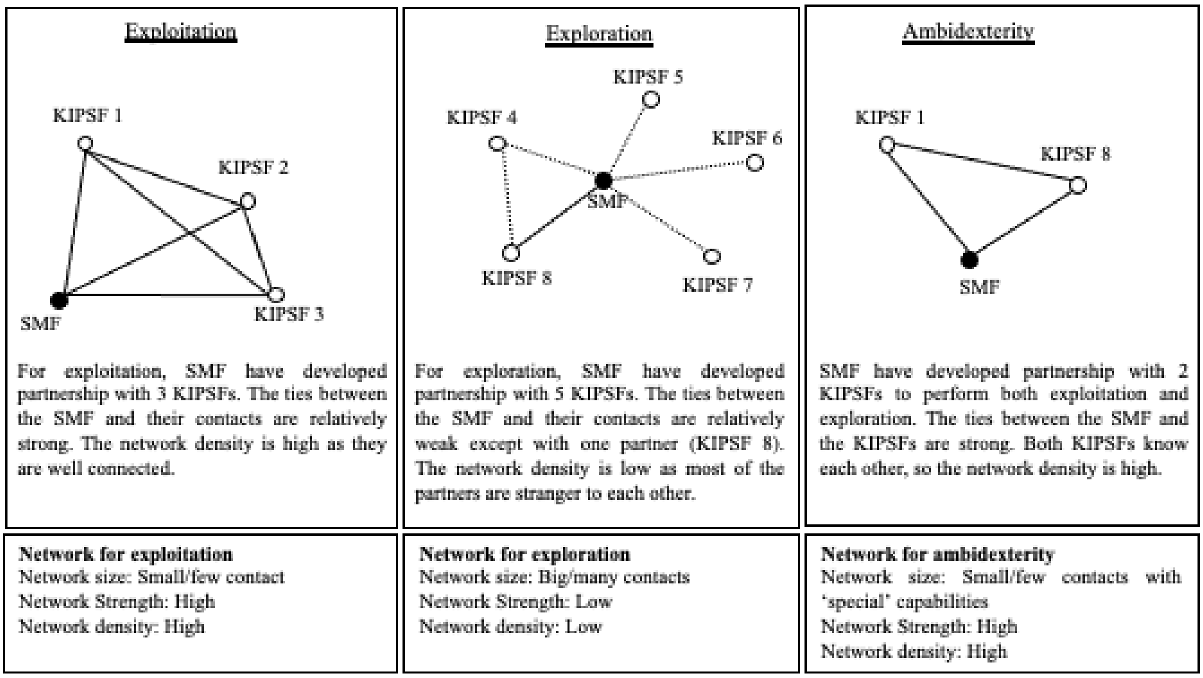

Note: ___ represents strong ties, while ..... represents weak ties. The network density is high when KIPSFs know each other and low when KIPSFs are stranger to each other.

2.2 The impact of different network configurations on NPD performance

In exploitation, SMFs rely on a network focusing on the quality of the relationship. While networks with KIPSFs clearly have some benefits, evolutionary perspectives suggest that firms should anticipate variable returns from their network partners due to difficulties in sourcing knowledge from them (Dhanaraj & Parkhe, 2006). Over time, SMFs will likely enjoy increasing returns based on their ability to source and appropriate novel information from partners (Lavie & Rosenkopf, 2006) but decreasing returns given the likelihood of path-dependent relationships with network partners (Grabher, 1993). In other words, putting too much effort into strengthening network ties with existing partners may adversely affect innovation performance (Lazer & Friedman, 2007). Moreover, adverse effects tend to impede SMFs' ability to receive further benefits as it takes more time and effort to maintain the network (Brattström et al., 2019). Hence, as network ties become denser and stronger, performance

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improves (Xie, Fang, & Zeng, 2016), but only to a point, beyond which increases in the effort to build a network will lead to a deterioration in performance (den Hamer & Frenken, 2021).

Two key reasons explain why overemphasis on building a network for exploitation will negatively influence performance. First, a network for exploitation shapes the willingness of network partners to share information, knowledge and resources because people are more likely to cooperate with others who are close (Uzzi, 1997; Xie et al., 2016). Based on homophily (McPherson, Smith-Lovin, & Cook, 2001), a network may constrain the search for new and novel information by limiting the range of alternative knowledge sources (Uzzi, 1997). Second, using resources originally allocated for other activities to maintain a reciprocal relationship may help to exploit knowledge or certain technologies in the short term, but it is unlikely to benefit the firm in the long term (Mao et al., 2020). Furthermore, the closer the network ties with partners the more the SMF loses autonomy as each decision requires their approval (Burt, 1992; Gargiulo & Benassi, 2000). Finally, developing such a network beyond the optimum point – when the costs of developing or maintaining the network exceed the benefits (Gupta & Zhdanov, 2012) – will cost firms in terms of time, resources and their ability to identify radical and gradual changes in the business environment, such as market, competition, customer and technological developments (Koryak et al., 2018). Hence, we propose the following hypothesis:

H1. A network for exploitation has a curvilinear (inverted U-shaped) relationship with NPD performance.

Thus, a curvilinear relationship between a network for exploration and performance is expected. Firms that seek new perspectives through exchanges of ideas with network partners they meet infrequently do not share the same background and operate in different contexts

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(Lyytinen, Yoo, & Boland, 2016). However, by focusing heavily on developing and maintaining many network partners with weak ties, SMFs risk losing not only the chance to receive refined information and knowledge that are important during NPD but also the ability to identify opportunities related to current technologies or products. In addition, expanding a network for exploration requires that resources are committed to unknown outcomes. This is a problem for SMFs as they must balance risks and allocate resources against the expectation of satisfactory outcomes. These arguments lead us to hypothesise the following:

H2. A network for exploration has a curvilinear (inverted U-shaped) relationship with NPD performance.

Similarly, the more KIPSFs that are involved in a network for ambidexterity, the greater the complexity of the relationships (Dhanaraj & Parkhe, 2006) and the greater the risk of adverse effects on the performance of NPD (Opper & Burt, 2021). Such a network cannot be managed effectively and SMFs may risk being locked in with their KIPSFs, which reduces the chances of receiving the benefits from a network that supports both exploration and exploitation activities. Having too many overlapped network ties with KIPSFs will also create redundant information and knowledge, which hampers the development of a new product. Here, the challenge is to manage the network by dynamically replacing and removing network partners (Greve, Rowley, & Shipilov, 2013). The idea is to maintain an optimum number of network ties to avoid any negative impacts from the cost of maintaining them. Hence, enjoying the maximum benefits of an overlapped network can be achieved only by finding an optimum point. Thus, the following hypothesis is constructed:

H3. A network for ambidexterity has a curvilinear (inverted U-shaped) relationship with NPD performance.

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3. Research approach

3.1 Samples

This study collected data from SMFs in the northwest of England that were developing one or more new products at the time. The study followed those firms by interviewing staff at least twice a year (four times per firm in total) to capture the network effects on innovation outcomes. Initially, 201 firms participated in this study, but only 164 met the criteria for exploitation and exploration and committed to our research for two years (see Table 1). Most of the firms were small with on average 17.55 full-time employees (FTEs). While 34 firms had fewer than 10 FTEs, 122 firms had between 10 and 50 FTEs. Job growth as measured by the number of employees was relatively moderate, with an average of 0.89 FTEs per year: 112 firms (68.3%) experienced job growth of 1 or less FTE per year, and 52 firms (31.7%) experienced job growth of more than 1 FTE per year.

Table 1. Characteristics of the firms (N = 164 firms)

	Frequency	**Percentage**
Size: Number of employees (mean: 17.55; SD:26.90)		
≤ 10 FTE	34	20.73
11–25 FTE	64	39.02
26–50 FTE	58	35.37
> 50 FTE	8	4.88
Jobs growth (mean: 0.89; SD:1.01)		
≤ 1 FTE	112	68.3
> 1 FTE	52	31.7

3.2 Using network mapping for data collection

This study employed an innovative research design to examine SMFs' networks. Data were collected through a series of workshops and individual sessions during the NPD process. Participants were briefed about the objectives of the study and were asked to provide

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information about firms and founders' demographics. In addition, questions about current innovation activities, firm characteristics, products and markets were also asked. In the next step, the participants were invited to generate a list of their KIPSF partners. They were also asked to describe their exploitation and exploration activities or both. For ambidexterity, this study considered whether exploitation and exploration were performed continuously or subsequently (Luger, Raisch, & Schimmer, 2018). Participants were given copies of Table 2 to define types of exploration and exploitation activity.

Table 2 Categories of exploration and exploitation activities during NPD

Dimension of activity	**Exploration**	**Exploitation**
Product development/ improvement	Firms search for new opportunities to develop new products.	Firms evaluate opportunities to exploit existing products.
Production and process	Firms explore new ideas, new approaches and new ways of production and management of NPD organisation.	Firms focus on improving the efficiency and the effectiveness of the process and management of NPD organisation.
Marketing	Firms explore diverse options for new markets and customers.	Firms exploit diverse options to increase economies of scale of the existing market and customers.
Distribution channel	Firms explore possibilities to open a new distribution channel as a result of NPD.	Firms focus on improving the current distribution channel to support NPD.
Technology	Firms search for opportunities with respect to new technology (i.e., not yet capitalised within the firm).	Firms exploit current technology.

The participants were then asked to draw their network with KIPSFs during exploitation. Using their network map as a base, more data about the network were collected, including length of relationship, frequency of interaction, content of conversation, etc. The participants were also asked to describe the types of activities performed by each KIPSF and their contribution to the firm's NPD efforts. The network mapping activity and data collection process were then repeated to examine participants' network with KIPSFs during NPD.

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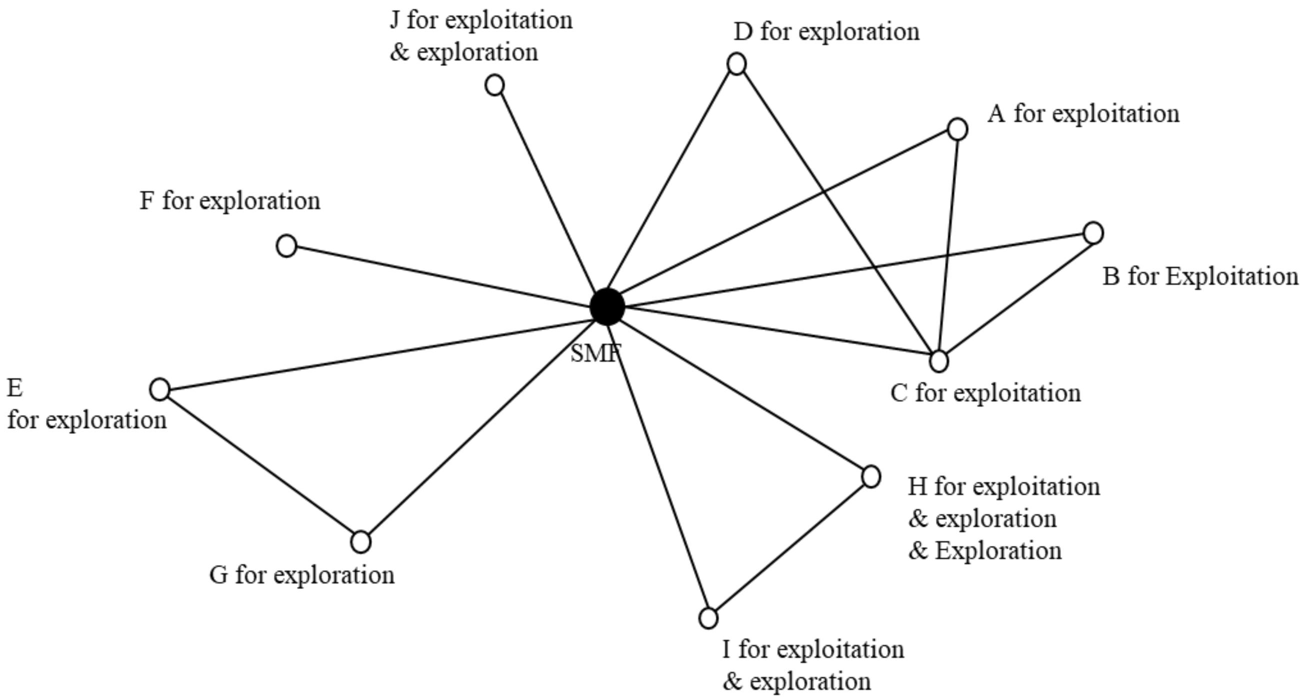
As the goal of this study was to capture the characteristics of the participants' network at different stages of NPD, data collection was repeated over two years, depending on the extent of NPD completion. By collecting data in batches, we were able to validate the data, reduce memory bias (which is typical in network studies) and triangulate the data as the firms progressed in their NPD process (Soetanto, 2019). Figure 2 illustrates a typical network map collected after the workshop and individual sessions.

Figure 2. Example of participant's network map (illustration)



3.3 Dependent variables

This study measures two sides of NPD performance: *product innovativeness* (the extent of technology or innovation involved during NPD) and *speed to market* (firms' intention to take first-mover advantages by launching their product on the market) (McKelvie, Johnson, & Mathisen, 2017). The variables were selected as they represent two different objectives during NPD. Firms focusing on innovativeness may reduce speed to market, while firms focusing on speed to market may sacrifice innovativeness (Lieberman & Montgomery, 1988; Hoang &

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Rothaermel, 2010). This study explores the impact of networks on the product innovativeness and speed to market.

Product innovativeness. This variable was adopted from Moorman's (1995) new product creativity scale. Respondents were asked to rank on a 5-point Likert scale the extent to which the developed component was novel to the industry and offered new ideas. The coefficient alpha is .851.

Speed to market. Respondents were asked to rate speed of market of their new product development on a 5-point semantic differential scale adopted from Griffin (1997). The coefficient alpha is .801.

3.4 Independent variables

The independent variables were generated based on the network maps produced by the participants. These variables used an ego-centred network measure based on McEvily and Zaheer (1999).

Network size was measured as the total number of KIPSF partners in SMFs' network.

Network strength was constructed as a composite variable derived from three-rank variables (Burt, 1992): frequency of face-to-face interaction (i), duration of relationship (d), and the firm's assessment of closeness of the relationship (c) with KIPSF partners (n). A high value indicates a strong network (min: 0; max: 1). The formula is as follows:

$$= \left(\frac{\sum_{p=1}^{n} i_p + \sum_{p=1}^{n} d_p + \sum_{p=1}^{n} c_p}{3n}\right)/3$$

where:

n = the total number of KIPSF partners appearing on the network maps,
i = frequency of face-to-face interaction with a KIPSF partner,
d = duration of the relationship with a KIPSF partner,
c = degree of closeness with a KIPSF partner.

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Network density describes the degree to which KIPSFs are tied to each other within a network. The networks were constructed based on two considerations: (1) participants' views on the relationships among KIPSFs and (2) the extent to which the KIPSFs know each other. A high value indicated a close network where most contacts knew each other, while a low value indicated that contacts were relative strangers (min: 0; max: 1). The network density was computed as follows:

= (Potential ties – Actual ties) / Number of contacts

where:

Potential ties = the maximum number of ties that could exist among contacts or n(n-1)/2; where n is the total number of contacts,

Actual ties = the number of ties that existed among contacts,

Number of contacts = the total number of contacts that appeared in the network maps.

Network size for ambidexterity. This variable was measured as a total number of KIPSFs with whom SMFs conducted both exploration and exploitation activities. The variable was calculated as follows:

= Number of KIPSFs for performing ambidextrous activities / Total number of all KIPSFs

3.5 Control variables

To tackle endogeneity problems, we used the following control variables.

Age of firm was measured as years since the firm was established. The variable aims to control whether old firms may have more resources to perform exploration, exploitation and ambidexterity.

Size of firm refers to the number of employees (including founders), and controls for the extent to which firms accumulate resources, competencies and network contacts as a function of their size.

R&D ratio was measured as a ratio between R&D expenditure and total sales in the last three year of firms' operation (Barker & Mueller, 2002; Chen & Hsu, 2009). This variable controls for the size effect and heteroscedasticity and better reflects a firm's commitment to innovation (Chen & Hsu, 2009; Hoskisson & Hitt, 1988).

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New product portfolio was measured by the number of new products introduced to the market in the last two years, controlling for SMFs' ability to conduct NPD.

4. Findings

In the first part of this section we report our findings on network characteristics. In the second part we present the results of hypothesis testing on the relationships between network configurations and their effects on the two dependent variables: product innovativeness and speed to market.

4.1 Network configuration for exploitation, exploration and ambidexterity

Table 3 illustrates what we discussed in the theory section: that there were fewer network configurations with KIPSFs supporting exploitation than there were with KIPSFs supporting exploration. The findings show that the network for exploitation possessed a significantly higher *network density* than the network for exploration. While the statistical analysis found no significant difference in terms of network strength for both networks, the network for exploitation was slightly stronger than the network for exploration.

Table 3. Network configuration for exploitation and exploration (N=164 firms)

	Network for exploitation Mean (SD)	**Network for exploration** Mean (SD)	**t-test**
Size of network	5.66 (2.12)	9.73 (4.03)	**
Network strength	0.60 (0.55)	0.49 (0.39)	n.s.
Network density	0.67 (0.32)	0.41 (0.21)	†

†: $p<.10$; *: $p<.05$; **: $p<.01$; n.s.: not significant

The results of our analysis of network size for ambidexterity are shown in Table 4: 29.27% of the firms had no overlapping KIPSF contacts, meaning each KIPSF in the network supported either exploitation or exploration. In contrast, around 70% of the firms had KIPSF partners supporting both exploitation and exploration. However, the size of such networks is

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quite diverse across firms, with most of the firms (34.76%) having <15% overlapping KIPSF contacts for ambidexterity, and 23.17% of the firms with 15%–25% similar KIPSF contacts. Interestingly, around 13% of the firms had more than 25% similar KIPSF contacts. This finding is interesting as it shows how small firms overcome their limitation to perform both exploitation and exploration by seeking help from few KIPSFs with 'special' capabilities.

Table 4. Network configuration for ambidexterity (N=164 firms)

Number of firms with the percentage of overlapped network for ambidexterity (x 100%)	N (firms)	Percentage
<0% (no KIPSFs for supporting exploitation and exploration)	48	29.27
0%–15%	57	34.76
16%–25%	38	23.17
26%–50%	12	7.32
51%–75%	8	4.88
>75%	1	0.61

4.2 The curvilinear relationship between network and performance of NPD

Prior to the analysis, we performed several checks: all correlations of the variables in this study were below the maximum recommended level of 0.70 for regression techniques, while the result of the VIF (Variance Inflation Factor) test shows that all values are below 1.60 with an average at 1.43, indicating that multicollinearity is not a problem. Examination of the residuals and scatterplots showed that heteroscedasticity in the regression was not a problem, either. The normality of the variables was examined graphically. We concluded that the analysis could be performed as we found no violations of the assumptions.

Using two dependent variables (product innovativeness, speed to market), the hypotheses predict a curvilinear (inverted U-shaped) relationship between networks for exploitation, exploration and ambidexterity, and NPD performance. Overall, the analysis (Models 1 and 2, Table 5) confirms a linear relationship between the network for exploitation and product innovativeness: *network strength* was positive and significant (β=.48; p=<.01) and

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network density was positive and significant (β=.29; p=<.05). When the squared term of those variables was entered, the result was statistically insignificant, indicating that the curvilinear trend does not exist in the model. These findings indicate that having a network characterised by strong ties and a high level of network density for exploitation positively impacts product innovativeness.

Models 3 and 4 show that *network strength* and *network density* were insignificant in networks for exploration and hence do not affect NPD performance in terms of product innovativeness. For Models 5 and 6, our findings show that having a higher number of KIPSFs for ambidextrous activities positively impacts product innovativeness: *network size* for overlapped networks was positive and significant (β=.42; p=<.01). However, when the squared term was entered, the trend took a curvilinear shape as the variable remained significant but negative (β=-.28; p=<.05). This finding shows that the impact of having a network for ambidexterity may not be optimal beyond a certain point as the cost of managing so many similar ties in the network overshadows the benefits of balancing exploitation and exploration.

Table 5. OLS regression analysis with product innovativeness as a dependent variable

	1	2	3	4	5	6
Age of firm	.12	.08	.10	.11	.12	.12
Size of firm	.19†	.16	.20†	.15	.14	.15
R&D ratio	.18	.19	.15	.20†	.21†	.19
New Product portfolio	.03	.01	.02	.01	.04	.04
The linear effect of network for exploitation						
Network size	.01	.02				
Network strength	.48**	.40**				
Network density	.29*	.26*				
The curvilinear effect of network for exploitation						
Network size^2		.09				
Network strength^2		-.04				

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Network density^2		-.06				
The linear effect of network for exploration						
Network size			.10	.09		
Network strength			-.15	-.11		
Network density			.04	-.02		
The curvilinear effect of network for exploration						
Network size^2				.15		
Network strength^2				.16		
Network density^2				.19		
The linear effect of network for ambidexterity						
Network size					.42**	.41**
The curvilinear effect of network for ambidexterity						
Network size^2						-.28*
R2	.39	.42	.47	.35	.39	.42
Adj-R2	.35	.38	.43	.31	.35	.37
f	25.64	27.98	34.56	22.15	25.67	29.34

Note: †: *p*<.10; *: *p* <.05; **: *p* <.01

The next section presents the results of the analysis of *speed to market* as a dependent variable. The regression results from Models 7 and 8 (Table 6) show that none of the variables for the network for exploitation were significant. However, Models 9 and 10 show that *network size* was positive and significant (β=.39; *p*=<.01), and the square term was negative and significant (β=.30; *p*=<.05). This indicates an inverted U-shaped relationship where the impact of network size is positive up to a certain point, beyond which adding more KIPSF relationships will negatively impact speed to market. The findings also show that *network strength* was negative but significant (β=-.26; *p*=<.10), indicating that the weaker the relationship, the more positive the impact on speed to market. However, the squared term for this variable was positive and significant (β=.22; *p*=<.10), demonstrating the presence of a curvilinear relationship.

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The findings further show that the linear effect of *network density* was negative and significant (β=-.44; p=<.01), meaning that the lower the density of the network for exploitation, the quicker the firms can launch their product on the market. Moreover, an inverted U-shaped relationship was observed as the squared term of the variable was positive and significant (β=.29; p=<.05). This indicates that having a low level of network density affects the allocation of resources, later affecting the ability to bring products to market. In other words, beyond a certain point, the cost of maintaining network relationships may outweigh the benefits.

In examining the role of a network for ambidexterity on speed to market, the regression analysis revealed that *network size* was significant (β=.40; p=<.01) and a curvilinear trend was detected (β=-.35; p=<.05). Overall, the findings show that when using speed to market as a performance indicator for NPD, the network for exploration and the overlapped network for ambidexterity have an inverted U-shaped relationship.

We conducted several tests to improve the robustness of our test results. First, instead of the two dependent variables, we changed the measurement of the dependent variables. For product innovativeness, we switched the dependent variable with other measures of innovation performance, such as share of turnover or profit with new products. For speed to market, we used the exact number of months for firms to produce their new product. In all tests, we arrived at the same conclusions, although the level of significance was slightly different. The control variables, such as size and age of firm, were significant in the robustness test models because larger and older SMFs have more experience and well-established networks.

Table 6. Regression analysis with speed to market as a dependent variable

	7	8	9	10	11	12
Age of firm	.12	.10	.08	.11	.13	.12
Size of firm	.20†	.19†	.17	.18	.16	.17

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R&D ratio	.21†	.22†	.20†	.20†	.17	.18
New Product portfolio	.05	.06	.05	.04	.06	.03
The linear effect of network for exploitation						
Network size	-.13	-.11				
Network strength	.19†	.17				
Network density	.09	.11				
The curvilinear effect of network for exploitation						
Network size^2		.02				
Network strength^2		-.07				
Network density^2		-.10				
The linear effect of network for exploration						
Network size			.39**	.23*		
Network strength			-.26*	-.21†		
Network density			-.44**	-.38**		
The curvilinear effect of network for exploration						
Network size^2				-.30*		
Network strength^2				.22†		
Network density^2				.29*		
The linear effect of network for ambidexterity						
Network size					.40**	.28*
The curvilinear effect of network for ambidexterity						
Network size^2						-.35**
R2	.49	.56	.47	.52	.39	.42
Adj-R2	.45	.52	.43	.50	.35	.37
f	27.21	28.18	39.01	40.33	31.11	33.84

Note: †: p<.10; *: p <.05; **: p <.01

5. Discussion

Our findings offer insights into the effects of different network configurations between SMFs and KIPSFs during NPD. As Figure 3 illustrates, various network configurations for exploitation, exploration and ambidexterity have different effects on the performance of NPD.

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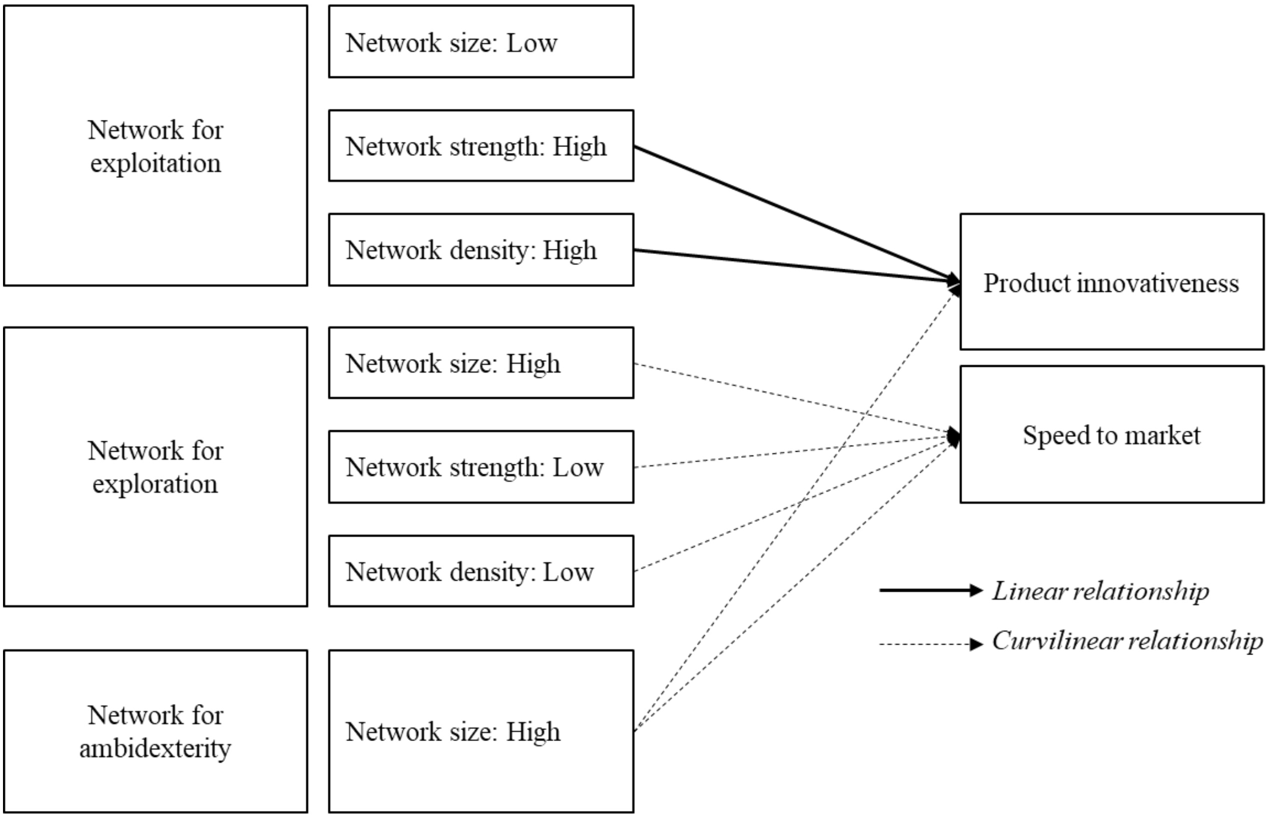
Figure 3. The impact of networks on the performance of NPD



5.1 A linear relationship between networks for exploitation and product innovativeness

The findings show that networks for exploitation have more direct effects on product innovativeness than speed to market as the relationship between such networks and product innovativeness is linear. By developing a network characterised by a few partners, high level of network strength and a high level of network density, SMFs enjoy a high level of product innovativeness. The more SMFs rely on those KIPSF contacts and commit resources to develop the network, the more positive its implication on innovation performance. These results confirm our argument that when SMFs engage in developing innovative products, they may rely on KIPSFs for supporting unproven ideas and new product innovation. Access to such networks will facilitate the development of routines for innovation (Gölgeci et al., 2019),

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reduce the likelihood of making errors and reduce the cost of searching and contributing to product innovativeness. This finding brings more depth to Tiwana (2008: 251) who argued that a 'network of collaborators with strong ties has greater capacity to implement innovative ideas'.

However, a potential drawback of networks for exploitation is that they do not influence the speed to market, probably due to the time it takes to build productive trust-based relationships (Brattström et al., 2019) and reciprocate resources needed for the development and appropriation of innovations (Arora, Belenzon, & Patacconi, 2021). Interestingly, this finding counters the general assumption of exploitation where such benefits are relatively more proximate in time than exploration-based collaborations (March, 1991). Networks for exploitation are – unlike contractual safeguards that may accelerate and secure the development of valuable knowledge for innovations (Arora et al., 2021) and their marketisation through different appropriation regimes (Teece, 1986) – subject to socialisation, learning and development of mutually beneficial modes of collaboration (Gilsing & Nooteboom, 2006). Given the complexity involved, networks for exploitation are relatively less beneficial to realise specific strategic goals such as first-mover initiatives in penetrating new markets (Stuart & Sorenson, 2007). This argument rests on prior findings, which show that, despite the importance of exploitative collaborations for product improvements (Faems et al., 2005), such partnerships tend not to yield much novelty due to potential issues with trust (Gilsing & Nooteboom, 2006) or with poor motivation for substituting low-value knowledge with high-value knowledge in the presence of 'outlearning' behaviours among network partners (Arora et al., 2021).

5.2 A curvilinear relationship between networks for exploration and speed to market

The findings show that almost all network configurations of networks for exploration positively influence the speed to market. The benefit of having a network focusing on expanding the

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number of KIPSF partners, a low level of network strength (weak ties) and a low level of network density helps SMFs bring their new products to market quickly (Mustak, 2019). This contradicts the assumption that relationships with multiple KIPSFs may negatively affect NPD over time due to the need to maintain relationships with partners with different or even inimical goals (Dhanaraj & Parkhe, 2006). The reason is because the network involve fewer KIPSFs partners in which SMFs may know them for a long period of time. As a result, they tend to be less bureaucratic, more flexible (Hitt et al., 2011) and have shorter strategic decision-making processes, which enable them to act quickly to seize opportunities for exploration.

Moreover, the finding shows that network for exploration has a curvilinear relationship with speed to market (see Figure 4). SMFs are also exposed to the risk of limited expertise when engaging in networks for accelerating speed to market. As noted in previous studies, firms will be exposed to vast amounts of information in their boundary-spanning activities, which may or may not be valuable for their decisions and activities, depending on their expertise in strategically exploiting the information for various technological domains (Moeen & Mitchell, 2020). When facing the risks stemming from exploration, firms are likely to hesitate before responding to market opportunities and thus decelerate speed to market. As Chen and Hambrick (1995: 461) put it, small firms ‘tend to be circumspect and hold their fire longer than large firms. Because of limited resources, they may have to be more selective in responding and more deliberate in making such decisions.

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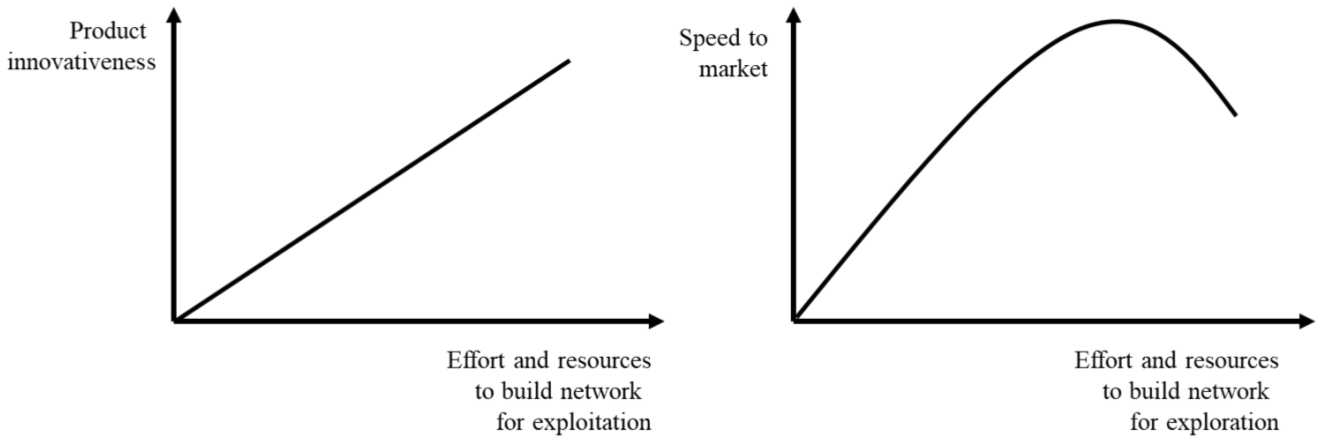
Figure 4. The linear and curvilinear relationship between the efforts and resources to build networks and performance of NPD



Moreover, relying on a network for exploration is a double-edged sword for many SMFs. On the one hand, SMFs can exploit diverse information and knowledge for accelerating speed to market. On the other hand, SMFs are more exposed to exogenous (e.g. environment and technology) and endogenous (e.g. strategic and technological expertise) constraints (Madrid-Guijarro, Garcia, & Van Auken, 2009) that limit the advantages of networks for speed to market. These dual effects are likely to be affected by firms' absorptive capacity (Fang & Zou, 2010) and neutralise the overall benefits of accelerating speed to market.

5.3 A curvilinear relationship between networks for ambidexterity and NPD performance

SMFs' newness and size (Hitt et al., 2011) make them vulnerable when engaging in ambidextrous activities. The networks SMFs develop for exploitation and exploration, respectively, can be both advantageous and disadvantageous. When SMFs are part of or at the edge of the technological trajectory of an industry or sector, they are likely to use their technological advancements to gain first-mover advantages over incumbents and other actors (Lieberman & Montgomery, 1988). Here, maintaining both types of networks can still be affordable from the SMFs' perspective: the network for exploration can help them search for

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innovations and gain legitimacy, while the network for exploitation can support innovation activities in existing products or technologies.

Our findings suggest that firms develop networks that help them benefit from both activities, but in a cost-effective way. SMFs in our sample developed an overlapped network with a few KIPSFs to perform ambidextrous activities. This strategy can be used to lower the cost of network development and provide an efficient mechanism to gain support for both exploitation and exploration. Having a separate network for each innovation activity may prove disadvantageous for innovation if the cost is too high (Arora et al., 2021), hence impacting the performance of NPD (Lieberman & Montgomery, 1998).

As such, our findings extend prior arguments (e.g. Faems et al., 2005; Rothaermel & Deeds, 2004) by showing that KIPSFs can play dual roles in supporting SMFs: they grant SMFs the benefits of exploration and exploitation simultaneously in the form of ambidextrous networks, suggesting that networks for ambidexterity do not require the assumed temporal decoupling (Junni et al., 2013) related to different NPD activities. Our study also reveals an inverted U-shaped relationship between networks for ambidexterity and innovation performance (product innovativeness and speed to market). There is an inherent trade-off between exploration and exploitation where exchanges in such networks will benefit from network size (more diversity) and novelty (more structural holes and weak relationships). Both components are contingent on the inherent problem of weak relationships, where more novel information is exchanged and is therefore more likely to contribute to complex knowledge valuable for NPD (den Hamer & Frenken, 2021). However, such novelty is likely to diminish over time as the SMFs' focus shifts from one NPD to another, and requirements for new sources of knowledge change. This line of argument builds on the obsolescence of knowledge or overlap tendency within innovation networks (Owen-Smith & Powell, 2004). Our study thus

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provides a more nuanced view on earlier studies showing that networks for ambidexterity generate positive performance effects for large firms but not for small firms (Lin, Yang, & Demirkan, 2007), like those in our study.

Our findings suggest that SMFs need to constantly reconsider their networking strategy, as having too few or too many KIPSF partners for ambidextrous networks may not be effective for improving NPD performance. This is an important finding, contributing some initial clues to the role of microfoundational approaches to ambidexterity in NPD (Tarba et al., 2020). Moreover, this suggests that SMFs need to understand the limits of their networks for improving NPD performance. For example, KIPSFs may face challenges to maintain capabilities to perform both exploitation and exploration in networks for ambidexterity, and SMFs should understand these potential changes in KIPSFs' capabilities over time (Pina & Tether, 2016) while recognising the potential risks of being locked into such (static) networks. This triggers an interesting debate regarding the role of ambidextrous network partners and whether they are beneficial for the long-term innovation activities of SMFs. Indeed, this debate could consider moving beyond ambidexterity to explore the opportunities for 'multidextrous' innovation activities (Demir & Angwin, 2021).

6. Conclusions

This study has examined the different network configurations underpinning relationships between SMFs and KIPSFs. This study argues that SMFs develop different network configurations to meet the demand of performing innovation activities during NPD. Even though exploitation, exploration and ambidexterity have been studied in depth, employing network perspective will potentially offer a new insights (Tarba et al., 2020). This study, therefore, offers valuable empirical findings on how SMFs overcome their resource limitations in pursuit of NPD.

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While the findings show that networks for exploitation positively impact product innovativeness, our findings suggests that SMFs need to find the optimum point before the benefits of networks for exploration and ambidexterity diminishes. SMFs may be stuck in a long-term relationship with KIPSFs that provides only redundant (Maurer & Ebers, 2006) or peripheral resources that no longer lead to successful NPD (Haneda & Ito, 2018). This finding extends recent observations suggesting that, while some degree of knowledge overlap contributes to innovation, maintaining such overlap with the same network partners over time will diminish the benefits (Mao et al., 2020). While there is a likelihood that networks with KIPSFs may yield negative or marginal returns (Amara et al., 2016; Rodriguez, Doloreux, & Shearmur, 2017), SMFs must find a network configuration that is sufficiently supportive for performing innovation activities during NPD.

This paper contributes to the growing literature on innovation in the context of small firms in several ways. The first contribution lies in the application of Social Network Theory in the context of SMFs' innovation activities. By exposing the detailed features of networks (such as network size, network strength and network density), a clear implication of the finding is that different network configurations serve different purposes and require different performance measurements. To capture the benefits of networks, SMFs need to understand their contexts, needs and expectations of innovation during NPD. Moreover, another contribution resides in our approach to the nature of relationships between network and NPD performance. Although examining non-linear relationships is not new, applying such an approach to networks with KIPSFs while drawing on evolutionary thinking and diminishing returns, is new, as is our insight that the benefits associated with ties to KIPSFs in such networks diminish beyond an optimum number. This highlights that networks have limits and distinguishes networks for exploitation from networks for exploration.

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Our second contribution focuses on explaining the motivation of SMFs to build and maintain networks with KIPSFs. Using RBV as backdrop, this study argues that SMFs overcome resource constraint by implementing collaboration and partnership with KIPSFs during NPD. This stream of argument has gained a strong momentum by the popularity of open innovation concept. However, recent arguments in the literature have started to consider when firms should cease open innovation activities (Dahlander, Gann, & Wallin, 2021; Dahlander, O'Mahony, & Gann, 2016; Demir & Knights, 2021; Dobusch, Dobusch, & Müller-Seitz, 2019). Our study complements those arguments by indicating a threshold level when companies should cease open innovation, that is when the value of more complex forms of innovation emerging from exploration and ambidexterity networks declines. We believe this threshold effect is also relevant for other types of firms such as digital and platform-based firms (Nambisan, Siegel, & Kenney, 2018). Hence, when firms recognize that they have reached the threshold, they should consider not only the implications of enlarging their network of contacts (in exploration and ambidextrous networks) with which they have weaker ties and low knowledge overlap (exploration networks), but also that doing so might cause intellectual property breaches, imperfect participation and ineffective governance.

Lastly, it adds to the limited pool of research on innovation intermediaries like professional service firms. In this context, we have noticed that despite many studies conducted on exploitation and exploration during NPD, very few have touched on how networks with KIPSFs affect the ability of firms to innovate. While some studies have indicated that certain types of KIPSFs, notably consultants and universities, make limited contributions to innovation (Wagner, 2013) and tend to attract larger firms (Fritsch & Lukas, 2001), our study demonstrates otherwise. Specifically, we focus on SMFs that cannot justify allocating resources for 'gatekeeping' certain R&D partnerships or spending excessively on internal R&D as larger

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firms do (Fritsch & Lukas, 2001). Furthermore, we focus on product innovativeness and speed to market as performance measures as opposed to service innovation, which tends to require that KIPSFs have more industry-specific knowledge, limiting their innovation contribution to partner firms (Wagner, 2013). These unique features of our study generate some intriguing insights that remain to be unpacked.

These findings also have practical implications for SMFs. Through a deeper understanding of the implications of efficient resource allocation, SMFs can achieve a sustainable balance between exploration and exploitation activities and foster genuinely ambidextrous activities, thus avoiding the exploitation or exploration trap (Sirén, Kohtamäki, & Kuckertz, 2012). This will allow SMFs to continue performing both activities while conserving resources or at least avoid investing them in activities that provide meagre returns. As seeking out KIPSFs can represent a resource-efficient approach to maximising innovation output, this strategy seems vital for SMFs whose resources and networking capability are limited. Moreover, another practical implication relates to SMFs' networking strategy. As there is a chance that developing networks can be counterproductive. Hence, SMFs should be cautious especially in expanding networks with KIPSFs in pursuit of exploratory and ambidextrous innovation. When the threshold levels are reached, firms should consider closing or reducing their partnership. This study therefore not only suggests ways that small firms with limited resources can use different types of innovation partnerships to generate the expected performance effects, but also indicates when they should consider withdrawing from (or reducing) such partnerships.

As with most studies, our study has some limitations. First, networks are complex. This study has examined common network characteristics such as network size, density and strength of ties, but studying networks during NPD requires careful observation as they may change as

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firms revise their strategic priorities. Hence, future studies could examine firms' strategies and organisational environments in the context of dynamic networks. Second, our limited sample and the selected location may limit generalisation of our findings, although SMFs in our sample are representative of most firms in developed countries. Such firms develop and maintain commercial relationships with similar firms nearby, however geographical remoteness and industrial specialisms may influence the development of innovation networks (Jaffe, Trajtenberg, & Henderson, 1993), which should be acknowledged in future studies. Finally, our analysis reveals that several control variables were insignificant, such as size of firm. The received view is that larger firms can perform exploitation or exploration activities in-house, without any support from KIPSFs. Therefore, we suggest enlarging the sample in future studies to include measures for firm size and age and to accommodate control firms.

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APPENDIX

Product innovativeness	
Please rate the degree to which the new product component is:	
1. Very ordinary for our industry/very novel for our industry.	.873
2. Not challenging to existing ideas in our industry/challenging to existing ideas in our industry.	.821
3. Not offering new ideas to our industry/offering new ideas to our industry.	.767
4. Not creative/creative.	.742
5. Uninteresting/interesting.	.709
6. Not capable of generating ideas for other products/capable of generating ideas for other products.	.875
Product speed to market	
Please rate the degree to which the development speed of the new product component is:	
1. Far behind our time goals/far ahead of our time goals.	.754
2. Slower than industry norm/faster than industry norm.	.890
3. Much slower than we expected/much faster than we expected.	.765
4. Behind where we would be had we gone it alone/ahead of where we would be had we gone it alone.	.812
5. Slower than our typical product development time/faster than our typical product development time.	.706

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