How Traditional Industries Use Capabilities and Routines to Tap Users for Product Innovation?

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Overview: While customer-centered innovation has thus far focused on best practices for user-producer collaboration and organizing users to obtain relevant inputs, the internal organization that enables firms to integrate user knowledge into product innovation outputs is less well understood. We analyzed five case studies to derive the innovation routines from firms in traditional industries that employ user knowledge to improve existing products or develop new products. The routines are linked to organizational capabilities relevant for incorporating user knowledge into innovative outcomes.

Keywords: Capabilities; Routines; Customer-centered innovation; Traditional industries; Product development

This is an Accepted Manuscript of an article published by Taylor & Francis in Research-Technology Management on 19 April 2021, available online: http://www.tandfonline.com/10.1080/08956308.2021.1891750.

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Firms typically look for external knowledge components to achieve innovative outcomes, and researchers have established that including external actors in a firm's innovation process leads to achieving better outputs (Chesbrough 2017; Randhawa, Wilden, and Hohberger 2016). Input from customers and users is essential because using their knowledge for innovation reduces market uncertainty and increases the market relevance of a firm's products and/or services (Laursen and Salter 2014). Although collaborative activities between a firm and its users enable organizations to search, acquire, and translate knowledge into innovation outcomes, these activities are insufficient.

According to innovation management researchers, a firm must possess complementary enablers such as organizational structure, capabilities, and processes (Crossan and Apaydin 2010; Martine, Neirotti, and Appio 2017). These enablers are internal to the organization and include firm capabilities such as communication flows and decision-making (Foss, Laursen, and Pederson 2011; Ooi and Husted 2016). Despite the importance of identifying these enablers, studies of customer-centered innovation focus more on value creation and delivery (Priem, Wenzel, and Koch 2018). They do not further explore a firm's decisions about which capabilities to use to create value. Our study sets out to address this weakness by investigating the following research question: what capabilities and routines allow firms in traditional industries to access and integrate user knowledge?

To determine the internal capabilities that are useful for firms to support user involvement in their innovation processes, we conducted a qualitative multiple case study of firms in traditional industries. Typically, traditional industries consist of firms operating with low and medium levels of technology and an R&D intensity of 2–5 percent (Hirsch-Kreinsen 2008; OECD 2005a; OECD 2005b). Studying customer-centered innovation in traditional industries is interesting because firms in these industries tend to innovate through trial-and-error, rather than through formal R&D activities; therefore, they have weaker or no formal R&D capabilities compared to firms in intense R&D industries (Chamberlin and Doutriaux 2010; Hervas-Oliver, Albors Garrigos, and Gil-Pechuan 2011; Spithoven, Clarysse, and Knockaert 2011; Selden and MacMillan 2006). Lack of intensive, formal R&D activities implies that firms are more likely to develop other capabilities to absorb and use external knowledge.

By drawing on case studies from traditional industries, we demonstrate the capabilities and embedded routines that firms can use to actively involve users in their innovation processes. We define users as customers who pay for a product and those who use a product but do not pay for it. Investigating how routines facilitate customer-centered innovation activities might be initially counterintuitive. However, without these routines, a firm cannot develop the relevant capabilities to source and integrate the knowledge obtained from its users.

Theoretical Background

Customer-centered innovation is the process of including customers in a firm's R&D activities to create and deliver value to customers through better value propositions (Selden and MacMillan 2006). Firms should adopt a customer-centered approach to involve both customers and users directly in a firm's innovation process. This customer-centered approach aims for firms to collaborate with users beyond merely collecting inputs about user needs and requirements through market research activities (Cooper and Sommer 2016). Although market research tools such as voice-of-customer (VOC) and surveys are useful for identifying unmet market needs as part of a firm's quality management process (Griffin and Hauser 1993), they primarily focus on sensing the market and satisfying these needs (Bharadwaj, Nevin, and Wallman 2012). Thus, a customer-centered approach is an upgrade from traditional market research (for example, VOC) in terms of user involvement. Designing and implementing organizational mechanisms are the main managerial tasks for coordinating user involvement initiatives during the conception and development stages of innovation (Desouza et al. 2008; Selden and MacMillan 2006).

Few scholars have examined the complementary enablers within an organization that allow it to access and integrate knowledge while using the customer-centered approach. Foss, Laursen, and Pedersen (2011) found that organizational practices, such as delegating decision-making and rewarding employees for searching and sharing information, help internalize and translate user knowledge in a firm's innovation process. Similarly, Salge et al. (2012) improved on the work of Foss, Laursen, and Pedersen (2011) by including innovation-related activities, such as cross-functional collaboration within a firm. Unlike previous studies, Abrell, Benker, and Pihlajamaa (2018) adopted an absorptive capacity lens to examine solely absorptive capacity managerial practices that are relevant for identifying, accessing, and transforming user knowledge into a competitive advantage for a firm in a complex product context. These three studies provided insights from various perspectives on practices and activities that are relevant for creating value from a customer-centered approach to innovation. Practices in these studies are akin to routines, where they have been considered patterns of managerial action (Felin et al. 2012). However, the capabilities (and their routines) that are related to these practices from previous studies are still unclear, particularly for capabilities that enable firms in traditional industries to successfully access and integrate user knowledge in their innovation processes (Reichert et al. 2016; Martini, Neirotti, and Appio 2017; Priem, Wenzel, and Koch 2018).

Organizational capabilities are the processes, routines, and mechanisms that provide a firm with the capacity to effectively perform organizational activities (Dosi, Nelson, and Winter 2000; Helfat and Winter 2011). These myriad organizational activities include generating product ideas collaboratively, making decisions about what to develop, and managing knowledge flows within and across organizational boundaries (Collis 1994; Helfat and Winter 2011; Felin et al. 2012). Developing the required set of capabilities to facilitate knowledge exchange with users and knowledge integration in the innovation process hinges on the routines within a firm (Crossnan and Apaydin 2010; Ooi and

Husted 2016) because innovation often requires constant reconfiguration of a firm's resources, routines, and capabilities (Kogut and Zander 1992; Nelson and Winter 1982). This constant reconfiguration suggests that routines can promote stability, and inertia can be a basis for a firm's change and growth (Cepeda and Vera 2007; Helfat and Winter 2011; Parmigiani and Howard-Grenville 2011). Therefore, a firm's capacity to integrate user knowledge depends on routines that facilitate constant renewal and reconfiguration of its resources, knowledge, and processes (Bessant, Caffyn, and Gallagher 2001).

Case Study

This study used a qualitative, explanatory multiple case study approach (Baxter and Jack 2008; Eisenhardt and Graebner 2007; Yin 2014). We opted for an explanatory orientation because it enables us to explicate closely the internal capabilities and routines within the customer-centered innovation and traditional industries contexts (Eisenhardt and Graebner 207; Ghauri and Grønhaug 2005). Furthermore, a multiple case study approach allows for collecting and analyzing the abundant and in-depth data necessary to achieve the study's aim, thereby increasing the rigor required to ensure the validity and reliability of the results (Baxter and Jack 2008; Yin 2014).

Our study sample includes five product development projects spanning three firms operating in traditional industries in New Zealand (NZ) and Australia (Table 1). We aimed to provide an in-depth analysis of these projects to gather insights into and an understanding of customer-centered innovation. We selected the firms based on four criteria:

- They operate in traditional industries, defined earlier as low and medium technology.
- They had, or still have, ongoing projects that employ users as a source of external knowledge.
- Their projects with users' involvement have led to successful product innovation.
- They have successfully introduced their product to the market.

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We collected primary data through semi-structured interviews and meetings. The interview questions were open-ended and related to the respective firm's innovation process, project details, user involvement during product development, organizational activities, and intra-firm innovation challenges (Bryman and Bell 2015; Ghauri and Grønhaug 2005; Kvale 1996). We collected secondary data from the field notes taken when citing firm documents and trade periodicals that exhibit routines in their explicit form (Pentland and Feldman 2005).

The fieldwork conducted over several months throughout 2014 at different locations in NZ and Australia involved iteratively collecting and analyzing data. We conducted 23 semi-structured interviews, with an average duration of 40 minutes. We transcribe

interview recordings verbatim for subsequent content analysis (Weber 1990) and imported the transcripts into NVivo 10 for coding.

We used inductive qualitative techniques to analyze the data (Eisenhardt 1989; Miles, Huberman, and Saldaña 2014; Spiggle 1994). First, we read the interview transcripts multiple times and coded themes based on the text data. We used the capabilities literature (Eisenhardt and Martin 2000; Kogut and Zander 1992) to guide our analysis of routines that enable organizations to recombine new knowledge with their existing knowledge base, such as those related to decision-making and internal communication. Second, we analyzed and organized chunks of raw data (interview quotes) coded into higher-order categories in Stage 1. Third, we examined the raw data again to look for examples that explain abstract constructs derived from the categories. At this stage, we triangulated the data by comparing interview data with meeting notes, trade periodicals, fieldnotes, and academic literature. We constructed a data structure table to illustrate the aggregation of the raw data into higher-order categories and concepts. Finally, one of our coauthors wrote in-depth case narratives for all five cases, which allowed us to understand the contextual background and use the narratives for within- and cross-case analyses (Eisenhardt and Graebner 2007).

Findings

We derived the findings from our within- and cross-case analysis of the interviews and documents for the five cases. First, the analysis revealed the customer-centered approaches applied in the cases to involve users in the firms' innovation processes (Table 2) and the commonalities between these cases (Table 3). Second, we inferred from the data the routines that facilitate implementing these customer-centered approaches.

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The Cases' Customer-centered Approaches

Case AUTO comprises an interdisciplinary team that develops software and hardware components of a proprietary PROT farm automation system. The AUTO team used three approaches to involve users in the ideation, development, and testing stages of its innovation process: rapid prototyping, innovation farms, and an inbound call center.

The team used *rapid prototyping* to involve users in the software components of its product. Users actively participated in team-led brainstorming sessions to generate ideas and test them. The team record these ideas and test results in an "ideas database" that it used to develop the ideas further.

It used *innovation farms* to test new hardware configurations and components. These user-operated, commercial farms provided AUTO with more comprehensive testing

capabilities than its in-house testing sandboxes. In these farms, the AUTO team and users evaluated the usage and practicality aspects of hardware prototypes.

The *inbound call center* provided technical support assistance to users in terms of the installing, maintaining, and troubleshooting the PROT system. The call center also facilitated the collection of user feedback on its PROT system when providing technical support.

Case GEN comprises a product team that focuses on artificial breeding and peripheral products, supporting efficient and effective artificial breeding for users. The GEN team used prototype testing and field research to involve users in its development and testing innovation stages.

With the *prototype testing*, users trialed product prototypes and provided feedback on these prototypes. When the GEN team was developing heat patches that indicate when a dairy cow is fertile, it conducted limited trials with users. The objective was to obtain feedback on the features of the heat patches such as their color and adhesiveness.

Conducting *field research* enabled the team to obtain need-based information from users through interactions during farm visits. Need-based information includes user preferences for the desirable genetic characteristics of their livestock herds. This information guided development of artificial breeding and complementary products (for example, heat patches).

Case DATA comprises an interdisciplinary team that develops multi-herd information reporting software and data analytics reports for large-scale farming corporations. The DATA team used rapid prototyping and consultation sessions to involve users in the ideation, development, and testing stages of its innovation process.

With *rapid prototyping*, users worked with the team to trial and create new products. The DATA team selected advanced users to trial data analytics products, and it addressed minor feedback instantly. Products requiring significant changes moved iteratively between development and testing, and the team involved users in further consultation and trial when necessary.

The *consultation sessions* allowed the team to interact with users through discussions and observations. These sessions helped identify user problems and evaluate initial product ideas. Through one such session with users, the DATA team developed a herd management tool that adopted asset management principles in assigning values to livestock.

Case WEIGH comprises an interdisciplinary team that develops weighing and electronic identification (EID) products, such as animal-weighing scales and EID tag readers. The WEIGH team used prototype testing and formal market research to involve users in the ideation, development, and testing stages.

Prototype testing helped the WEIGH team trial its product prototypes with users for product improvement through iterative development. The team trialed prototype versions of the weighing scale with advanced, ordinary, and low-end user groups. Users provided interface and usage feedback through interviews, discussions, and observations.

The team's *formal market research* initiative enabled it to formally understand user behaviors in the use of animal-weighing scales. The team commissioned an international market research company to carry out the interviews and surveys of WEIGH's global users. The resulting report provided the team with insight about its global users' perceptions of and usage behaviors with weighing scales.

Case GET comprises a team of engineers and industrial designers that focuses on developing bucket teeth, wear liners, and complementary products for open and underground mining operations. The GET team used prototype testing and field research to involve users in its development and testing stages.

The *prototype testing* activities allow the team to collect performance data for further product prototype improvement. Miners (end users) conducted bucket teeth prototype trials at mine sites and by mine excavator developers (intermediate users). Intermediate users provided technical feedback, while end users provided feedback on usage-related issues.

Through *field research* the team collected insight on end-user needs and problems using its products. Field engineers visited mines to obtain an understanding of user needs and problems. Users also offered feedback after product launch; the team received this information, which it used as a guide to product improvements and new product development.

Routines That Facilitate Customer-centered Approaches

In general, teams across the five cases used several routines to facilitate their customer-centered activities (Table 4). In most cases, the project teams decided who, what, and how to involve users in their innovation processes. More importantly, the teams chose the ideas and feedback to be implemented during product development. For the DATA case, in addition to its customer-centered approaches for involving users, the team collaborated with other departments—such as sales, R&D, and production or manufacturing—to access and transfer relevant user knowledge that it would otherwise have not had access to. For the AUTO case, the team often worked closely with user-facing staff in other departments to access user feedback that might be relevant for product development. In both instances, individual team members decided which user ideas and feedback were helpful. They screened these inputs and selected what they deemed the most appropriate information to share with other team members.

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Unlike the other cases, product development decisions in the GEN case were centralized at the business unit level. While the team engaged users in prototype testing and

conducted field research, they discussed ideas, feedback, and comments in their monthly business unit meetings for product development. These meetings normally included other project teams and senior management from the business unit. The GEN team attributed this decision-making process to the long development cycles and scientific nature of genetic products. The scientifically driven product development characteristics of GEN products limited the team's authority to make development decisions. However, evidence showed that the GEN team made product development decisions when it came to non-scientific complementary products, such as heat patches and marketing materials. For these products, the team used the information it obtained from observations during product testing to improve, for example, the color of heat patches to make them brighter, allowing users to see them more clearly through monitors.

Teams in all cases were interdisciplinary to a certain extent. For example, the members of the WEIGH team have technical, marketing, and design backgrounds. This background variation helped the team to comprehend and integrate most of the relevant user knowledge for the product while also increasing innovation capability. Moreover, the interdisciplinary composition of the teams in most of the cases enabled more fluid and decentralized decision-making and supported their customer-centered activities. When user knowledge components were more complex and uncertain, teams, such as in the GEN case, worked closely with other departments to understand and translate the knowledge they gathered from users, before deciding its relevance for further development.

Effective communication in the team and across departments within the organization was essential to assess and integrate user knowledge. Across all cases, the teams applied formal and informal communication routines to promote knowledge access and transfer when implementing customer-centered approaches. For the DATA case, informal knowledge sharing communication routines included activities such as brainstorming and discussions; the team uses these techniques regularly to facilitate knowledge transfer, especially for more tacit forms of knowledge. Furthermore, in the GET case, the emphasis on open communication functioned as a conduit for searching, accessing, transferring, and evaluating user knowledge. The team used more face-to-face interactions within the team and across departments to comprehend and address these knowledge components. Meanwhile, the WEIGH team employed user profiling to store and communicate unique information and knowledge about its users. Team members created "personas," which they used to communicate the needs of different user groups. These personas served as a template for knowledge transfer, which members updated after every customer-centered interaction.

In all cases, the firms needed to maintain consistency in their commitment to user involvement activities. The respective companies explicitly encouraged their teams to involve users in their innovation processes, whether through prototype testing or field research. In general, all firms had customer-centered cultures, which functioned as an indirect tool to shape team members' commitments to customer-centered activities. The teams did not receive additional compensation for engaging with users; however, the team members routinely involved users at the ideation, development, and testing stages of

product development. Ultimately, these members understood the importance of working with their users to improve existing products and develop market-relevant one. For instance, the DATA team expended considerable time working with users to test their products and exploring whether the feedback from users was relevant for improving existing prototypes or developing new products. In the GET case, directly involving users in product development was part of the team's organizational-level culture. The team members exhibited their enthusiasm and willingness to work closely with users to validate their ideas and prototypes, ultimately producing products better designed for the market.

The AUTO team stored relevant information they obtained from users through rapid prototyping and innovation farms in an organization-wide repository. This repository allowed easy storage and retrieval of important user inputs. It also allowed other departments to access and use the information to ensure the alignment of organizational priorities. In the DATA case, the team used a business-case type of document to manage access to and usage of users' innovation-related knowledge. In addition to the document's role as a Stage-Gate mechanism in product development, it also served as a tool for guiding and engaging the members inside and outside the team toward organizational goals.

Discussion

Firms in traditional industries tend to have weaker absorptive capacity because of their trial-and-error approach to innovation, unlike the intensive R&D approach of high-technology firms. To create products with users, they rely on complementary capabilities that support their trial-and-error approach (Figure 1).

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Firms in traditional industries develop internal mechanisms that enable them to apply user knowledge obtained through customer-centered innovation approaches. The choice of approach depends on an organization's innovation objective. Four organizational capabilities emerged from grouping these routines: collaboration, decision-making, intra-firm communication, and staff engagement (Table 5). We discuss the implications of these capabilities and their underlying routines for organizations in traditional industries that want to adopt customer-centered approaches to innovation (Table 6).

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Collaboration

Collaborative innovation often occurs as multiple parties within and across organizational boundaries bring their knowledge and capabilities together to achieve shared innovation objectives (Chesbrough 2017). While users have been instrumental collaboration partners for firms in traditional industries, uncertainties exist about how firms achieve

collaboration. Our findings show that three routines demonstrate a firm's capability for collaboration:

- Interacting with different conduits within the organization who have pertinent knowledge about users and technology;
- Working together with other departments to improve product development; and
- Organizing an interdisciplinary project team.

These three routines are key to building and maintaining a firm's collaboration capability, but an interdisciplinary project team has significant implications. Although most organizations have multidisciplinary teams, interdisciplinarity is a major step-up related to design thinking (Micheli et al. 2019). A key difference between these multidisciplinary and interdisciplinary is how the team uses their members' disciplinary knowledge. Interdisciplinarity involves team members using their disciplinary knowledge to formulate a holistic solution that combines different disciplinary perspectives, rather than assigning problems to subject-matter experts within a multidisciplinary team (Klein 2010).

The DATA and AUTO case demonstrate interdisciplinarity. Technical and non-technical members in these cases often work together to share user observation information and address product development problems that arise from product testing. For a firm operating in a more traditional industry, interdisciplinarity boosts collaboration capability because it compensates for an organization's lack of intensive R&D activities by recombining team members' various disciplinary knowledge.

Decision-making

Firms, especially those in low- and medium-technology industries, who mostly rely on trial-and-error processes, must make timely and effective product development decisions (Chamberlin and Doutriaux 2010). Without strong formal R&D processes, these firms encounter uncertainty when they adopt customer-centered approaches due to bounded rationality and an inability to grasp users' perspectives. As shown in the AUTO, WEIGH, and GEN cases, two routines underpin the capability of firms in these sectors to make product development decisions:

- Delegating decision-making authority to the project team; and
- Centralizing decision-making authority at the business unit or organizational level.

How a firm makes decisions in its innovation process is highly dependent on factors such as the project team's disciplinary competencies and the type of products under development (Foss, Laursen, and Pedersen 2011; Leonard-Barton 1992). As observed in the GEN case, most of the development decisions for its scientific products were made at the business unit level. In the AUTO and WEIGH cases, project teams made these decisions. A noticeable advantage of decentralizing decision-making is that team

members can respond more quickly to user feedback. This approach also increases the team's sense of ownership of and responsibility for the development process. If a firm lacks R&D competencies, prides itself on its responsiveness to user feedback, or operates with a flat hierarchical structure, then decentralization allows it to build decision-making capability. However, if the opposite is true and the products are highly technical and require complex knowledge components, the firm should build decision-making capability through centralization.

Intra-firm Communication

To stimulate creativity and innovation activities, an organization needs communication channels to share and transfer knowledge and promote best practices. Intra-firm communication is critical when an organization relies on interdisciplinarity and user-producer collaboration during product development (Klein 2010). Two routines demonstrated in the cases reinforce intra-firm communication capability:

- Practicing open and effective communication; and
- Profiling users as a means of communicating information about them.

As innovation is the creation of something new by combining and recombining vast numbers of knowledge components, successful transfer of knowledge within a firm is an important requisite for innovation performance (Kogut and Zander 1992). As evident in the GET and DATA cases, transparent avenues for sharing ideas and opinions obtained by members when working with users enhanced product development. In the WEIGH case, user profiles proved important for communicating assumptions and knowledge about different user groups both within and outside the team. As the findings from these cases show, practicing open communication is likely to enhance a firm's intra-firm communication capability. Moreover, firms can implement creative methods—for example, brainstorming techniques, discussions, and workshops—to further build on this capability.

Staff Engagement

Engaging staff at work ensures that they perform collectively toward a consistent innovation objective within the organization (Amabile 1998). Even if a firm collaborates with users, makes sound product development decisions, and communicates within the firm, a group of disengaged staff can hinder any progress toward achieving innovative outcomes. Staff engagement implies the firm's ability to set the right conditions for employees to adopt customer-centered approaches to creating product innovation. The cases demonstrated two routines that relate to staff engagement:

- Aligning priorities between different parties within the organization; and
- Providing encouragement to staff for adapting customer-centered innovation approaches

Firms that incorporate external parties into their innovation practices constantly face resistance from employees. This resistance can be in various forms, with the most popular being the not-invented-here (NIH) syndrome. NIH is where staff irrationally reject any effort to obtain and use external inputs, or directly involve external parties in a firm's innovation process (Antons and Piller 2014). In our study, all the cases have a deep-rooted customer-centered culture, and the NIH attitude is almost non-existent. Customer-centered mechanisms and practical actions are likely to be strategies that the teams in these cases employ to compensate for the lack of formal R&D in traditional industries. The firms in these cases recognize the need to expand their knowledge bases by actively seeking users' involvement in innovation activities. Following this logic, such an intimate focus on customers is likely a stepping-stone strategy. Some of the team members or even the organizations themselves may exhibit the NIH attitude in the future once they build sufficient knowledge and competencies.

Limitations

Our research has two limitations, which are also avenues for future research. First, we collected data from firms operating in traditional industries in NZ and Australia. We acknowledge that not being able to generalize our findings is a limitation, as firms have different innovation processes depending on the industrial dynamics of their sectors. A similar study could examine the relationship between customer-centered innovation and routines in other industrial contexts. Second, this study assumes successful knowledge transfer and does not examine the role possibly played by existing capabilities in reinforcing or changing existing capabilities. Future research could explore the differences (if any) between operational and dynamic capabilities, such as whether the routines underlying these capabilities are different or how these routines emerge.

Conclusion

Our study uses a capabilities perspective and analyzes original empirical data based on five cases. We argued that unlike high-technology firms' intensive R&D approach, firms in traditional industries tend to have weaker absorptive capacity because of their trial-and-error approach to innovation. This makes the internal organization that enables firms to integrate user knowledge into product innovation crucial. Our analysis led us to propose four internal capabilities and the embedded routines that foster the knowledge use resulting from these approaches. While there were some differences across the cases we investigated, there were essential commonalities that we suggest should be taken on board. Importantly, firms in traditional industries should develop additional internal capabilities beyond their absorptive capacity to capitalize on customer-centered approaches for innovation. This can be achieved via different mechanisms, and we outlined the ones the studied companies have adopted: collaboration, decision-making, intra-firm communication, and staff engagement. We advise that collaboration is particularly relevant when product development requires technical and non-technical expertise. Decision-making is appropriate as a routine when teams for example utilize joint-prototyping and piloting, and business unit product development meetings. Intra-firm communication is a common routine, which teams utilize for discussions and

informal catch-ups as it promotes sharing of codified and uncodified knowledge. Finally, staff engagement is used when a firm needs to directly and indirectly align different priorities between departments.

References

Abrell, T., Benker, A., and Pihlajamaa, M. 2018. User knowledge utilization in innovation of complex products and systems: An absorptive capacity perspective. *Creativity and Innovation Management* 27 (2): 169–182. Doi: https://doi.org/10.1111/caim.12244

Amabile, T.M. 1998. How to kill creativity. *Harvard Business Review* 76(5): 76–87. https://hbr.org/1998/09/how-to-kill-creativity

Antons, D., and Piller, F.T.. 2014. Opening the black box of "not invented here": Attitudes, decision biases, and behavioral consequences. *Academy of Management Perspectives* 29 (2): 193–217. https://doi.org/10.5465/amp.2013.0091

Baxter, P., and Jack, S. 2008. Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report* 13 (4): 544–559. https://nsuworks.nova.edu/tqr/vol13/iss4/2

Bessant, J., Caffyn, S., and Gallagher, M. 2001. An evolutionary model of continuous improvement behaviour. *Technovation* 21 (2): 67–77. https://doi.org/10.1016/S0166-4972(00)00023-7

Bharadwaj, N., Nevin, J.R., and Wallman, J.P. 2012. Explicating hearing the voice of the customer as a manifestation of customer focus and assessing its consequences. *Journal of Product Innovation Management* 29 (6): 1012–1030. https://doi.org/10.1111/j.1540-5885.2012.00954.x

Bryman, A., and Bell, E. 2015. *Business Research Eethods*. 4th ed. Oxford: Oxford University Press.

Cepeda, G., and Vera, D. 2007. Dynamic capabilities and operational capabilities: A knowledge management perspective. *Journal of Business Research* 60: 426–437. https://doi.org/10.1016/j.jbusres.2007.01.013

Chamberlin, T., and Doutriaux, J. 2010. Sourcing knowledge and innovation in a low-technology industry. *Industry and Innovation* 17 (5): 487–510. https://doi.org/10.1080/13662711003633413

Chesbrough, H. 2017. The future of open innovation. *Research-Technology Management* 60 (1): 35–38. https://doi.org/10.1080/08956308.2017.1255054

Collis, D. J. 1994. How valuable are organizational capabilities? *Strategic Management Journal* 15: 143–152. https://doi.org/10.1002/smj.4250150910

Cooper, R.G., and Sommer, A.F. 2016. The agile–stage-gate hybrid model: A promising new approach and a new research opportunity. *Journal of Product Innovation Management* 33 (5): 513–526. https://doi.org/10.1111/jpim.12314

Crossan, M.M., and Apaydin, A.F. 2010. A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies* 47 (6): 1154–1191. https://doi.org/10.1111/j.1467-6486.2009.00880.x

Desouza, K.C., Awazu, Y., Jha, S., Dombrowski, C., Papagari, S., Baloh, P., and Kim, J.Y. 2008. Customer-driven innovation. *Research-Technology Management* 51 (3): 35–44. https://doi.org/10.1080/08956308.2008.11657503

Dosi, G., Nelson, R. R., and Winter, S. G. eds. 2000. *The nature and dynamics of organizational capabilities*. New York: Oxford University Press. https://doi.org/10.1093/0199248540.001.0001

Eisenhardt, K.M. 1989. Building theories from case study research. *Academy of Management Review* 14 (4): 532–550 https://doi.org/10.5465/amr.1989.4308385.

Eisenhardt, K.M., and Graebner, M.E. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal* 50 (1): 25–32. https://doi.org/10.5465/amj.2007.24160888

Eisenhardt, K.M., and Martin, J.A. 2000. Dynamic capabilities: What are they? *Strategic Management Journal* 21: 1105–1121. https://doi.org/10.1002/1097-0266(200010/11)21:10/11%3C1105::AID-SMJ133%3E3.0.CO;2-E

Felin, T., Foss, N. J., Heimeriks, K. H., and Madsen, T. L. 2012. Microfoundations of routines and capabilities: Individuals, processes, and structure. *Journal of Management Studies* 49 (8): 1351–1374. https://doi.org/10.1111/j.1467-6486.2012.01052.x

Foss, N.J., Laursen, K., and Pedersen, T. 2011. Linking customer interaction and innovation: The mediating role of new organizational practices. *Organization Science* 22 (4): 980–999. https://doi.org/10.1287/orsc.1100.0584

Ghauri, P.N., and Grønhaug, K. 2005. *Research Methods in Business Studies :A Practical Guide*. 3rd ed. New York: Financial Times Prentice Hall.

Griffin, A., and Hauser, J.R. 1993. The voice of the customer. *Marketing Science* 12 (1): 1–27. https://doi.org/10.1287/mksc.12.1.1

Helfat, C.E., and Winter, S.G. 2011. Untangling dynamic and operational capabilities: Strategy for the (n)ever-changing world. *Strategic Management Journal* 32 (11): 1243–1250. https://doi.org/10.1002/smj.955

Hervas-Oliver, J.-L., Albors Garrigos, J., and Gil-Pechuan, I. 2011. Making sense of innovation by R&D and non-R&D innovators in low technology contexts: A forgotten lesson for policymakers. *Technovation* 31 (9): 427–446. https://doi.org/10.1016/j.technovation.2011.06.006

Hirsch-Kreinsen, H. 2008. "Low-tech" innovations. *Industry and Innovation* 15 9(1): 19–43. https://doi.org/10.1080/13662710701850691

Klein, J.T. 2010. A taxonomy of interdisciplinarity. In *The Oxford handbook of interdisciplinarity*, ed. R. Frodeman, 15–30. 1st ed. New York, USA: Oxford University Press. https://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780198733522.001.0001/oxfordhb-9780198733522.

Kogut, B., and Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* 3 (3): 383–397. https://doi.org/10.1287/orsc.3.3.383

Kvale, S. 1996. *Interviews: An introduction to qualitative research interviewing*. Thousand Oaks, California: Sage Publications.

Laursen, K., and Salter, A.J. 2014. The paradox of openness: Appropriability, external search and collaboration. *Research Policy* 43 (5): 867–878. https://doi.org/10.1016/j.respol.2013.10.004

Leonard-Barton, D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal* 13 (S1): 111–125. https://doi.org/10.1002/smj.4250131009

Martini, A., Neirotti, P., and Appio, F.P. 2017. Knowledge searching, integrating and performing: Always a tuned trio for innovation? *Long Range Planning* 50 (2): 200–220. https://doi.org/10.1016/j.lrp.2015.12.020

Micheli, P., Wilner, S. J. S., Bhatti, S. H., Mura, M., and Beverland, M.B. 2019. Doing design thinking: Conceptual review, synthesis, and research agenda. *Journal of Product Innovation Management* 36 (2): 124–148. https://doi.org/10.1111/jpim.12466

Miles, M.B., Huberman, A.M., and Saldaña, J. 2014. *Qualitative data analysis: A methods sourcebook*. 3rd ed. Thousand Oaks, CA: SAGE Publications Inc.

Nelson, R.R., and Winter, S.G. 1982. *An evolutionary theory of economic change*. Cambridge, MA: Belknap Press of Harvard University Press.

OECD. 2005a. *OECD Science, technology and industry scoreboard*. Paris: OECD Publishing. http://www.oecd-ilibrary.org/docserver/download/9205071e.pdf?expires=1438748120&id=id&accname=guest&checksum=7FD140D7C05620EE317150163D93E00E.

OECD. 2005b. *Oslo Manual: Guidelines for collecting and interpreting innovation data*. 3rd ed. The measurement of scientific and technological activities. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264013100-en. https://doi.org/10.1787/9789264013100-en

Ooi, Y.M., and Husted, K. 2016. Knowledge characteristics and organisational practices in user innovation. *Kindai Management Review* 4: 22–39.

Parmigiani, A., and Howard-Grenville, J. 2011. Routines revisited: Exploring the capabilities and practice perspectives. *Academy of Management Annals* 5 (1): 413–453. https://doi.org/10.5465/19416520.2011.589143

Pentland, B.T., and Feldman, M.S. 2005. Organizational routines as a unit of analysis. *Industrial and Corporate Change* 14 (5): 793–815. https://doi.org/10.1093/icc/dth070

Priem, R.L., Wenzel, M., and Koch, J. 2018. Demand-side strategy and business models: Putting value creation for consumers center stage. *Long Range Planning* 51 (1): 22–31. https://doi.org/10.1016/j.lrp.2017.07.007

Randhawa, K., Wilden, R., and Hohberger, J. 2016. A bibliometric review of open innovation: Setting a research agenda. *Journal of Product Innovation Management* 33 (6): 750–772. https://doi.org/10.1111/jpim.12312

Reichert, F. M., Torugsa, N., Zawislak, P.A., and Arundel, A. 2016. Exploring innovation success recipes in low-technology firms using fuzzy-set QCA. *Journal of Business Research* 69 (11): 5437–5441. https://doi.org/10.1016/j.jbusres.2016.04.151

Salge, T. O., Bohné, T.M., Farchi, T., and Piening, E.P. 2012. Harnessing the value of open innovation: The moderating role of innovation management. *International Journal of Innovation Management* 16 (3): 1240005. https://doi.org/10.1142/S1363919612400051

Selden, L., and MacMillan, I. C. 2006. Manage customer-centric innovation--systematically. *Harvard Business Review* 84 (4): 108–116. https://hbr.org/2006/04/manage-customer-centric-innovation-systematically

Spiggle, S. 1994. Analysis and interpretation of qualitative data in consumer research. *Journal of Consumer Research* 21 (3): 491–503. https://doi.org/10.1086/209413

Spithoven, A., B. Clarysse, and M. Knockaert. 2011. Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation* 31 (1): 10–21. https://doi.org/10.1016/j.technovation.2010.10.003

Weber, R. P. 1990. *Basic Content Analysis: Quantitative Applications in the Social Sciences*. 2nd ed. Vol. 49. SAGE Publications Inc. https://doi.org/10.4135/9781412983488

West, J., and Bogers, M. 2014. Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management* 31 (4): 814–831. https://doi.org/10.1111/jpim.12125

Yin, R. K. 2014. *Case study research: Design and methods*. 5th ed. Los Angeles, CA: Sage Publications.

Table 1.—Overview of case studies

Case	**Business area**	**Product**	**Interviewees' Roles**
AUTO	Farming	Farm automation system	Product managers, business analyst, engineer
GEN	Farming	Dairy genetics	Team lead, product managers
DATA	Farming	Multi-herd information reporting	Team lead, software engineer, relationship managers
WEIGH	Farming	Animal-weighing scale	Business development, R&D managers
GET	Steel casting	Mining excavator part (that is, bucket teeth)	Design, field engineers, project manager

Table 2.—Customer-centered approaches to involve users

Case	Approach	Representative Quote
AUTO	*Rapid prototyping:* Users work with the team to generate and test ideas	"Users don't have to wait until we have finished developing the full product. Engaging users early provides them an opportunity to question and challenge us all the way through." – AUTO team member
	Innovation farms: User-operated farms as testing ground for hardware components and configurations	"It's run as a commercial dairy farm, so it's not like a research farm where we do experiments on animals. We don't do that at all. It's actually a proper commercial milking dairy farm. It's as close as possible to a commercial farm. We use this farm to put devices out there and measure things." – AUTO hardware manager
	Inbound call center: Collect feedback on product	"Someone would ring into the call center, and they would just punch into a little database. The customer would ring up about this issue to be resolved, or an outstanding query." – AUTO product development manager
GEN	*Prototype testing*: Users test product prototypes and provide feedback for further development	"So just recently working with the information department around getting what we call a genetics tab on our genetics web program. And that tab's all around displaying genetic gain information for a particular herd. And that's gone really well, because it's gone through prototyping." – GEN project manager
	Field research: The team visits users to understand needs that inform new product development	"We'll get out onto user farms and listen to a lot of the issues that they would have with the products, as well as what they like and what they want, in comparison to what we're providing them." – GEN team member
DATA	*Rapid prototyping*: Users work with team to test and shape new products	"I got together with R&D and decided to get some rapid prototyping members to co-locate with us to facilitate product development better. The purpose would be to get more ideas to market quicker. We set up like a website basically where we could publish our ideas for a selected group of customers to evaluate." – DATA project manager
	Consultation sessions: Observe and discuss how users use the products to generate and evaluate product ideas	"Some of the feedback we get from users is useful to sharpen our reporting products. Users told us that what we're supplying was great when they were milking cows, but now they are at a more strategic level, and it doesn't fit what they need. They commented that they need overviews that show whether a cow is performing well or not, and what do we need to change." – DATA team member
WEIGH	*Prototype testing*: Users test prototypes of the product and provide feedback for further development	"I was actually just out yesterday doing interface testing with users on how to make the product easier to use and what features are important. It's something we do a lot now as part of product development." – WEIGH team member
	Formal market research: Allow the team to understand global user behaviors that are important for	"The insight that we got from user interviews and observations enabled us to understand what was happening in the market in a setting that was probably a more correct observation. This is because when we ask users, they will give us much the same answer as our competitors were telling them. So this study allowed

	new product development	us to see exactly what users were doing with their hands." – WEIGH business development manager
GET	*Prototype testing*: Users test product prototypes and provide feedback for further development	"We inform our end users at mines such as Rio Tinto or BHP. We only tell them we have a whole new product we want to try. Sometimes they'll accept our request. So they conduct the field trials and we get the feedback." – GET designer
	Field research: Field engineers visit mines to observe user's usage patterns and discuss potential needs and problems	"When I go to the iron ore mine site, the operator, he said it's [that is, the bucket teeth] wearing very quickly. And he was not surprised because all of the bucket teeth do the same. The team, we know it is due to the application." – GET field engineer

Table 3.—Four common approaches across the cases

	AUTO	**GEN**	**DATA**	**WEIGH**	**GET**
Prototyping with users	Users participate in brainstorming and product testing	Users provide direct input after testing the prototype	Users share new product ideas and feedback from testing	Users participate in testing and provide feedback on interfaces and functionality	Users provide technical efficacy data and practical use-related issues
Piloting concepts at user's premises	Test hardware components and configurations at user-operated farms	Users test product prototypes and provide feedback for further development	Selected advanced users test early-stage products before further development or market introduction	Advanced, ordinary, and low-end users test various prototypes	Intermediate and end-users test prototypes in factories and mine sites
Observing usage behaviors	Observe how users operate the products when piloting concepts at user-operated farms	Observe how users operate the product when testing the prototype	Observe how users use the products to identify latent needs	Observe how different user groups use the product during testing to identify non-verbal use patterns	Observe how end-users use the product to identify use-related problems
Market research tools	Collect product feedback through inbound call center	Understand users' needs through official farm visits	Discussion sessions after user observation facilitate identifying problems and needs	Conduct interviews, discussions, and surveys to understand usage behaviors	Conduct mine visits and discussions to solicit user problems and needs

Table 4.—Routines from the cases

Routine	**Representative Data**
Delegate decision-making in product development	"We have an ideas channel where they could feed those in. Generally, it's the product managers who are responsible for doing various layers of business-case analysis to see, you know, is this is worth spending a little bit of time on to assess. And then is this worth developing a technical feasibility study? And then is this worth doing some full-on discovery of the risks that might be involved in it?" – WEIGH R&D manager
Centralize decision-making in product development	"The people further down the food chain and probably the sales force, sometimes they hear constant themes from farmers about issues or problems with the products. And to try and get them actioned they have to go up a number of levels." – GEN project manager
Organize interdisciplinary product development team	"We interface a lot with farm software members because they develop the software side of our product. We provide all the hardware, we set them up, and we work in constant interface because they say once they've released the product, we have to support it, and if there are any issues, and if [they are] software related, we need to understand how this has been built and try to fix it if necessary." – AUTO hardware manager
Work with other departments to improve product development	"I think there are about 20 different people from across the business who are going to be participating in the [user] interviews. And then we'll all get together to say what do we think, where do we think the market is going? Do we think that we need to react? And then, yeah, at that stage we would put a plan in place." – GEN team member
Open and effective communication	"[In] our department, we have a monthly meeting every Friday. And we discuss all product development matters and user feedback. And then we assign follow-up tasks accordingly among ourselves." – GET team member
User profiles to communicate information about users	"It was when we came to user-interface design that we fleshed this [user profiles] out a bit more and really started to use it. But it's a good mechanism anyway for just making sure that the design decisions you make are actually targeted towards a carefully segmented market and not a hypothetical market. We did that not just to drive the interface, but also features, and we had conversations around the features and the main user-story." – WEIGH team member
Align priorities within the team and with other departments in the organization	"I was thinking of the SRS stick [the EID reader] here. We moved it from an idea to a marketable product fairly quickly, because that's what the situation demanded. And it was done more or less with aligned agreement on priority as well. Once it was given its priority, it was followed through by the rest of the business unit." – WEIGH R&D manager
Provide explicit encouragement to staff for adopting customer-centered approaches to innovation	"Part of our ethos within MULTI is that you understand what it's like at the cow level. I mean I'm quite happy to put on a pair of gumboots, go out in the paddock and talk with the farmer about the cow he likes." – DATA team member
Interact with conduits within the organization to tap their knowledge	"The representative obtaining the feedback will brief us about it, and usually encourage us to talk directly with the users. Apart from reading the business cases and drawings, I also talk to the sales representative, to iron out any

Routine	Representative Data
	further requirements. And the representative will talk to the users if more information is needed.”– GET project manager

Table 5.—Capabilities and routines in action

Capability	Routine	Case	Mechanisms	Example of a Routine in Action
Collaboration	Interdisciplinary team	AUTO, DATA, WEIGH	Brainstorming and joint-prototyping, including fast iterations between prototypes	During brainstorming, DATA team members take turns evaluating each other's ideas, regardless of whether the ideas fall within their functional knowledge (for example, marketing, coding). Collectively, they discuss and choose the ideas based on criteria such as potential for adoption, available team expertise, and potential costs and benefits.
	Inter-departmental collaboration	AUTO, DATA, GEN	Informal, joint-product development with other departments	GEN team invites representatives from field-based departments such as installation and maintenance to the initial idea conceptualization meetings. Inter-departmental representatives share ideas and suggestions derived from user feedback or observation. Ideas are discussed and evaluated by meeting participants. One or two ideas from these meetings are chosen for presentation to business unit level product development meetings.
	Knowledge sharing through conduits	AUTO, DATA, GET	Vehicles for knowledge sharing include database maintained by inbound call center and written business cases	GET team identifies an idea through user feedback, observation, or technology-scoping and begins writing a business case. The team shares the business case with other departments (for example, foundry, production). Reading the business case allows other departments to understand the motivation behind the proposed idea, user evaluations from testing, product specifications, and timeline of the project.
Decision-making	Team-based decision-making	AUTO, DATA, WEIGH, GET	Joint-prototyping and piloting concepts with users	AUTO team develops new products or functionalities and brings them to the user's premises for pilot testing. Iteratively, the team discusses with users about the testing results, tweaks the prototype, and implements user's suggestions. The team ends the day with a workshop-like session with users to elicit more feedback and any ideas users might have. The team implements changes in final product without needing business unit level approval.
	Centralize decision making	GEN	Business unit level product	Prior to business unit level product development meeting, GEN team collates product ideas, and inputs from user testing in a report and

			development meetings	presentation. The team shares the report and presents the content to participants at the product development meeting. In the meeting, business unit management staff, decide if and which suggestions to incorporate in the product after conducting a cost and benefit analysis.
Intra-firm communication	Open communication channels within firm	AUTO, DATA, GEN, GET, WEIGH	Brainstorming, discussions, informal catch-ups	DATA team holds meetings once a week to discuss ongoing projects, share user inputs, and brainstorm solutions to address these inputs. Outside these meetings, members tend to have informal conversations and impromptu brainstorming when they face issues or have interesting findings or ideas.
	User profiling	WEIGH	Printed personas that acted as "manuals" for communicating information about users	Using information from market research report and internal marketing database, WEIGH team sorts information about users into persona groups based on users' usage behaviors, expected objectives from using the product, and location. Personas act as operating manual for the team and other departments when developing new products and selecting users for joint-prototyping and piloting.
Staff engagement	Aligning priorities	DATA, GEN, GET, WEIGH	Written business cases, centralized database	AUTO team and an inbound call center record all information about and from users such as feedback, testing evaluations, usage behaviors, and purchases in centralized database. Before engaging specific users for any purposes, relevant staff retrieves data about the targeted users. Ensures staff focuses on similar market and product development priorities and message consistency when interacting with users.
	Customer-centered culture	AUTO, DATA, GEN, GET, WEIGH	Vision and mission statements, posters, product development priorities	In the GET case, a customer-centered culture is explicit in the firm's vision and mission statements. Posters throughout the office reinforce this culture. Solving a user problem is a key criterion in all product development activities and during stop-go development assessments..

Table 6.—Managerial implications of customer-centered routines and capabilities

Managerial Implications	**Routine**	**Capability**
Rivalry between different teams, departments, and/or business units could be counterproductive	Work with other departments to improve product development	Collaboration
Manage the tensions that arise from interdisciplinary project teams	Organize interdisciplinary product development team	
Know who to look for and for what type of issue requires an established “expert” database	Interact with conduits within the organization to tap their knowledge	
Faster product development decisions, but the team could lack sufficient knowledge to make effective decisions	Delegate decision-making in product development	Decision-making
Draw on a wider pool of knowledge to make effective product development decisions, but the process is usually time consuming	Centralize decision-making in product development	
The size of the organization could impact the effectiveness of open communication channels	Open and effective communication	Intra-firm communication
Profiles are not a replacement for practical interactions in the field to understand users	User profiles communicate information about users	
Use business cases and user information database as an overarching tool to minimize NIH syndrome in project teams and other organization actors	Align priorities within the team and with other departments in the organization	Staff engagement
Staff possibly requires other engagement initiatives that encourage continually adopting customer-centered approaches	Provide explicit encouragement to staff for adopting customer-centered approaches to innovation	