Knowledge Creation in an Integrated Product-Service

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***Abstract*—The paper is about the investigation of how new knowledge is created when customer knowledge captured during the use-phase and retirement stage, and firm internal knowledge in an integrated product-service development cycle. Customer knowledge is integrated with firm-internal knowledge and converted into new ideas or solutions through knowledge conversion process, as such enhance the customer value proposition in terms of product and service performance. The main contributions to the literature are threefold. First, we provide how customer knowledge captured from other product life cycle and firm-owned knowledge towards affect new knowledge creation in developing an integrated product-service design. Second, we provide evidence new knowledge creation in an integrated product-service design is crucial in enhancing customer value proposition in terms of product and service performance. Third, we offer knowledge creation process in an integrated product-service design as an important determinant for product-service performance.**

***Index Terms*—Product-service, knowledge creation, product-service performance, SECI.**

I. Introduction

In functional economy, functional sales is addressed rather than the physical product [1], which getting much attention, particularly in developed countries [2]. The terms such as Product-Service (PS), product-related services or full-services are interchangeably used to designate the integrated of PS offerings [3] for selling functions. Functionality describes the ability of integrated PS [4] to provide the ability, usability, or purpose of it, rather than the physical artifact.

PS firms move from traditional selling artifact manufactured to combination of services and products to enhance customer loyalty by having long-term business relationship with customers [5] and offer sustainable solutions [6]. Subsequently, PS enhance existing customer value [7] generate more profit [8] and reduce environmental effect [9]. Flexibility becomes crucial issue as any specific product can be combined with services to meet customer requirement through distinct operational processes [10], [11]. Customer's experience are explored to improve existing firm core product concept and manufacturing capabilities [12], reduce the needs for service throughout the product usage phase. Hence, PS focus on lengthening the durability of a PS which reduce material/resource usage but at the same time retain the quality [13]. Exploring customer's experience (CK) and exploiting firm internal knowledge (FIK) gathered from each phase of new PS development are crucial to integrate product functionality and its related services into one solution may have opportunities to succeed [14]. A firm may choose to maintain internal knowledge if the firm is very competitive and at strong position in the industry which that knowledge is sufficient [15]. Explorative and exploitative learning are a complementary concept for optimizing resources and turns the essential processes efficient and effective [16]. Both approaches offer renewed in knowledge, but both differ in cost, learning ability and duration [7].

In the past, much of the researches have shown the importance of customer integration in the concept and design process of new product development [17], [18], innovation [19], [20], product quality [21], service quality [22] and operational performance. On the other hand, previous research on exploitation of FIK also have been discussed by many scholars such as [17]. However, researches on issues captured from a different stage of product development for PS design, is less focused especially customer experiences or the designers' past experiences which can be transferred to the design phase to facilitate future product improvements [23]. Furthermore, previous researches have shown that designing PS requires multiple discipline perspectives [24] such as different background that contribute to new insights and innovative ideas gained from experiential learning [25] to reduce service requirements during use-phase [17].

Second, with the advance of IT, the larger volume of information available for new insight and options [26], provide better solutions. However firm who fail to leverage knowledge effectively, instead of experience competitive advantage, they will suffer various information related anxiety. Nowadays, individuals and firm face challenge of keeping up with filtration of relevant information. As mentioned by [27], there is no such excess information, but the failure of filter system that create difficulty for decision making due to longer searching and processing time from many information sources. Although the knowledge captured can be stored, distributed and manipulated, but due to high volume it may end as a threat rather than provide positive outcome [28]. The excessive existing and new information without proper filtering process lead to increase in documentation and affect the quality of knowledge created [29]. However, many authors exclude the filtration stage during knowledge creation (e.g. [30]–[32]) except [33] which include filtration stage at the end of knowledge creation cycle, however to the author's knowledge none apply knowledge creation concept in PS context.

Third, although crucial ideas from the customer are captured, and firm skills and experiences are enormous, that knowledge has less impact if they cannot be converted, integrated, applied and shared. Since new knowledge is the source of innovation, it is crucial to interpret knowledge obtained and to integrate with firm's owned knowledge to improve current product design and its capabilities. The

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previous research has proven knowledge creation process affect new product development [34]–[36] product success [37], service quality [22] and co-creation for new product development [38]. Knowledge creation process (KCP) can also be conceptualized as a mediator variables between external knowledge and service quality [22]; and buyer-seller social capital and innovation [39]. However, study to test KCP during product design in PS is a mediator between product-service performance and CKE and FIKE.

Understanding the importance of knowledge creation process, therefore the research address three main research question: How knowledge creation process in PS design affect the performance of PS system? The main research question can be answered by the following questions: Do CKE and FIKE enhance KCP during new PS design, and if so, how? How does filtration process play its role in KCP during new PS design? How does the absence of KCP during new PS design will affect the performance of PS? As such, the research main objectives are threefold: first to investigate and explore the role of CKE and FIKE in facilitating KCP during PS design; second to examine how filtration process fit into the existing KCP and enhance PSP; third to examine the role of KCP as a mediator between CKE and PSP, and FIKE and PSP.

The research provides three genuine contributions for literature on knowledge creation process. First the study deepens our understanding how a theoretical framework with additional concept of filtration enhance the knowledge creation process and yield to better PSP. Second, identify crucial input factors such as CKE and FIKE from the middle of life and end of life of a product development stage to improve PS design through new knowledge creation. Third, discover the importance of KCP in creating more creative, newness, and distinguished knowledge which enhance PSP. In Section II, we will introduce PS development phase, knowledge creation process, customer knowledge followed by our conceptual framework in Section III. In Section IV we conclude this research by discussion and conclusion remark.

II. Theoretical Development and Hypothesess

A. PS Development Phase

With adequate resources and supported, PS will be success, if the product critical success factor such as distinctive paybacks to customers, high quality, innovative design, and reasonable price are well planned, designed and implemented [40]. In new product development, the product is created based on market needs that determine the firm success and competitiveness. Furthermore, the information can be collected by understanding the market needs through having communication with them. PS development integrate alignment of existing design and its realization processes of both product and services [41] which apparently becomes a challenge to manufacturing firm, when the firm processes and approaches have to match with the new system [42]. In addition, the provider core capabilities in manufacturing physical products and its corporate culture may lead to anticipated solutions related to the product but in restrict manner [41]. The product development process must ensure the functionality and services are offered to customers, as such integrated PS development integrate tangible product and intangible service to provide solution to customers [43] instead of pure product ownership [44].

Previous research on new product development can be found in many studies (e.g. [4], [17], [45]). Ref. [45] state several phases in product development include (a) Beginning of life (BOL) which refer to the starting point new product concept is developed, clearly defined, manufactured and delivered to customers; (b) Middle of life (MOL) is the utilization of product, services delivered and maintenance for the product; (c) End of life (EOL) product refers to the stage that product is recycled, remanufactured, reused or disposed. Having similar layout of product development, as proposed by [17], the modified version of PS development using CKE and FIKE is shown in Fig. 1.

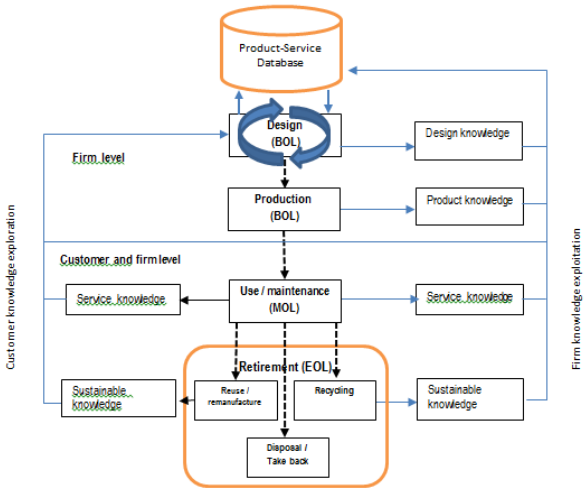

Fig. 1. PS product life cycle for knowledge exploration and exploitation. Modified version of [17].

B. How CKE and FIKE Are Transferred from One Process to Another and Create New Knowledge during PS Design and Development Phase

There are many models related to managing knowledge, among them are von Krogh and Roos, Nonaka/Takeuchi, Choo, Wiig, Boisot and Bennet [46]. These models help firms to appreciate what they have gone through and forecast the future. However, in this research, only Nonaka and Takeuchi model is discussed in detailed, as it is seen relevant in the context of the KCP. Nonaka & Takeuchi's knowledge creation model is a dynamic model by assuming human knowledge interplay between tacit knowledge and explicit knowledge through human interaction between persons known as Socialization, Externalization, Combination and Externalization (SECI) [47]. During the development of integrated product and service, several types of knowledge are required, they are explicit knowledge (strategies and rationale for products and processes), and tacit knowledge (awareness or insight about processes) [48] and conversion process of new customer tacit knowledge into explicit knowledge. Another element of knowledge filtration is added to Nonaka's model to purify the quality of knowledge captured and prior knowledge owned by employees through scanning and selection process shown in Fig. 2. Those firms who fail to leverage firm knowledge effectively will suffer

various information related anxiety and face challenge of keeping up with high volume of information that poorly organized and difficult to access and summarize [49]. It also affects stress on individuals in terms of mental overload [50], productivity and financial losses to firms [51]. Several criteria used to scan the knowledge captured: safety, newness, and relevance. Once, scanning process are done, next step is to choose which knowledge is the best suited with the firm's business objectives.

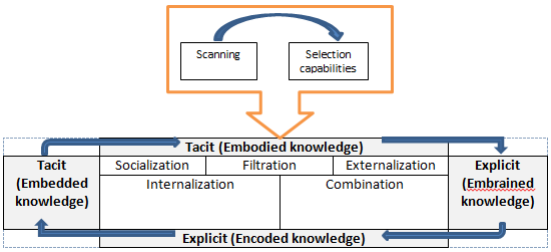

Fig. 2. Modified knowledge creation model.

III. Research Model

This research model comprises of four main constructs, CKE, FIKE, KCP in PS design and PSP. The research model of the study is as shown in Fig. 3.

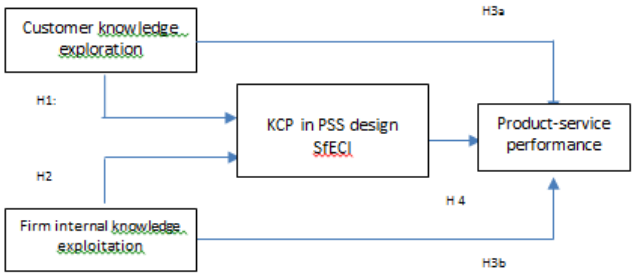

Fig. 3 Research model.

A. CKE, FIKE and KCP

Socialization. Employees gather knowledge by learning from past experience, developing and extending the FIKE [5] such as expert knowledge, diagnosis skills, facilities and professional equipment, experience, objectivity and integrity, ethical codes; and relational capital [52]. This knowledge can be gathered from different employees at different stages of PS development phase: product design, manufacturing, use-phase and retirement phase. In addition, new knowledge can be obtained from external sources through socializing with customers [32]. During idea generation, provider starts identifying customer demands through customer suggestion and complaint [53] based on PS operation, direct experience, outcome and value received [54]. In order to solve the current problem, it requires defining problems appropriately, which lead to specifying the requirement that meets PS characteristics. This can be done by focusing on lead users of a product or processes [55]. Different approaches may be used to acquire such knowledge such as customer visits, brainstorming with customer, dialogues, in-depth interviews, knowledge repository / firm databases, customer management systems, and decision support tools, observations of social networking sites, blog, online communities, and forum. These "experiential sharing" or exchange of specialized skills enhances new knowledge created during PS design.

Filtration. Filtration is a process where knowledge gathered or created is filtered to ensure knowledge obtained conform to the firm predefined goals and objectives [56] and potential harmful knowledge will be eliminated from the database [57]. This step requires careful discussion among team members to decide which knowledge will stay or face out. Unnecessary, spillover or redundant knowledge are discarded to improve the quality of knowledge asset using the filtering system [58]. Only unique, relevant, and potential knowledge will be selected for creation of new knowledge. The more customer knowledge captured, the more filtration process has to take place, to purify new knowledge obtained. As for FIKE, the filtration process is as equally required for CKE. The reason is knowledge can decline in value based on several factors, such as time, environment, different sectors/ target customers, and technology changes. Thus, filtration process applies to newly captured knowledge or prior knowledge owned by employees.

Externalization. In the externalization stage, customer knowledge is articulated in common terms and explicit concepts such as metaphors, analogies, hypotheses and models [59], images, symbols, and language including design and product concepts [60]. Nonaka & Takeuchi also refer this activity as "creating new concept'. For example in PS modelling, both product and service are equally important, thus the designing of both aspects must take place concurrently at the beginning of the new PS development [61]. Customer support during after-sales service is crucial for customer satisfaction, firm competitiveness, increase product success [62]. As such the authors suggest, the concept of service should be designed in the product for cost efficiency and effectiveness. Furthermore, the decision making during designing new product concept will affect product reliability, maintenance and repair [62]. Because of that, customers' feedback from the use-phase and retirement stage must be analyzed carefully and need to be translated into understandable meaning. Therefore, a new concept of the new solution can be determined. At this stage, not only CKE is important, but FIKE such as experiences gathered through all stages in PS development. By utilizing IT application system [63], the interaction of both knowledge can be simplified.

Combination. FIKE such as experience, mental models, and thoughts and the new explicit knowledge articulated by individual employees are combined with other employee knowledge, later processed into more complex and systematic, explicit knowledge [64]. For example in PS design, once, new unique ideas either related to product or its services functions are collected, customers' need can be developed by combining with FIKE [42] such as skills, strategy, and previous experiences gathered during PS developments. The combination process involves reconfigure current explicit knowledge through sorting, adding, reorganizing, and combining processes which yield to new explicit knowledge [65] using IT system [64]. The service concept is a solution to a customer problem through activities and interaction experienced during consumption. Seven examples of service elements suggested by [62]: installation, user training, documentation, maintenance and repair, on-line support,

warranty, and upgrades. Another product concept that need to be incorporated during product design is sustainability issue, in terms of reduce waste, reduce the usage of material, recyclable and re-use material and easy to disassemble for disposal [66]. Later, new concept must be analyzed in terms of its feasibility such as technical availability, adaptability, viability, and cost-benefit before it is executed. Once the detail design is defined, a model or a prototype is built to validate, and verify the product design appear as what it is planned.

Internalization. During internalization process, embedded knowledge such as shared norm and firm routines are formed once explicit encoded knowledge is transformed into new tacit knowledge by embodying explicit knowledge through learning by doing, training, documentation or simulations [67]. During training, new product and service concept are applied so they become individual's knowledge [64]. Later, this trigger a new cycle of knowledge creation when team members socialize and share the new ideas [67]. This phase is crucial [68] as it affects knowledge creation and respond to changes, innovate and achieve firm competitive advantage. It also contributes to the development of competency among employees and innovative capability of the firm. In order to allow knowledge can be reused for future use, knowledge should be recycled and upgraded whenever necessary. Finally this collective new concept and design knowledge is transformed into new tacit when it is embodied in shared norm and firm routines through learning by doing, training and simulation [67]. At this stage, an increase in capturing customer knowledge will increase the ability of employees to embodying explicit knowledge, similarly firm past experiences are crucial input for new knowledge creation.

B. CKE, FIKE and PSP

A customer value proposition is the basis understanding how the products or services are experienced by the target user and gain the benefits of consuming the products. It is the core element of business model and the first step in developing a business model that describes the logic connection of products and services offer to the customer [69] and solve customers' needs or their problems [70]. The relationship between firms and their customers is clearly defined by value proposition, which develop not because of specific products or services but relatively by the value exchange between provider and intended users whom the products are designed for [71]. Without customer value proposition, it is similar to business without the target in the marketplace. Hence, new product development is considered success when it can contribute to earning revenue and meeting firm objectives by fulfilling customer needs and satisfaction PSP is measured based on product and service quality. Product quality include such as product functionality, durability, compatibility, its design [37] and price [72]. The service quality measures the effective and efficient transformation of resources in the form of services that satisfy customer's need [73].

The objectives of CKE are to enhance customer satisfaction through value proposed to them besides gaining other benefits such as innovativeness [74] flexibility, timely response to customer demands, long term relationship and increase in revenue [75]. Furthermore, previous study already proved customer knowledge provides some sort of benefits such as PS offering [76], service quality [22], and firm's sustainable innovation [77]. Similarly, FIKE is also an important enabler for PS design, quality, and its development speed [17]. The provider may customize product offering by utilizing its resources to identify specific patterns and rules regarding domain-specific knowledge about customer needs through relationship invested for their knowledge exchange [78]. The capabilities of the provider to create new and utilize previous knowledge is depending on how the provider interprets and integrate them [45]. Previous research has clearly stated that exploitation and exploration activities have a different effect on firm performance [79]. It seems that FIKE improves current performance in the existing environment in terms of its efficiency and effectiveness of the existing system. On the other hand, CKE provides long-term benefit through employees' abilities, experience, training and skills are enhanced internally from time to time to perform the assigned task [79]. This may affect the efficiency and effectiveness of product offering while at the same time innovate the approach used to deliver customer service. PSP is the final research output or value proposed to customers based on product design performance.

C. KCP and PSP

Socialization. Knowledge captured from service delivery during use-phase and retirement stage is crucial for product design phase to enhance existing and future product design. The customer may share their personalized experience [80] with the team members for example personal expertise, value search [81], feeling, emotion, experience and mental model [80] through creative dialogue. This knowledge provides idea generation to solve current problem by focusing on lead users as they represent strong influences of a future product or process [37]. Socialization during concept development with customers enable customer experiential learning in terms of product quality standards, design of products, production plans, and costs are shared [75]; allow PS provider to be in a better position to integrate their knowledge for innovative product concept [37]; and ensure the concept for the new functionality meets their requirements [82].

Filtration. Through socialization process, however, ideas or suggestions captured can be enormous that lead to knowledge spillover. In addition, the high volume of knowledge may not guarantee they meet the pre-specified quality and conform to the firm predefined goals and objectives [56]. Harmful knowledge should be discarded from the firm database [57] as they cause firm to have difficulties in searching, handling, evaluating knowledge, and making right decision, besides facing disappointment and personal stress [49]. Only, unique, relevant, and potential knowledge will be considered for the creation of new knowledge. The more CKE and FIKE, the more filtration process activities will take place to purify new or existing knowledge according to specified targets in designing new integrated PS.

Externalization. During the planning stage the focus is on generating new knowledge, new solution for both types of PS developments by identifying customer suggestions and

complaints [53]. The key ideas are to define problems appropriately which lead to specifying the requirement that meet PSP. One way is to focusing on lead users of a product or processes as they represent strong influence of a future product or process [55]. After distinguished ideas captured from customers, employee generates understanding of what to be developed by externalizing the understanding into metaphors or concept creation. By identifying the customers' need, customer satisfaction is enhanced. During this mode, the team able to apply metaphor to replicate the current requirement in future product that enabled them to produce the desired effects and create new concept. This mode is crucial during product design for both product and service modeling. PS design focus on the durability of a product by reducing resources usage without jeopadising the quality [13], enhance existing customers' value [7] generate more profit [8] and reduce environmental effect [9], [12].

Combination. Internal and external knowledge design are combined, expecially knowledge from service designers or customers feedbacks on service, maintenance and product retirement. These feedbacks are required to create new complicated and systematic concepts: diagrams, flowcharts, graphs, and models, which will enhance previous design in terms of product functions or service quality. Combination assists the new product based on the firm's existing capabilities, technically and economically thus project team has a better understanding of the new product concept created objectives and requirement [37].

Internalization. In planning for concept design, PS focus to generate as many ideas that might be feasible for developing PS. Internalization of explicit knowledge to tacit knowledge (embodying explicit knowledge into tacit knowledge) stimulates the realization of new product innovation in the firm [83]. New knowledge in terms of technical know-how or mental model [65] which can improve service processes and performances are internalized via application or participation [84], simulation or experiment [64]. The new knowledge applied through prototyping, testing and benchmarking then disseminated to other functional units. Furthermore, many studies have proven internalization lead to greater flexibility in distributing information [84] that leads to better idea generation in planning and designing PS, reduce response time and obtaining better adaptation of environmental change. Finally, the newly created concept is disseminated to other unit during planning and implementation of product design.

D. The Mediating Effect of KCP in PS Design on CKE-FIKE and PSP

PS delivery, offer several benefit life and use, efficient use of resources, reduced life-cycle environmental impact [85]. At the same time, customer gain benefits in terms of accessibility, evolve-ability, interoperability, maintainability, modularity, portability and scalability [85]. In other words, customers may enjoy new functionalities and value delivered to them through service enhancement. In product development, customer knowledge and firm experience provide valuable knowledge to design new product concept. New knowledge created through KCP: sharing, filtering, creating concepts, justifying new concept, and application of new concepts. Without KCP, the interaction between new knowledge captured from external sources and previously acquired knowledge may have little impact on new knowledge creation thus performance of an integrated PS becomes stagnant. Previous finding by [22] shows knowledge chain play full mediated role between external knowledge and service quality. The mediator, at this point provides a process where internal and external knowledge can be interpreted, upgraded, applied and shared in the new project development.

IV. Conclusion

The study has implication on theoretical and practical. First, in terms of theoretical the paper offers novel views of how the KCP using SEfCI approach during an integrated PS design to mediate the effect between the PSP and CKE and FIKE. Second, additional process during knowledge creation, Filtration is added to the original SECI process to ensure the information gathered during socialization is filtered according to the firm's objective and requirement. Third, the research also demonstrates the importance of new search especially customer knowledge from the user-pays and retirement stage during the PS product design, while at the same time maintain the exploitation of existing capabilities to enhance new concept creation that has the ability to embed the service and end-of-life options in the product design.

References

[1] Y. Park, Y. Geum, and H. Lee, "Toward integration of products and services: Taxonomy and typology," *J. Eng. Technol. Manag.*, vol. 29, no. 4, pp. 528–545, Oct. 2012.

[2] F. Akasaka, Y. Nemoto, K. Kimita, and Y. Shimomura, "Development of a knowledge-based design support system for product-service systems," *Comput. Ind.*, vol. 63, no. 4, pp. 309–318, May 2012.

[3] V. K. Velamuri, A.-K. Neyer, and K. M. Möslein, "Hybrid value creation: a systematic review of an evolving research area," *J. fÜr Betriebswirtschaft*, vol. 61, no. 1, pp. 3–35, Mar. 2011.

[4] C. Durugbo and J. C. K. H. Riedel, "Readiness assessment of collaborative networked organisations for integrated product and service delivery," *Int. J. Prod. Res.*, vol. 51, no. 2, pp. 598–613, Jan. 2013.

[5] T. Alonso-Rasgado, G. Thompson, and B.-O. Elfström, "The design of functional (total care) products," *J. Eng. Des.*, vol. 15, no. 6, pp. 515–540, Dec. 2004.

[6] H. N. Nguyen, C. Schnürmacher, and R. Stark, "Research on how to introduce the PSS engineering into industry," *Procedia CIRP*, vol. 16, pp. 74–79, 2014.

[7] S. Kang and S. A. Snell, "Relational arhetypes, organizational learning, and value creation: Extending the human resource architecture," *Acad. Manag. Rev.*, vol. 32, no. 1, pp. 236–256, 2007.

[8] B. W. Husted and D. B. Allen, "Strategic corporate social responsibility and value creation," *Manag. Int. Rev.*, vol. 49, no. 6, pp. 781–799, Dec. 2009.

[9] Y. Shimomura, Y. Nemoto, and K. Kimita, "State-of-art product-service systems in Japan — The latest Japanese product-service systems developments," *Procedia CIRP*, vol. 16, pp. 15–20, 2014.

[10] K. Ueda, T. Takenaka, J. Váncza, and L. Monostori, "Value creation and decision-making in sustainable society," *CIRP Ann. — Manuf. Technol.*, vol. 58, no. 2, pp. 681–700, Jan. 2009.

[11] W. Reim, V. Parida, and D. Örtqvist, "Product-service systems (PSS) business models and tactics — A systematic literature review," *J. Clean. Prod.*, Jul. 2014.

[12] M. J. Goedkoop, C. J. G. Halen, H. R. M. Riele, and P. J. M. Rommens, *Product Service systems, Ecological and Economic Basics*, March 1999.

[13] O. K. Mont, "Clarifying the concept of product — Service system," *J. Clean. Prod.*, vol. 10, pp. 237–245, 2002.

[14] C. K. Prahalad and V. Ramaswamy, "Co-creation experiences: The next practice in value creation," *J. Interact. Mark.*, vol. 18, no. 3, pp. 5–14, Jan. 2004.

[15] J. S. Denford, "Building knowledge: Developing a knowledge-based dynamic capabilities typology," *J. Knowl. Manag.*, vol. 17, no. 2, pp. 175–194, 2013.

[16] R. M. Guidice, J. T. Heames, and S. Wang, "The indirect relationship between organizational-level knowledge worker turnover and innovation: An integrated application of related literature," *Learn. Organ.*, vol. 16, no. 2, pp. 143–167, 2009.

[17] D. Zhang, D. Hu, Y. Xu, and H. Zhang, "A framework for design knowledge management and reuse for product-service systems in construction machinery industry," *Comput. Ind.*, vol. 63, no. 4, pp. 328–337, May 2012.

[18] W. Song, X. Ming, and Z. Xu, "Risk evaluation of customer integration in new product development under uncertainty," *Comput. Ind. Eng.*, vol. 65, no. 3, pp. 402–412, Jul. 2013.

[19] C. W. Y. Wong, C. Y. Wong, and S. Boon-itt, "The combined effects of internal and external supply chain integration on product innovation," *Int. J. Prod. Econ.*, vol. 146, no. 2, pp. 566–574, Dec. 2013.

[20] M. Schaarschmidt and T. Kilian, "Impediments to customer integration into the innovation process: A case study in the telecommunications industry," *Eur. Manag. J.*, vol. 32, no. 2, pp. 350–361, Apr. 2014.

[21] R.-H. Weng and C.-Y. Huang, "The impact of customer knowledge capability and relational capability on new product development performance in Taiwan's hospitals," in *Proc. 2010 7th International Conference on Service Systems and Service Management*, 2010, pp. 1–6.

[22] S.-M. Tseng, "Correlations between external knowledge and the knowledge chain as impacting service quality," *J. Retail. Consum. Serv.*, vol. 19, no. 4, pp. 429–437, Jul. 2012.

[23] S. Ahmed-Kristensen and G. Vianello, "A model for reusing service knowledge based on an empirical case," *Res. Eng. Des.*, vol. 26, no. 1, pp. 57–76, Oct. 2015.

[24] N. Morelli, "Product-service systems, a perspective shift for designers: A case study: the design of a telecentre," *Des. Stud.*, vol. 24, pp. 73–99, 2003.

[25] I. Nonaka and G. von Krogh, "Perspective — Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory," *Organ. Sci.*, vol. 20, no. 3, pp. 635–652, Jun. 2009.

[26] V. Y. Yoon, R. E. Hostler, Z. Guo, and T. Guimaraes, "Assessing the moderating effect of consumer product knowledge and online shopping experience on using recommendation agents for customer loyalty," *Decis. Support Syst.*, vol. 55, no. 4, pp. 883–893, Nov. 2013.

[27] S. Bergamaschi and B. Leiba, "Information overload," 2010.

[28] A. Addis, G. Armano, and E. Vargiu, "Using progressive filtering to deal with information overload," pp. 0–4, 2010.

[29] I. Anette Wulff, B. Rasmussen, and R. H. Westgaard, "Documentation in large-scale engineering design: Information processing and defensive mechanisms to generate information overload," *Int. J. Ind. Ergon.*, vol. 25, no. 3, pp. 295–310, 2000.

[30] M. Alavi and D. E. Leidner, "Knowledge management and knowledge management systems: Conceptual foundations and research issues," *MIS Q.*, pp. 107–136, 2001.

[31] B. S. Sandhawalia and D. Dalcher, "Developing knowledge management capabilities: A structured approach," *J. Knowl. Manag.*, vol. 15, no. 2, pp. 313–328, 2011.

[32] T. Andreeva and A. Kianto, "Knowledge processes, knowledge-intensity and innovation: A moderated mediation analysis," 2011.

[33] L. Karadsheh, "A theoretical framework for knowledge management process: Towards improving knowledge performance," *Commun. IBIMA*, 2009.

[34] A. Richtnér and P. Åhlström, "Top management control and knowledge creation in new product development," *Int. J. Oper. Prod. Manag.*, vol. 30, no. 10, pp. 1006–1031, 2010.

[35] N. Jing and C. Yang, "The interrelationship among learning environment, knowledge process and new product development performance," in *Proc. 2010 IEEE Int. Conf. Ind. Eng. Eng. Manag.*, pp. 144–148, Dec. 2010.

[36] B. L. Winegard, "Knowledge creation in new product development teams: A contingency theory of the effectiveness of knowledge integration mechanism," York University Toronto, Ontario, 2010.

[37] A. Schulze and M. Hoegl, "Knowledge creation in a new product development projects," *J. Manage.*, April, pp. 1–45, 2005.

[38] F. Kohlbacher, "Knowledge-based new product development: Fostering innovation through knowledge co-creation," *Int. J. Technol. Intell. Plan.*, vol. 4, no. 3, p. 326, 2008.

[39] Y.-H. Tsai, S.-W. Joe, C. G. Ding, and C.-P. Lin, "Modeling technological innovation performance and its determinants: An aspect of buyer–seller social capital," *Technol. Forecast. Soc. Change*, vol. 80, no. 6, pp. 1211–1221, Jul. 2013.

[40] S. L. Brown and K. M. Eisenhardt, "Product development: Past research, present findings, and future directions," *Acad. Manag. Rev.*, vol. 20, no. 2, pp. 343–378, 1995.

[41] J. C. Aurich *et al*., "Configuration of product-service systems," *J. Manuf. Technol. Manag.*, vol. 20, no. 5, pp. 591–605, 2009.

[42] P. Marques, P. F. Cunha, F. Valente, and A. Leitão, "A methodology for product-service systems development," *Procedia CIRP*, vol. 7, pp. 371–376, Jan. 2013.

[43] K. Exner, K. Lindow, C. Buchholz, and R. Stark, "Validation of product-service systems — A prototyping approach," *Procedia CIRP*, vol. 16, pp. 68–73, 2014.

[44] T. S. Baines, H. W. Lightfoot *et al*., "State-of-the-art in product-service systems," in *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, vol. 221, no. 10, pp. 1543–1552, Jan. 2007.

[45] P. Hadaya and P. Marchildon, "Understanding product lifecycle management and supporting systems," *Ind. Manag. Data Syst.*, vol. 112, no. 4, pp. 559–583, 2012.

[46] S. Cristea and A. Capatina, "Perspectives on knowledge management models," *Ann. "Dunarea Jos" Univ. Galati. Econ. Appl. Informatics.*, vol. 2, pp. 355–366, 2009.

[47] I. Nonaka and N. Konno, "The concept of 'Ba': Building a foundation for knowledge creation," *Calif. Manage. Rev.*, vol. 40, no. 30, pp. 40–15, 1998.

[48] S. A. Schenkl, D. M. Schmidt, D. Schockenhoff, and M. Maurer, "Knowledge evaluation for PSS providers," *Procedia CIRP*, vol. 16, pp. 86–91, 2014.

[49] J. MacDonald, P. Bath, and A. Booth, "Information overload and information poverty: challenges for healthcare services managers?" *J. Doc.*, vol. 67, no. 2, pp. 238–263, 2011.

[50] J. B. Strother and J. M. Ulij, "The challenge of information overload," in *Prof. Commun. Conf. (IPCC), IEEE Int. IEEE*, Oct. 2012.

[51] M. Cloete and R. Snyman, "The enterprise portal — Is it knowledge management?" *Aslib Proc.*, vol. 55, no. 4, pp. 234–242, 2003.

[52] L. Aarikka-Stenroos and E. Jaakkola, "Value co-creation in knowledge intensive business services: A dyadic perspective on the joint problem solving process," *Ind. Mark. Manag.*, vol. 41, no. 1, pp. 15–26, Jan. 2012.

[53] C. Homburg and C. Kuehnl, "Is the more always better? A comparative study of internal and external integration practices in new product and new service development," *J. Bus. Res.*, vol. 67, no. 7, pp. 1360–1367, Jul. 2014.

[54] J. Clark, "Materials and methods," p. 1, 2001.

[55] V. Hippel, "Lead users: a source of novel product concepts," *Manage. Sci.*, vol. 32, no. 7, pp. 791–805, 1986.

[56] Jamal El-Den, "Knowledge transfer in virtual groups," in *Proc. the 3rd International Conference on Intellectual Capital and Knowledge Management*, 2006, pp. 157–166.

[57] S. Markovitch and D. Paul, "Information filtering: Selection mechanisms in learning systems," *Mach. Learn.*, vol. 10, pp. 113–151, 1993.

[58] D. Yingnan, L. Yuduo, and Q. Xiongfei, "Spatial knowledge spillovers: 'New 3-zone interaction engineering,'" *Syst. Eng. Procedia*, vol. 3, pp. 307–311, 2012.

[59] I. Nonaka and H. Takeuchi, *The Knowledge-Creating Company*, Oxford University Press, 1995.

[60] W. D. Schulte, "Exploring the role of Ba in family business context," *VINE J. Inf. Knowl. Manag. Syst.*, vol. 38, no. 1, pp. 104–117, 2008.

[61] X. Geng, X. Chu, and Z. Zhang, "An association rule mining and maintaining approach in dynamic database for aiding product–service system conceptual design," *Int. J. Adv. Manuf. Technol.*, vol. 62, no. 1–4, pp. 1–13, Dec. 2011.

[62] K. Goffin and C. New, "Customer support and new product development an exploratory study," *J. Oper. Prod. Manag.*, vol. 21, no. 3, pp. 275–301, 2001.

[63] L. Varra, C. Buzzigoli, and R. Loro, "Innovation in destination management: Social dialogue, Knowledge Management processes and Servant leadership in the tourism destination observatories," *Procedia — Soc. Behav. Sci.*, vol. 41, pp. 375–385, Jan. 2012.

[64] I. Nonaka and R. Toyama, "The knowledge-creating theory revisited: Knowledge creation as a synthesizing process," *Knowl. Manag. Res. Pract.*, vol. 1, pp. 2–10, 2003.

[65] M. A. Chatti, "Knowledge management: A personal knowledge network perspective," *J. Knowl. Manag.*, vol. 16, no. 5, pp. 829–844, 2012.
[66] K. S. Khor and Z. M. Udin, "Reverse logistics in Malaysia: Investigating the effect of green product design and resource commitment," *Resour. Conserv. Recycl.*, vol. 81, pp. 71–80, Dec. 2013.
[67] I. Nonaka, R. Toyama, and N. Konno, "SECI , ba and leadership: A Uni ® ed model of dynamic knowledge creation," *Long Range Plann.*, vol. 33, pp. 5–34, 2000.
[68] P. D. D. Dominic, "The use of KMS in organizations: A conceptual framework and preliminary tests of instruments," *Natl. Postgrad. Conf. IEEE*, p. 2011, 2011.
[69] O. Petrovic and C. Kittl, "Capturing the value proposition of a product or service position paper for the international workshop on business models lausanne, Switzerland, 4.10.2003," 2003.
[70] OECD, "The future of eco-innovation: The role of business models in green transformation," Copenhagen Denmark, 2012.
[71] F. Boons, C. Montalvo, J. Quist, and M. Wagner, "Sustainable innovation, business models and economic performance: an overview," *J. Clean. Prod.*, vol. 45, pp. 1–8, 2013.
[72] D. Morschett, "Firm-specific influences on the internalization of after-sales service activities in foreign markets," *J. Serv. Mark.*, vol. 20, no. 5, pp. 309–323, 2006.
[73] B. Yoon, S. Kim, and J. Rhee, "An evaluation method for designing a new product-service system," *Expert Syst. Appl.*, vol. 39, no. 3, pp. 3100–3108, Feb. 2012.
[74] H. Yli-Renko, E. Autio, and H. J. Sapienza, "Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms," *Strateg. Manag. J.*, vol. 22, no. 6–7, pp. 587–613, Jun. 2001.
[75] C. Claycomb, C. Dröge, and R. Germain, "Applied customer knowledge in a manufacturing environment: Flexibility for industrial firms," *Ind. Mark. Manag.*, vol. 34, no. 6, pp. 629–640, Aug. 2005.
[76] M. a. Abebe and A. Angriawan, "Organizational and competitive influences of exploration and exploitation activities in small firms," *J. Bus. Res.*, vol. 67, no. 3, pp. 339–345, Mar. 2014.
[77] S. Ayuso, M. Á. Rodríguez, R. García-Castro, and M. Á. Ariño, "Does stakeholder engagement promote sustainable innovation orientation?" *Ind. Manag. Data Syst.*, vol. 111, no. 9, pp. 1399–1417, 2011.
[78] P.-C. Sun, "The correlations among domain knowledge specificity, joint new product development and relationship performance," *Int. J. Commer. Manag.*, vol. 17, no. 1/2, pp. 44–55, 2007.
[79] A. Bocanet and C. Ponsiglione, "Balancing exploration and exploitation in complex environments," *VINE J. Inf. Knowl. Manag. Syst.*, vol. 42, no. 1, pp. 15–35, 2012.
[80] S. M. Hosseini, "The application of SECI model as a framework of knowledge creation in virtual learning," *Asia Pacific Educ. Rev*, vol. 12, pp. 263–270, 2011.
[81] A. K. Paswan, D. D'Souza, and R. K. Rajamma, "Value co-creation through knowledge exchange in franchising," *J. Serv. Mark.*, vol. 28, no. 2, pp. 116–125, 2014.
[82] K. Kimita and Y. Shimomura, "Development of the design guideline for product-service systems," *Procedia CIRP*, vol. 16, pp. 344–349, 2014.
[83] Y.-H. Li, J.-W. Huang, and M.-T. Tsai, "Entrepreneurial orientation and firm performance: The role of knowledge creation process," *Ind. Mark. Manag.*, vol. 38, no. 4, pp. 440–449, May 2009.
[84] K. J. L. and S. P. Gudergan, "Knowledge integration in organizations: an empirical assessment," *J. Knowl. Manag.*, vol. 10, no. 4, pp. 43–58, 2006.
[85] J. R. A. C. Durugbo, A. Tiwari, "Managing Information Flows for Product-Service Systems Delivery," in *Proc. CIRP IPS Conference 2010, Sakao, Tomohiko Larsson, Tobias Lindahl, Mattias*, 2010, pp. 365–370.

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