How customer knowledge affects exploration: Generating, guiding, and gatekeeping

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Abstract

The importance of understanding customers in order to sustain the long-term success of the company has been claimed by academics and practitioners for decades, to the point that the claim has turned into a truism. And still, the role of customer knowledge in organizational renewal, especially via explorative new product development (NPD), remains ambiguous. While existing literature generally emphasizes the value of customer knowledge, critics argue that a strong customer focus can also de-motivate and misguide exploration. This study adds clarity to our understanding of this tension by drawing from an intensive analysis of the corporate archives of a rapidly growing high-tech company. The authors trace the impacts of customer knowledge on twelve explorative NPD projects. The findings reveal three distinct mechanisms through which customer knowledge influences exploration: generating, guiding, and gatekeeping. The impact of customer knowledge on exploration depends on the selective deployment of these mechanisms. The authors further argue that managers should seek to find a fit between the deployment of customer knowledge mechanisms and the exploration project type in order to increase the likelihood of exploration project success.

Keywords: customer involvement, customer knowledge, exploration, market orientation, mechanisms, new product development

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1. Introduction

To ensure long-term viability, organizations must occasionally *explore* "new possibilities" in new product development (NPD) instead of just *exploiting* "old certainties" (March, 1991, p. 71). While an organization's ability and willingness to engage in explorative NPD is increasingly important as markets become more dynamic and competitive (Day, 2011), exploration is notoriously risky. Therefore, firms tend to favor exploitation instead of exploration (Atuahene-Gima, 2005; Levinthal & March, 1993). A fundamental management challenge is to counter this tendency by ensuring that the likelihood of positive outcomes in exploration are reasonably high, and that the relative ease and predictability of exploitation does not lead to excess exploitation at the expense of exploration.

There is a tension in existing literature concerning the role of customer knowledge in explorative NPD. The majority of existing research emphasizes the value of customer knowledge. To support exploration, firms monitor customer feedback, conduct market research, and involve customers as co-creators in NPD projects (e.g., Chang & Taylor, 2016; Coviello & Joseph, 2012; Khanagha, Volberda, & Oshri, 2017). These activities help ensure that the developed products address real market needs (Cooper, 2019; Im & Workman, 2004; Joshi & Sharma, 2004) and that the projects survive the firm's internal resource competition (Christensen & Bower, 1996). Nevertheless, critics argue that customers lack the imagination of new products that do not yet exist (Magnusson, 2009). Therefore, customer knowledge may narrow the firm's scope of search and promote incremental rather than radical innovations (Govindarajan, Kopalle, & Danneels, 2011). More generally, an extensive search for external

information is costly and can become detrimental to innovation performance (Ardito & Messeni Petruzzelli, 2017; Laursen & Salter, 2006).

We address this tension by examining the detailed effects of customer knowledge over the course of explorative NPD projects. While existing studies have produced important insights about the utility of customer knowledge in explorative NPD, they are mainly cross-sectional, quantitative, and focus on firm-level outcomes (e.g., Atuahene-Gima, 2005; Augusto & Coelho, 2009; Joshi, 2016; Khanagha et al., 2017; Nijssen, Hillebrand, de Jong, & Kemp, 2012). As a consequence, these studies have focused on theorizing about the mechanisms behind observed correlation patterns, without directly examining how those patterns are generated at a finer level of granularity. This "assumption-omitted theory testing" (Tsang, 2006) makes it difficult to reconcile conflicting findings since the underlying mechanisms are not empirically scrutinized.

In this study, we analyze the mechanisms through which customer knowledge affects explorative NPD projects and their outcomes by conducting a historical study of the meteorological instrument company Vaisala. Our study focuses on the company's NPD activities in the 1970s by analyzing detailed project-level evidence. During this time, Vaisala branched out to multiple new product categories and markets through explorative NPD. This provides grounds for analyzing how customer knowledge creation activities influence explorative NPD projects and how managers could engage in such activities to enhance the effectiveness of explorative NPD.

Through our empirical inquiry, we make three contributions to marketing and innovation literatures. First, we add clarity to the tension in literature concerning the role of customer knowledge in explorative NPD. We postulate three mechanisms through which customer knowledge creation influences the NPD process and its outcomes: *generating*, *guiding,* and *gatekeeping*. While existing literature has discussed these mechanisms using varying terms

(Augusto & Coelho, 2009; Cooper, 2019; Danneels, 2002; Rosenzweig, 2017; Rubera, Ordanini, & Calantone, 2012), they are mostly inferred from higher-level correlation patterns, rather than directly observed. Moreover, conflicting empirical findings have left the question of the overall impact of customer knowledge partly unanswered. We argue that the overall impact of customer knowledge on NPD projects and their outcomes depends on managers' selective deployment of these mechanisms. Consequently, it is not fruitful to make blanket statements about the impact of customer knowledge on explorative NPD projects without examining in detail how customer knowledge is used in specific projects.

Second, our study complements existing insights on how to successfully make use of customer knowledge along different NPD stages (e.g., Chang & Taylor, 2016; Coviello & Joseph, 2012). We develop a 'fit' argument concerning *how* and *when* managers should deploy customer knowledge. In brief, the appropriate mix and timing of customer knowledge creation activities depends on the type of NPD project being carried out. The concept of fit adds to our understanding of how customer and technology viewpoints can be employed in a complementary fashion, rather than as oppositional forces in explorative NPD (Moorman & Slotegraaf, 1999). Our findings highlight the importance of using customer knowledge in a contextually sensitive manner, and that the effective use of customer knowledge may take different forms from project to project. As such, our arguments complement prior research, which has mostly explained the varying benefits of customer knowledge by proposing different modes of customer knowledge use (e.g., customers as information sources vs. customers as co-developers), and by identifying organizational and environmental contexts that increase or diminish the utility of customer knowledge in explorative NPD (e.g., Cui & Wu, 2017; Joshi, 2016).

Finally, we make a methodological contribution to the marketing literature by revitalizing the use of historical analysis in marketing (see Cooper, 2000; Savitt, 1980). Our study illustrates

how historical evidence and methods can help address vexing questions in strategic marketing research by shedding light on the mechanisms that ultimately give rise to macro-level (e.g., firm-level) correlation patterns (that can be studied using, e.g., regression-based techniques). Our analysis also shows how historicizing important strategic marketing constructs can help challenge established notions about the historical development of marketing thought since Vaisala employed many activities related to customer-centric business before they were conceptualized or elaborated in the academic marketing literature.

2. Research background

2.1. Exploration–exploitation dilemma

Balancing exploration and exploitation is a key organizational learning dilemma, where exploration relates to "variation, risk taking, experimentation, play, flexibility, discovery, innovation," while exploitation relates to the activities of "refinement, choice, production, efficiency, selection, implementation, execution" (March, 1991, p. 71). Achieving a balance between these two activities can ensure both the short- and long-term success of a company. While the lack of either exploration or exploitation can be detrimental, conducting a sufficient amount of exploration appears to be the greater challenge for two reasons. First, organizations have a general tendency to conduct local search (Cyert & March, 1963), and realize immediate gains (March, 1991). This can drive out exploration since exploitation generates short-term performance and repeat exploitation increases its efficiency (Levinthal & March, 1993). Second, the benefits of exploration are also much more distant and uncertain (March, 1991). This can lead managers to favor short-term over long-term performance.

A company's ability to solve the exploration-exploitation dilemma by conducting both incremental and discontinuous innovation activities has been referred to as ambidexterity

(Messeni Petruzzelli, 2014; O'Reilly & Tushman, 2013). The creation and use of customer knowledge has been suggested as a way to achieve ambidexterity (Ardito, Messeni Petruzzelli, Dezi, & Castellano, 2020), because it can direct NPD activities to focus on both existing and emerging customer needs (Andriopoulos & Lewis, 2009; Atuahene-Gima, 2005). This directs exploration and exploitation activities to the creation of customer value (Rubera et al., 2012) and can help turn inventions into marketable innovations (Ardito, Messeni Petruzzelli, & Albino, 2015).

While the creation and use of customer knowledge has been suggested as a potential source of ambidexterity in the context of NPD (Andriopoulos & Lewis, 2009; Ardito et al., 2020), the reverse has also been argued. As pointed out by a number of studies (e.g., Im & Workman, 2004; Menguc, Auh, & Yannopoulos, 2014), customer knowledge tends to steer the organization towards pre-existing or at least pre-conceivable market opportunities. Furthermore, work on disruptive innovation demonstrates that a firm's focus on existing customers and markets hinders the company's ability to generate breakthrough innovations (Christensen & Bower, 1996). In sum, while the creation and use of customer knowledge quite undeniably benefits the firm's exploitation activities (Cui & Wu, 2016; Shi, Su, & Cui, 2020), the same cannot necessarily be said about exploration. Thus, we next turn to examine how customer knowledge has been found to affect exploration.

2.2. Customer knowledge and exploration

In light of the challenges related to exploration, our goal is to understand how customer-knowledge creation and use can affect the firm's explorative NPD. Customer knowledge pertains to understanding customers' current and potential needs for new offerings, as well as their business and operations more generally (Li & Calantone, 1998). While our main interest

is in the demand-side of the market, customer knowledge is intimately intertwined with competitor knowledge, and cannot be fully disentangled empirically. On the one hand, competitor identification depends on customer knowledge, as competition is usually understood in terms of satisfying overlapping customer needs (Bergen & Peteraf, 2002). On the other hand, knowledge about competitors is essential in forming an understanding of the customer's decision-making options, and the focal firm's ability to create *superior* value to customers (Narver & Slater, 1990). This is also line with Kohli and Jaworski (1990, p. 3) who argue that "a customer focus involves obtaining information from customers about their needs and preferences", but also consideration of "exogeneous market factors (e.g., competition, regulation)" (*ibid.)*.

We can further distinguish two modes of customer knowledge creation and use: market intelligence and customer involvement (Cui & Wu, 2016, 2017; Kohli & Jaworski, 1990; Wang, Jin, Zhou, Li, & Yin, 2020). The first mode emphasizes the generation and dissemination of customer and market information and responsiveness to it. These activities are primarily associated with the constructs of market orientation and customer orientation (e.g., Atuahene-Gima & Ko, 2001; Joshi, 2016; Kohli & Jaworski, 1990; Kyriakopoulos & Moorman, 2004; Zhou, Yim, & Tse, 2005). The second mode pertains to actively involving customers in the NPD process where they can assume different roles, such as co-developer or innovator. These activities are mainly associated with the constructs of lead user involvement (e.g., Coviello & Joseph, 2012; Nijssen et al., 2012), and co-creation (e.g., Khanagha et al., 2017; Mahr, Lievens, & Blazevic, 2014). A large number of studies have focused on how these two forms of customer knowledge creation and use affect exploration, but the evidence that these studies provide is mixed (see Table 1).

Table 1
How customer knowledge influences exploration

Reference	Beneficial effects of customer knowledge in/on exploration	Detrimental effects of customer knowledge in/on exploration
Christensen and Bower (1996)	Powerful customers can facilitate technological innovation by helping the firm overcome organizational barriers to innovation	Focusing on mainstream markets can lead companies to ignore new technologies that fail to meet immediate customer needs
Lukas and Ferrell (2000)	Customer orientation positively influences the introduction of new-to-the-world products	
Im and Workman (2004)		Customer orientation has a negative effect on new product novelty
Atuahene-Gima (2005)	Customer orientation has a positive effect on competence exploration	
Fang (2008)	When downstream customer network connectivity is low, customer participation as an information source has a positive effect on product innovativeness	When downstream customer network connectivity is high, customer participation as an information source has a negative effect on product innovativeness
	When process interdependence is high, customer participation as co-developer has a positive effect on product innovativeness	When process interdependence is low, customer participation as co-developer has a negative effect on product innovativeness
Andriopoulos and Lewis (2009)	Tight coupling with customers directs focus on meeting customer needs,	Loose coupling with customers enables experimentation and probing of emerging opportunities
Augusto and Coelho (2009)	Customer orientation has a positive effect on new-to-the-world product innovation	
	Firm innovativeness strengthens the positive effect of customer orientation on new-to-the-world product innovation	
Govindarajan, Kopalle, and Danneels (2011)	Mainstream customer orientation has a positive effect on radical innovations	Mainstream customer orientation has a negative effect on disruptive innovations
	Emerging customer orientation has a positive effect on disruptive innovations	
Arnold, Fang, and Palmatier (2011)	Customer acquisition orientation has a positive effect on radical innovation performance	Customer retention orientation has a negative effect on radical innovation performance
Coviello and Joseph (2012)	Successful innovators leverage customer participation throughout the innovation process to create major innovations	

Table 1
Continued

Reference	Beneficial effects of customer knowledge in/on exploration	Detrimental effects of customer knowledge in/on exploration
Nijssen, Hillebrand, de Jong, and Kemp (2012)	Strategic value assessment enhances lead user collaboration and its effect on explorative learning	
Rubera, Ordanini, and Calantone (2012)	Integrating knowledge of customer needs and preferences with technological knowledge leads to market success across different exploration project types	Integrating knowledge of customer needs and preferences with technological knowledge leads to process failure in technology exploration projects
Mahr, Lievens, and Blazevic (2014)	Co-creation with lead users during innovation process produces novel knowledge	
Menguc, Auh, and Yannopoulos (2014)		Customer involvement in the design process is detrimental for companies with radical innovation capability
Chang and Taylor (2016)	Customer participation in the launch stage positively influences new product innovativeness	
Joshi (2016)	Customer orientation is positively related to radical product innovation in the presence of strategy-based rewards	Customer orientation is negatively related to radical product innovation in the presence of outcome-based rewards
Cui and Wu (2017)	Using customers as an information source is more beneficial to performance when a company adopts an experimental NPD approach	Using customers as co-developers is less beneficial to performance when a company adopts an experimental NPD approach
Khanagha, Volberda, and Oshri (2017)	Managerial attention and initiatives mediate the relationship between customer co-creation and exploratory innovation	
Rosenzweig (2017)	Non-customers can be initiators of radical innovation since they have high knowledge of needs that a supplier can fulfill	
Wang, Jin, Zhou, Li, and Yin (2020)		When developing technologically new products, using customer as co-developers increases customer-developer conflicts
Wang, Aggarwal, and Wu (2020)		Deep customer relationships hinder novelty-based adaptation to demand-side change (i.e., development of completely new products and technologies)

Several studies have found that customer knowledge increases a firm's propensity to engage in explorative NPD (Coviello & Joseph, 2012; Lukas & Ferrell, 2000; Mahr et al., 2014), which subsequently enhances firm performance (Atuahene-Gima, 2005). Customer knowledge aids explorative innovation activities by steering the NPD process to fulfill customer needs

(Augusto & Coelho, 2009; Coviello & Joseph, 2012; Cui & Wu, 2017), and by increasing the meaningfulness of new products to customers when they are commercialized (Im & Workman, 2004). Customer understanding can also act as a starting point when initiating technology exploration (Andriopoulos & Lewis, 2009; Danneels, 2002; Rosenzweig, 2017; Rubera et al., 2012). These factors can significantly decrease the commercial risk that companies face in explorative NPD. Thus, the central argument for the positive relationship between customer knowledge and explorative NPD concentrates on the idea that exploration has to be transformed into products that customers can understand and buy.

There are also a number of studies which argue that customer knowledge hampers explorative NPD. These studies highlight that following established customer needs may lead firms to miss novel technological opportunities (Wang, Aggarwal, & Wu, 2020), and emerging market needs (Christensen & Bower, 1996). In terms of the product development process, researchers have found that development personnel may be reluctant to accept customer input (Chang & Taylor, 2016), that customer involvement can increase the difficulty of information processing in already experimental projects (Cui & Wu, 2017), and that customer involvement can stir conflict between the developer and the customer (Wang, Jin, et al., 2020). Following a similar line of reasoning, Tang and Marinova (2020) argue that customer knowledge sharing in teams has an inverted U-shaped relationship with NPD performance.

In addition, a number of studies have discussed the use of market knowledge without separating customer knowledge from other types of market signals (most importantly, competitor-related information). These studies make broadly similar arguments as those focusing purely on the customer side of the market (e.g., Atuahene-Gima & Ko, 2001; Chandy & Tellis, 1998; Kyriakopoulos, Hughes, & Hughes, 2016; Kyriakopoulos & Moorman, 2004; Wang, Jin, et al., 2019; Zhou et al., 2005). Interestingly, a recent meta-analysis (Shi, Su, & Cui, 2020) finds a positive association between market orientation and exploration. The meta-analysis thus

suggests that, on average, market orientation is beneficial for exploration purposes. Nevertheless, a meta-analytical summary of extant findings does not fully explain the diverging arguments and findings across individual studies.

The open innovation literature has also discussed how external knowledge influences exploration, where customers are one frequently used source of information (Laursen & Salter, 2006). This literature has found that the widespread use of external knowledge can be detrimental to innovation performance (Ardito & Messeni Petruzzelli, 2017; Laursen & Salter, 2006). For example, Greco, Grimaldi and Cricelli (2016) argue that search breadth is curvilinearly associated with innovation performance (search depth does not display similar diminishing returns). Similarly, Ferreras-Méndez, Fernandez-Mesa and Alegre (2016) propose that search breadth has an inverted U-shaped relationship with exploration. However, Chen, Chen and Vanhaverbeke (2011) suggest that extensive and intensive use of external knowledge sources does not always hamper innovation performance in the manner predicted by Laursen and Salter (2006).

What explains this apparent discord in the literature? In general, existing studies employ a cross-sectional survey method and study exploration at relatively high levels of aggregation (e.g., company-level), without zooming in on the detailed dynamics of creating and using customer knowledge (see Andriopoulos & Lewis, 2009; Coviello & Joseph, 2012 for notable exceptions). In brief, existing literature has focused on detecting effects, rather than uncovering the mechanisms linking customer knowledge to explorative NPD. Existing literature of course *assumes* mechanisms when building towards hypotheses, but those assumptions are not usually subjected to empirical testing (Tsang, 2006). This is not a problem at the level of individual studies, but the diversity of observed effects (Table 1) is difficult to account for on the aggregate level without a detailed understanding of the underlying mechanisms.

2.3. Mechanism-based explanations

In order to add clarity to the role of customer knowledge in explorative NPD, we focus on the mechanisms underlying the effects reported in earlier literature. While strategic marketing literature usually theorizes mechanisms based on observed effects or correlations, the development of a mechanism-based explanation starts with the lower-level interactions between system components in order to build an understanding of the higher-level effects. To do so, the mechanism-based approach focused on building an explanatory understanding (Hedström & Wennberg, 2017; Pajunen, 2008) of "how and through what kind of a process an outcome is brought about" (Sihvonen & Pajunen, 2019, p. 256). Therefore, they elucidate why certain outcomes occur by explaining how they occur (Bechtel & Abrahamsen, 2005). These explanations can then open up statistical black box models and show how the outcomes are produced (Hedström & Ylikoski, 2010).

To understand mechanism-based explanations, Pajunen (2008) has argued that mechanisms have four interrelated characteristics:

> "First, mechanisms consist of component parts and their activities/interactions. Second, they produce something. Third, this productive activity depends essentially on the hierarchical (part–whole) structure of mechanisms. Fourth, mechanism explanations are representations or models of mechanisms that, if accurate, describe relevant characteristics of the mechanisms operating in organizational processes." (p. 1451)

This conceptualization can be translated into four key steps that orient our study of customer knowledge mechanisms and their influence on explorative NPD projects.

First, the component parts of mechanisms are the entities that partake in the actualization of mechanisms (Hedström & Ylikoski, 2010). In an organizational context, these entities can be individuals, groups of individuals, or organizations that can perform activities (Hedström & Ylikoski, 2010; Sihvonen & Pajunen, 2019). This means that the initial step in building a

mechanisms explanation is to analyze who partakes in the creation and use of customer knowledge during explorative NPD projects.

Second, since mechanisms are productive processes, we need to analyze what activities the entities conduct (Hedström & Wennberg, 2017), and how these activities interact with each other (Kaidesoja, 2013). This enables an understanding of how customer knowledge is created and used during NPD projects and how activities are combined together to influence the projects. To do so, we need to analyze how market intelligence and customer involvement are used and combined during explorative NPD.

Third, the hierarchical part-whole structure of mechanisms implies that activity constellations remain incomprehensible if we don't understand how they function together on a more abstract level (Machamer, Darden, & Craver, 2000). This means that it is necessary to analyze how activities related to customer knowledge creation and use co-produce mechanisms and how these mechanisms explain the co-productive nature of these activities. Simultaneously, this also enables an analysis of how the proposed mechanisms function in different cases and contexts (Sihvonen & Pajunen, 2019).

Finally, as an outcome of this analysis process, a mechanism-based explanation should generate a representation of how the mechanisms produce the phenomenon under study. In our study, this translates to an explanation of how customer knowledge mechanisms influence different exploration projects. This then provides grounds for addressing the discord in literature regarding the impact of customer knowledge on exploration by showing how customer knowledge influences explorative NPD projects.

For developing mechanism-based explanations, extant research provides three potential approaches: experiments, simulations, and historical research (Hedström & Ylikoski, 2010; Miller & Tsang, 2010; Pajunen, 2008; Vaara & Lamberg, 2016). The first two provide for an

opportunity to isolate individual mechanisms and study their effects, while minimizing the influence of other intervening factors stemming from the context (Hedström & Ylikoski, 2010; Miller & Tsang, 2010). This then provides for a closed system in which the mechanisms can be studied (Bhaskar, 2008). While experiments and simulations are invaluable tools for causal inference, their external validity is always questionable because, in reality, context matters. This is particularly true in matters pertaining to strategic management and marketing. In contrast, historical research focuses on the accurate reconstruction of past events as a basis of mechanism-based theorizing (Pajunen, 2008; Vaara & Lamberg, 2016). In that respect, time sets events and their relations in place, which then provides for a partially closed system (Bhaskar, 2008) that is preferable when changes in the context and their interaction with the mechanisms cannot be controlled.

3. Methodology

3.1. Methodological approach

To understand how customer knowledge affects exploration, we employ a historical (Golder, 2000; Savitt, 1980) and process-oriented (Langley, 1999) methodology. We draw from the historic turn in organization and management studies, and continue the lineage of historical studies that were once common in marketing journals (e.g., Cooper, 2000; Golder, 2000). Specifically, we try to reconstruct historical events and processes, in order to further develop theory of a phenomenon that is timeless and general. This is known as the "history to theory" approach (Kipping & Üskiden, 2014, p. 541), in which historical data is used to develop, elaborate, and modify theories.

3.2. Data collection approach

In this study, we utilized historical documents as research data. These documents can be understood as nonintentional evidence that depicts the decision-making realities that managers face (Rowlinson, Hassard, & Decker, 2014). This follows historians' usual preference for verifiable archival evidence over retrospective interviews since interviews may be colored by the events that occurred afterwards (Golden, 1992). However, the archival evidence is not taken at face value and all evidence is subjected to source criticism (Kipping, Wadhwani, & Bucheli, 2014; Savitt, 1980). In particular, this relates to asking what the conditions and actions were that produced the evidence and, consequently, what the reliability of the source is (Golder, 2000). To the extent that the validity of sources remains uncertain, triangulation across sources is used to enhance objectivity of the research (Kipping et al., 2014).

The challenge of using archival documents is that they are not structured by a rationalizing narrative, unlike interviews. This adds a layer of difficulty to the analysis process. Composing a plausible narrative of the organizational reality under investigation is a burdensome process requiring intensive reading of archival materials aided by theoretical interpretation. Counterfactual reasoning, facilitated by a deep understanding of the organizational and historical context, is a key to constructing causal links between events and actions (Gaddis, 2002). This moving back and forth between evidence and theory, combined with counterfactual reasoning, ultimately results in a coherent and plausible account of historical events under scrutiny. At the same time, the process usually also reveals gaps in literature, providing an opportunity to extend and elaborate theory (Kipping & Üskiden, 2014).

3.3. Research site and source materials

The study context of this paper is the meteorological instrument company Vaisala and its NPD activities from 1969 to 1981. While Vaisala started in 1936 as a single-product company, the company expanded its technological and market scope considerably during the study period and consequently its turnover grew tenfold and the number of employees more than doubled. This was not a period of blind technology exploration without regard to marketplace realities. Rather, it was the explicit strategy of the company to grow through customer-focused and explorative NPD. This was manifested in the activities to generate and use customer knowledge during NPD. In doing so, our decision to choose Vaisala as a research site rests on two theoretical reasons. First, this period in Vaisala's history constitutes an exceptional case (Ermakoff, 2014) since the company conducted continuously successful exploration without losing sight of customers. This fits well with the idea that exceptional cases magnify relations that in more mundane settings remain less visible, that is, how to successfully combine exploration and customer focus. Second, since Vaisala conducted different kinds of exploration projects during the period of inquiry, it can be considered a diverse case (Seawright & Gerring, 2008). The diversity of exploration projects enables analysis of customer knowledge creation and use in different kinds of NPD projects.

The company archive of Vaisala was used as the main data source. It consists of approximately 128 shelf meters of material and it is openly accessible at the Central Archives for Finnish Business Records. During the research process, we collected a number of different types of documents to understand the organization and its NPD activities (3926 pages in total). This included annual reports of NPD, minutes of the New Product Group weekly meetings, and research program documentation among other material.

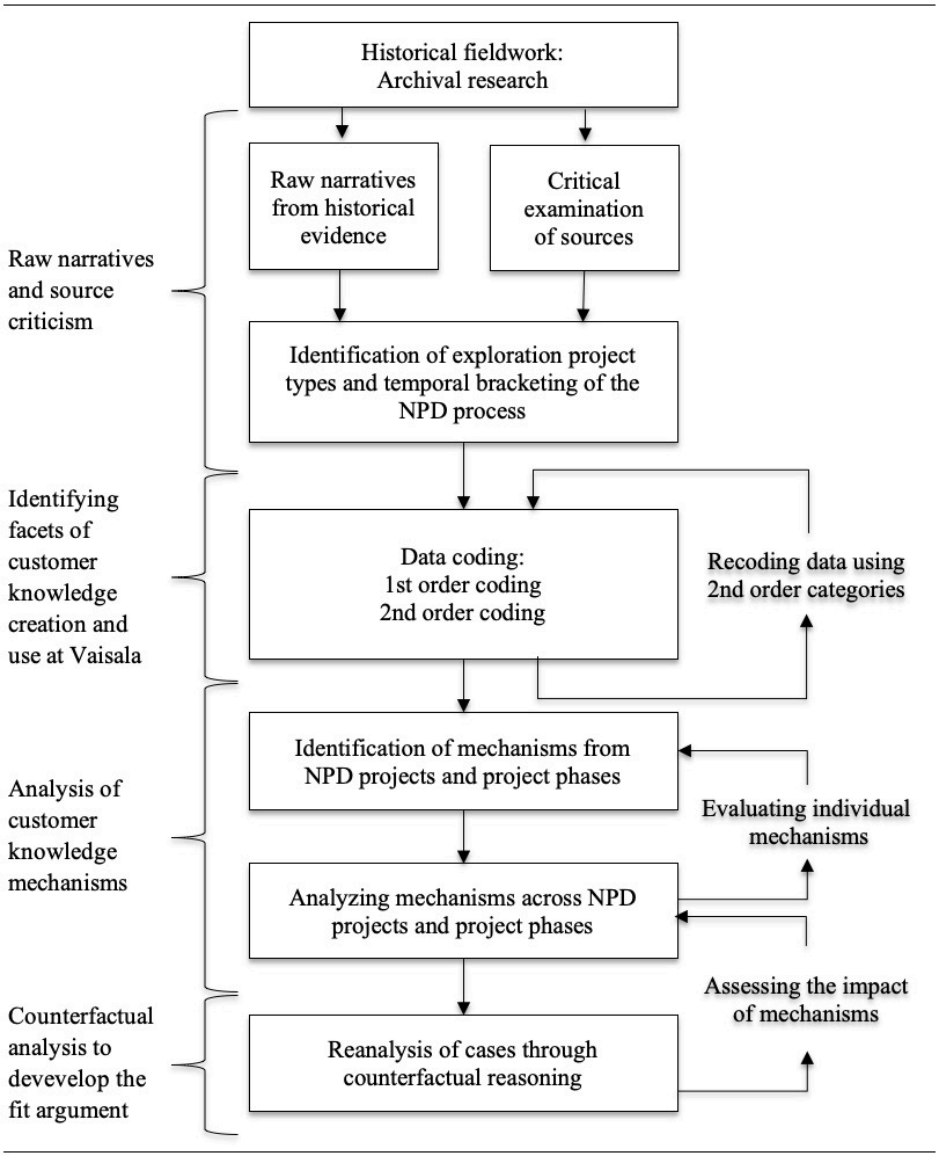
As is typical in historical research, source criticism was performed. The documents we investigated were produced for company internal use and the New Product Group meeting

memos were circulated only to the members of the group. This led us to treat them as reliable sources. The documents provided a rather comprehensive picture of the decision-making activities pertaining to NPD projects, covering all the major projects throughout their lifecycles. The archival material was supplemented with written histories of the company and book chapters related to its activities to develop an overall understanding of the history of Vaisala. Subjecting the documents to internal and external criticism led us to trust the evidence and complete one of the critical steps in the historical research process (Golder, 2000; Savitt, 1980).

3.4. Data analysis

The purpose of our data analysis was to uncover mechanisms through which customer knowledge influences explorative NPD. To do this, we analyzed central NPD projects that Vaisala undertook during the period of inquiry. These projects were very heterogeneous in terms of their technological and commercial challenges, which is characteristic for exploration. Despite this, the top managers of the company deemed most of the new products successful. Figure 1 provides an overview of how we implemented the data analysis process.

Figure 1
Data analysis process



In the initial stage, an overall understanding of the NPD of Vaisala was developed. This revealed the New Product Group to be a nexus of decision-making as it was a team of top executives who managed NPD activities. The group effectively led the NPD activities of the company and also acted as a platform to disseminate and use customer knowledge. Therefore, our analysis mainly concentrates on their activities. Simultaneously, we identified 16 central NPD projects that the company had undertaken during the period of inquiry. We wrote

narratives of each of the projects to make sense of the sequences of events through which the new products were developed (Gaddis, 2002).

By using temporal bracketing (Langley, 1999), we then reconstructed the NPD process of Vaisala around four critical points: 1) project initiation, 2) completion of a prototype/concept, 3) product launch decision, and 4) product launch. To make the projects comparable, the time between these points was used to bracket NPD process phases. The projects were then analyzed to determine whether they were explorative in terms of technologies or markets (Danneels, 2002; Rosenkopf & Nerkar, 2001). This led us to the exclude four projects that were deemed to be exploitative in nature. These projects mainly focused on the development of new radiosondes which were a crucial business for the company but not explorative in terms of technologies or markets. Simultaneously, we found three different exploration project types based on whether the project was conducted in-house or in collaboration with a third party (Rosenkopf & Nerkar, 2001). The first project type can be characterized as *collaborative explorations* where Vaisala conducted technology exploration with an external collaborator such as a university. The second project type involved customers in the development process and can be understood as *exploration with customers*. The third project type was *in-house exploration*, in which the company developed the products itself. Table 2 provides a description of the studied projects.

Table 2
Description of the studied explorative NPD projects

Project name	# of customer knowledge activities	NPD project type	Outcome of the project	Launch year	Project description
ELSA	6	Collaborative exploration	Launched product	1971	ELSA was an automatic antenna for receiving satellite signals. Helsinki University of Technology developed the initial prototype and it was thereafter jointly developed into a commercial product.
Electronic microscope	2	In-house exploration	Project terminated	---	Idea for the electronic microscope came from a prototype that was developed for internal use but the project was soon ended as it would have required too much investment to market the product.
CORA	17	In-house exploration	Launched product	1973	CORA was an automatic upper-air observation system that could be used in ships. It was built in-house to function in the OMEGA network that was predicted to cover the whole globe in the near future.
HUMICAP	18	Collaborative exploration	Launched product	1974	HUMICAP was a thin film-based humidity meter that eventually became its own product line. The initial idea and prototype was developed by VTT Technical Research Centre of Finland as a response to a bid laid out by Vaisala.
METOX	15	In-house exploration	Launched product	1974	The project concentrated on redeveloping the METOX theodolite into a semiconductor-based product. The product was developed in-house and gave Vaisala access to the market of METOX (which is a French radiotheodolite producer).
Kemi lighthouse	8	Exploration with customers	Launched product	1975	Kemi lighthouse was the first automatic weather station that Vaisala built. It was built for the Finnish Maritime Association and the development was aided by American Sierra Corporation. Its development was preceded by market analyses and pre-studies.
HATTARA	10	Exploration with customers	Launched product	1976	HATTARA was the first automatic weather station built for an airport. Its development was initiated by an in-depth study of automatic weather stations in airports done in collaboration with the Finnish Meteorological Institute.

Table 2
Continued

Project name	# of customer knowledge activities	NPD project type	Outcome of the project	Launch year	Project description
MIDAS	8	Exploration with customers	Launched product	1976	MIDAS was an automatic weather station developed in the confines of the European COST initiative that involved Vaisala, a pilot customer, and Finnish public research institutions.
New sonde batteries	4	In-house exploration	Launched product	1976	New sonde batteries were developed in-house to lower the price and increase the delivery reliability of batteries for radiosondes.
Personal dust sampling pump	4	Collaborative exploration	Project terminated	---	The University of Tampere proposed to Vaisala the development of a personal dust sampling pump. When a prototype of the product was ready new competitors had entered the market and it was perceived that the product would not succeed in the market.
SODAR	9	Collaborative exploration	Launched product (commercial failure)	1979	SODAR was an acoustic radar used to measure the inversion layer in the atmosphere. The product was developed in collaboration with the University of Oulu, which had a key role in the project.
Meteor Scatter	9	Collaborative exploration	Not available[a]	---	Meteor Scatter was a data transfer system for automatic weather stations that was developed in collaboration with VTT Technical Research Centre of Finland.

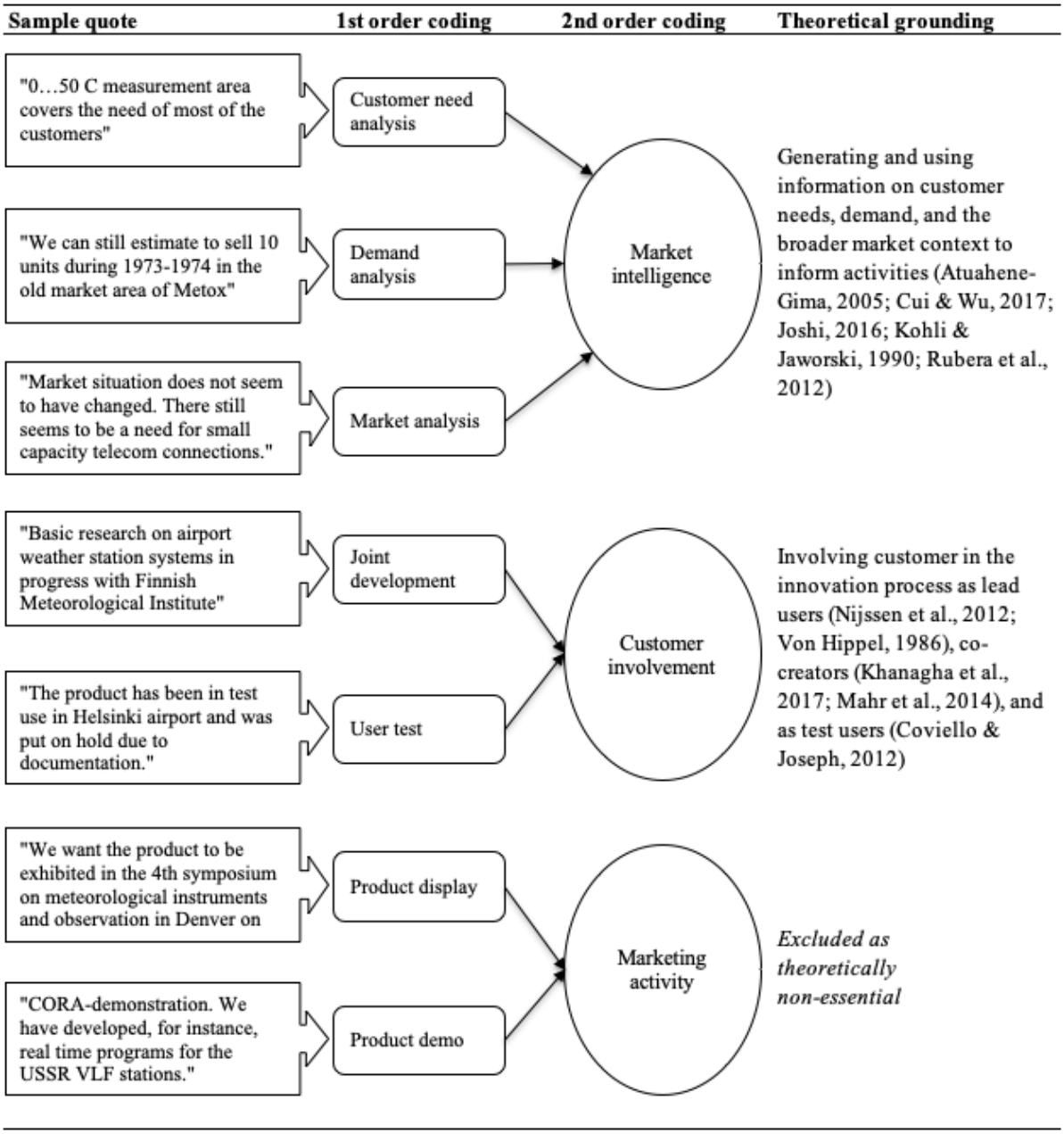
[a] The process could only be traced to the launch decision

Next, we coded customer knowledge creation and use activities by drawing from grounded theory techniques (Gioia, Corley, & Hamilton, 2013; Strauss & Corbin, 1990). We initiated coding by chronologically listing relevant events in each of the projects, which led to a list of 179 events. These events were then grouped into categories following first order coding (Gioia et al., 2013) which resulted in seven distinct codes. Thereafter, we engaged in axial coding, whereby we searched for similarities and differences between the first order categories. This led us to formulate three second-order categories. At this point two of the authors independently recoded the data with the new second-order categories to test that the categories

fit with the data and adequately represented its different dimensions. Upon reflecting the second-order categories against our phenomenon of interest (Gioia et al., 2013), the category of marketing activity was excluded because it did not directly relate to customer knowledge creation and use.

The coding process resulted in two second-order categories that depict different facets of customer knowledge creation and use at Vaisala. First, *market intelligence* concentrated on the company's effort to develop knowledge of customers' needs, quantity of demand, and the market context. In some instances, this also involved analyzing competitors in order to ascertain demand, evaluate the amount of competition, and understand how the new products met customer needs in comparison to competitors' offerings. Second, activities related to engaging the firm's customers in the product development process (e.g., user tests and joint projects) were coded as *customer involvement*. This activity category directly involved customers in the NPD process. Following the suggestions on transparent data coding (Gioia et al., 2013), Figure 2 presents the data structure of our coding procedure.

Figure 2
Data structure



To postulate customer knowledge mechanisms from the identified activities, we employed both within- and cross-case analysis techniques (Eisenhardt, 1989). In particular, we first analyzed how customer knowledge was used in individual projects and project phases to understand the type and timing of activities. Then we compared these findings across projects to understand how these activities co-produce particular outcomes, such as the initiation of a new exploration project. This enabled us to propose three mechanisms that explain the logic behind these

activity constellations (Machamer et al., 2000). Thereafter, following the suggestions of Sihvonen and Pajunen (2019), we analyzed how these mechanisms function in different NPD project types. This provided us with an understanding of how customer knowledge mechanisms were employed in different exploration project types. These findings were then discussed with respect to each of the projects individually to see if the overall pattern identified for the project type also matched the project in question.

Finally, we employed counterfactual reasoning (Durand & Vaara, 2009; Gaddis, 2002) to develop the notion of fit. Counterfactuals are a historical analysis technique where an event is reanalyzed by changing one variable to determine how that would have impacted the outcome of the event (Gaddis, 2002). This enables one to analyze whether a factor (or its absence) is necessary in causing an event (Durand & Vaara, 2009). In practice, we reanalyzed each NPD project separately in order to understand how the addition of mechanisms (not present in the project) would have influenced the NPD process and how the subtraction of mechanisms (present in the project) would have influenced the process. The proposed function of the three mechanisms provided the grounding for this analysis. The project-level analysis then enabled us to analyze how the addition and subtraction of mechanisms in each project type could have affected the NPD process and its outcome. Our conclusions from this analysis is summarized in Table 8. This then formed the basis of our fit argument.

4. Findings

We present our findings in two steps. First, we present how Vaisala created and used customer knowledge across different types of explorative NPD projects. Although theory informs our analysis, we keep this part of the analysis absent of explicit theoretical claims, and instead focus on describing the empirical material richly so that the reader can better judge the veracity

of our theoretical claims. Second, we subsequently engage in an analytical generalization of our findings to elaborate our theoretical understanding of the mechanisms linking customer knowledge to explorative NPD process and its outcomes.

4.1. Customer knowledge activities in different exploration project types

4.1.1. Customer knowledge and collaborative exploration

Collaborative exploration projects involved external partners (such as universities and research institutions) in the development process and many of the projects were both ambitious in their aims and highly uncertain in their outcomes. Collaboration was intense during the early stages of the development process because the third party had a focal role in the prototype/concept development. Most of the prototypes were developed with minimal financial investment from Vaisala and the final products were intended to target new markets. Prior to the completion of a prototype/concept, the projects mainly focused on technological development, while customer knowledge was used to guide the project and act as a gatekeeper after a prototype had been developed. Table 3 shows how customer knowledge was created and used during collaborative exploration projects.

Table 3

Customer knowledge and collaborative exploration

Project name	Before project initiation	Before completion of a prototype/ concept	Before product launch decision	Before product launch	After product launch
ELSA			A customer test used the system and subsequently it was deemed suitable for commercialization. (0; 1)		Market and demand analyses were made on potential product extensions but none of them proved commercially feasible. (5; 0)
HUMICAP			To determine commercial viability, the potential sales volume, selling price, and different applications were analyzed. (3; 0)	Sales volumes of different applications were analyzed. Analyses were made of how the products would be sold to customers and third parties. (4; 0)	Further development was based on analyses of customer needs and demand for new applications. (10; 1)
Personal dust sampling pump	Project goals were analyzed against market conditions. (1; 0)		The project was terminated due to increasing competition, low sales volume estimates, and poor fit with existing marketing organization. (3; 0)	*The project was terminated when potential product launch was evaluated*	
SODAR	Market research was conducted among customers to determine whether the project should be started. (2; 0)	Potential demand was analyzed to determine the feasibility of the product. (1; 0)	Market analyses revealed that competitors had already entered the market with similar products but the product area was still deemed promising. (2; 0)	The product was put into test use at Helsinki airport. Market analyses indicated that the product would enter the market substantially later than competition but that the market was at an early development stage. (2; 1)	Analyses of sales revealed that the product generated inquiries but did not lead to closed sales and that the customers deviated substantially from the existing customer base. (1; 0)
Meteor Scatter		A potential customer inquired about the system and consequently the company started to familiarize itself with the market. (2; 0)	The prototype was compared to competitors' offerings and analyses of potential market demand were made. (2; 0)	The product was deemed to have commercial potential and fulfill a specific customer need. Field tests were organized with potential customers. (3; 2)	*The project could not be traced beyond product launch.*

The number of customer knowledge activities is shown in parentheses in the order of market intelligence and customer involvement.

Customer knowledge influenced the development process when a concept/prototype was ready and could be evaluated. At this point the New Product Group analyzed potential sales price and volume of the final product, and gauged possible product extensions to determine the commercial potential of the prototype. This led to a decision to either commercialize the product or to terminate the project. Obviously, the above activities also guided the project beyond the go/no-go decision. For instance, the wide array of applications was a crucial influencer in the decision to commercialize the HUMICAP humidity meter:

> "Discussion on marketing issues. Potential applications [of the technology] include:
> -Own sondes
> -Other meteorological devices
> -Automatic weather stations
> -Agrometeorology
> -Air conditioning
> -Greenhouses
> -Agriculture
> -Laboratory instruments
> -Humidity measurement devices for consumers"
> (New Product Group meeting 24.8.1972)

After a commercialization decision, customer knowledge was primarily used to guide the project towards product launch. User tests were often made in order to turn the prototype into a commercial product. For instance, a potential customer test used the Meteor Scatter system so that feedback could be generated and the system could be tested in action:

> "The system is being tested with potential customer in Libya"
> (New Product Group meeting 5.6.1981)

The New Product Group also used customer knowledge to inform product launch activities and identify potential product modifications. After the decision to launch the new humidity meter HUMICAP, the New Product Group closely outlined how the product would be sold and what extensions could be made:

"Applications:

1) Humidity meter for laboratory use (about 100 units/year)

2) Monitoring patients in life support units (single use about 10 000 units/year)"

(New Product Group meeting 16.4.1973)

After product launch, customer knowledge continued to guide the project's follow-up activities. This revolved around analyzing the market to determine the future of the product. For instance, after the commercialization of the satellite receiver ELSA, the New Product Group predicted that it would not be a long-lasting product in the portfolio.

4.1.2. Customer knowledge and exploration with customers

These projects focused on the development of complex system products together with pilot customers. As shown in Table 4, customer knowledge played a central role in the early stages of the NPD process. Based on their understanding of target markets, Vaisala managers knew that there would be demand for the products and that the time was ripe for seizing the opportunity. Prior to project initiation, Vaisala also focused on understanding what the product could be from a technological perspective. This was crucial for understanding the technological side of large system products, but it was also a prerequisite for proposing collaboration to a potential pilot customer. In sum, markets and technology were jointly responsible for the initiation of these projects.

Table 4
Customer knowledge and exploration with customers

Project name	Before project initiation	Before completion of a prototype/ concept	Before product launch decision	Before product launch	After product launch
Kemi lighthouse		Existing systems and requirements of World Meteorological Organization were analyzed to understand customer needs. The Finnish Maritime association was contacted to initiate collaboration. (2; 1)	Weather station components and different weather station configurations were analyzed to determine market potential. (2; 0)	Market development was analyzed in light of the entry of new competitors. (1; 0)	Tenders to build new weather stations were analyzed to determine demand. Requests to build new components for existing weather stations were analyzed to understand new customer needs. (2; 0)
HATTARA	Initial product specifications were sent to potential customers to determine demand. (1; 0)	Initial market size was analyzed to understand market potential. The company initiated collaboration with the Finnish Meteorological Institute to specify a new weather station type. (1; 3)	Bid to build a weather station at Helsinki-Vantaa airport was received and winning the bid was deemed extremely important because it would enable the company to enter a new market segment. (1; 0)	Potential demand for the product and additional features were analyzed. (2; 0)	Bids to build new weather stations and weather station components were analyzed. These analyses also accounted for the markets that the development would open up. (3; 0)
MIDAS	Analysis of potential customers' needs revealed that they had started to take a more positive stance towards the project. (1; 0)	Vaisala initiated development collaboration with the previously identified potential customer. Potential demand beyond the immediate project was analyzed. (2; 4)			The demand for MIDAS type weather stations was analyzed to guide further development. (1; 0)

The number of customer knowledge activities is shown in parentheses in the order of market intelligence and customer involvement.

Once commenced, customer knowledge played a strong role in the projects. Early on, the New Product Group analyzed existing products and competitors to understand the market situation, and subsequently directed efforts into acquiring a pilot customer. The role of the pilot customer was to jointly plan product specifications with Vaisala staff. This enabled the integration of component development projects in order to make a coherent product that would satisfy

customer needs. In many instances this required intense interaction with the customer, which the following excerpt on the development of HATTARA highlights:

> "Seutula [site of project implementation]: The project is in the development stage at the Finnish Meteorological Institute. 100.000.- FIM[1] reserved. Meetings will continue in February -74."
>
> (New Product Group meeting 14.12.1973, underlining in original)

Simultaneously, the New Product Group analyzed the market situation to steer the project so that the resulting system would stand up to competition and meet customer needs. For instance, the following was noted on the development of the first automatic weather station:

> "Based on the information collected since 1966 we sent an inquiry to all known producers of weather stations to gauge technical specifications, prices and delivery times. We sent 31 inquiries and received 15 answers. The collected data was analyzed with a form."
>
> (New product development annual report 1971-1972)

When a prototype/concept was completed, the New Product Group reanalyzed the project to determine how it would be taken further. This included analyzing both the commercial feasibility of the immediate project and the market potential beyond it. This was the case in the development of HATTARA that the following excerpt from the minutes depicts:

> "An invitation to bid was received from the Finnish Meteorological Institute to automatize the weather equipment at Helsinki airport. The bid has to be submitted 30.5.1974.
>
> The bid has been sent to multiple companies.
>
> This work would be very important in the long run because it would lend us access to the market of automatic observation systems."
>
> (New Product Group meeting 8.5.1974)

To some extent, the market analyses were also continued after the launch decision in order to update understanding on the market situation, and to determine product launch activities and possible product modifications. Otherwise, the project was moved towards launch. Once the product was launched (i.e., first product was delivered to the pilot customer), the New Product

[1] FIM = Finnish Markka which was the currency of Finland from 1860 until 28 February 2002

Group started processing market feedback. In many instances this meant analyzing bids for building new products for both the pilot customer and new prospective customers.

4.1.3. Customer knowledge and in-house exploration

These projects focused on in-house exploration that used the company's own resources and personnel. What characterizes these projects is the constant use of customer knowledge throughout the project (see Table 5). These activities primarily focused on aligning the product to the market and minimizing risks.

Even before these projects were officially started, the New Product Group analyzed market potential of the product and the product area. After project initiation, they concentrated on affirming market potential and aligning the product to the market. The following excerpt highlights how the market potential of the CORA sounding system was analyzed and how market knowledge was used to steer its development process:

> "Of the NAVAID networks, OMEGA will cover the whole earth in the near future. WMO [World Meteorological Organization] thinks that the OMEGA system is central in the weather measurement networks of the future. OMEGA system provides the only known possibility to make upper air observations from moving ship stations with reasonable costs."
>
> (New product development annual report 1971-1972)

Table 5
Customer knowledge and in-house exploration

Project name	Before project initiation	Before completion of a prototype/ concept	Before product launch decision	Before product launch	After product launch
Electronic microscope		*The product prototype already existed when the project was initiated.*	The needed marketing efforts for successful commercialization were evaluated in comparison to potential sales volume. Based on this, the project was terminated. (2; 0)	*The project was terminated when the potential product launch was evaluated.*	
CORA	Based on market analysis, three viable ways for developing an upper air wind measurement system were identified. (1; 0)	Due to market developments, the commercial potential of NAVAID systems was deemed to have greatly increased. This led to the initiation of a project to develop a NAVAID system. (5; 0)	Market analysis indicated that market penetration could be rapid if the system could convert customers from other product types. (1; 0)	The product was compared to competing offerings to determine its attractiveness and profit potential. Further development of the product was discussed with regard to customer-specific solutions that would open up new market areas. (3; 0)	Market potential and customer needs were analyzed to determine how the product should be further developed and what product modifications should be developed. (8; 0)
METOX	Current market potential of METOX products was analyzed. New market opportunities that developing a METOX system would generate were also analyzed. (3; 0)	Existing products and potential development paths were analyzed to specify a commercially viable project. (1; 0)	Market demand for the product was analyzed to ascertain commercial viability. Potential revenue streams for maintaining devices were also analyzed. (6; 0)	Market demand was determined based on incoming inquiries and survey sent to potential customers (5; 0)	
New sonde batteries	The potential for manufacturing own battery was compared to existing offerings in the market.(1; 0)	In-house manufacturing was compared to outsourcing. It was noted to increase quality and reliability, which are essential to end customers.(2; 0)			Further development of the battery was decided based on end customer needs.(1; 0)

The number of customer knowledge activities is shown in parentheses in the order of market intelligence and customer involvement.

When a prototype/concept was ready, the New Product Group used customer knowledge to determine whether the product should be launched. This included analyzing how the product

would meet customer needs, how it would compare to other offerings, and how much revenue it could generate. The following excerpts from the minutes characterize these activities regarding the development of the METOX system:

> "The estimated sales price of the renewed Metox in 1976 is about 30.000 US$. This fits a niche in the market."
>
> (New Product Group meeting 14.11.1974)

> "Annual sales goal: at least 10 units/year 80.000 US$ each
>
> total amount approx. 50 units."
>
> (New Product Group meeting 29.12.1974)

After product launch decision, the New Product Group often continued to use analyze the market. These analyses concentrated on informing the execution of the product launch by determining the selling price, how the product would stand up to competing offerings, and predicting how much revenue the product would generate. The following excerpt highlights these intertwined activities prior to launching the CORA system:

> "Pricing indicates that the ground equipment could be sold at a price of US$ 75.000.- (50% contribution margin, 10% commissions and US$ 5.000.- additional training fee). The price can be considered competitive against Beukers WF-3 radar and the renewed METOX.
>
> Beukers: potentially equal in performance but more expensive
>
> WF-3: same price but weaker performance and less automatized (without PTU)
>
> METOX: cheaper, weaker performance and less automatized
>
> Tentative schedule: 1974 2 units (France), 1975 4 units (potential buyers: South Africa, Australia, Japan, India, USA, International Aeradio etc.)."
>
> (New Product Group meeting 1.3.1974)

After the product launch, the New Product Group continued assessing market feedback and commercial potential of the product to determine whether its further development could be feasible.

4.2. Customer knowledge mechanisms and their influence on exploration projects

Based on the evidence summarized above, we identify three ways in which customer knowledge influences exploration projects by 1) *generating exploration,* 2) *guiding exploration*, and 3) *gatekeeping exploration*. Table 6 summarizes the characteristics of these mechanisms and their empirical instances in the data. Although we identified the three mechanisms inductively, by examining the empirical evidence across Vaisala's explorative NPD projects, these mechanisms have also been referred to in prior literature (last row in Table 6). However, references to these mechanisms are usually made without direct empirical evidence, and different studies cite different mechanisms. Thus, the findings here help elaborate and systematize our theoretical understanding of the range of mechanisms that underlie the effects that can be observed at a higher level of abstraction (Hedström & Wennberg, 2017; Hedström & Ylikoski, 2010).

Table 6
Customer knowledge mechanisms in exploration

	Generating exploration	Guiding exploration	Gatekeeping exploration
Function	Using customer knowledge to initiate an NPD project	Steering NPD project in light of customer knowledge	Using customer knowledge to make go/no-go decisions during the NPD project
Characteristic timing	Before and during prototype development	After prototype development	Over the course of the project
Primary rationale	To match product features with the customer's functional product requirements	To ensure the commercial viability of the developed technological solution	To lower risks in deploying own resources to the project
Secondary rationales	Reducing the financial risk of product development	Fine-tuning prototype or concept to a final product	Analyzing demand to identify further market opportunities
	Establishing a reference case	Preparation of a go-to market strategy	
		Analyzing demand to identify further market opportunities	
Projects	Kemi lighthouse, HATTARA, MIDAS, CORA, METOX, New sonde batteries	ELSA, HUMICAP, SODAR, Meteor Scatter, Kemi lighthouse, HATTARA, MIDAS, CORA, METOX, New sonde batteries	ELSA, HUMICAP, Personal dust sampling pump, SODAR, Meteor Scatter, Electronic microscope, CORA, METOX, New sonde batteries
Related references	Andriopoulos and Lewis (2009); Danneels (2002); Rosenzweig (2017); Rubera, Ordanini, and Calantone (2012)	Augusto and Coelho (2009); Chang and Taylor (2016); Coviello and Joseph (2012); Cui and Wu (2017); Rubera, Ordanini, and Calantone (2012)	Cooper (2019); De Luca, Verona, and Vicari (2010); Mahr, Lievens, and Blazevic (2014); Sukhov, Sihvonen, Netz, Magnusson, &Olsson (2021)

First, the mechanism of *generating exploration* relates to the use of customer knowledge to initiate exploration projects. This mechanism is actualized before or during prototype development and it can involve analysis of customer needs or collaboration with customers in order to define an exploration project. The rationale for these activities is that they enable defining of product features based on customer needs. These activities can also reduce development risk, while collaboration can establish a reference case. For instance, when the HATTARA system was developed, the New Product Group analyzed potential demand and initiated collaboration with the Finnish Meteorological Institute to develop a product that

would match customer needs but also garner interest from other potential customers. In doing so, these activities generated a technology exploration project that would match those needs. This mechanism is related to assertions in earlier literature that customer needs can act as a starting point for technology exploration (Andriopoulos & Lewis, 2009; Danneels, 2002; Rosenzweig, 2017; Rubera et al., 2012).

Second, the mechanism of *guiding exploration* explains the use of customer knowledge to steer projects by influencing product specifications, by shaping the execution of the product launch, or by helping determine whether spin-off projects could be launched. This mechanism is generally deployed after prototype development and it influences projects by ensuring commercial viability of the technological solution, while also steering the project towards the creation of marketable product. The functioning of this mechanism is well exemplified in the HUMICAP project, where customer knowledge was used to steer the project to ensure its commercial viability and to map further applications for the technology. With regard to existing literature, this mechanism is related to the idea that customer knowledge can steer exploration projects towards the creation of customer value and fulfilment of customer needs (Augusto & Coelho, 2009; Coviello & Joseph, 2012; Cui & Wu, 2017; Rubera et al., 2012) and facilitate the successful launch of new products (Chang & Taylor, 2016).

Third, *gatekeeping exploration* refers to the use of customer knowledge to make go/no-go type decisions over the course of the NPD project. To do so, senior executives (also known as gatekeepers) use customer knowledge to analyze whether a project should pass a decision gate and move forward in the development process (Cooper, 2019). This mechanism generally influences the exploration projects throughout the development process in order to lower the risk of deploying resources to the project but also to gauge further market opportunities. For instance, when the CORA system was developed, the New Product Group constantly analyzed the market situation in order to ensure that there would be demand for the product and that it

would stand up to competition. This mechanism shows how customer knowledge can be used to mitigate development risk (De Luca, Verona, & Vicari, 2010), which is an inherent characteristic of exploration projects (March, 1991). In this regard, while previous studies have argued that listening to customers can lead to less novel products and ignorance of new technologies (Christensen & Bower, 1996; Im & Workman, 2004), gatekeeping exploration appears to ensure that there is actual demand for the products and that it is relevant to the customers (Mahr et al., 2014).

Taken together, we propose that

> *Proposition 1a: Customer knowledge influences exploration through three distinct mechanisms: generating, guiding and gatekeeping.*

According to the evidence, the three mechanisms were activated differently across different exploration project types (see Table 7). First, the initial stages of collaborative exploration projects were the products of technological opportunities rather than customer knowledge. The function of customer knowledge in collaborative exploration projects was mainly to guide these projects and act as a gatekeeper in the later stages of the NPD process. Second, Vaisala's understanding of its target markets was essential in generating exploration projects co-conducted with customers. Selected customers played an essential role in defining the projects in the early stages, while market intelligence guided these projects in the later stages. Finally, in-house exploration projects were often driven by the company's understanding of unmet market needs and heavily influenced by market intelligence over the lifecycle of the project.

Table 7
Customer knowledge mechanisms and their effect on different exploration project types

	Generating exploration	Guiding exploration	Gatekeeping exploration	Overall effect of customers knowledge
Collaborative exploration		**Present** Market intelligence and customer involvement were used to guide projects towards product launch, inform further development of new products, and influence post launch activities.	**Present** Market intelligence was used to determine the commercial viability of prototypes in order to make go/no-go decision on product launch.	Customer knowledge was used to transform initial technologies and prototypes into commercially viable products.
Exploration with customers	**Present** Market intelligence and customer involvement were used to initiate and specify the projects.	**Present** Customer involvement was used to determine final product specifications and market intelligence was used to align the product to the market, determine launch activities and potential product extensions.		Customer knowledge was used to specify system development projects and determine final product features so that they would meet customer needs.
In-house exploration	**Present** Market intelligence was used to chart development paths and determine the commercial viability of the opportunity during project initiation.	**Present** Market intelligence was used to guide product launch activities, relate the product to competing offerings, determine potential sales volume and opportunities for developing product extensions.	**Present** Market intelligence was used to determine whether new prototypes should be launched.	Customer knowledge was used throughout the process to ensure commercial viability

According to our evidence, Vaisala clearly had the capacity to create and use customer knowledge to influence NPD projects. However, its managers chose to deploy the capacity in heterogeneous ways (see Table 7), with differing effects on the NPD process. This indicates that selective deployment, or "managerial enactment" (Grand & Bartl, 2019), of customer knowledge mechanisms can account for the diversity of effects reported in earlier research. By selective deployment, we refer to managerial choices regarding which customer knowledge production activities are conducted, and how the resulting knowledge is used in the NPD

process. The debate about the positive and negative impacts of customer knowledge in the context of exploration has thus far assumed, if somewhat implicitly, that the impact of customer knowledge on exploration is fairly uniform across situations (e.g., Cui & Wu, 2017; Lukas & Ferrell, 2000; Menguc et al., 2014). That is to say, managers do not exercise their capacity for selective deployment. In contrast, we argue that it is not possible to establish a single, law-like statement about whether customer knowledge is beneficial or detrimental to exploration. Rather, the overall effect of customer knowledge on exploration is the product of selective deployment of the mechanisms that are used to influence exploration. More formally,

> *Proposition 1b: The overall effect of customer knowledge on exploration is the product of selective deployment of the three customer knowledge mechanisms (generating, guiding and gatekeeping).*

4.3. The notion of 'fit'

The evidence suggests that Vaisala's senior managers' selective deployment of the three mechanisms was highly effective. Vaisala was able to considerably broaden its portfolio of products, technologies, and capabilities, while maintaining a high level of NPD performance. We argue that the effectiveness of Vaisala's explorative NPD can be attributed to the managers' ability to appropriately match the type and timing of customer knowledge creation and use with the needs of each NPD project, in particular, their key uncertainties. Our fit argument can be supported with counterfactual reasoning (Durand & Vaara, 2009), which we applied to each project type (see Table 8 for a summary). In brief, our counterfactual reasoning suggests that the way in which Vaisala deployed customer knowledge in each of the three project types would have produced weaker results, if deployed in the context of the remaining two project types.

Table 8
Summary of counterfactual analysis across project types

Project type	Analysis type	Generating exploration	Guiding exploration	Gatekeeping exploration
Collaborative exploration	Original	Absent	Present	Present
	Counterfactual	*Using customer input as a starting point for these projects would have limited technology exploration because customers would not have been able to recognize and demand the technologies that were key to these innovations.*	*Without using market intelligence and customer involvement, it would have been challenging to turn prototypes into commercial products, chart further development paths, and ensure demand.*	*Without using market intelligence, commercializing new technologies would have been risky.*
Exploration with customers	Original	Present	Present	Absent
	Counterfactual	*Without using market intelligence and customer involvement in the specification of these projects, it would have been difficult to define what functionalities the systems should have.*	*Without using market intelligence and customer involvement, Vaisala would not have been able to match final product specifications with customer needs and align the product to the market.*	*Making go/no-go decisions based on customer knowledge would have been unnecessary since the initial customer already covered the cost of developing the system.*
In-house exploration	Original case	Present	Present	Present
	Counterfactual	*Without using market intelligence, it would have been challenging to ascertain whether there was need for the products in the first place. This would have also increased development risk.*	*Without using market intelligence, it would have been challenging to determine whether the developed technologies matched customer needs and how they should be commercialized.*	*Without using market intelligence, developing and commercializing new technologies would have been risky.*

Note: For a detailed description of the role of the mechanisms in the original cases, see Table 7

First, collaborative exploration projects focused on conceiving novel technological products for new markets. While the initial stages of development focused on technology and prototype development, customer knowledge was used to transform them into commercial products and ensure their viability. Thus, over the course of the project, balance shifted from technology development to the creation of commercial products. Based on our counterfactual analysis, using customer knowledge as a starting point for these projects would have been challenging.

This is because customers would have lacked technological knowledge (Magnusson, 2009) that was key to these innovations and resided in Vaisala and its development partners. However, without using customer knowledge to guide and gatekeep these projects, transforming the prototypes into commercial products would have been more challenging. This is because customers' use knowledge can be leveraged to understand how technological solutions create value to them (Magnusson, 2009; von Hippel, 1994). For instance, in the development of the HUMICAP humidity meter, customer knowledge could have been used to pinpoint challenges with the traditional hair hydrometers, but it would have not helped in conceiving thin-film technology as an alternative way of measuring humidity. However, later in the development process, customer knowledge was crucial for pinpointing what customer problems the HUMICAP technology could solve.

Second, exploration with customers focused on the development of complex system products to new markets. Vaisala interacted intensively with the selected pilot customers early in the project to specify the product features to match their needs. Later in the process, customer knowledge was used to define the final product and gauge market potential beyond the initial project. Based on our counterfactual analysis, without involving customers in the early development, it would have been challenging to define what functionalities the systems should have since options were plentiful. Similarly, forfeiting the use of customer knowledge to guide the final product specifications would have made it difficult to configure the systems to meet customer needs. Thus, unlike collaborative exploration projects that focused on key technologies, projects conducted with customers focused on the development of systems that needed to match customer needs from the beginning. This is in line with the suggestions to co-develop complex systems in close relation with customers to match their needs (Aspara, Hietanen, Mattila, Sihvonen, & Tikkanen, 2013; Crespin-Mazet & Ghauri, 2007), which can then open up further project opportunities and create references (Mandják & Veres, 1998;

Tikkanen, Kujala, & Artto, 2007). Simultaneously, the participating customers also acted as development buyers, which negated the need to make go/no-go decisions during the NPD process since customer-based funding already mitigated financial risk (Coviello & Joseph, 2012). For instance, the development of HATTARA would not have been possible without the Finnish Meteorological Institute, with which Vaisala co-developed the system since the Institute had an active role in specifying what functionalities the new system type should have. This collaboration also established a reference case and enabled sales of the system to other potential customers.

Finally, in-house exploration projects focused on the development of technologically novel products for new markets. In contrast to the other exploration project types, customer knowledge was important across the development process. The New Product Group initially used customer knowledge to conceive a project with commercial potential and then focused on guiding and gatekeeping the project to ensure its commercial viability. If Vaisala managers would have forfeited these activities, the risk of deploying own resources to these projects could have outweighed the perceived benefits. This is because knowledge of customers' needs and wants lowers the perceived risk of development (De Luca et al., 2010; Sukhov, Sihvonen, Netz, Magnusson, & Olsson, 2021). The development of new sonde batteries provides a good example of this logic. Since the project marked an expansion into battery technology that Vaisala had previously outsourced, the management constantly compared the company's own technological solution to outsourcing in order to verify that in-house development and manufacturing incurred greater customer benefits than outsourcing. Without such activities, it would have been challenging to justify why the company should expand into this new product area.

Taken together, we propose that

> *Proposition 2: Fit between the selective deployment of the three customer knowledge mechanisms (generating, guiding and gatekeeping) and project type (collaborative, involving customers, or in-house) enhances likelihood of exploration project success.*

5. Discussion and conclusion

5.1 Theoretical implications

Our study is motivated by the tension in literature regarding the impact of customer knowledge on explorative NPD. While the majority of studies emphasize the value of customer knowledge in exploration (e.g., Atuahene-Gima, 2005; Chang & Taylor, 2016; Coviello & Joseph, 2012), critics still argue that focus on customers can limit the firm's scope of search and promote exploitation rather than exploration (e.g., Christensen & Bower, 1996; Govindarajan et al., 2011). The rich empirical evidence concerning Vaisala's explorative NPD processes provides insights into how firms can manage this tension and use customer knowledge to influence explorative NPD without hampering or leading it astray.

First, our study adds clarity to the innovation management literature regarding the impact that customer knowledge can have on exploration. Based on our findings, we postulate three mechanisms through which customer knowledge influences exploration: *generating*, *guiding* and *gatekeeping*. Our work complements existing research, which has focused on the effects of customer knowledge rather than the underlying mechanisms. That said, our findings are in line with prior work that has acknowledged that customer knowledge can act as a starting point for exploration (Andriopoulos & Lewis, 2009; Danneels, 2002; Rosenzweig, 2017; Rubera et al., 2012), guide exploration towards the creation of viable commercial offerings (Augusto & Coelho, 2009; Coviello & Joseph, 2012; Cui & Wu, 2017; Rubera et al., 2012), and gatekeep

projects to ensure that there is demand for them (Cooper, 2019; Mahr et al., 2014). However, much of extant work has *assumed* these mechanisms in order to provide an explanation for higher-level correlation patterns, without providing detailed evidence for their existence (Tsang, 2006). As such, our research provides empirical substantiation for prior theoretical claims. Moreover, our study brings together somewhat disconnected claims, and thus contributes to a more systematic theoretical picture of the potential impacts of customer knowledge on explorative NPD.

More importantly, our findings help explain why different studies have reported contradictory findings about the effect of customer knowledge on explorative NPD (Atuahene-Gima, 2005; Joshi, 2016; Mahr et al., 2014; Menguc et al., 2014). Our findings show that managers can selectively deploy the three customer knowledge mechanisms identified in this study. The possibility of selective deployment makes it conceivable to observe a wide variety of effects at a higher level of abstraction, rendering the conflicting findings in existing research rather unsurprising. In light of this, we argue for caution in making covering-law statements about the impact of customer knowledge on explorative NPD, as the contextual specifics of customer knowledge creation and use can considerably impact its overall effect on exploration.

Second, our findings highlight the importance of 'fit' in the deployment of customer knowledge. Our analysis reveals that Vaisala managers matched customer knowledge creation activities with project-specific needs, such as emerging risks related to resource deployment. This allowed Vaisala to engage in extensive exploration without losing sight of marketplace realities. In other words, customer knowledge supported rather than hindered exploration. However, our counterfactual analysis reveal that, equally, a mismatch between the type or timing of customer knowledge creation and use, and exploration project type, can hamper performance (Chang & Taylor, 2016). For instance, if Vaisala managers had *not* generated

customer knowledge to guide collaborative exploration, the company could have faced challenges in transforming prototypes into commercial products.

Third, we bring historical research methods closer to marketing. There is a long tradition of historical research in strategy and this approach is currently gaining increasing attention in management and strategy literatures (e.g., Vaara & Lamberg, 2016). We believe that this approach could benefit marketing literature as well. On the one hand, historical research complements traditional qualitative case studies as a method that can provide in-depth insights into marketing phenomena. Historical research emphasizes *in situ* evidence (rather than retrospective oral accounts), and source criticism, which fits well with the notions of critical realism that underpin much of marketing research. Also, the focus of historical research on past events allows us to analyze mechanisms behind important phenomena that persist over technological generations. Identification of mechanisms based on historical research is a natural complement to other approaches such as laboratory and field experiments and computational modeling (e.g., Hedström & Ylikoski, 2010; Miller & Tsang, 2010). Historical mechanism research is particularly valuable for the study of strategic issues where the scope of application for experiments and computational modeling can be limited.

Additionally, historical research can help to gain an understanding of the origins and nature of marketing constructs. For example, our research shows that many topical concepts related to customer-centric business (e.g., customer orientation, co-creation, lead user involvement) have been used in practice much before the concepts have been coined or elaborated in the academic marketing literature (e.g., Narver & Slater, 1990; Prahalad & Ramaswamy, 2000; von Hippel, 1986). Vaisala was "customer oriented" and engaged in "co-creation" much before these constructs existed officially in the academic marketing lexicon. Similarly, Berghoff et al. (2012, p. 9) emphasize the importance of "practical men" in shaping marketing thought, before and in parallel to the efforts of academics. A historical approach can also help historicize

important marketing ideas. This means looking at constructs such as customer knowledge, not as objective facts but as products of specific historical conditions. This perspective can help illuminate the technological and institutional conditions that make certain marketing ideas and practices possible in the first place.

5.2. Managerial implications

From a managerial standpoint, our study provides three suggestions. First, our study shows that customer knowledge is not detrimental to exploration when it is correctly applied. This means that companies should not steer away from customer knowledge when conducting exploration, but rather interweave it into exploration projects in order to develop products that are both explorative and meet customer needs. In practice, this means that projects need to oscillate between technology development and customer needs during the development process in order to ensure that there is a genuine need for the final commercialized offering.

Second, the three customer knowledge mechanisms provide managers with three archetypical ways to use customer knowledge to influence exploration projects. Our analysis of how these mechanisms fit with different kinds of exploration project types provides further guidance on how they can be successfully used. Therefore, the three mechanisms and our analysis of their fit with different kinds of projects could be used as a template for implementing the creation and use of customer knowledge in exploration. While this might not provide a one-size-fits-all solution, it provides managers with a starting point for designing how and when to use customer knowledge to influence exploration projects.

Finally, since managers can selectively deploy customer knowledge mechanisms, our study suggests that they should actively manage the creation and use of customer knowledge. This can ensure that it has the desired impact. In doing so, managers should lead the creation and

use of customer knowledge, while tracing its influence on exploration. Inherently, this also emphasizes managers' capacity to design processes that accommodate project-specific needs and their agility in matching customer knowledge to these needs.

5.3. Limitations and avenues for future research

This study has certain limitations that point to opportunities for future research. First, while our study shows how matching the creation and use of customer knowledge with project-specific needs can create commercially successful exploration projects, these dynamics should also be studied in the context of exploitation. By understanding how different customer knowledge mechanisms can be used to support both exploration and exploitation projects, it would be possible to establish how the mechanisms promote ambidexterity. This is because customer knowledge is inherently neither explorative nor exploitative in nature (e.g., Ardito et al., 2020; Atuahene-Gima, 2005) and therefore its influence on both types of activities should be examined.

Second, we have focused in our study on customer knowledge, but future research could shift the focus to competitors. In Vaisala's context, the main uncertainties related to explorative NPD pertained to technology and customers (Danneels, 2002). However, in our empirical analysis we noted that competitor-related information was to some extent in use in the decision-making as well, in conjunction with the customer considerations. Future research could take competitor knowledge as a more central element in the analysis, and examine how the generation and use of information about competitors shapes the firm's explorative NPD process. Prior literature has noted that a competitor focus may lead to improving operational effectiveness at the expense of strategic differentiation (Banker, Cao, Menon, & Mudambi, 2013), and that a competitor orientation is ill-suited for uncertain markets (Gatignon & Xuereb,

1997). As such, one might assume that extensive use of competitor knowledge hampers explorative NPD, but recent research has also offered counter-evidence (O'Dwyer & Gilmore, 2019). In-depth empirical analyses in contexts where competitor knowledge plays a larger role could be conducted to shed further light on the phenomenon.

Third, our counterfactual analysis is based on counterfactual reasoning which follows the suggestions of Durand and Vaara (2009) and Gaddis (2002). While conducting counterfactual analyses based on reasoning is common in historical research (Gaddis, 2002; Gould, 2019) and the study of mechanisms (Hedström & Ylikoski, 2010; Machamer et al., 2000), analyzing cases with diverging patterns of customer knowledge creation and use with diverging outcomes could help to further establishing how the found mechanism function and what might be their boundary conditions. Therefore, we suggest that future studies could further examine how the theorized mechanisms function in different cases and context.

Finally, our research highlights the need to expand the methodological repertoire in research on customer centricity and customer knowledge. Given the more nuanced view on the influence that customer knowledge can have on exploration, future research could develop new survey instruments to better capture this. This could help in establishing how the different mechanisms influence different kinds of processes and their outcomes. Such survey instruments could also be coupled with configurational analysis methods to better establish how the fit between customer knowledge mechanisms and their context of application shapes performance (see Frösén et al., 2016).

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