Contextualising the role of external partnerships to innovate the core and enabling processes of an organisation: A resource and knowledge-based view

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Abstract

The knowledge-based view (KBV) theory argues that organisations gain a competitive advantage by adopting strategies to capitalise on their knowledge resources, e.g., organisational culture, managerial decision-making and innovative new processes. Large organisations partner with external technology suppliers to develop such technology-driven processes. However, within the context of large organisations, there remains a lack of insight into the motivation and structures of how and why large organisations collaborate with external partners to create such technology-driven processes. To explore the identified problem of understanding the collaborating mechanisms that contribute to technology-driven process innovation in large manufacturing organisations, we analyse and develop inductive concepts using multiple data points. Our research illustrates that external technology partners act as a mediating influence in process-innovation projects by contributing to the capabilities or capacity of an organisation.

Keywords: Technology-driven processes, knowledge-based view, process innovation, decision-making

1.0 Introduction

Organisations innovate by modifying or developing new processes that are often underpinned by emerging technologies (Masucci et al; 2020; Carrillo & Gaimon, 2002; Edquist et al, 2001; Meeus & Edquist, 2006; Chirumalla, 2021; Rust & Espinoza, 2006). For example, BMW Motoren GmbH has partnered with Siemens to reduce the lifecycle energy consumption of car engines using its Tecnomatix plant simulation solutions (Siemens, 2020). The concept of adopting new and emerging technologies to boost an organisation's innovation capability is well documented in the literature (Carrillo & Gaimon, 2002; Edquist et al, 2001; Meeus & Edquist, 2006; Chirumalla, 2021; Milewski et al, 2015; Milewski, 2015). Studies have shown that an organisation's competitive

performance is increased as a direct result of adopting new and emerging technologies to modify or develop new processes (Chirumalla, 2021; Reichstein & Salter, 2006). Using tangible and intangible resources via a series of coordinated business functions to create value within an organisation is referred to as the resource-based view (RBV) of the organisation (Penrose, 1959). Large organisations often develop strategic partnerships with external suppliers to create value. For example, organisations often acquire new processing equipment from external sources to induce change or improve product outputs (Dubey et al, 2019; Reichstein & Salter, 2006). Mechanisms of using external linkages to give a competitive advantage to an organisation are referred to as the extended RBV (Popli et al, 2017, Cao and Zhang, 2011, Dyer and Singh, 1998). Another derivation from this view is that knowledge is an essential resource for an organisation to be competitive (Grant, 1996). This knowledge-based view (KBV) offers a “rationale for considering knowledge as a strategic resource” of an organisation (Pereira & Bamel, 2021). Studies have shown that issues of knowledge absorption (Martínez-Sánchez et al, 2020; Xie, Zou & Qi, 2018), transferability (Su et al, 2020; Bacon et al, 2020) and reuse (Lee et al, 2021) are important elements for an organisation to compete. This also implies that the issues associated with efficiency and effectiveness of knowledge transfer are important (Grant, 1996; Xie, Zou & Qi, 2018). Grant & Baden-Fuller (2004) show that organisations use several mechanisms, ranging from strategic alliances to network ties, to either develop knowledge internally or acquire/access knowledge externally.

The mechanisms of using external linkages to gain competitive advantage are also one of the central tenets of open innovation (OI) literature (Chesbrough, 2003). Organisations work with partners or suppliers using strategic alliances to advance their

process competencies. The benefits of developing strategic partnerships to improve an organisation's performance in the market are well documented in both the KBV and OI literature (Von Krogh, Netland & Wörter, 2018). Both KBV and OI literature has researched the role of external partnerships in studies covering topics ranging from alliances to mergers and acquisition (Barney, 2001). Barney (2001) studies these within the context of assets, capabilities, knowledge and processes, and argues that these dimensions form the basis of the competitive advantage of an organisation.

The importance of both KBV and OI literature within the context of product innovation is highlighted in the literature (Liu et al, 2017; Huizingh, 2011; Robertson, Casali & Jacobson, 2012; West & Gallagher, 2006). But only a few studies have investigated how process innovation links to value-creation mechanisms using external partnerships (Tsinopoulos, Sousa & Yan, 2018; Von Krogh et al, 2018). This aspect of understanding how external partnership mechanisms can create value within an organisation is critical for two reasons within the context of this paper: 1) product and process innovation are neither orthogonal nor mutually exclusive (Adner & Levinthal, 2001; Utterback & Abernathy, 1975) and 2) facilitating a better interplay between product and process innovation holds the potential for the development of a long-lasting competitive advantage (Hullova et al, 2019). Therefore, this paper investigates how the underpinning collaborating mechanisms between an organisation and external partners create capabilities and capacity, which has not been systematically explored in any previous literature. In addition to this novelty, this paper specifically addresses the context in which knowledge absorption takes place in technological process innovation using data from five large German manufacturing organisations. This study, therefore, makes a significant contribution to extending KBV theory on how decision-

makers manage effective collaboration with external partners for the development and implementation of new internal processes (Tower, Hewett & Saboo, 2021; Ko et al, 2020; Huang & Rice, 2012; Terjesen & Patel, 2014). Specifically, we show that external technology partners act as a mediating influence in process-innovation projects by contributing to the capabilities or capacity of organisations. Furthermore, at a practice level, our results show that managers need to be aware of the type of process they develop, to make adequate plans for interaction with external partners. By doing this, we make a step-change in the current studies (Cherbib et al, 2021; Santoro et al, 2021; Frishammar et al., 2012), which have focused on external contributions towards technological change but have not distinguished between different types of processes and how this can affect a company's motivation to work with external partners.

In this study we show that collaborating mechanisms between an organisation and its external partners can create capabilities and capacity from a process lifecycle perspective. Our study specifically shows that external technology organisations give a large organisation the required and missing internal capabilities and capacity to develop and implement new processes. Our empirical findings make both contextual and theoretical contributions. From a contextual perspective, this study shows how and in which context knowledge absorption takes place in technological process innovation. Our study shows that managers need to be aware of the type of process they develop to make adequate plans for interaction with external partners. We show that this element is an important theoretical contribution because, while the advantages of working with external partners are well covered in both KBV and OI literature, there remains a lack of insight into the motivation and structures of collaboration with external partners that result in the creation of technology-driven processes. By doing

so, we make contributions to both KBV and innovation management literature by focusing on the motivations to obtain external contributions to internal process innovation and the structure of such collaborations. Our study specifically aims to understand how technology-driven processes allow large organisations to internalise external expertise, and the effects of this phenomenon on the capability of an organisation over its innovation lifecycle.

Our findings also distinguish between enabling and core processes (Milewski et al, 2015), which is critical for managers to maximise the collaboration opportunities between an organisation and an external partner. We also find that this area has not been explored from a process lifecycle perspective. Therefore, our paper makes two contributions to theory. Firstly, we uncover the underpinning collaborating mechanisms between an organisation and external partners to create capabilities and capacity. Secondly, our research addresses the context in which knowledge absorption takes place in technological process innovation. Specifically, we show that external technology partners act as a mediating influence in process-innovation projects by contributing to the capabilities or capacity of an organisation. Furthermore, our results show that managers need to be aware of the type of process they develop to make adequate plans for interaction with external partners.

The paper is structured in five sections: First, we provide a brief review of the existing literature that informs the theoretical background of our study. Second, we outline the methodological approach we applied. Third, we present the descriptive results of our study. Fourth, we discuss and analyse our results to advance new theoretical constructs of open process innovation. Finally, we conclude the paper with a summary

of our contributions, implications for theory and managerial practice, limitations and avenues for future research.

2.0 Literature review

The RBV, since its inception in 1959 (Penrose, 1959) has emerged to be one of the most popular management frameworks for understanding an organisation's strategic and market position (Varadarajan, 2020; Pereira & Bamel, 2021). As argued in the call for this special issue and articulated by Preim & Butler (2001), RBV makes an important contribution in explaining the nature of an organisation's strategic resources and capabilities. Specifically, Preim & Butler (2001) show that RBV, when coupled with other demand-oriented perspectives, is likely to yield the greatest potential. Within this context, demand focuses on the supply side of an organisation's capabilities (Wernerfelt, 1984, 1985) and is often linked to the notion that "resources must be valuable, rare, inimitable and non-substitutable (VRIN) to provide real advantages".

The key argument in these studies (Amit & Schoemaker, 1993; Penrose, 1959, Kor & Mahoney, 2004; Collis & Montgomery, 1995) is that organisations create value by controlling these supply-side resources. Studies have shown that different supply-side strategies allow organisations to harness external environments (Kor & Mahoney, 2004; Collis & Montgomery, 1995) to achieve a competitive advantage. Supply-side strategies have ranged from the use of physical, human and organisational resources to compete, survive and grow (Barney, 1991). Wernerfelt (1984, 1985) and Barney (1991) state that resources need to be mobilised and varied, bringing to the forefront the notion of temporality. Studies (Martin & Javalgi, 2019; Amankwah-Amoah & Adomako, 2021) show that the ability of an organisation to possess or access timely

and relevant knowledge from its resource network is critical to competitiveness. Timely knowledge, albeit internal or external, is therefore seen as an essential resource for an organisation to be competitive (Grant, 1996). Therefore, this knowledge-based perspective, referred to as KBV, offers a “rationale for considering knowledge as a strategic resource” of an organisation (Pereira & Bamel, 2021). From a theoretical perspective, we build on these two issues: temporality or timeliness of accessing knowledge and mechanisms for accessing knowledge. Both issues have been independently highlighted in the literature. Studies have shown that issues of timely absorption (Martínez-Sánchez et al, 2020; Xie, Zou & Qi, 2018), transferability (Su et al, 2020; Bacon et al, 2020) and reuse (Lee et al, 2021) are important elements for an organisation to compete. This implies that the issues associated with efficiency and effectiveness of knowledge transfer need to be considered (Grant, 1996; Zou & Qi, 2018). Grant & Baden-Fuller (2004) show that organisations use several mechanisms – ranging from strategic alliances to network ties – to either develop knowledge internally or acquire/access knowledge externally.

External knowledge acquisition takes place when organisational partners are willing and have the appropriate transfer mechanisms and structures to absorb and assimilate knowledge (Buckley et al, 2009). The issue of willingness or managerial decision-making directly affects issues of innovativeness, responsiveness, sustainability and agility (Durst et al, 2019). However, decision-making activity as a process needs to be underpinned by appropriate processes so organisations can use both exploitative and exploration alliances to enhance their performance (Pereira et al, 2020; Yamakawa et al, 2011). These underpinning collaborating mechanisms need to be timely and organised to create synergies between capabilities and capacity. This is a key issue,

as organisations that are unable to develop timely collaborating mechanisms will not be able to match supply-side resource usage with the demand side of the market. However, this issue cannot be considered in isolation (Preim & Butler, 2001), as understanding the context in which knowledge absorption can take place is equally important for process innovation. Neither of these issues have been fully explored in the existing literature from a process lifecycle perspective. Our study directly addresses these two theoretical gaps.

On the issue of structures, there is overwhelming research on collaborating models – ranging from mergers and acquisitions to strategic alliances – that show how organisations compete (Tower, Hewett & Saboo, 2021; Ko et al, 2020). These studies show that organisations can create value and process innovation using external alliance structures. In particular, the research that has received particular attention is the relationship between an organisation and its external technology partners. Ko et al (2020) use financial data to empirically examine how a strategic alliance (as an enabling structure) impacts an organisation's value in different technological environments or conditions. These findings, as in previous studies (Gupta et al, 2006; Kauppila, 2015), indicate that technological conditions play a moderating role in strategic alliances, and are central to process development and implementation, i.e., process innovation. Additionally, external technology suppliers can support process innovation during different stages of the innovation lifecycle (Milewski, 2015).

An additional issue that has been largely neglected is the difference between different types of processes while studying external technological contributions. This context is critical for large organisations, as managers need to plan and structure their

companies' collaboration with external partners, and scholars need to further improve our understanding of the mechanisms that govern the RBV of organisations (Liu et al, 2017). The issue of motivation (i.e., decision-making) and the conditions under which organisations can maximise their knowledge absorption (Buckley et al, 2009; Durst et al, 2019) is critical to this special issue due to the massive growth in new digital technologies, like 3D printing (Chaudhuri et al, 2018), artificial intelligence, blockchains etc (Pereira et al, 2020). It is well known that large organisations adopt different enabling structures (Gupta et al, 2006; Kauppila, 2015) to work with external technology partners to build internal capabilities. Dubey et al, (2019) show that new technologies, coupled with an organisation's tangible resource base, offer a competitive advantage to organisations. Masucci et al (2020) show that large oil and gas producers use emerging technologies to collaborate with organisations to remove technology bottlenecks in their ecosystems. To this effect, technology has become an enabler of both process and competency in business ecosystems.

However, within the context of how and why large organisations partner with external technology partners, there remains a lack of knowledge into the motivation and structures of how and why large organisations collaborate with external partners to create technology-driven processes. We therefore directly contribute to this special issue by showing how large organisations absorb external knowledge. In doing so, we seek to address the following theoretical gap by 1) examining the underpinning collaborative mechanisms between an organisation and external partners to create capabilities and capacity from a process lifecycle perspective and 2) understand the context in which knowledge absorption takes place in technological process innovation. We do this by studying primary data collected from five large German

manufacturing organisations. We have analysed data from over 90 hours of interviews with a wide range of managers.

2.1 Process innovation and capabilities due to external partnerships

In this section we show that the reconfiguration of technology to fit an existing organisation (and vice versa), or mutual adaptation, is a prerequisite condition for process innovation. From a KBV perspective, mutual adaptation means exploring the necessary conditions for leveraging potential synergistic effects in the adoption of technological and organisational change, i.e., managers using “stocks of available factors that are owned and controlled by the organisation” to deliver competitive advantage (i.e., demand from markets). This notion of mutual adaptation resonates with Preim & Butler’s (2001) view that RBV, when coupled with other demand-oriented perspectives, is likely to yield the greatest potential. It is clear from literature that process innovation is critical in creating capabilities and capacity within an organisation (Chirumalla, 2021). Organisations use both exploitative and exploration strategies to modify or create new processes to enhance their performance (Collinson & Liu, 2019; Yamakawa et al, 2011). Buckley et al (2009) show that organisations absorb and then assimilate external knowledge by developing explicit partnership with external organisations. Several models – ranging from mergers and acquisitions to strategic alliances (Tower, Hewett & Saboo, 2021; Ko et al, 2020) – underpinned by digitalisation, have been used to create value within organisations. The advantages of working with external partners have been well documented in literature, and range from digitisation of processes to reliability, flexibility and an increase in productivity (Chirumalla, 2021). As advocated by the call for papers and the context of Industry 4.0, it is clear that new technologies promise organisations opportunities to re-engineer or

innovate their processes (Carrillo & Gaimon, 2002; Edquist, et al, 2001; Meeus & Edquist, 2006; Chirumalla, 2021). Therefore, working with external technology partners to adopt technology knowledge and bring about innovation is critical for companies to compete and survive (Chirumalla, 2021). Within the context of KBV, this means the issues of timely decision-making (Cao et al, 2019) and the type of process affected because of managerial decision-making are critical to the success of a process innovation project (Bai et al, 2021), i.e., mutual adaptation.

Processes within this context are a structured sequence of activities that transform inputs into specific outputs for a particular customer or market (Davenport, 1995). Similarly, Armistead & Machin (1997) distinguish between 'operational processes', 'support processes', 'direction-setting processes' and 'managerial processes'. More generally, the different types of processes can be aggregately grouped as either core or enabling processes (see Table 1). Core processes relate to the primary activities of the organisation, while enabling processes facilitate the context in which primary activities are carried out. From a KBV perspective, managerial actions and decision-making can affect both core and enabling processes. Positive effects, because of such managerial actions, are referred to as process innovation, i.e., improvements to both core and enabling processes.

Table 1. Different types of processes

Studies show that process innovation is primarily realised by the adoption of relevant technologies (Chirumalla, 2021; Carrillo & Gaimon, 2002; Edquist et al, 2001; Meeus & Edquist, 2006). In the context of process innovation, relevant technologies refer to

technologies such as big data, artificial intelligence, blockchain, augmented reality, as well as software as services (SaS). Durst et al (2019) show that managers (i.e., decision-makers) play a critical role in deciding the most relevant technology for an individual type of process to produce maximum benefits (e.g., cost savings, increases in productivity, better connectivity, etc). Dodgson et al. (2006) distinguish between three generic types of technology and outline how they benefit the innovation process (see Table 2).

Table 2: Different types of technology

Studies have shown that the acquisition and use of relevant technology is critical to process innovation. Managers adopt new process technologies for various reasons. New production technology can reduce yield loss and lower production costs, while new software technology can help monitor operations more precisely in terms of output quality (Carrillo & Gaimon, 2002; Chirumalla, 2021). From a KBV perspective, while there is a strong argument that managers can potentially use internal resources to acquire new technology, there is little evidence to show that the use of internally focused technology development is a superior strategy to working with external sources or using a hybrid strategy (i.e., a combination of both internal and external resources) (Cropper et al, 2008; Cooper, 2007; Lager, 2011; Stock & Tatikonda, 2004). Goyal et al (2020) uses data from over 655 organisations to show that external knowledge is critical for organisational innovation. They further posit that “different forms of external knowledge acquisition contribute differentially toward innovation outcomes” (Goyal et al, 2020).

The main arguments for using external resources or a hybrid strategy are the lack of internal expertise, the pace of technological change and the complexity of core and enabling processes and their effect on productivity (Madsen & Mikkelsen, 2018). Organisations can benefit from the experience and knowledge that external partners accumulate during their involvement with other customers and industrial lead users (Goyal et al, 2020; Brusoni et al., 2001; Davies, 2003; Flowers, 2007). In addition to mere technology transfer, access to experience and knowledge is the main reason for organisations to engage in close interaction with technology suppliers (Petersen et al., 2005; Romijn & Albaladejo, 2002). If managers decide to use internal resources for acquiring and implementing new technologies there is a risk that process innovation may lead to equivocality (Frishammar et al, 2011) and uncertainty (Stock & Tatikonda, 2004). Equivocality refers to “the existence of multiple and conflicting interpretations among project participants” (Frishammar et al, 2011). It is characterised by confusion and a lack of consensus and mutual understanding resulting from the different mental models of a project’s participants. Uncertainty, on the other hand, refers to a negative “difference between available information and the information needed to complete a task”, and is characterised by a lack of relevant information (Frishammar et al, 2011). Equivocality and uncertainty depend on project participants but also the new technology’s attributes (Stock & Tatikonda, 2004). Goyal et al (2020), for example, show how technological novelty, complexity and tacitness determine the degree of uncertainty involved in technological product and process-innovation projects.

It should be noted that process innovation typically entails the adoption of both technological and organisational innovation (Donbesuur et al, 2020). While technological and organisational process innovation can have positive effects on

organisational performance independently of each other (Georgantzas & Shapiro, 1993), the empirical literature typically agrees that organisations can exploit synergies from the dual adoption of complementary technological and organisational innovation (Donbesuur et al, 2020; Georgantzas & Shapiro, 1993).

Empirical evidence from literature shows that collaboration with external technology partners lets organisations lower their process-innovation costs, improve quality and increase productivity (Donbesuur et al, 2020; Pittaway et al, 2004; Ragatz et al, 2002; Ritter & Gemünden, 2003). Additionally, managers can gain access to technology prototypes as well as external technical expertise. This additional expertise enables managers to detect potential problems earlier in the development process than they could have without the help of suppliers (Gómez, et al, 2016). As a result, fewer engineering change orders become necessary throughout the development of a new product or process technology (Boncarossi & Lipparini, 1994; Lau et al, 2010; Monczka et al, 2000). In addition to development-related contributions, external partners can engage proactively with managerial decision-making processes by providing information about technologies and their application (Athaide et al, 1996; Gerwin, 1988; Petersen et al, 2005). Technology suppliers often provide information on potential technological solutions and help reduce uncertainty during the early stages of an innovation project. Despite the benefits of working with technology suppliers, organisations need to be aware of challenges such as divergent objectives and expectations (Tyre & Hauptman, 2008) or the suppliers' limited experiences with a novel or particularly complex technology (Gerwin, 1988). More recently, literature has increasingly maintained an interest in the digital approaches to acquiring external knowledge to enhance internal innovation (Nucciarelli et al, 2017).

From a KBV perspective, congruency is a necessary condition for leveraging potential synergistic effects in the adoption of technological and organisational change, i.e., managers using “stocks of available factors that are owned and controlled by the organisation” to deliver competitive advantages. Mutual adaptation, thus, is a prerequisite for process innovation (Wang et al, 2021; Mukherji & Francis, 2008; Tyre & Hauptman, 2008). In this context, mutual adaptation refers to the reconfiguration of technology to fit with the existing organisation, and vice versa (Milewski et al, 2015).

2.2 OI and KBV

In this section we show that there is a knowledge gap in the type and nature of capabilities the external partner provides to the organisation in helping it develop its resource capabilities. We build our theoretical arguments from the standpoint that, while the benefits of working with external partners are well documented, there is a gap in theory in the type and nature of capability that can be absorbed from an external partner. From a KBV perspective, our study advances the discourse on why and how external partnerships can help organisations create value and thereby have an edge over their competitors. This is primary done by uncovering the underlying mechanisms of partnerships, which are subject to temporal contingencies.

Organisations choose a variety of structural arrangements for working with external partners (Tower, Hewett & Saboo, 2021; Ko et al, 2020). This idea of working across boundaries is widely discussed in OI literature (Wang et al, 2021; Xie & Wang 2020). OI, like KBV, calls into question the traditional perspective of non-permeable company

boundaries in the context of innovation management. The permeability of organisational boundaries enables the purposive flow of ideas, knowledge and technology into and out of the company at different stages of the innovation lifecycle (Chesbrough, 2006). ‘Lifecycle’, in this context, means the different stages of the generic innovation process: ideation, adoption, preparation and installation (Milewski, 2005). There is a distinction made by scholars about inbound and outbound interactions (Gassmann & Enkel, 2004; Lichtenthaler & Lichtenthaler, 2009). From a KBV perspective, inbound interactions concern the influx of relevant external sources of knowledge and technology, which emphasise an outside-in process of knowledge or technology integration that is transferred from the external environment into the company (Chirumalla, 2021; Donbesuur et al, 2020; Gassmann & Enkel, 2004).

Relevant knowledge sources include universities (Liu & Huang, 2018), R&D enterprises, consultants, competitors, suppliers or customers (Xie & Wang 2020; Chirumalla, 2021). Mechanisms for inbound innovation include technology in-licensing, acquisition or collaboration, and joint development mechanisms, among others (Spithoven et al, 2011). Outside-in knowledge transfer is useful when a company lacks internal resources, when superior external technology is available or when market barriers are low and technology transferability is high (Chirumalla, 2021; Gassmann & Enkel, 2004). Since the focus of our paper is primarily on the “outside-in perspective of knowledge transfer from external partners”, we focus only on inbound interactions. From a KBV perspective, the issue of search breadth (Gölgeci et al, 2019; Markovic & Bagherzadeh, 2018) is essential for an organisation’s innovation openness. Search breadth, from OI literature, has also been addressed in several studies and refers to the scope or number of different external search channels used during innovative

activities (Gassmann & Enkel, 2004; Lichtenthaler & Lichtenthaler, 2009). Search channels in this context are the different types of external sources that companies can access or exploit to gather knowledge and technology for improving innovative performance (Gölgeci et al, 2019; Laursen & Salter, 2006, 2014; Terjesen & Patel, 2014). The main conclusions of the research are that – while search breadth is beneficial up to a certain point – organisations risk over-searching by investing too much time, labour and funding (Laursen & Salter, 2006).

While the aforementioned studies focus on the impact of search breadth on product innovation, Terjesen and Patel (2014) present different results for process innovation. They find evidence to support their hypothesis that search breadth is negatively related to process innovation, as organisations that divert their resources and attention to a broader range of external sources impede their ability to obtain tacit knowledge and cope with the complexity and systemic impact involved in process innovation. However, they also demonstrate that industries with high process heterogeneity demand a broader search for companies to identify potentially relevant knowledge. This emphasises the need for a managerial (decision-making) perspective on search breadth in different process-innovation projects, in terms of lifecycle (i.e., the stages of the generic innovation process: ideation, adoption, preparation and installation).

Lager and Frishammar (2012) provide a seminal study on the collaboration between process technology buyers and suppliers during the development of process technology. They suggest that collaboration for process development depends on lifecycle stage contingencies and different lifecycle stages offer different opportunities for external contributions. Other recent studies support this suggestion (Cherbib et al,

2021; He et al, 2020; Santoro et al, 2021). Within this context, Bader et al (2021) highlight, the critical role of innovation capability in the way organisations structure their interactions to obtain capability contributions. Such contributions are cross-cultural and dependent on the decision-making ability of the managers (Muskat et al, 2021). This study distinguishes between short-term and long-term cultures and concludes that long-term cultural practices place a higher value on “accessible knowledge” (Muskat et al, 2021). From a KBV and OI perspective, this relates to the issue of external knowledge absorption and assimilation (Chesbrough, 2006; Laursen & Salter, 2006; Terjesen & Patel, 2014). Researchers state that managers develop a balanced approach to develop both short-term and long-term cultures by strengthening their adaptability (Muskat et al, 2021; Lumpkin et al, 2010). They suggest that short-term approaches consider strategies to absorb and develop a practical understanding of innovation factors. These often adopt capacity-building strategies, i.e., developing strategies to absorb capacity from external partners, and we therefore define these as ‘applied contributions’. Applied contributions focus on absorbing the capacity of an external partner to develop an experience-based understanding of new concepts (i.e., technology, processes, etc). On the other hand, studies (Muskat et al, 2021; Lumpkin et al, 2010) argue that long-term cultures can only be developed by placing a higher premium on accessing high-quality knowledge. Lumpkin et al (2010) show that organisations develop strategies to develop long-term capability of an organisation to complete. We define this as “conceptual contribution”, as the focus here is on absorbing high-quality information and knowledge (i.e., capability) and not necessarily on the practical experiences of the external partner. From an OI and KBV perspective, this distinction is useful as both views argue that knowledge is critical to knowledge absorption and innovation.

However, these studies mainly focus on the effect external contributions may have on process innovation, as they only consider interaction with technology suppliers in the context of technological change. Another common thread to these studies is that they neglect opportunities for organisational change as well as other important process-innovation components. Furthermore, since the scope of external partners is limited to suppliers, the search breadth dimension of process innovation and the capabilities for management knowledge absorption from recipient organisations remain an unexplored domain.

In summary, technological change is a central aspect of process development and implementation, i.e., process innovation. Existing research highlights the motivation and the challenges of working with technology suppliers for technological process innovation. According to literature, external technology suppliers can support process innovation during different stages of the innovation lifecycle. The distinction between different types of processes, namely core and enabling processes, is also well established. However, the existing literature has not yet explored the motivations for interaction with technologies suppliers at different stages of the innovation lifecycle. Furthermore, the current literature has largely neglected the differences between different types of processes while studying external technological contributions. Understanding these differences is crucial for managers to plan and structure their company's collaboration with external partners, and for scholars to further improve our understanding of the mechanisms that govern OI.

While the benefits of working with external partners are well documented, it is unclear from existing literature the nature of the contribution an organisation seeks in developing such external partnerships. From a technical perspective, there is a gap in knowledge on the type and nature of capability the external partner provides to the organisation in helping it develop its resource capabilities. From an extended RBV perspective, these issues are critical to advance the discourse on why and how external partnerships can help organisations create value and thereby develop a competitive edge. We argue that, if these underlying mechanisms are not understood, it is difficult to draw valid conclusions on external contributions to process innovation. While we recognise that temporal contingencies might affect motivation and openness, this paper focuses on collaboration at the project stage level and distinguishes between qualitatively different process types, namely enabling processes and core processes.

Therefore, our study aims to examine the collaborating mechanisms that contribute to technology-driven process innovation in large manufacturing organisations. We specifically aim to understand how technology-driven processes allow large organisations to internalise external expertise and the effects of this phenomenon on the capabilities of an organisation over its innovation lifecycle.

3.0 Methodology

3.1 Justification

To explore the identified problem of understanding the collaborating mechanisms that contribute to technology-driven process innovation in large manufacturing organisations, we analysed and developed inductive concepts using multiple data

points, which is a well-accepted methodology in qualitative research (Eisenhardt, 1989). Our study specifically aims to understand “how technology-driven processes allow large organisations to internalise external expertise and the effects of this phenomenon on the capability of an organisation over its innovation lifecycle”.

As shown in our literature review, organisations adopt several complex and dynamic mechanisms to collaborate with external partners (Smolander et al, 2021). Therefore, our investigation requires an “intensive focus” on the process dynamics as well as the “nature of the social world” in which the phenomenon resides (Gioia et al, 2013). We do not focus on refining constructs, but rather on the understanding of the underpinning processes as the basis of uncovering the phenomenon (Gioia et al, 2013; Gioia and Chittipeddi, 1991; Harrison and Corley, 2011). Therefore, to balance the conflicting need to develop “new concepts inductively while meeting the high standards for rigour demanded”, we take a holistic approach to inductive conceptual development (Gioia et al, 2013).

Analysing and developing inductive concepts using multiple data points is a well-accepted methodology in qualitative research (Eisenhardt, 1989) and fits the theoretical paucity surrounding our topic of interest. In our study, we look at managerial decision-making effects (through a KBV lens) on technology-driven process innovation within the context of an innovation lifecycle. We do this by investigating this phenomenon in five large manufacturing organisations headquartered in Germany. Such an approach will not only allow us to create a robust and testable platform (Barratt et al, 2011) but also ensure that we fully capture the rich patterns from this context (Eisenhardt, 1989; Gioia et al, 2013). Therefore, adopting the four-step ‘Gioia

Methodology' to uncover the patterns of interest in our study was the most appropriate method for our research. The four steps are: research design, data selection and collection, data analysis and articulation (Gioia et al, 2013).

3.2 Research design

Gioia et al (2013) state that articulating the phenomenon of interest is perhaps the most important part of an inductive research study. As shown in our literature review, our investigation is primarily concerned with understanding the collaborating mechanism that contributes to technology-driven process innovation. This relationship between two organisations is complex and mediated by managerial decision-making and aimed at internalising external knowledge (absorption) at different stages of an innovation lifecycle. As advocated by Gioia et al (2013), we suspend any judgement about the conclusion of our findings to allow and discover new insights and patterns that might emerge from the relationship between two organisations. The key element that needs to be considered in our study to undercover any "inter-relationship" context (Gioia et al, 2013) is a domain that relies on external partnership for process innovation. There are several studies that have listed the issue of process innovation (Qin et al, 2021; Gauger et al, 2021; Rönnberg-Sjödin, 2013) as well as the importance of external partnerships (Tsinopoulos, Sousa & Yan, 2018; Von Krogh et al, 2018). The manufacturing sector is an excellent example that offers us a unique window into both these issues and has therefore been the basis of several studies (Trujillo-Gallego et al, 2021; Freije et al, 2021; Chapman et al, 2018). This sector is also highly heterogeneous and complex, and therefore provides us with a unique opportunity to focus on the contextual domain of our study, which is central to this special issue.

3.3 Data selection and collection

In case-based research, cases are selected for specific reasons, rather than seeking random distributions (Barratt et al, 2011). Cases can, for example, be chosen to replicate or extend previous cases. They can fill theoretical categories or provide illustrative examples of particular types of companies (Eisenhardt, 1989). In this context, 'theoretical sampling' refers to choosing cases that are particularly illuminating for a specific phenomenon under investigation (Eisenhardt & Graebner, 2007). Our study focuses collaborating mechanisms at the level of processes within the context of lifecycle stage as the focal unit of analysis. Against this background, cases were chosen according to pre-defined criteria to ensure the phenomenon of process innovation was likely to occur. Our selection criteria were mostly informed by previous literature, as shown in Table 3.

Table 3. Case selection criteria

We focused our selection on large manufacturing companies with strong investments in externally developed technologies and process innovation (first-order criteria). While keeping these criteria constant, variation among the cases along second-dimension criteria was needed to capture further potential insights into the motivation for and execution of open process innovation (cf. Gioia et al, 2013). Miles & Huberman (1994) call this "stratified purposeful sampling", the purpose of which is to "illustrate subgroups and facilitate comparison" (p. 28). This approach is particularly suited to "maximize the utility of information from small samples and single cases… to obtain information about the significance of various circumstances for case process and outcome" (Flyvbjerg, 2006, p. 230). In line with the insights of the extant literature, the type of process

(enabling vs core) was thus chosen as the relevant criterion along which to replicate or contrast the results of the different cases (cf. Milewski et al, 2015).

Gioia et al (2013) state that collection of appropriate data gives “extraordinary voice to informants” who are “treated as knowledge agents”. They further state that collected data should allow the researchers to “preserve flexibility to adjust interview protocol based on informant responses.” Following these suggestions, the present study was mainly informed by semi-structured interviews with knowledgeable representatives from the different case study companies. All interviewees had at least five years of experience in process development and implementation at the time of data collection. Furthermore, ‘snowball sampling’ was applied, in which interviewees were asked to suggest further interviewees. Using Gioia et al (2013)’s “backtrack” strategy, we interviewed the informants until there was no new information to be collected, i.e., the state of data saturation was reached (Gioia et al, 2013; Ness & Fusch, 2015). The interviews lasted between 30 minutes and 2.5 hours. In total, our data comprises 32 participants and 55 interviews, which yielded around 91.5 hours of interview data, excluding pilot and follow-up interviews. Additional data sources, such as company presentations, projects reports (secondary data) and notes taken during workshops were used for data triangulation (Barratt et al, 2011; Yin, 2003) as well as ensuring robustness and corroboration (Gioia et al, 2013). An overview of the selected cases is provided in Table 4. An overview of the participants and interview metadata is provided in Table 7.

Table 4. Case selection overview

3.4 Data analysis

Gioia et al (2013) advocate that data is robust, corroborating and maintains the integrity of first-order (i.e., informant-centric) information. They state that researchers develop an initial data coding which can be used to structure and organise into second-order themes and finally distilled into meaningful constructs. Against this backdrop, Ketkovi and Choi (2014) propose the “duality criterion” as a necessary condition for scientific rigour in case-based research. The duality criterion posits that the theoretical constructs generated from case-based research should be contextually grounded in concrete and empirical evidence, and at the same time provide a sense of generality to emphasise their general abstract theoretical implications. To meet the duality criterion, the present study follows a principle of increasing abstraction by moving from the empirical data to the content of categories and sub-categories, to themes within and across lifecycle stages and ultimately to new constructs (cf. Gioia et al, 2012; Saldana, 2009). The analysis procedures in this study are informed by the works of Eisenhardt (1989) and Miles & Hubermann (1994) and thus characterised by within-case and cross-case analysis. We began within-case analysis, with initial coding to organise the data from each case according to our pre-defined framework of four generic innovation stages and the motivation for OI at each stage. Following Miles & Hubermann (1994) we started with an initial set of literature-informed codes but allowed for emergent codes during the analysis process. We documented the sources and the number of references to which the codes would apply. In total, we ended up with 138 codes (49 initial based on literature, 89 emergent). An illustrative excerpt of our coding schedule is shown in Table 5.

Table 5. Illustrative excerpt of our coding schedule

Within the different lifecycle stages, we structured the first-order data according to the motivation for interaction as reported by the key informants. We used QSR NVivo matrix queries to display the coded data as “motivation for interaction across within each lifecycle stage”. Based on the results of the queries, the content of the original data was extracted and summarised for every lifecycle stage. This step facilitated data reduction and translated the data into the more analytic language of the study, thus generating the first step towards abstraction.

This process resulted in a set of very large data tables that provided an overview of the relevant content in each category, for each individual company (cf. Miles & Huberman, 1994, p. 178: “monster dogs”). The large tables enabled a structured write-up for each case. This led to two forms of output: 1) case description summaries and 2) comprehensive case write-ups of c. 60,000 words. These documents were used for member checking (Stake, 1995). The comprehensive case write-ups provided a standardised format for cross-case comparison.

Subsequently, we conducted cross-case analysis. This helped us to identify the emerging patterns across cases to enforce a rigorous analysis that overcomes initial impressions. To create the themes as suggested by Gioia et al (2013), we analysed and discussed the findings across all organisations at each lifecycle stage separately. This was necessary to account for the characteristics of each stage and to identify important patterns within each stage. We then discussed the key themes emerging from the reflection on the motivation for interaction and the differences between enabling processes and core processes among ourselves, as well as with academic

peers and expert practitioners. The patterns (i.e., central contents) were then identified by looking for similarities and differences across cases (cf. Eisenhardt, 1989). More specifically, the insights from the companies that reported on the development of enabling processes (cases A-E) were compared for literal replication. This means that an emergent pattern was recognised when the same insight was found in multiple cases without any contrasting evidence. At a later stage, theoretical replication was sought by contrasting these patterns with the findings from the case that reported on the development of core processes.

The cross-case patterns at each stage were then further analysed to elicit the key themes of open process innovation at individual lifecycle stage. Themes resulted from the reflection on the linkages between the different framework categories and from explicating the role of different characteristics of the selected cases (enabling processes vs core processes). Miles & Huberman (1994) call this approach “pattern coding”, in which organised and summarised material is pulled into “more meaningful and parsimonious units of analysis” (p. 69). Furthermore, this process involved “enfolding” existing literature to confirm, contrast or complement the empirical results of the present study and integrate them with the broader body of knowledge (cf. Eisenhardt, 1989). In addition, the emerging themes were constantly compared with the data and vice versa, to successively approach a theory that closely fits the data (cf. Eisenhardt, 1989). Quotes or excerpts from the interview data were sought for each of the emergent themes. To illustrate how we made our interpretations and provide a basis for replicating the research, we documented the contents relating to each emergent theme at each stage and illustrated them with direct quotes from our data. Table 6 provides an illustrative example regarding openness towards external

partners. Two sub-categories were identified, their main contents laid out and case references kept.

Table 6. Illustrative example regarding openness towards external partners

For example, MOT-2.21 refers to the emergent theme, and the insight (i.e., observable content generalised) is that technology suppliers provided relevant, experience-based expertise on new technologies. This includes information not only on estimated time and cost for technology development, installation and ramp-up, but also estimations of qualitative and quantitative improvements in operations. “Of course, it is often our intention for them to give us information at this stage. It may be the case that a supplier offers an interesting technology and has already implemented it in three other companies. Then, of course, it is our expectation that this supplier can tell us exactly what to watch out for, what potential pitfalls there are, how long the implementation may take, and so on” [R2-I2].

The different themes across the different stages were finally put together into meaningful constructs. The constructs were also critically assessed with reference to the underlying theoretical reasons as to why they exist, and the logic of their implications for the relationships between different variables to increase their validity. The analysis process only ended once saturation was reached. That is, once further iteration between theory, data and literature yielded no further significant changes to the themes (Gioia et al, 2013; Eisenhardt, 1989).

Table 7. Data overview

3.5 Articulation

Our insights and findings were structured around the four stages of the generic innovation process: ideation, adoption, preparation and installation (Milewski et al, 2015). Gioia et al (2013) state that dynamic patterns among second-order concepts can transform static data structures into dynamic patterns. Results of our articulation are shown in the next sections. We notice two key patterns emerging from our second-order analysis: 1) the conditions when managers from large organisations seek external knowledge in process innovation projects and 2) the nature of the knowledge absorbed by large organisations based on the type of interaction with the external partner. We conducted additional consultation with literature to position our contributions, which is detailed in sections 4 and 5.

4.0 Articulation of our analysis

In the following section, we will articulate our findings from our case study, organised according to the four stages of the generic innovation process: ideation, adoption, preparation and installation.

4.1 Ideation

All organisations reported that the anticipated effort of achieving compatibility was the most important criteria for technology pre-selection during the ideation stage. “In a company like ChasComp, we cannot simply install something new. There must be appropriate interfaces between new and old technology, the new technology must be adaptable. We try to assess the chances of a new technology being implemented relatively early on,” [R27-I2]. According to company reports, compatibility can refer to the fit of potential new technology with expectations of new technology, the existing technological infrastructure and systems landscape, corporate strategy, and existing

operator skills and sophistication. The interviewees further reported that technological uncertainty was the main challenge during early technology assessment.

During ideation, potential new technology is not yet acquired or developed. As a result, observability and communicability remain low. This makes it difficult to evaluate new technology about its relative advantage, compatibility and complexity. To tackle this issue, the organisations reporting on the development of enabling processes (AutoComp, ChasComp, SubComp and TrainComp) stated that they interacted with various external technology experts during ideation: “Well, in the beginning, when we have to be creative, we use every input we can get to generate ideas,” [R28-I2] and “to get an impression of what is available out there” [R27-I2]. AutoComp, TrainComp, SubComp and ChasComp further reported that the interaction with external technology experts during ideation did not involve any significant commitment or collaboration. “At the early stages interaction is very much without any commitment. It is about gathering input and strengthening our understanding of specific issues to evaluate potential solutions. We are not talking about concrete implementation plans. Often there is not even any reference to specific products or technologies. It is a very general level we are talking about here” [R28-I2]. In contrast to the other cases, ElecComp stated that ideas for core process technology had to be specified at an early stage. ElecComp initially searches the market for available information, but the interviewees also clarified that they “[…] cannot purchase standard equipment because our technology is strongly adapted to our facilities and our products. There are various technology suppliers. With their systems, we would not be as strong in the market as we are. Therefore, we develop core technologies in-house” [R22-I1]. ElecComp, therefore, tries to generate specific information through interaction with only a very few selected technology

experts (research institutes or known suppliers). This approach allows ElecComp to front-load the specification of process ideas and absorption of relevant knowledge to operate largely independently of external partners as early as possible.

4.2 Adoption

All organisations in this study typically carry out concept development to understand potential technologies in more detail. This occurs during the adoption stage. During adoption, AutoComp, TrainComp, SubComp and ChasComp develop conceptual solutions based on externally available information. Due to the lack of readily available external information, ElecComp develops early prototypes and carries out substantial testing for potential core process technologies. As one ElecComp interviewee elaborated: “We try to gain as much in-depth insight as possible, to get comfortable with a potential solution. Of course, we also have to carry out tests and provide evidence to show that the solution is feasible” [R19-I1]. Another ElecComp interviewee added that “It requires a lot of time and very intense efforts [to develop technology concepts]. We must consider what we have to do, when we have to do it, and where we can do it, early on. After all, these are our core processes. This is a delicate issue and a huge cost factor” [R23-I1]. All organisations suggested that despite concept development, significant uncertainty always remained due to the limited technological knowledge at this stage. “Ultimately, we cannot account for every contingency anyway” [R7-I1]. All interviewees reported interacting with different technology suppliers to obtain relevant information and details on potential new technologies. AutoComp, TrainComp and SubComp, for example, explained that technology suppliers provided relevant, experience-based expertise on new technologies. This includes information

on estimated time and cost for technology development, installation and ramp-up, but also estimations of qualitative and quantitative improvements in operations. Regarding the expectations of external partners in this context, one interviewee stated that: “of course it is often our intention for them to give us information at this stage. It may be the case that a supplier offers an interesting technology and has already implemented it in three other organisations. Then, of course, it is our expectation that this supplier can tell us exactly what to watch out for, what potential pitfalls there are, how long the implementation may take, and so on” [R2-I2].

The organisations reporting on external technology acquisition for the development of enabling processes (AutoComp, TrainComp, SubComp and ChasComp) seek access to readily available information on existing standard solutions. The feedback from the technology providers informs the interviewees about technological possibilities, and thus shapes the process description. ElecComp, in contrast, reported that the main motivation for interaction with suppliers of technological components at this stage was to benefit from external expertise in creating relevant information. This was because relevant technological solutions were typically not readily available from external sources. Illustrating this issue, one ElecComp interviewee explained: “Our projects often require initial basic research. When we looked at laser-cutting as an alternative approach to stamping, for example, and we could not find any relevant information, we had to do different experiments, make various developments, and tests. If we find that such tests do not suffice, we also collaborate with universities or research institutions. Once we have enough evidence to determine the potential benefit of a new solution, we proceed to plan the next development steps” [R21-I1].

4.3 Preparation

The interviewees from AutoComp, TrainComp, SubComp and ChasComp suggested that the preparation stage provided an opportunity for them to understand new technology and its implications in-depth before further internal dissemination. “When we engage with technological change and repeatedly discuss the new technology in-depth, we increase the level of technological change specification, and it suddenly also becomes much clearer what organisational adaptations are necessary” [R2-I1]. Consequently, technology modifications or developments were named as key activities during preparation. The interviewees reporting on externally acquired solutions emphasised the importance of avoiding extensive technological modifications. “Our ambition is to use standard software without modifications and simply configure it properly. Configuration instead of customisation, if possible” [R28-I2]. ElecComp, however, reported achieving compatibility through technology development guided by frequent alignment checks with the existing organisation and key operators.

All task forces reported interacting with external partners for technology development during preparation. However, the reports across the organisations revealed different motivations for working with external partners, depending on the development of enabling processes (AutoComp, TrainComp, SubComp and ChasComp) and core processes (ElecComp and ChasComp). AutoComp, TrainComp, SubComp and ChasComp reported the following motivations (in no particular order) to work with technology suppliers during preparation: 1) accessing suppliers’ capabilities for technology modification, 2) learning from prior experiences of technology preparation, implementation and operation, and 3) learning about limited technological adaptability. The following excerpts from ChasComp and SubComp highlight the relevance of

interacting with external partners during preparation: “We increasingly proceed towards project implementation, where we relatively quickly strongly involve a software partner who helps us adapt the software, although we try to stick to what the provider has suggested as the industry-specific solution when we adopt standard solutions” [R27-I2]. Similar experiences were described by SubComp: “The supplier clearly discussed with us how we could do things differently, or that certain basic functionalities already delivered 80% of what is actually expected and that maintaining the basic functionality saves all the effort for ineffective adjustments. I remember quite a few projects where suppliers actually told us that certain changes would not make sense given our systems landscape” [R13-I2]. TrainComp, SubComp and ChasComp further specified that it was necessary to develop a technological understanding during preparation in order to configure and maintain the technology independently during installation and operation. ElecComp, in contrast, reported that technology was primarily developed internally. The external partner modifies and delivers technological components, while ElecComp develops the technological solution internally: “Our partners deliver the components, but when we develop the new technology, we aim to keep the development work largely in-house” [R25-I2]. Only in the case of insufficient internal capacity does ElecComp assign external partners to work on technology development in close interaction with the internal task force.

4.4 Installation

All organisations in the study agreed that, typically, it was necessary to configure rather than customise new technology. The main issue, as reported by all organisations, is the operators’ uncertainty about their own ability to work with new technology. This can lead to coping mechanisms. One interviewee’s statement exemplifies this issue: “Of

course they claim that there are issues with user-friendliness, partially missing functionality, or generally the ease of use" [R1-I2]. All interviewees thus stated that it was imperative to provide communication and extensive training. The following statement from an ElecComp interviewee reflects the importance of training: "Our task during handover is to make our stakeholders understand the application and the implication of the new technology, and how they can benefit from it" [R21-I1]. The task forces thus considered it necessary to have an adequate support infrastructure (e.g., training, hotlines) in place to provide training and ad-hoc troubleshooting. As a result, all cases showed that technology roll-out typically requires substantial capacities (especially in terms of manpower) to install technology, provide training to operators and solve emerging problems.

All the organisations which discussed the introduction of externally acquired standard solutions reported that their typical motivation for interaction with external partners during installation was to gain additional capacity, as the following statement illustrates: "yes, if we consider the topic of IT solutions for enabling processes, then clearly more work is shifted towards the external partner" [R2-I2]. AutoComp and ChasComp, for example, explained that they worked with external partners in order to access additional capacities or capabilities that were not required internally, as the following excerpt clarifies: "It's simply the huge amount of work. Our internal capacity does not suffice for that. Question: So, working with external partners at this stage is mostly about additional capacities? Answer: At the end of the lifecycle, it's simply a matter of capacity, not more and not less. While it's all about knowledge transfer at the beginning, it is all about capacities at the end of the innovation project" [R29-I2]. All organisations emphasised that they had to possess sufficient internal knowledge of the

new technology to perform configuration internally. “Our internal people, the ones that were involved in the project would be able to perform these tasks internally. But we generally do not have the necessary capacities given the large number of operators that we have to address” [R28-I2]. TrainComp, for example, reported using technology suppliers for the physical installation of new technology because this capability was not needed internally. It was often cheaper and faster to let the external partner carry out this activity.

5.0 Discussion and proposition development

5.1 Motivations for external contributions

The results of our study document a variety of motivations for the interaction with external technology partners (see Table 8). The results also show that the motivation to work with external technology partners differs between the lifecycle stages of process innovation. Furthermore, the results suggest that the patterns of motivations for interaction across the innovation lifecycle differ for the development of enabling and core processes. In the following sections, we discuss the individual lifecycle stages and show how the findings compare to past studies on process innovation (Lager 2011; Wagner & Hoegl, 2006, Su et al, 2003; Terjesen & Patel, 2014; Qin et al, 2021; Gauger et al, 2021; Rönnberg-Sjödin et al, 2011).

Table 8. Summary of key findings

5.2 Capability and capacity contributions by external partners

The results of this study show that absorbing knowledge and developing new capabilities are key motivations for interaction with external partners during the ideation, adoption and preparation stages of the innovation lifecycle. This supports the fundamental position of both RBV and KBV, which state that organisations create value

by controlling their resources (Amit & Schoemaker, 1993; Penrose, 1959). Specifically, we note that organisations use physical, human and organisational resources to compete, survive and grow (Barney, 1991). However, during the innovation lifecycle these motivations are not static (Su et al, 2020), but dynamic. In fact, the much-debated issue in RBV/KBV about the ability of an organisation to possess or access timely and relevant knowledge from its resource network (Martin & Javalgi, 2019; Amankwah-Amoah & Adomako, 2021) was noted in our study. Knowledge, whether internal or external, is an essential resource for an organisation to be competitive (Grant, 1996). For example, during installation, organisations accessed additional workforce and resources to carry out specific tasks, when there was a lack of internal capacity or when the required capabilities were not required internally. When an external partner provides process innovation, there is a need for training and sufficient internal expertise to absorb and implement innovations. We see that absorbing knowledge to create new processes and capabilities advances process innovation. Large organisations work collaboratively with external technology suppliers to internalise this external knowledge, and therefore create a synergistic working environment/ecosystem of operations. Thus, the combined effects of internal and external resource integration are achieved (Martin & Javalgi, 2019; Amankwah-Amoah & Adomako, 2021).

As noted in our literature review, we distinguished between capability and capacity issues in line with arguments from the literature (Muskat et al, 2021; Lumpkin et al, 2010). We observed that organisations develop appropriate structures to obtain both capability and capacity contributions. This distinction between capability and capacity contributions for process innovation is similar to Wagner and Hoegel's (Wagner &

Hoegl, 2006; Su et al, 2020) distinction between ‘know-how projects’ and ‘capacity projects’ in the context of supplier integration for new product development. From a KBV perspective, we note that organisations use both exploitative and exploration strategies to modify or create new processes to enhance their performance (Collinson & Liu, 2019; Yamakawa et. Al., 2011). However, the main shortcoming of current studies is that they do not focus on individual lifecycle stages. This distinction is critical, as within the context of KBV the issue of both timely decision-making (Cao et al, 2019) and the type of process affected because of managerial decision-making is critical to the success of a process-innovation project (Bai et al, 2021). The analytical distinction between different forms of contribution enables a more dynamic discussion of process innovation. The lifecycle perspective applied in our study shows that both forms of contributions are necessary during process innovation, thus supporting studies that argue for a multi-pronged approach to collaboration (Muskat et al, 2021; Lumpkin et al, 2010). Earlier studies have documented examples of collaboration where installation suppliers teach organisations how to apply new technologies (Rönnberg-Sjödin, 2013).

Based on our findings we agree that external contributions support installation in different ways. However, based on our results we can now suggest that these contributions are mainly capacitive, i.e., short-term in nature (Muskat et al, 2021). On the other hand, organisations develop relevant internal knowledge and capabilities during earlier stages of process innovation i.e., long-term in nature (Muskat et al, 2021). During process installation and operation, organisations apply new knowledge internally. Independent internal application is necessary to prevent a loss of capabilities (Muskat et al, 2021; Flowers, 2007) and protect access to confidential internal

knowledge. Our results thus reflect strategic considerations of keeping core competencies in-house while outsourcing less relevant activities at the operational level (cf. Quinn & Hilmer, 1994).

Our results lead us to make the following propositions:

Proposition 1: External partner contributions towards technological change in process-innovation projects can broadly be grouped into capability and capacity contributions.

Proposition 1a: Large organisations seek capability contributions when the interaction with external partners is aimed at absorbing knowledge and developing capabilities that are not yet available (lack of internal expertise) but considered necessary to possess internally.

Proposition 1b: Organisations seek capacity contributions when they are motivated to interact with external partners to access additional workforce or resources to carry out specific tasks (lack of specialist internal resource), although the necessary capabilities to perform these tasks might be available.

5.3 Conceptual and applied capability contributions by external partners

The lifecycle perspective on process innovation applied in the present study reveals differences in the way organisations structure the interaction with external partners to obtain capability contributions. KBV studies show that organisations choose a variety of structural arrangements for working with external partners (Tower, Hewett & Saboo, 2021; Ko et al, 2020). This is also widely discussed in OI literature (Wang et al, 2021; Xie & Wang, 2020). There is an equally strong emphasis on the validity of knowledge sources, as studies argue that reliable sources like universities, R&D enterprises,

consultants, etc. should be considered while developing knowledge (Liu & Huang, 2018; Xie & Wang 2020; Chirumalla, 2021). Some organisations place premia on developing robust inbound mechanisms to ensure the quality of knowledge absorbed by an organisation (Spithoven et al., 2011). The fundamental argument in these studies is that external knowledge can provide an organisation with the necessary edge over its competitors (Tower, Hewett & Saboo, 2021). Studies have looked specifically at the innovation capability of an organisation from different perspectives, viz., product vs process, incremental vs radical or elastic vs plastic (Zhou, et al, 2017). However, these do not consider the nature of the contribution towards process innovation (i.e., what type of knowledge capability emerges as a result of this contribution). As argued in the previous section, we distinguish between conceptual and applied capabilities. We note in our case studies that conceptual contribution is achieved when large organisations are trying to achieve a theoretical or conceptual understanding of new technology. This supports the view that organisations which aim to develop long-term competitive strategies will focus on methods to develop relevant internal knowledge and capabilities (Muskat et al, 2021). For example, AutoComp worked with an external organisation to develop its conceptual understanding of blockchain technologies but has not gained any practical experience. On the other hand, we observed that large organisations use the capability of external partners to support technological change, which enables the organisation to develop an experience-based understanding of new technology. This supports the findings from KBV literature that organisations adopt short-term strategies to support capacity-building agendas (Muskat et al, 2021). We observed that large organisations use the capabilities of external partners to develop an experience-based understanding of new technology and to develop their applied capacity. For example, ElecComp had worked with an external technology

organisation to develop a new cloud-based, multitenancy IoT platform based on their experience in implementing such technologies.

Against this background, we propose that:

Proposition 2: External technology contributions in the context of process innovation can generally be distinguished between conceptual and applied capability contributions.

Proposition 2a: Capability contributions are conceptual if external technology experts use their capabilities to help organisations generate a conceptual/theoretical understanding of new technology, based on the provision of information but not practical experience.

Propositions 2b: Capability contributions are applied if external partners use their capabilities to provide tangible support for technological change, which enables organisations to develop an experience-based understanding of new technology.

The distinction between both forms of capability contributions is important to discern to understand the different ways of obtaining these contributions. To illustrate the distinction between conceptual and applied capability contributions, consider first the case of developing enabling processes (AutoComp, TrainComp, SubComp and ChasComp). During ideation, the organisations access external capabilities by obtaining general information from various external technology experts. This enables the interviewees to access relevant external capabilities and develop knowledge of potentially relevant solutions, even though the external experts do not transfer any particular technology or specific information (conceptual contribution). The suppliers'

technology presentations during adoption provide more specific information than during ideation, and help the organisations increase internal technological knowledge. Yet, the organisations are motivated to access external knowledge through information and presentation rather than conjoint work activities (Conceptual contribution). During preparation, however, external technology partners actively transfer tangible technology and applied knowledge through close interaction with the organisations' internal task forces. In contrast to the earlier stages, this illustrates the organisation's motivation to seek capability contributions through close interaction with technology suppliers and practical knowledge application (applied contribution). The newly gained knowledge enables the organisations to work largely independently during installation and only engage with external partners for capacity contributions. A different path emerged for the case of ElecComp. Like the other organisations, ElecComp seeks general information for core process innovation from external sources, early on (conceptual contribution). Yet, the limited availability of relevant information on potential solutions pushes ElecComp to engage in early conjoint prototyping with external partners. In these collaborations, the task force in ElecComp practically generates relevant information about new technologies (applied contribution). This knowledge lets ElecComp work largely independently during the development and installation of core technology, only engaging with external partners if internal capacities do not suffice. We argue that this motivation results from the higher demand for knowledge protection when working with external partners for core processes that directly relate to the substantiation of the company's value proposition. Table 9 outlines the different contributions that organisations seek along the innovation lifecycle.

Table 9. Different paths of process innovation

In this paper we extend the concept of ‘know-how projects’ as posited by Wagner and Hoegel (Wagner & Hoegl, 2006), who do not consider different forms of capability contributions. This distinction is relevant because it points towards different structures of interaction by which organisations can obtain capability contributions. Wagner and Hoegel suggest that capability contributions involve highly intense interaction with selected suppliers in a “partnership-like relationship” (p. 939), which requires time, trust, and significant information exchange. Although investments in close interaction have a positive effect on successful process innovation (Terjesen & Patel, 2014), external searching also incurs substantial costs and presents organisations with the challenge of the adequate allocation of limited resources (Horváth & Enkel, 2014; Laursen & Salter, 2006). Organisations thus have to understand external technologies sufficiently well to make investment decisions without engaging in close partnerships at the outset of the innovation lifecycle. This is especially relevant when organisations choose from a broad range of potentially relevant knowledge sources, as in the case of acquiring external standard solutions. With the distinction between conceptual and applied capability, we contribute to explaining how organisations cope with this challenge by choosing between different forms of capability contributions throughout the innovation lifecycle.

6.0 Conclusion

To the best of our knowledge, this is the first study to examine the collaborating mechanisms that contribute to technology-driven process innovation in large manufacturing organisations. In doing so, we advance the extended RBV discourse on why and how external partnerships can help organisations create value and thereby

develop a competitive edge. Using empirical data, we show that technology-driven processes allow large organisations to internalise external expertise which, in turn, increases the conceptual and applied capability of an organisation. While previous studies have shown the positive benefits of external collaboration, they do not discuss the “influencing” nature of external collaborative relationships (Chapman et al, 2018). Du (2021), while showing that organisations make use of “orchestrated openness” to “leverage a network of connected projects in both its core and non-core technologies”, argues that the nature of connections is critical to the success of an organisation. These studies, along with many other previous studies, have shown that organisations can leverage external partnerships for process innovation by developing strategic partnerships, network ties and alliances. However, the empirical evidence on the collaborating mechanisms that contribute to technology-driven process innovation is very limited. A recent longitudinal study highlights this limitation and shows that external partners need to “adjust their collaboration mode dynamically to the new situation and its requirements” (Smolander et al, 2021). In addition to the issue of collaborative mechanisms, questions associated with motivations for interaction with technologies suppliers at different stages of an innovation lifecycle is underexplored (Hadjielias et al, 2021; de Oliveira et al, 2021).

Our research directly addresses these important knowledge gaps by offering empirical evidence from five large German manufacturing organisations. The manufacturing sector is the basis of this study, because several studies (Trujillo-Gallego et al, 2021; Freije et al, 2021; Chapman et al, 2018) have shown that large manufacturing organisations are focused on both process innovation and external partnerships for creating competitive advantages. In line with existing literature, we show that external

partners contribute towards technological change in process innovation within an organisation by increasing an organisation's capabilities and capacity. While several studies have shown the importance of new technologies (Dubey et al, 2019) in building an organisation's resource capability and competency, our study directly addresses the conditions under which organisations can (or should) seek external partnerships. This directly addresses the call to understand the conditions under which external partnerships can boost the resource and knowledge capability of organisations. In doing so, we show that motivation for external collaboration varies based on internal conditions and motivations. This issue of context is critical for the success of a partnership, which in turn affects the competitive edge of an organisation. This is critical, as we show that organisations engage with external technical partners to either absorb specific knowledge or seek additional resources. In this study, we address two issues: the importance of knowledge absorption and the conditions in which an organisation can benefit from the process of knowledge absorption. These two issues are often seen as one from an organisational capability perspective, where researchers have argued that variance in performance comes from an organisation's dynamic, operational and dual-purpose capabilities (Benitez et al, 2018; Helfat & Winter, 2011; Jerez-Gómez et al, 2005). We argue that these one-dimensional views do not capture the complexities associated with the conditions in which an organisation can develop different partnership strategies. We contribute to this debate by showing that variance in performance is also a function of the conditions in which an organisation plans to bring about process innovation through external collaboration. In our study, we show that managers explicitly seek capability and capacity contributions and absorb external knowledge not only when there is a lack of internal expertise within an organisation but more specifically when this is considered a necessity. This implies that managerial

decision-making (i.e., the quality of the resource) is an important aspect when considering how knowledge can be absorbed within an organisation. While there have been significant advances in new digital and disruptive technologies such as machine learning, blockchains etc, such technologies can only benefit an organisation if managerial decision-making can identify both the type of knowledge and the need for the knowledge (Roldan et al, 2018; Chesbrough, 2006).

Our study also addresses a key question about the type and nature of the external contribution. This cutting-edge research question aims to address theoretically and investigate empirically. Previous studies have shown that external contributions can increase the ability of an organisation to compete (Guo et al, 2021; Qin et al, 2021). Qin et al (2021) show that IT infrastructure and capability positively impact performance. However, they also state that more work needs to be done to specifically understand the nature of the external contribution. Given this impetus, we theorise that capability contributions can be conceptual or practical and can provide tangible support for technological change which enables organisations to develop an experience-based understanding of new technology. Within the context of the special issue, this is critical as “new technologies are undergoing continuous change” and understanding the nature of the technical contribution to process innovation is important.

Our distinct contribution is that, unlike most past studies that have highlighted the importance of external collaboration, we studied the underpinning mechanisms of how and why large organisations partner with external organisations to innovate processes. Literature from both the OI and organisational capability perspective, has often assumed (either implicitly or explicitly) that external partnership is often a linear or

iterative process (Chesbrough, 2006). In contrast, we observe that there are different patterns to obtaining different forms of external contributions to process innovation. This process is dynamic, and we advance the discourse about why open process innovation occurs. We strongly argue that such a distinction is critical, as without it, it will be difficult to draw valid conclusions on how and when external partners contribute to process innovation. This distinction can be of significant value to further studies, which might otherwise underestimate the general role of external partners if they investigate core processes but fail to acknowledge that limited motivation results from the deliberate protection of critical knowledge which is characteristic for core process development.

Different findings would probably emerge when investigating the development of enabling processes. Likewise, future studies should account for temporal contingencies that affect motivation and openness. As in the present study, a lifecycle perspective can capture different external contributions to process innovation before, during and after technology development in a structured way (Qin et al, 2021; Gauger et al, 2021; Rönnberg-Sjödin et al, 2011). Studies would miss the differences between external contributions if they ignored the context that different lifecycle stages provide. Such insights are, however, critical for managers to systematically plan the interaction with external partners throughout their projects. More differentiated insights on open process innovation will be of value to practitioners. This study thus provides a basis for the design and discussion of future research on open process innovation. We should state that these results are consistent across all the five case studies, albeit within the context of one country (Germany). However, it should also be pointed out that all five

organisations have global supply chains with external partners located in multiple countries and continents. Table 10 summarises the findings from our case studies.

Theoretical contributions

Our paper makes two contributions to theory. As shown in our literature, examining the underpinning collaborating mechanisms between an organisation and external partners to create capabilities and capacity has not been explored from a process lifecycle perspective. Firstly, from a KBV perspective, we argue that technology-driven processes allow large organisations to internalise external expertise, which in turn increases the conceptual and applied capability of an organisation. Based on our empirical data, we specifically show the conditions in which large organisations can maximise benefits accrued via collaborative partnerships, especially in developing technological capabilities. Our study shows that, under different conditions, large organisations can not only benefit from external knowledge but also improve their internal capabilities and capacity. Our study thus extends and enriches the KBV-organisational capability literature (Gueler & Schneider, 2021; Suoniemi et al, 2021; Pereira & Bamel, 2021) by addressing the conditions under which external partnerships can boost the resource and knowledge capability of organisations. Our empirical findings also shed light on the importance of motivation and the decision-making ability of a manager, as this directly affects the type of knowledge absorbed by an organisation. While previous research underlines the essential role of decision-making and motivation (Gueler & Schneider, 2021; Suoniemi et al, 2021), no studies have investigated the type of knowledge absorbed under different partnership conditions. Drawing on KBV, we explored the distinction between different forms of

capability contributions, as these enhance an organisations' theoretical understanding of new technology. By demonstrating this distinction, our study finds that external technology contribution aids the creation of process innovation and ultimately impacts the competitive performance of an organisation.

Thus, our study not only contributes to the KBV-organisational capability literature (Gueler & Schneider, 2021; Suoniemi et al, 2021; Pereira & Bamel, 2021) but also bridges the gap between organisational capability and the technological process lifecycle, thereby extending the limited but growing research in this area (Qin et al, 2021; Gauger et al, 2021; Rönnberg-Sjödin et al, 2011).

KBV theory highlights the need for understanding the social and intellectual capital process of knowledge absorption (Pereira & Bamel, 2021). Motivated by this call, our research aims to address the context in which knowledge absorption takes place in technological process innovation. As highlighted by the call for this special issue, "we need to investigate the consequences and implications for the RBV and KBV theories" with the emergence of new digital and disruptive technologies. Our research illustrates that external technology partners act as a mediating influence in process-innovation projects by contributing to the capabilities or capacity of an organisation. Additionally, our study shows that these contributions vary in terms of the nature of the knowledge imparted. By doing so, this study provides empirical evidence for providing support for future research for the design and discussion of open process-innovation systems.

Practical implications

In the present study, we advanced a distinction between conceptual and applied capability contribution, as well as capacity contributions and the different stages at which organisations seek them. Managers of large manufacturing organisations can take advantage of the key outcomes of our study as a framework for developing new partnership strategies. Managers wanting to address core processes may have good reason to prioritise internally generated technological change as a means to accentuate competitive advantage with proprietary technologies. Conversely, the results suggest some justification for emphasis on organisational change to leverage the benefits of externally sourced standard technology solutions when managers seek efficiency gains in non-core processes. Additionally, managers from technical companies can be assured that their technologies contribute to an increase in both the capabilities and capacity of their partners. This is particularly important within the context of this special issue, as our empirical data shows that external technology companies can generate both conceptual/theoretical understanding of new technologies and provide tangible support for technological change. Managers from both large manufacturing and technology organisations need to develop the partnership capabilities identified in our study. This is particularly important for specialised small technology organisations that are typically not first-tier suppliers to large manufacturing organisations. Practitioners can also note that the success of implementing technology solutions not only depends on the sophistication or quality of the solution itself, but also on how organisational processes are changed to support the adoption. Many organisations are unable to realise the benefits of technology-enabled process innovation mainly because organisational processes or incentives are not changed, or organisational silos continue to exist. While addressing these

challenges will require investment in social capabilities, this study provides practitioners with a framework for developing these capabilities.

Limitations

The study is limited because it only considers technological aspects of process innovation. Yet, it is well documented that process innovation involves components other than just technological change. Further research should thus account for technological characteristics, organisational characteristics and organisational culture (Pereira & Bamel, 2021) in more detail, to understand their implications for open process innovation at different lifecycle stages. The specific technological and organisational characteristics deserve more investigation than could be conducted in the present study alone. We suggest that the configuration of search breadth and depth be investigated at the lifecycle stage to understand in more detail how the dynamic adjustment of openness may affect innovation outcome. This will help managers make adequate plans for choosing the best possible baseline for interacting with external partners throughout the innovation process.

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Tables

Process Type	Sub-Type	KBV focus	Definition(s)
Core	Operational	Managerial action with an internal and external focus – extended RBV	The way in which work gets done within an organisation to produce goods or services
Enabling	Support	Managerial action with an internal focus – RBV	Enable the operational processes [and] are concerned with the provision of support technology, or systems, with personnel and human resource management, and with accounting management
	Direction-Setting	Managerial action with an internal and external focus – extended RBV	Set the strategy for the organisation, its markets, and the location of resources as well as managing change within the organisation
	Managerial	Managerial action with an internal and external focus – extended RBV	Are to some extent superordinate to the other categories and contain decision-making and communication activities; entrepreneurial, competence-building and renewal processes … are managerial processes

Table 1. Different Types of Processes

Type	Definition	Benefits	Examples
Information and communication technology (ICT)	Enable the provision of a ubiquitous digital infrastructure to facilitate inexpensive, rapid, and secure storage and transfer of information and data	Improve speed, processing power, connectivity, and physical interfaces, enable cost reductions and collaborative or concurrent development work	▪ Artificial Intelligence ▪ Blockchains ▪ 3D Printing
Operations and manufacturing technology (OMT)	Facilitate implementation and operation of new processes Enable, automate, standardise, and control, the flow of information, components, and	Process, make, and assemble varieties of products predictably, quickly, and cheaply Enable increasing reliability, flexibility, and accuracy, and reducing prices and costs in production	▪ Digital Twins ▪ Drones

Type	Definition	Benefits	Examples
	products in production Comprise combinations of machines, robots, and software to manage coordination of information		
Innovation technology	Provide the means to assist organisations in their innovation activities Bring together multiple inputs into the innovation process	Facilitate economies of effort and specification of innovations Provide opportunities to explore new options, collaborate, and 'play' with design and different solutions Ensure that ICT and OMT are used to maximum effect	▪ Augmented reality ▪ Visualisation/virtual reality ▪ 3D prototyping

Table adapted from visual and definitions in Dodgson et al. (Dodgson et al., 2006)

Table 2: Different types of technology

Criteria	Details	Illustrative References
First order criteria		
Large companies	Comprise 10,000+ employees	Pavitt (1991)
	Are likely to invest in process innovation and possess better process innovation capabilities than small and medium sized enterprises	Reichstein and Salter (2006)
	Provide a rich setting for studying innovation management because process change needs to be coordinated across relatively more complex organizational structures than in small and medium sized companies	Vossen (1998) Pavitt (1991)
Manufacturing industries	Develop process innovation in conjunction with new products but also independently of them	Martinez-Ros (2000)
	Production intensive manufacturing companies build on process	Pavitt (1991)

	innovation for organizational competitiveness	
	Frequently obtain technologies from external sources	Pavitt (1991)
Second order criteria		
Type of process	Distinction between core and enabling processes	Armistead and Machin (1997); Milewski et al. (2015)
	Core processes are directly related to the creation of the primary value for customers	Smart et al. (1999)
	Enabling processes are important organizational processes but not directly related to a company's primary activities; instead, they facilitate them.	Lager and Frishammar (2010)

Table 3: Case selection criteria

Case	Case background	Type of process	Size (Employees)
A	AutoComp is a global car manufacturer in the high-priced luxury segment. The company's competitive advantage and appropriability regime are determined by the quality of its products and production competencies. The information that AutoComp provided related to the development and implementation of higher order enabling processes. These processes use standard IT solutions to coordinate and enable all organisational processes ranging from idea generation to product offer.	Enabling	100,000+
B	TrainComp is the world's leading manufacturer of braking systems for rail and commercial vehicles. The company has global manufacturing operations that work independently. The information that TrainComp provided related to the development and implementation of IT-driven, enabling processes. This involves the introduction of externally acquired standard technology solutions, which drive efficiency.	Enabling	20,000+
C	SubComp is a global leader in non-nuclear submarines and high-level naval vessels. They have a strong focus on product differentiation. Production predominantly relies on skilled, manual labour rather than automated processes and robotic support. Nevertheless, SubComp	Enabling	8,000+

Case	Case background	Type of process	Size (Employees)
	has started to research advanced technologies to support production. The information that SubComp provided mainly relates to the development and implementation of externally acquired standard IT solutions for production.		
D	ElecComp is a global electronics company that produce switches and connectors for the automotive industry. The company has a high-quality focus, but, due to ease of imitation, competes using a high production volume leveraging specific production competencies. The information that ElecComp provided related to the development and implementation of an internally developed production technology in the company's core operations.	Core	100,000+
E	ChasComp is a major global supplier of automotive driveline and chassis technology. The company develops and manufactures high quality products and has pronounced product development and production competencies. ChasComp provided information on the development and implementation of higher-level enabling processes and core production processes via externally acquired and internally developed technology respectively.	Enabling	80,000+

Table 4. Case selection overview

Code	Name & status [1] initial; [2] emergent)	Description	No of sources	No of refs
Innovation lifecycle				
Ideation				
ILC_01.1	General [1]	Content relating to general issue of ideation	36	269
ILC_01.2	Performance gap assessment [2]	Content relating to problem identification and triggering ideation	27	56
ILC_01.3	Idea Origin [1]	Content relating to the source of ideas for potential solutions	30	99
ILC_01.4	Idea Generation Methods [1]	Content relating to how ideas are initially identified and generated	6	8
ILC_01.5	Pre-selection [2]	Content relating to the informal elimination of	2	3

		process candidates to create a set of pre-selected ideas		

Table 5. Illustrative excerpt of our coding schedule

LIFECYLE STAGE	THEME	CODE	OBSERVABLE CONTENT	PROCESS TYPE CORE	PROCESS TYPE ENABLING	Cases
Adoption	Access to technological information as motivation for interaction with technology suppliers	MOT-2.1	The interaction with technology suppliers mainly serves the purpose of obtaining relevant technological information	X	X	ALL
		MOT-2.2	Access readily available information on existing solutions from technology supplier		X	A, B, C, E,
		MOT-2.3	Benefit from external expertise for generating relevant information on new technologies	X		D

Table 6. Illustrative example regarding openness towards external partners

Case	Company	No. interviewees	No. interviews	Interview hours	Additional data
A	AutoComp	4 [R1-R4]	7	10.5	▪ Secondary data
B	TrainComp	4 [R5-R8]	9	15	▪ Field notes ▪ Secondary data
C	SubComp	8 [R9-R16]	12	20	▪ Field notes

D	ElecComp	9	[R17-R25]	14	23.5	▪ Field notes ▪ Secondary data
E	ChasComp	7	[R26-R32]	13	22.5	▪ Field notes ▪ Secondary data
	Total	32		55	91.5	

[Rx] is used as the identifier for the individual respondents that participated in this study

Table 7. Data Overview

LIFECYLE STAGE	THEME	CODE	OBSERVABLE CONTENT	PROCESS TYPE CORE	PROCESS TYPE ENABLING	Cases
Ideation	Gathering information on available technologies to fertilize ideas	MOT-1.1	Initial interaction with various technology experts to gather general information and fertilize ideas	X	X	ALL
		MOT-1.2	Early specification of solutions makes it necessary to gather very specific information from only a few technology experts early on (typically the case for production technology development)	X		D
Adoption	Access to technological information as motivation for	MOT-2.1	The interaction with technology suppliers mainly serves the purpose of obtaining	X	X	ALL

	interaction with technology suppliers		relevant technological information			
		MOT-2.2	Access readily available information on existing solutions from technology supplier		X	A, B, C, E,
		MOT-2.3	Benefit from external expertise for generating relevant information on new technologies	X		D
		MOT-3.1	Accessing external capabilities for technological change	X	X	ALL
Preparation	Differences in external support for technology development exist between enabling and core processes	MOT-3.2	Access the capabilities of the supplier in modifying the technology; learn from the experience relating to the preparation, implementation, and use of the technology; understand the limitations of technological modification		X	A, B,C E,
		MOT-3.3	Access to externally developed technological components	X		D
Installation	External contributions are	MOT-4.1	Using supplier's skills for quick installation of		X	A, B, C, E

relevant for capacity and temporarily necessary capabilities	MOT-4.2	new technology Gaining support for ad-hoc problem solving	X	X	ALL
	MOT-4.3	Accessing temporary capacities for supporting the provision of technology training	X	X	ALL

Table 8. Key Findings

External contributions towards technological change across the innovation lifecycle				
	Ideation	Adoption	Preparation	Installation
Enabling processes	Conceptual capability contribution	Conceptual capability contribution	Applied capability contribution	Capacity contribution
Core processes	Conceptual capability contribution	Applied capability contribution	Applied capability contribution (restricted) / Capacity contribution	Capacity contribution
Capability contribution	Organisations seek capability contributions when they seek interaction with external partner to absorb knowledge and develop capabilities that are not yet available but considered necessary to possess internally			
Conceptual capability contribution	Capability contributions are conceptual if external technology experts use their capabilities to help organisation s generate a theoretical understanding of new technology, based on the provision of information but not practical experience			
Applied capability contribution	Capability contributions are applied if external partners use their capabilities to provide tangible support to technological change, which enables organisation s to develop experience-based understanding of new technology			
Capacity contribution	Organisations seek capacity contributions when they are motivated to interact with external partners to access additional workforce or resources to carry out specific tasks, although the necessary capabilities to perform these tasks are available or when they are not needed internally			

Table 9. Different paths of process innovation