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Knowledge Resources and Design Activities' Impact on Innovation Types

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Abstract

More companies are using design to gain an advantage in today's highly competitive business market. However, there are few empirical studies on its innovation impact on organizational performance. The purpose of this study is to clarify the relationship between the knowledge resources of companies, moderated by the degree of design activities, and innovation types. Based on the sensemaking organizational model, this study examines how companies' knowledge resources mediate design activities and influence innovation. This study introduces design activities as a moderator to link the corporate knowledge resources' (human, social, and organizational knowledge) impact to incremental and radical innovation. The sensemaking organizational model is extended through a human-centered lens. Analysis of 151 companies showed that human, social, and organizational knowledge had a selective impact on incremental and radical innovation. Interestingly, the findings supported the hypothesis that organizational knowledge enhances radical innovation through design activities. This paper bridges the gap between corporate knowledge resources and innovation moderated by design activities enhancing the sensemaking organizational model. It points to the need for design activities for creative problem-setting and enabling the discovery of problems found during the research phase through innovation. Long-term corporate activities increase knowledge resources and reduce the potential for radical innovation. Mechanisms that promote new connections between organizations and leverage corporate knowledge resources benefit radical innovation. This explains the managemental impact on the various knowledge resources in innovation and the role of design activities.

Keywords: Radical Innovation; Incremental Innovation; Design Activities; Knowledge Resources.

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1 Introduction

The design perspective is indispensable to product innovation and company success (Moultrie et al., 2007). Superior design differentiates products to attract customers from the competition, retain them, and provide a competitive advantage for companies (Verganti, 2008; Gemser and Leenders, 2001). Scholars have argued that human-centered design contributes positively to innovation in new product development (Dorst, 2011; Veryzer and de Mozota, 2005). D Design contributes to product differentiation by enhancing product quality and customer experience (Hertenstein et al., 2005), and it also increases its value (Moultrie et al., 2007). Existing research has shown a positive relationship between corporate performance (Moultrie et al., 2007) and design and sales growth (Hertenstein et al., 2005).

Traditionally, innovation occurred by accumulating technical knowledge within a closed enterprise environment (Thompson, 1967; Chandler, 1977). However, in fiercely competitive markets such as consumer electronics, technology alone cannot guarantee commercial success, and the

core technology of a product alone is not sufficient for market success (Ulrich and Eppinger, 2008). Influenced by the service economy based on information technology (Lipsey et al., 2006), innovation research has expanded from traditional R&D-driven (R&D) closed innovation to open innovation (Chesbrough, 2006; Gassmann et al, 2010). In fact, knowledge is already spreading from the R&D of the provider firms, and opportunities for knowledge acquisition are increasing, as seen in user innovation (von Hippel, 1986, 1994, 1998, 2001). In addition to corporate R&D, innovation activities create knowledge by absorbing technological capabilities from outside and integrating them with internal resources (Levitt and March, 1988; Cohen and Levinthal, 1990).

In recent years, there has been a growing awareness among innovation scholars about the role and importance of design in connecting company resources (Lau et al., 2010; Luchs and Swan, 2011, Micheli et al., 2017). There is growing evidence for design activities' central contribution to innovation (Walsh, 1996; von Stamm, 2004; Verganti, 2008). They are also an important resource for companies involved in learning and knowledge generation via external connections (Verona and Ravasi, 2003; von Stamm, 2004. Organizations that lack extensive research may have difficulty with future innovation activities because they lack a knowledge base other than those related to existing technologies and products (Teece et al., 1997). Knowledge resources and their integration are fundamental elements of innovation research (Tushman and Nadler, 1978; Williamson, 1981). However, many companies still ignore broad knowledge acquisition and design that integrates various sources of knowledge as a competitive advantage; treating design as non-essential additives (Buxton, 2007), or as decoration (Ulrich and Eppinger, 2008). The mainstream and scholarly focus in the innovation literature is often in the area of new product development, and design is not always well studied despite its importance (Zhang et al., 2011).

Despite early research suggesting design activities may improve organizational innovation; researchers do not fully understand how they relate to organizations. Nevertheless, many companies require knowledge acquisition and integration to design new products and services. To that end, some companies are increasing activities that involve other parties, including customers and suppliers; however, the activities remain unclear, and there is a lack of empirical evidence on whether design activities influence innovation. Despite the practical contributions of design thinking, which has been introduced to companies to integrate their knowledge and drive innovation, the theoretical research is insufficient (Ford, 1996).

Sensemaking is "the process through which people work to understand issues or events that are novel, ambiguous, confusing, or in some other way violate expectations" (Maitlis and Christianson, 2014, p.57). The sensemaking approach has been highly successful for explaining a variety of topics including identifying the problem through information gathering, shaping the discussion, and interpretation (Dutton and Dukerich, 1991; Dutton and Jackson, 1987). Sensemaking research is expanding into areas such as strategy formulation (Porac et al., 1989), change management (Gioia and Chittipeddi, 1991; Poole et al., 1989), and technology dissemination (Barley, 1986) among top management teams. Additionally, researchers use a sensemaking framework to study general innovation processes, but the focus is limited to product advantages in advanced technology development (Dougherty, 1992; Hill and Levenhagen, 1995; Ring and Rands, 1989). To clarify companies' innovation mechanism, the theoretical position of this study assumes the sensemaking organizational model to be effective for the technological innovation of products and service innovation, including process and experience value. Human-centered design activities based on design thinking, which were introduced into companies as a way to respond to service economy, are deeply involved in organizational sensemaking, especially creative problem-setting and problem-solving. To that end, this study examines the relationship between knowledge resources and innovation in companies through design activities. More specifically, it introduces design

activities as moderators to link the corporate knowledge resources' impact to incremental or radical innovation. It extends the sensemaking interpretation model for an organization through a human-centered lens and relates a company's human, social, and organizational knowledge resources with radical and incremental innovation.

This paper addresses two more notable research questions to bridge the gap between innovation research, design research, and the literature on organizational sensemaking. The first points to the need for design activities for creative problem-setting and enabling the discovery of problems found during the research phase through innovation. In innovation, discovering problems is as important as problem-solving, which naturally relates to the degree of how intrusive the organization is in the information-gathering phase. However, there is no focus on how analyzing the collected information and subsequent problem-setting will impact the innovation's characteristics. Therefore, the involvement of design activities provides empirical evidence on how the interpretation of information and the development and use of knowledge resources affect the types of innovation.

The second gap is the lack of understanding regarding analytical methods and evaluation criteria when integrating corporate knowledge and the impact of different innovation types. Design thinking places importance on a human-centered, empathetic story that complements the conventional analytical evaluation from the company and provides new opportunities that go beyond the core technology development. Considering the movement toward the service economy in recent years, it is even more important to adopt a human-centered lens, which forms the basis of service-dominant logic in the area of innovation exploration. This point is not fully understood in innovation theory, which has focused on product and technology development. Therefore, the purpose of this study is to clarify the relationship between innovation types by investigating the knowledge resources of companies and the degree of design activities.

By integrating design activities into the innovation process, companies can incrementally develop their current business, and expect radical innovation through the discovery of new opportunities in service systems that embrace core technologies. It is an important challenge for companies to understand the innovation mechanism that creates new value by recombining a company's knowledge resources with outside information and knowledge. The next section describes the theoretical background of this research and develops hypotheses. Next, we report the results of hypothesis testing using data collected from Japanese firms. Finally, we conclude with a discussion of the contribution and role that design activities play to various knowledge resources and types of innovation in firms.

2 Conceptual Background

Key concepts including design thinking, service system design, which is an application of design thinking toward service innovation, and knowledge and innovation are discussed in this section.

2.1 Design Activities

The origin of the study of design activity is the "designerly thinking" research that began in the 1960s on the skills and abilities of professional designers, such as to architects. Simon focuses on artifacts created by intentional human processes, and defines design as something "to change the existing situation to a favorable one" (Simon, 1969). Design activity is a nonlinear process of recognizing and interacting with the situation that is occurring there (Schön, 1983). Design activity, characterized by its nonlinear design process, is adapted to "wicked problems" (Buchanan, 1992). A methodology that simplifies designerly thinking and adapts it to the general domain is design thinking (Johansson et al., 2013). In comparison to designerly thinking, design

thinking is particularly focused on people involved in management and business, i.e., non-designers who incorporate design into their organizations. Design thinking has emerged as an important complementary field to previous organizational management (Johansson et al., 2013). A forerunner in its adaptation to corporations is the design consulting firm IDEO, which positions design thinking as "a discipline that uses the sensibilities of designers" (Brown, 2009). It is a methodology for aligning people's needs with feasible business strategies, identifying market opportunities, and translating them into customer value. Currently, design thinking methodologies are being adapted from new product development to service design development, and are being supported by design consulting firms and spread throughout the industry (Liedtka, 2015).

As we have seen, design is a concept and process for artifacts (Simon, 1969; Bruce and Bessant, 2002). Design management is a collection of managerial and organizational practices and skills for implementing and realizing design in product development (Bruce and Cooper, 1997; Gorb and Dumas, 1987; Dumas and Mintzberg, 1991). In recent years, its application has not been limited to physical product development and is expanding to service systems such as the user experience and process, as well as the interaction between actors. In particular, service design is attracting attention as a service system design method (Marger, 2004; Wetter-Edman et al., 2014). From 1990 onward, the field of service design research expanded from designing interfaces and experiences between products and users to designing interactions between actors. Service design is a human-centered design of a service system consisting of products, various actors, and their interactions (Spohrer and Maglio, 2009, 2010; Sawatani, 2014, 2019).

The reasons companies introduce design thinking depends on their purpose. The main reason is the need for human-centered design methodologies to break the deadlock in technological innovation (Brown, 2008). Other companies intend to improve their management skills to solve organizational problems (Dunne and Martin, 2006; Boland and Collopy, 2004) and effective learning processes for knowledge creation (Beckman and Barry, 2007). Traditional analytical approaches are effective when dealing with well-defined problems or when the product under development is relatively well understood, but they do not work well for complex service systems involving a wide variety of actors. For this reason, design thinking, an approach for dealing with complex human problems, has received much attention (Buchanan, 1992).

Design thinking has played a more strategic role in businesses since 2000 and is recognized as beneficial to the company (Kootstra, 2009). The integration of design functions in strategic areas by introducing design thinking into corporate management and innovation processes has received attention (Brown, 2009; Martin, 2009; Johansson et al., 2013; Gruber et al., 2015; Liedtka, 2015). Recent studies on design thinking for management have demonstrated that it can have a positive impact on a company's performance in terms of growth and profitability (Gemser and Leenders, 2001; Chiva and Alegre, 2009) and the ability to integrate innovation knowledge (Filippetti, 2011; Menguc, et al., 2014). Design thinking helps practitioners by providing a methodology for discovering potential customer needs and gaining a deeper understanding of their context when exploring a problem (Leonard and Rayport, 1997). In seeking solutions, practitioners of design thinking engage in activities that generate creative ideas and test them with potential customers (Brown, 2008). Interpretation and decision-making activities based on design thinking promote human-centered value and co-creation of organizations and actors across corporate boundaries (Liedtka, 2015; Wetter-Edman et al., 2018; Sawatani, 2019).

2.2 Service System Design

The service economy is an ongoing worldwide phenomenon (Levitt, 1976; Normann, 1991), shifting the focus of innovation from physical standalone products to service systems that include

experiences and processes. The environment surrounding companies is changing from the 20th century's manufacturing-centered model, where the market is driven by the stable supply of products, to the 21st century's model, where the market is shaped by the various values created by people's experiences and empathy. In the discussion of services, represented by service-dominant logic, products are considered tools for creating experiences, and almost all product manufacturers are considered service providers (Levitt, 1972, 1981; Vargo and Lusch, 2004). In other words, competitiveness extends between physical products focused on conventional technology and the design of service systems and the user experience (Ettlie and Rosenthal, 2011; Maglio and Spohrer, 2013). The combination of human, information, technological, and organizational elements to co-create value is called a service system (Maglio et al., 2009; Spohrer and Maglio, 2010). The expansion of the design field from products for the service economy to service systems entails new challenges for innovation management. Service-dominant logic is advocated in service research, and it indicates the importance of value co-creation between actors, such as customers and providers, in addition to the integration of resources held by actors (Vargo and Lusch, 2004; Vargo et al., 2008; Vargo et al., 2015). Innovation combines organizational skills and knowledge in an original way to meet the implicit needs of actors inside and outside the organization (Renko et al., 2009). Innovation activities are expanding within companies and with various actors. The roles of technology and products, which have been the source of innovation until now, are being reconsidered (Hobday et al., 2012), and design thinking is more widely recognized as a mechanism for creating human-centered innovation.

When designing a service system, the product function, and the interaction between various stakeholders, such as customers, employees, and suppliers are considered. Also, the service system's design integrates multiple touchpoints. These integrate individual human experiences into one system. In other words, human-centered design encourages the interaction of diverse actors and deepens situational understanding through empathy. Moreover, it promotes the co-creation of value and can drive innovation (Wetter-Edman et al., 2018). Design thinking is characterized by integrating collective cognition from a human-centered perspective through the empirical processes it facilitates. In particular, the empirical nature of design thinking facilitates the development of a common understanding of user-focused, future-oriented solutions that are not bound by existing problem-solving frameworks.

Today, companies improve their innovation skills by developing service systems in addition to physical products. Companies design new service systems by discovering and defining problems from a broader perspective, beyond the current strategic focus on physical product development. Companies transform themselves to embrace the creation of new values as they change with the environment (Siltaloppi et al., 2016). Firms that are able to innovate are able to act more appropriately and quickly on these changes in the external environment than firms that do not innovate (Brown and Eisenhard, 1995). To do so, firms must extend their learning capabilities outside their traditional boundaries (Wetter-Edman et al., 2018).

2.3 Corporate Knowledge

Data, commonly referred to as "raw" data, is a collection of texts, numbers, and symbols that reflect individual, objective facts about world events. Information is usually the result of processing data and is organized around a set of data. When the data are processed into information, they become interpretable and more important. Knowledge is richer and deeper than information and is the product of human introspection and experience. Just as information is derived from data, knowledge puts information into context and either exists in an individual or organization or is embedded in a routine or process (Gupta and Govindarajan, 2000). It is incorporated into

documents that encode and store information and the organization's tasks, norms, and visions. Knowledge is an important resource that businesses use to maintain a competitive advantage (Grant, 1996). Knowledge is a combination of contextual information, expert insights, and structured experience that provides a basic model for evaluating and incorporating new information and experiences (Davenport and Prusak, 1998).

Conceptually, knowledge is categorized into human, social, and organizational knowledge (De Long and Fahey, 2000). Human knowledge consists of individuals knowing what and how, including sensory, cognitive, conceptual, and abstract ideas. Human knowledge manifests itself as skills or expertise and is used by a human being (Schultz, 1961; Snell and Dean, 1992; De Long and Fahey, 2000). Social knowledge, on the other hand, exists only within relationships or groups between individuals. It is embedded in the interaction between individuals and the network of their interactions; it is largely tacit knowledge. It can be used by individuals or group members and is defined as knowledge developed by working with others (Burt, 1992; Nahapiet and Ghoshal, 1998; Gupta and Govindarajan, 2000). Organizational knowledge is the knowledge built into an organization's systems, processes, tools, and routines. It is explicit, rule-based, and specific to the organized knowledge and systematic experience (Walsh and Ungson, 1991; Davenport and Prussak, 1998).

In many cases, human knowledge is systematized, institutionalized (organizational knowledge), and transferred to communities and networks for later use (social knowledge). The creation, preservation, and enhancement of organizational knowledge takes place through structured and repetitive activities, which are organized (Nelson and Winter, 1982; Walsh and Ungson, 1991). The exchange of information that takes place within these shaped processes and organizational structures becomes established as certain systematic rules. The various manuals, databases, rules, patents, etc. within a company are the mechanisms by which organizational knowledge is accumulated, retained, and used. As a result, organization-specific knowledge tends to be restricted, stored, coded, and used in traditional ways within defined and acceptable limits (Brown and Duguid, 1991). In physical product-driven new product development, organizational knowledge-preserving activities that improve, extend, and integrate organizational knowledge are compatible with the goals of technology development. Likewise, the process of new product development is enhanced and structured by the use of organizational knowledge and benefits from collaboration, including extensive information exchange among members of the organization (Subramaniam and Venkatraman, 2001).

In contrast, human knowledge associated with individual expertise may or may not remain within the organization. Although social knowledge consists of a private network of individuals, it is stored primarily within the organization, regardless of individual changes (Putnam, 1995). Furthermore, a unique feature of knowledge associated with social knowledge is having a flexible means of exchanging and sharing knowledge that does not follow any prescribed rules or procedures for accessing, sharing, or exchanging information. Thus, networks of interactions within contexts accumulate uncoded knowledge that is used within those relationships. Therefore, social knowledge acts as a facilitator that enhances human and organizational knowledge use within an organization (Burt, 1992; Kostova and Roth, 2003).

2.4 Radical and Incremental Innovation

Innovation is the identification and exploitation of opportunities to create products, services, and ways of working that have never existed before (Van de Ven, 1986). Knowledge resources are important in corporate management and business strategy, and when integrated with corporate value creation, they contribute to the creation of new economic and social value (Hargadon and

Sutton, 1997). The knowledge and skills needed for innovation essentially reside within and are utilized by individuals. Organizations accumulate, store, and integrate knowledge necessary for organizational activities in patents, regulations, manuals, and databases, and build appropriate systems for future use by the organization (Garud and Nayyar, 1994). Information and knowledge stored in organizations are also newly added to, assimilated, or integrated into existing organizational knowledge through group and intra-organizational interactions, and facilitated by communication among individuals to share, exchange, and transfer (Allen, 1970, 1977; Wei et al., 2014). In contrast, social knowledge has a flexible means of sharing and exchanging knowledge. It acts as a catalyst for integrating knowledge of individuals and organizations in an organization (Burt, 1992; Kostova and Roth, 2003).

Given that innovation uses substantially diverse knowledge, the link between them is not surprising. Since knowledge accumulates in different ways, interactions among people and organizations can affect a company's activities for innovation in different ways. The different types of innovative characteristics noted by innovation research are helpful in understanding these influences. The most accepted classification is radical or incremental (Saeed et al., 2015; Dewar and Dutton, 1986). Radical innovation is a change in product, technology, service, or customer value that makes an existing traditional product or service obsolete (Chandy and Tellis, 2000). In other words, it is a change in trajectory that deviates from the company's ongoing direction. Therefore, companies need to be capable of radical innovation, such as making significant improvements to existing products and services or creating markets that did not exist before. On the other hand, incremental innovations are those that increase the potential of already developed artifacts or accumulated knowledge, such as developing technologies or modifying customer experiences to improve existing products or services (Ettlie, 1983).

The essential difference between incremental or radical innovation is more apparent in how knowledge depends on the integration of existing systems (Subramaniam and Youndt, 2005). In other words, incremental innovation involves improving and using existing technological trajectories and strengthening existing knowledge's applicability, while radical innovation disrupts existing technological trajectories and destroys the existing knowledge base's value (Gatignon et al., 2004).

In recent years, companies have introduced design thinking based on human-centered design (Brown, 2008) and service systems that involve various actors as a mechanism for innovation. Activities based on design thinking are carried out by groups consisting of extremely diverse members. Corporate group activities carried out by such members play an essential role in innovating knowledge in an organization (Nonaka, 1994). Group activities improve the organizational use of knowledge, such as patents, databases, and licenses. Furthermore, these activities influence how knowledge resources are updated and enhanced. Subramaniam and Youndt (2005) provide a basis for relating the interaction between types of knowledge and innovation in firms to business management.This study examines the relationship between knowledge resources and innovation in companies through design activities.

3 Hypothesis Development

3.1 Design Activities When Exploring Sensemaking

Of the sequence of innovation activities, research, problem discovery, and problem-setting are essential starting points for the journey, and each can lead to discontinuous trajectories. Daft and Weick (1984) categorized sensemaking activities in an organization into four categories, which are determined by "organizational intrusiveness," the degree to which an organization actively intrudes into the environment, and "environmental assumptions" regarding analyzability.

Organizations must interpret the diverse data and information acquired. Its members assess events surrounding the organization and actively try to understand them (Braybrooke, 1964). Interpretation translates data and information, drawing meaning from them to understand and construct conceptual schemes among key members (Daft and Weick, 1984). The sensemaking process that makes up the overall learning process in an organization can be roughly organized into three stages: scanning, interpretation, and learning. The first step is scanning, which entails monitoring the environment and providing that data to senior management. Interpretation takes place in the second stage, where meaning is given to the data and information collected, and this is shared with members. The third stage, learning, involves new reactions or actions based on interpretations (Argyris and Schön, 1978; Daft and Weick, 1984).

Design thinking is a practical problem-solving approach based on human-centered design that emphasizes empathy and is characterized by cooperation with diverse people and iterative practices (Brown, 2008; Norman, 2013; Liedtka, 2015). It emerged as a series of methods to deal with uncertain and unclear "wicked problems" (Buchanan, 1992). It aims to discover insights through a process of abstraction by discussing observed facts from a variety of perspectives, and to generalize patterns and motivations of social behavior (Cross, 2011; Dorst, 2011). Design thinking can act as a trigger mechanism for sensemaking, a cognitive process that allows organizations to understand "what is happening here." (Weick, Sutcliffe, and Obstfeld, 2005; Elsbach and Stigliani, 2018). Scanning, interpretation, and learning in sensemaking are similar to design thinking (Stigliani and Ravasi, 2012). Design thinking is a powerful method of interpretation based on qualitative data when an organization assumes it cannot analyze the external environment.

3.2 Design Activities in Environments Where Analytical Approaches are Difficult

When an organization assumes the external environment is concrete, measurable, and decisive, it uses conventional methods to find the correct interpretation. Organizations seek clear data and solutions for discovery based on information gathering, rational analysis, and accurate measurements. In contrast, when an organization assumes it cannot analyze the external environment, it applies a completely different strategy. Soft and qualitative data, along with judgment and intuition, play a greater role in the interpretation process (Daft and Weick, 1984). In these cases, design activities based on design thinking as specific organizational activities are considered. In this study, design activities are defined as "mechanisms that promote new combinations of knowledge resources through a human-centered approach." They derive insights from qualitative data that leverage diversity and to set and solve human-centered problems.

In practice, design activities to create new service systems are discussed by group members with diverse perspectives, and these activities play an important role in advancing organizational knowledge in new directions (Nonaka, 1994). However, the method is different from conventional quantitative analysis, which collects and analyses a large amount of data, and the activity repeats the steps of observation, empathy, problem-setting, idea creation, prototyping, and verification. New insights can be found in people's unusual and extremely diverse behaviors, such as extreme users, discomfort, and unexpected situations (Wetter-Edman, et al., 2018). These insights are recognized through the interpretations of various parties and their interactions (Brown et al., 2015; Weick, 1995; Melton and Hartline, 2012). By taking qualitative and discussion-based data, it is possible to perform problem-setting from a new perspective. It promotes new connections between the company's knowledge resources and knowledge outside it. This creates a new service system from innovative problem-setting through the co-creation of value with various members. Below (Figure 1) are four types of sensemaking organizational models that expand with design activities according to Daft and Weick (1984).

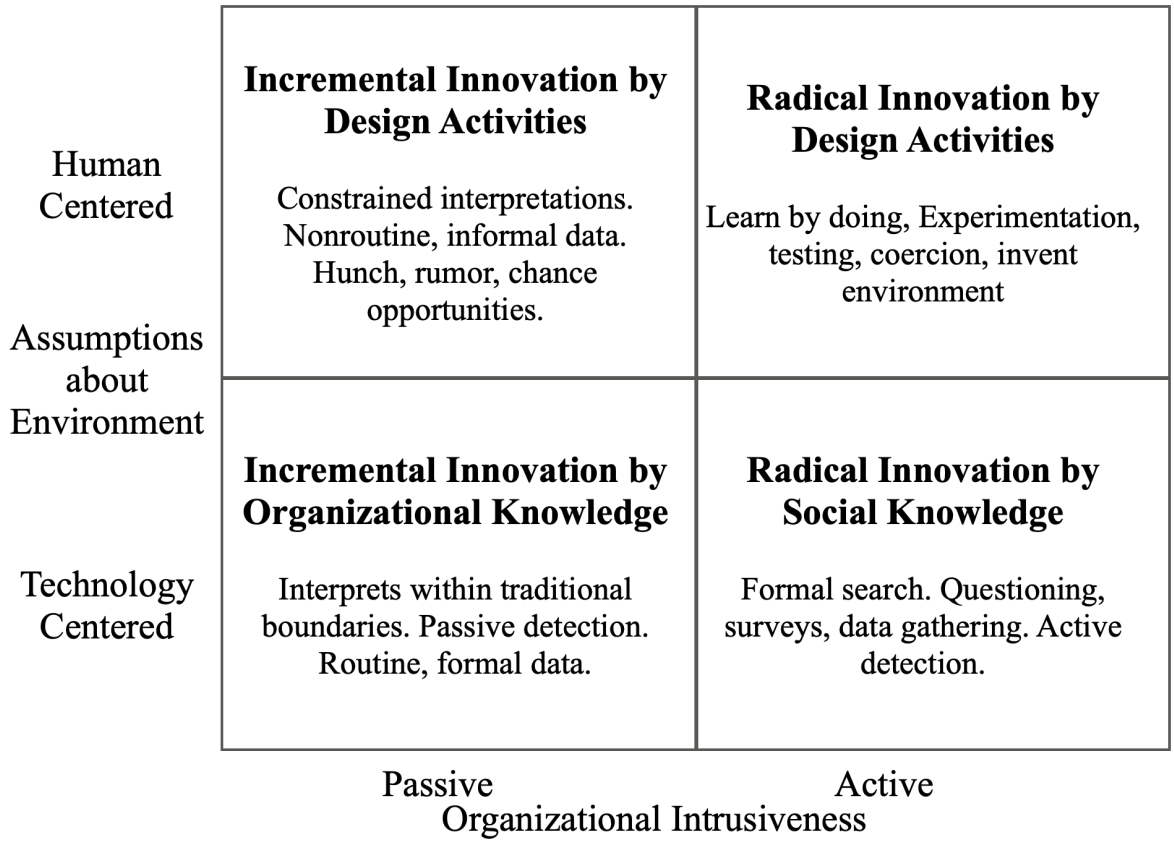

Figure 1. Expansion of the Organizational Model of Sensemaking Through Design Activities

3.3 Involvement of Design Activities in Organizational Knowledge

The basic process of service innovation begins with the establishment of new issues and the clarification of problems. Strange events found in the observation and interaction of actors inside and outside the company or organization are examined from different perspectives and serve as a starting point for new insights. Design Thinking focuses on the extreme user to discover problems based on empathy. Based on the behavior of a wide variety of individuals, new insights are discovered through observation and empathy, focusing on unexpected scenes and situations (Wetter-Edman et al.) There are various design methods that can be used to gain common understanding among diverse members. Sensemaking is associated with the recognition of new perspectives, insights based on deep understanding, and the social practice of ideas (Weick, 1995; Brown et al., 2015). The same is true for design thinking, which finds insights from observed facts and generalizes the patterns and motivations behind social behavior through a process of abstraction (Cross, 2011; Dorst, 2011). In the interaction of various members and actors of a network, design thinking enhances design activities, situations are understood, and problems are set from new perspectives (Cooney et al., 2017).

Problem-setting, discovered through dialogue with internal and external stakeholders, provides an opportunity for organizations to become aware of new ways to solve existing problems through access to diverse knowledge domains (Rosenkopf and Nerkar, 2001). Inspired by the discovery of new problems, organizations transform their organizational knowledge by accessing and engaging with a variety of alternative knowledge domains. Transformation of organizational knowledge requires a multidimensional questioning of the rules that have been positioned as common and a search for radically different solutions to existing problems that are not limited by them (Tushman

and Anderson, 1986). As a result, the knowledge of insiders and outsiders and the problem-solving capabilities of different organizations can be utilized to promote integration through new connections. Based on the diverse interactions, the knowledge possessed by the organizations presents discontinuous innovative solutions and solves the problems. In other words, design activities enable problems to be set and solved from new perspectives that commonly arise across current organizational boundaries. This leads to innovative problem solving as a mechanism to facilitate new combinations of knowledge resources focused on people and new combinations of changes in the knowledge stored in the organization.

> Hypothesis 1: The involvement of design activities in organizational knowledge is actively related to radical innovation.

The process of incremental innovation begins with solving a problem with an existing product or service that is strategically important. This can be done by developing new technologies, systems, and processes to solve the problem (Chiva and Alegre, 2009). However, the more substantive organizational knowledge an organization has about existing products, the more the knowledge development and exchange for problem solving is consistent with the current direction and the more limited the scope for change. The targeted problem domain is related to an existing product or service, and the solution is highly sustainable and continuous (Baker and Sinkula, 2007; Costa et al., 2018).

On the other hand, the application of design thinking in organizations promotes the development of human-centered, collaboration-oriented, risk-taking, and learning organizational cultures (Elsbach and Stigliani, 2018). The emotional experiences that result from design thinking motivate organizations to build such a culture. Management theories related to organizational development focus on dynamic changes in sensemaking and the dynamic capabilities framework (Teece et al., 1997; Weick et al., 2005; Teece, 2014). The detection and capture of opportunities in the dynamic capabilities framework (Teece, 2007) relate to design thinking (Brown, 2008; Beverland et al., 2015). The concept of dynamic capability refers to practical activities and patterned systems for combining organizational resources to evolve routines, abilities and resources (Helfat, 2008). Design thinking, on the other hand, can discontinuously expand existing business areas and may damage ongoing developments. Taking a design activity that focuses on front-line operations is said to help improve the customer experience, although it is only part of the effect of design thinking (Andreassen et al., 2016). In other words, in incremental innovation, human-oriented design activities such as usage status and function changes/optimization based on input from customer support are carried out (Yu and Sangiorgi, 2018), but some design activities can damage the current ongoing knowledge development.

> Hypothesis 2: The more important the design activity in an organization, the weaker the influence of the organization's knowledge on incremental innovation.

3.4 Involvement of Organizational Knowledge in Incremental Innovation

The knowledge accumulated in an organization influences the tendency to reinforce that knowledge in existing directions. Accumulated organizational knowledge is often used iteratively in previously formalized processes and is generally considered to be more reliable and long-lasting than other types of knowledge (Martin and Mitchell, 1998; Katila, 2002; Lyles and Mitroff, 1980). Manuals, databases, patents, processes, and routines that classify and organize knowledge, store it, and facilitate its use are hallmarks of sustained knowledge accumulation (Hansen et al., 1999).

Established processes and routines that use organization-level knowledge often lead to the evolution of knowledge because organizations find it challenging to store and use it (Nelson

and Winter, 1982). Improving the quality of relationships, interactions, and cooperation among individual groups acting on the basis of accumulated knowledge ultimately constitutes a path-dependent trajectory of organizational knowledge (Teece, Pisano, & Shuen, 1997; Cohen and Levinthal, 1990; Daneels, 2002). Thus, organizational knowledge deepens existing stored knowledge and influences incremental innovation in organizations.

> Hypothesis 3: The importance of organizational knowledge in an organization is actively related to incremental innovation.

Involvement of Social Knowledge in Radical Innovation

Radical innovation heads in a discontinuous trajectory that differs from previous directions. Ideas for radical service innovation may originate from interactions with actors inside and outside the organization. In addition to expanding the existing knowledge base, significant opportunities to create new knowledge are likely to be driven by interactions with external actors (Sawatani, 2019). Insights gained from these observations and interactions with diverse actors cause foundational knowledge. Solving problems and accessing knowledge from social network interactions facilitates new connections. Mediating and combining previously unrelated ideas is essential for radical innovation (Hargadon and Sutton, 1997).

Various studies have emphasized the role of social networks in promoting the acceptance of individual extreme ideas within inclusive organizations and industries (Schön, 1963; Schilling, 1998; Tushman and Murmann, 1998). Connections and the resulting communities that encourage diverse individuals to share information and knowledge are an essential feature of social knowledge resources. Social knowledge, based on relationships among people and organizations, provides a platform for the exchange of diverse ideas. Social knowledge also facilitates collaboration within and between organizations. It also allows individuals to establish the legitimacy of innovative ideas within an organization and to combine widely organized resources. Moreover, social knowledge helps to combine them to create unexpected and unusual combinations and to achieve fundamental breakthroughs.

> Hypothesis 4: The importance of social knowledge in an organization is actively related to radical innovation.

4 Research Methodology

The data for this study was collected through a questionnaire survey and secondary sources administered to Japanese companies. The survey population included a wide range of industries and organizations in order to maximize the range of variables and to increase the likelihood of generalizing the results. However, only listed and unlisted companies with more than 100 employees were included in the study. The selected organizations with more than 100 employees are more likely to have some formal R&D and have established internal innovation systems. We extracted 1,256 companies that met these criteria from Diamond, a Japanese database of corporate information. Individually addressed packages (cover letter, survey form, and postage-paid return envelope) were mailed directly to the appropriate managers of the 1,256 selected companies in December 2018. The collection period was until March 2019. Of the 156 responses collected, 151 were valid responses, with a response rate of 12.4%.

The questionnaire was designed according to the structured survey method proposed by Fowler (2002). The level of activity associated with each question item was measured using a 5-point Likert scale. Various information providers were used in researching information on independent

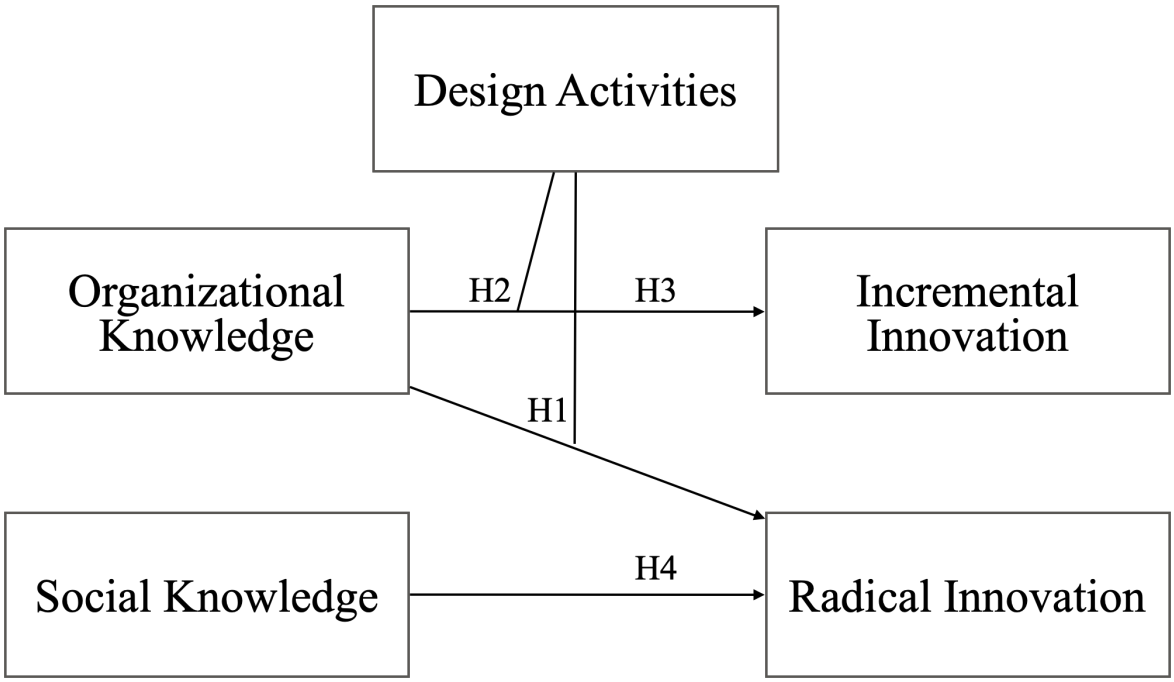

Figure 2. Hypothesized Research Model

variables (knowledge resources), moderators (design activities), and dependent variables (types of innovation). All data for the three control variables were collected from secondary sources.

The three items used to assess human knowledge indicate the overall skills, expertise, and knowledge level of employees in the organization (Schultz, 1961; Snell and Dean, 1992). Organizational knowledge was measured based on three items that assessed an organization's ability to store knowledge in physical organization-level repositories, including databases, manuals, and rules (Davenport and Prussak, 1998; Walsh and Ungson, 1991). The four items that measure social knowledge are the core ideas of social structure literature (Gupta and Govindarajan, 2000; Burt, 1992) that assess the general ability of organizations to share knowledge within a network of customers, suppliers, employees, and partners. Design activities were identified as design thinking processes, such as problem-setting, concept development, and testing (Liedtka, 2015; Wetter-Edman et al., 2018). The two types of innovation are based on six items measuring incremental and radical innovation (Henderson and Clark, 1990; Tushman and Anderson, 1986; Subramaniam and Youndt, 2005). Incremental innovation was measured using three items assessing current expertise and the organization's ability to strengthen and expand its product lines. Radical innovation was measured using three assessment items, including the organization's ability to terminate current product and service lines in order to pursue new products. The appendix contains a list of the 19 questions used in this study.

Several organizational factors, other than knowledge resources, can affect innovation capabilities. For example, a large-scale organization may develop innovative functions based on a productive resource base. On the contrary, smaller organizations can be more innovative because of their flexibility (Henderson and Cockburn, 1994; Cohen, 1995). The same applies to the company's history from its founding year to the present. Therefore, unrelated impacts on organizational size and history were controlled for. Also, because certain innovations may be more useful in products than services, whether these innovations were product-based or service-based was controlled for. Company size, history, and product/service type were obtained from Diamond's database.

5 Results

First, the reliability of the measured values was verified. Cronbach's alpha coefficient was calculated to examine the internal consistency of the scales for each knowledge resource, design activity, and innovation type. All the scales exceeded the recommended value of .70. The hypothesis was tested using a moderated regression analysis. Following Venkatraman (1989), the use of moderated regression analysis centered on independent variables and moderators to minimize the effects of collinearity between multiple variables. When the independent variable and the moderator are centered, the correlation between the interaction terms and the variables that compose it is expected to be small (Cronbach, 1987). Even when the interaction terms were used, the confidence interval of the coefficient of the interaction term and the result of the significance test did not change (Jaccard and Turrisi, 2003). Table 1 shows the mean value, standard deviation, and reliability/validity estimates for each factor, and Table 2 shows the results of the analysis.

Table 1. Correlations

	Means	SD	Cronbach α	1	2	3	4	5	6	7	8	9
1 Product / Service-based	.56	.50		1								
2 History	53.75	27.02		-.55**	1							
3 Size	10264.15	44253.58		.09	.13	1						
4 Human Knowledge	1.12	.69	.70	-.10	.06	.03	1					
5 Social Knowledge	3.49	.79	.82	-.01	-.04	.06	.50**	1				
6 Organizational Knowledge	2.92	.86	.75	-.11	-.06	.03	.33**	.52**	1			
7 Design Activities	3.46	.95	.84	-.06	.08	.12	.63**	.65**	.35**	1		
8 Incremental Innovation	2.99	.81	.83	.03	-.13*	-.01	.21**	.29**	.51**	.19*	1	
9 Radical Innovation	2.42	.92	.93	.05	-.27**	-.02	.24**	.40**	.44**	.28**	.64**	1

*p<.05, **p<.01, n=151

Table 2. Results of Regression Analysis for Knowledge, Design Activities and Types of Innovation

	Incremental Innovation			Radical Innovation		
	Model1	Model2	Model3	Model1	Model2	Model3
Control						
Product/Service-based	-.12	.01	.01	-.15	-.06	-.06
History	-.23*	-.13	-.13	-.35***	-.28**	-.27**
Size	.04	-.01	-.01	.04	-.01	-.01
Knowledge Resources						
Human Knowledge		.08	.09		.03	.05
Social Knowledge		.01	.01		.17	.17
Organization Knowledge		.49***	.46***		.29***	.23*
Knowledge Resources related interactions						
Design Activities		-.02	.01		.07	.11
Organizational Knowledge × Design Activities			.08			.15*
R2	.035	.295	.301	.066	.258	.271
F	1.768	8.628***	7.691***	4.520**	8.466***	7.954***

*p<.05, **p<.01, ***p<.001 n=151

Organizational knowledge showed a meaningful positive relationship with radical innovation (β = .23, p <.05). The interaction of organizational knowledge through design activities (Hypothesis 1) was significantly associated with radical innovation (β = .15, p <.05). Contrary to expectations, however, the hypothesis for the involvement of incremental innovation in organizational knowledge and design activities was not supported (Hypothesis 2). The involvement of design activities showed a slight reduction in the organization's knowledge of incremental innovation, but there was no indication that it hindered it.

For the rationale-based hypothesis that knowledge resources strengthen current knowledge of incremental innovation, organizational knowledge is significantly associated with incremental innovation (β = .46, p <.001); therefore, Hypothesis 3 was supported. Concerning the rationale-based hypothesis that knowledge resources changed the general knowledge of radical innovation, social knowledge was not significantly associated with radical innovation (Hypothesis 4). In the analysis of knowledge resources and innovation, human and social knowledge were not related to either innovation type. Interestingly, an analysis of the impact of design activities and knowledge resources found that only the interaction between organizational knowledge and design activities was significant for radical innovation. Figure 2 shows the effects of this interaction. When there was a lack of organizational knowledge, there was passive involvement of design activities in radical innovation. In contrast, if there was sufficient organizational knowledge, active involvement in radical innovation through an emphasis on design activities was observed.

As expected, when looking at the control variables, the number of years since the company's establishment had a significant negative relationship with radical innovation (β = -.27, p <.01), and long-term corporate activities reduced the possibility of radical innovation. A company's age had a negative impact on its radical innovation. In contrast, the size of the company and whether innovations were product-based or service-based did not affect the innovation type. Longer-term corporate activities increased the company's resource knowledge while reducing the potential for radical innovation. To create radical innovation, there is a need for mechanisms that promote new connections between organizations, in addition to developing and making use of corporate knowledge resources. The role of design activities in companies has been suggested as a means of improving the accumulation of knowledge resources for radical innovation in discontinuous problem settings.

6 Discussion and Conclusion

Overall, the survey findings strongly supported the assumption that various aspects of a company's knowledge resources and interactions influenced the incremental and radical innovation capabilities. However, contrary to expectations, organizational knowledge influenced radical innovation, while social knowledge did not. This result differed from that of Subramaniam and Youndt (2005), who mainly targeted US-based companies and showed that social knowledge played an important role. For the Japanese companies in this survey, the results showed that organizational knowledge, not social knowledge, played an important role in radical innovation. Although organizational knowledge was fully used, Japanese companies may not have fully explored opportunities for innovation based on social knowledge. Also, organizational knowledge had a positive impact on incremental innovation. The institutional knowledge accumulated from the organization in patents, databases, structures, systems, and processes appeared to strengthen dominant knowledge and further incremental innovation.

The interaction between organizational knowledge and design activities produced a positive impact on radical innovation, which was a striking result. This suggested that design activities

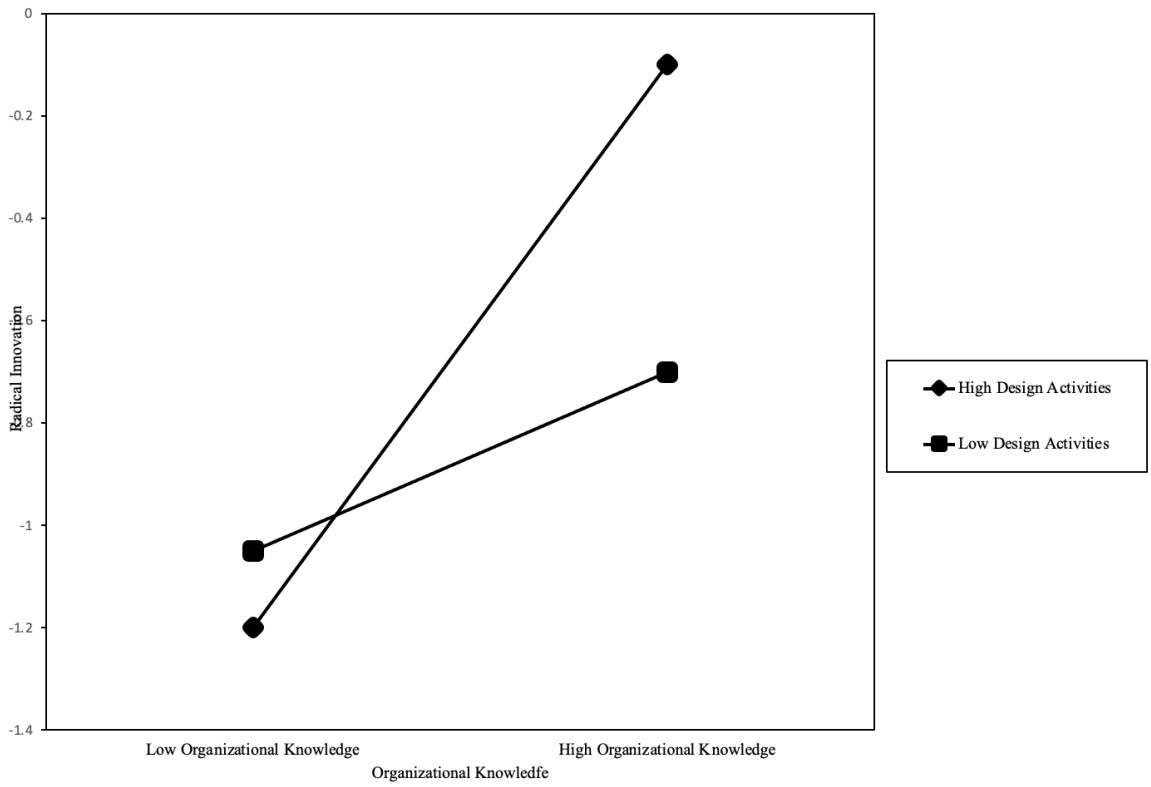

Figure 3. Hypothesized Organizational Knowledge and Design Activities Interaction Plot

facilitated internal and external collaboration and influenced options in decision-making. Design activities encouraged the discovery of new problems and increased the potential for further value creation through new combinations of organizational knowledge. Also, the interaction effect increased with radical innovation and design activities. Furthermore, the effect increased when organizational knowledge was built upon. However, if the organizational knowledge was insufficient, design activities had little effect (Figure 3). Because of the results obtained on the interaction between organizational knowledge and design activities, an investigation was carried out to determine whether other combinations were effective. However, no other combination was found to enhance the impact of knowledge resources on innovation. Consequently, only organizational knowledge and design activities had a significant impact on radical innovation. Therefore, while both types of innovation had strengths in the institutionalized procedure for organizational knowledge accumulation and use, the importance of design activities by various actors was emphasized in radical innovation.

The results of this survey have two important implications: improving the conceptualization of relevant knowledge, design activities, and innovation, and providing useful and concrete guidelines for management practices. First, it was suggested that design activities that strengthen internal and external interactions influenced radical innovation. Innovation is a collaborative effort, and the successful incorporation of diversity based on human-centered design plays a central role in creating radical innovation. Since innovation is a collaborative process, the incorporation of diversity based on human-centered design in those activities is central to the creation of radical innovation. Diversity in communication and information exchange, and the sharing and assimilation of such knowledge, is an essential element of innovation capability, regardless of the type of innovation. Merely processing routine work and path-dependent information in an organization will not produce

radical innovation. Investing in design activities that promote internal and external interaction and the co-creation of value enables problem-setting from a new perspective. Design activities involving internal and external interactions and a variety of actors facilitate the unique association of organizational knowledge. Selectively using these capabilities will create a basis for gaining flexibility in responding to emergencies in the market or competition. Therefore, design activities inside and outside the company may be essential for perceiving and capturing opportunities. Dynamic capabilities allow organizations to respond flexibly to external changes, generate ideas from new perspectives, and reframe their competitive focus to gain new forms of competitive advantage (Daft and Weick, 1984; Teece et al., 1997). Second, in order to generate discontinuous ideas from internal and external interactions, continuous investment in design activities that facilitate the discovery and formulation of new problems is essential. However, a bias toward reinforcing design activities that neglects the growth of organizational knowledge or only reinforces organizational knowledge will result in insufficient radical innovation. Potential enhancements depend on staying consistent with the basic aspects of the company's organizational knowledge and resources. And it depends on improving individual skills and strengthening the company's radical innovation capability.

Limitations and Future Research Directions

Innovation has become an increasingly essential and challenging task for companies. Innovation is achieved by connecting a company's knowledge resources to values that change over time and generations. This study was conducted as a first step to focus on the design capability to integrate the knowledge resources of companies. However, the survey was limited to Japanese companies. Furthermore, although design activities in companies were the subject of this paper, it is necessary to consider the definition of design activities in other areas. In the future, a universal recognition of design activities in early-stage companies is expected. Innovation by nature is a complex phenomenon that involves factors other than knowledge resources, such as organizational climate. Therefore, it will be necessary to deepen the understanding of innovation and design activities by combining methods such as interviews in the future.

Innovation initiatives and forms, especially service system innovation, are attracting attention as future research areas. The initial innovation state has been studied in the process of new product development (NPD). In particular, the time and activity leading up to the first review of the fuzzy front end of the NPD process, or a new product idea, is seen as the source of success for companies involved in new product innovation. In the case of product development, problems or opportunities that are discovered are structured and placed at the current organizational level. However, opportunities for service systems such as products, software, networks, and services are difficult to understand from the perspective of division into ordinary organizations. The current design processes and management systems created on the premise of innovation by isolated organizations, especially decision-making, such as opportunity assessment, are insufficient for discovering new issues related to service innovation focused on the experience value with service systems. Even if these challenges are recognized, awareness of problems different from the usual trajectory and potential solutions are often ignored. Therefore, it is difficult to implement in existing organizations.

Moreover, service systems, extended from the traditional systems for physical products, are based on the relationships among multiple actors and the complementary resources they bring. In order to build a new service system, it is necessary to consider the following issues at the initial stage: the cost of encouraging actors composed of social ties to participate continuously, the cost of connecting newly participating actors, the assets provided by the actors, the risk premium,

and the maintenance mechanism of the service system. challenges in the early stages need to be considered. To establish service system innovation, human-centered design activities are required, in addition to the development of mechanisms that promote value co-creation across company boundaries. Companies must change their behavior in a wide range of areas, such as problem recognition, idea development/implementation, and decision-making. Knowledge resources can be integrated through human-centered design activities to leap beyond organizations' limitations and expand the company's current horizons and create innovation.

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Appendix

Knowledge, Design Activities and Types of Innovation Questionnaire Items

The following items had this stem and response format: "To what extent do you agree with the following items describing your human, organizational and social knowledge? (1 strongly disagree; 5 strongly agree)."

Human Knowledge

Our employees are highly skilled.

Our employees are experts in their particular jobs and functions.

Our employees develop new ideas and knowledge.

Social Knowledge

Our employees are skilled at collaborating with each other to diagnose and solve problems.

Our employees share information and learn from one another.

Our employees interact and exchange ideas with people from different areas of the company. Our employees apply knowledge from one area of the company to problems and opportunities that

arise in another.

Organizational Knowledge

Much of our organization's knowledge is contained in manuals, databases, etc.

Our organization's culture contains valuable ideas, ways of doing business, etc.

Our organization embeds much of its knowledge and information in structures, systems, and processes.

Design Activities

Our employees are encouraged to encourage necessary stakeholders to realize ideas and service concepts.

Our employees are examining the customer value of ideas and service concepts through various stakeholders and workshops inside and outside the company.

Our employees are using various design methods and tools to realize ideas and service concepts.

The following items had this stem and response scale:

"How would you rate your organization's capability to generate the following types of innovations in the products/services you have introduced in the last five years? (1 = weaker than competition; 3 = similar to competition; 5 = stronger than competition)."

Incremental Innovation

Innovations that reinforce your prevailing product/service lines.

Innovations that reinforce your existing expertise in prevailing products/services.

Innovations that reinforce how you currently compete.

Radical Innovation

Innovations that make your prevailing product/service lines obsolete.

Innovations that fundamentally change your prevailing products/services.

Innovations that make your existing expertise in prevailing products/services obsolete.

Biographies

Yuriko Sawatani. Dr. Yuriko Sawatani is Professor and Director of the Entrepreneurship Center at NUCB Business School. She received her PhD from the University of Tokyo. She worked at IBM Research before becoming a professor at Waseda University in 2013, where she has been in her current position since April 2018. Her research focuses on the mechanisms of innovation in organizations from the perspective of human-centered design and service systems. Research topics include: service system, human-centered design, service design, innovation management, and entrepreneurship. On these themes, she has initiated several externally funded research projects in partnership with businesses to transform their organizations into service economies. Her accomplishments include the Ministry of Education, Culture, Sports, Science and Technology's "Global Entrepreneurship Development Enhancement Program" and its follow-up programs. She is the author of books on service research and papers on innovation management. Main books: Handbook of Service Science, Volume II(Springer), Global Perspectives on Service Science: Japan(Springer), Serviceology for Designing the Future(Springer).
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