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Knowledge Asymmetries and Service Management: Three Case Studies

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Abstract

The purpose of this paper is to investigate how information systems are used by knowledge-intensive service firms and identify their effects on client-provider interactions. The paper uses data from case studies of service-related departments of three multinational firms. We identified several broad trends present in all three case companies. The degree of knowledge specialisation required, coupled with the ability to leverage knowledge created during service interactions resulted in high degrees of knowledge asymmetries between service provider and clients, which led to clients becoming the recipients of knowledge rather than co-creators. Differences between the cases related to the varying degrees to which information systems had been used to support service interactions. We therefore provide a model that outlines three key phases of activity. Individualization involves the categorization and location of tacit knowledge. This was followed by the codification and leveraging of service interactions through standardization. Finally, the ability to provide alternative, more customized services, was achieved through modularization. Increasing levels of specialization of labor resulted in increasing knowledge asymmetries between service provider and client, reducing the need for client participation and co-production. Firms progress through three stages of development using information systems to support leveraging knowledge required for service delivery. The findings are based on case studies of departments within three multinational firms and would benefit from further empirical testing. The paper contributes to the existing literature in several ways. It focuses specifically on knowledge-intensive service firms, where labor is highly specialized. It gives information systems an explicit and significant role in examining how service elements may be leveraged. Finally, it outlines an exploratory model for managing this process.

1. INTRODUCTION

The purpose of this paper is to investigate how information systems are used by knowledge-intensive service firms and identify their effects on client-provider interactions, and to examine the interaction between service provider and customer as well as the balance to be struck between providing unique and standardized services. Service innovation or servitization (Burton et al., 2017, Shi et al., 2017, Lindstrom et al., 2015) is a key concern for many firms (Kindstrom et al., 2013) because it is a critical way for firms to differentiate themselves from their competitors (Bitner et al., 2008), and sustain competitive advantage while honing their key capabilities (Burton et al., 2017, Salunke et al., 2013, Gray et al., 2007, Johne and Storey, 1998) as well as being a key factor both in economic growth and innovation strategy (Sakata et al., 2013). Due to commoditization, there has been an increasing need for some product-centric firms to add a service component to remain

competitive (Spring and Araujo, 2013). This involves firms strategically repositioning themselves from being manufacturers to providing customized solutions (Nordin et al., 2011b; Nordin and Kowalkowski, 2010; Olivia and Kallenberg, 2003; Brady et al., 2005; Davis, 2004).

Previously, innovation researchers "disregarded" service activities (Vence and Trigo, 2009a) which were "stigmatised" in the economic literature (Djellal and Gallouj, 2005) in preference of a focus on products (Kindstrom and Kowalkowski, 2009). This negative view existed in spite of services accounting for over 70% of GDP and employment in most developed countries (Gallouj, 2002; Rubalcaba et al., 2012). Seen as "innovation laggards" (Freel, 2006), few studies have focused on innovations in services, with a number of authors arguing research of this topic is still at an early stage (Van Der Aa and Elfring, 2002; Toivonen and Tuominen, 2009; Bitner et al., 2008; Hauser et al., 2006). Rubalcaba et al. (2012) argue that opportunities for research in service innovation are interdisciplinary and multidimensional and that research should address how firms systematize such change. It is also important to recognize differences within the services sector. As Vence and Trigo (2009b) argue, service firms are involved in diverse and differentiated areas of activity so that there are significant differences among the processes they follow to be innovative.

2. THEORETICAL BACKGROUND

2.1 SERVICE STANDARDIZATION VERSUS UNIQUENESS

Each service transaction may result in a particular set of circumstances, either in response to a specific client problem or as a result of production on demand (Gallouj and Weinstein, 1997a). In addition, high degrees of interaction with clients can lead to the development of customized products (Xie et al., 2016; Vence and Trigo, 2009a). The chances of improving efficiency through codification, so as to achieve standardization, are reduced where "bespoke service provision" exists (Bettiol et al., 2012) or where it is unlikely the customer's problem will be repeated (Sundbo, 1997).

That some service characteristics cannot be determined a priori means that the firm may not be able to create products that are perfectly codified or standardized (Gallouj and Weinstein, 1997a). Providing highly customized solutions requires providers have a better understanding of their customers that enable the development of closer relationships (Nordin et al., 2011b) as outlined in Section 2.2. Such customized offerings involve the risk of higher costs due to a need for dedicated resources, customer-specific knowledge, and a requirement to continually adjust the offering in line with changes in the needs and situation (Johnson and Selnes, 2004). The ability of both front- and back-office activities to adapt to service the customers' needs are, according to Aranda and Molina-Fernandez (2002), a source of innovation. For a new service concept or formula to be diffused requires it to be codified, with its essential elements transplanted to other parts of the firm: this in itself being an important firm capability (Den Hertog et al., 2010). Service automation has been facilitated by information technology (Rust and Miu, 2006), leading to more self-service and pushes to standardize services and create mass production (Sundbo, 1994; Sundbo, 2008).

Olivia and Kallenberg (2003) argue that a balance needs to be struck between standardization, where services are transferable across markets, and customization, where they are tailored to specific customers. Davies et al. (2007) found approximately three-quarters of telecoms solutions in Eriksson were based on predefined service modules with only a quarter being customized. Bettiol et al. (2012) point out that some studies (Peters and Saidin, 2000; Sundbo, 2002) found knowledge-intensive service firms took a modular approach to providing services, combining standardization with final service customization; this also provided additional efficiency and reduced cost (Qu et al., 2016). A balance is indicated by Nordin et al. (2011b) who suggest that a compromise is possible through modularity where components can be reconfigured based on customer needs, such as through the assembly of standard products and services. Less complex services require exploitation, while new process-orientated solutions require exploration (Kowalkowski et al., 2011a).

According to Rust and Miu (2006), the way in which services are performed has been "revolutionised" by technologies, which enable long-term individualized relationships with customers to be developed. The service provider can use codification to exploit high levels of replication of knowledge developed through standard codified services (Bettiol et al., 2012).

2.2 CUSTOMER-PROVIDER INTERACTION:

There is more interaction and feedback from customers in services than in manufacturing (Kindstrom and Kowalkowski, 2009), and likely this has been partly driven by value creation from big data in the digital age (Xie et al., 2016). The degree of interaction between service provider and client has been identified as a key difference between services and manufacturing activities (Burton, 2017; Gallouj and Weinstein, 1997a) contributing to successful innovation in services (Alam, 2006; Sundbo, 1997) and improving service-firm performance (Salunke et al., 2013; Agarwal and Selen, 2009; Carbonell et al., 2009; Frambach et al., 1998; Haliday and Troth, 2010;, Melton and Hartline, 2010). Close and continuous interaction between client and providers required due to the intangible nature of services (Miles, 1993). Customers are no longer seen as passive (Xie et al., 2016; Tuli et al., 2007a; Edvardsson et al., 2005) but are seen as the co-creators of services (Bitner et al., 2008). A major impediment to designing service changes is the need to understand and adjust to the changing client role (Martin et al., 1999), and offering and identifying "different hybrid approaches that support their combined product- and services-offering strategy", Burton et al., 2017: 35). Indeed, much of the recent scholarly research advocates for traditional firms investing in digital platforms that facilitate the collection, storage, and analysis of customer generated "big data" (Xie et al., 2016). As Xie et al (2016) found, such investment allows firms to transform customer-generated big data resources into valuable cooperative assets. Value is realised, in turn, through customer participation in improving existing or creating new products and services (Xie et al., 2016).

When the service provided involved "customized solutions," services have been found to be more complex than standard offerings provided by the firm and place additional demands on the service provider (Lindstrom et al., 2017; Nordin et al., 2011b). This is similar to previous

work (Noyelle, 1986; Gadrey, 1996; Meisenheimer, 1998) that found service jobs were more qualified than those in manufacturing, resulting in Gallouj (2002) arguing that it is a myth that service activities involve deskilled jobs. Knowledge is important in service firms in the form of expertise related to the technical and service characteristics of goods (Gallouj and Weinstein, 1997a). It is argued by Freel (2006) that knowledge intensity is a relative concept and involves an interplay between the knowledge provider and user: this interplay being central for client participation or co-production in services and service innovation. The very nature of services, according to Cheng and Krumwiede (2012), necessitates establishing greater credibility with customers. Knowledge-intensive services were found to "intrinsically use and transfer knowledge; they develop their activities in direct contact with clients and therefore have a more intense level of interaction" (Vence and Trigo, 2009a: 1655) than do enterprises in other service sub-sectors. Companies providing a comprehensive service offering need to manage deeper technical knowledge and the ability to integrate systems both inter- and intra-organizationally (Nordin et al., 2011b).

It is rare that firms organize service provision only in-house (Kowalkowski et al., 2011b). Firms exist, according to the knowledge-based theory of the firm (Grant, 1996), because they possess and are efficient mechanisms for integrating specialized knowledge, which they provide to a recipient firm. Their existence is predicated on their specialized knowledge (Spender, 1996). In situations where this knowledge cannot be easily transferred, decision rights must move (Kogut and Zander, 1992), in this context, to the service provider. Innovation is possible in knowledge-intensive services when different types of highly specialized knowledge are combined to problem-specific solutions (Amara et al., 2009). This is reiterated in the services literature by Zablah et al. (2005), who argue that one reason service firms are required is the efficiency and effectiveness of coordination, which can be provided by inter-firm dependencies, providing benefits through integrating intra-firm capabilities (Neu and Brown, 2005; Neu and Brown, 2008). A disadvantage from the service provider's perspective is that, over time in "close supply relationships," involuntary knowledge transfer is difficult to avoid (Leiponen, 2008), thus enabling client firms to access the service provider's specialist knowledge, though its success is predicated on the absorptive capacity of the recipient (Cohen and Levinthal, 1990).

Specialization of knowledge may result in knowledge asymmetries, according to Tuli et al. (2007b), who argue that when customers have a limited understanding of their own needs, it is difficult for them to explain what they need to a solutions provider. Asymmetries may be reinforced by the underlying degree of knowledge intensity required. While a key characteristic of knowledge-intensive services is client participation, the resultant interaction may also reflect issues around the balance of power between parties, partly involving the exchange of information and knowledge (Gallouj, 2002).

Freel (2006) categorises knowledge-intensity as dependent on the service provider's knowledge demands and the resultant requirements placed on the client. The greater the intensity of these two requirements, the greater the intensity of the knowledge service. Knowledge demands may also be affected, according to Nordin and Kowalkowski (2010) by the following:

- whether the problem is linear/rational or emergent/iterative.
- how problems are communicated to and perceived by problem-solvers.
- the degree to which problems are defined, ranging from structured to ill-structured problems containing unknown elements to which multiple or no solutions are possible.
- the problem-solver's expertise and familiarity with similar problems.

Risks may exist due to uncertainties regarding customer input, due both to the diversity of customer demand from unique customers and the uniqueness of desired outcomes, as well as the customer's disposition and motivation to participate in information exchange (Martin et al., 1999). A way of reducing such risks is through clarification of the responsibilities of each party in the interaction (Nordin et al., 2011b).

The service provider's internal process needs to be standardized in cases where a standard service is to be offered (Meyer and DeTore, 2001). A consequence identified by Bettiol et al. (2012) is that the need to produce knowledge with customers is reduced. Nordin and Kowalkowski, (2010) point out that where solutions are "inherently customized" the outcomes are unique to the context rather than generic. The outcomes of solutions range from solving a defined problem to providing "peace of mind" (Nordin and Kowalkowski, 2010). Kindstrom et al. (2013) found that firms could use repetitive cycles of interactions with customers as a way of identifying ways to innovate their service provision. Such firms, according to Davis et al. (2006), were better at converting what they learned from service interactions into components that could be reused, making future activities more simple.

This ability to use knowledge to develop solutions for clients, as outlined in Section 2.1, is a characteristic of a knowledge-intensive firm. A core capability of knowledge-intensive firms is their ability to combine codified scientific and technical knowledge, with knowledge in a tacit form, to make a unique body of knowledge (Amara et al., 2009). Leiponen (2006) sees the value of knowledge-intensive firms as their ability to transform knowledge and skills for client firms.

> **Research Question:** The main research question at the core of this paper is: What is the interaction between the service provider and customer and what is the balance to be struck between providing unique and standardized services?

3. METHODOLOGY

3.1. RESEARCH SITES

Case A is a pioneer in the fields of orthopaedics, spinal care and neuroscience therapies. It established a manufacturing facility in Ireland in 1998 with an innovation center established in 2008 to support advanced product and process development for the next generation of orthopaedic solutions. This center focuses on (1) Advanced Manufacturing Technologies (2) New-Product Development and (3) Quality Management.

Type of IS used in firm: The Agile System

Purpose: Used to store and deploy (in various combinations) new explicit knowledge and offer modular solutions. The eventual goal was to move toward a system that would have a repository of accurate solutions that would eventually solve problems without the need for a constant rotation of subject specialists.

Case B is a global leader in the supply of metal shafts for cardiovascular applications. It has won awards for innovation as well as for being the fastest growing company in the European Union. This growth was driven by customers' perceptions of the company as being willing to modify its work practices and its flexibility to ensure their requirements were met, particularly for innovations in new-product development, enabling a contract-design business to be established. Another key service provided to clients is the ability to fulfil increasing portions of their supply-chain requirements. This enabled it to become a strategic supplier to a number of large multi-national companies and win supplier awards for quality and service.

Type of IS used in firm: The User Productivity Kit (UPK) system

Purpose: Used to locate and reuse knowledge, some of which had been previously hidden, or did not have designated ownership.

Case C is a multi-billion-dollar corporation providing storage and associated software to large corporate customers. The product support function was organized by level of expertise. Level 1, the focus of this study, was the first point of contact. It resolved highly technical problems, for which solutions typically existed, and escalated more difficult problems to higher support levels. The services provided to clients were detailed in formal service-level agreements that committed it to resolving clients' problems with its products within strict time limits.

Type of IS used in firm: The Primus System

Purpose: As problems were typically recurrent across the client base, a key knowledge-management objective for Company C was to benefit from both economies of scale by reusing explicitly codified solutions and customization by mixing and matching elements from existing solutions (called knowledge articles). This was termed "knowledge-centered support."

3.2 RESEARCH DESIGN

A case-study design (Yin, 2002) was employed. It was considered appropriate as the phenomena was to be examined in its natural context (Darke et al., 1998). Case studies also enable an in-depth understanding of a particular context without necessarily having *a priori* relationships and constraints (Cavaye, 1996) and enable further clarification rather than

measurement (Riege & O'Keeffe, 2007). They are appropriate for an examination of human action and interpretations surrounding the use of information systems (Walsham, 1995), providing rich detail on how information systems are used (Howcroft and Wilson, 2003). Case studies have been used for knowledge-management research to explore how knowledge has been embodied and disseminated (Hazlett et al., 2008), in the development of a knowledge classification system (Walters et al., 2007) and systems implementation in a call center (Minami, 2009). In this paper, multiple cases have been chosen to show different perspectives, (Creswell, 2007) with advantages including improved theoretical understanding and methodological rigour (Yin, 2009; Eisenhardt, 1989) as well as providing increased robustness (Creswell, 2007) as results are compared across multiple cases. Indeed, there is a strong case-study tradition in the academic field of management information systems (Lee, 1989) and service innovation (Lightfoot & Gebauer, 2011; Essen, 2009). The authors have attempted to address the issues inherent in case-study research. Guba and Lincoln (1985) address confirmability by establishing a detailed collection of all the raw data, field notes, interview transcripts, and correspondence in a research audit file using QSR NVivo, to aid what they refer to as the "confirmability audit." Such a design is common in the Information Systems field (Li, 2011; Fonstad & Subramani, 2009). The authors used a similar approach to Hawk et al. (2009) to enhance their contextual understanding of their interviews by examining other data sources, such as company brochures, website material, contract and service-level agreements, and network-design diagrams. Kirk and Miller (1986) critiqued qualitative researchers for focusing on issues of validity over and above reliability, an argument refuted by Guba and Lincoln (1985: 316), who argue, "since there can be no validity without reliability (and thus no credibility without dependability), a demonstration of the former is sufficient to establish the latter". As proposed by Guba and Lincoln (1985: 317), the authors conducted an "inquiry audit" with the aid of other research cases and the case companies. This allowed examination of the research process and outcomes for consistency, allowing for feedback into the process throughout. As Lee (1989) states, generalizability is a quality describing a theory that has been tested and confirmed in a variety of situations, whether such testing is conducted through case research or natural experiments. As such, generalizability poses no more, and no less, of a problem for Information Systems case research than it does for the studies conducted in the natural sciences. Finally, the authors also address the issue of credibility (the naturalistic response to the conventional construct of internal validity). Internal validity, which refers to the extent that findings adequately describe reality, is critiqued in that to determine a study's adherence to reality, one would have to know "the precise nature of reality" and thus, there would be no need to test it (Guba & Lincoln, 1985). Naturalistic researchers seek to represent multiple realities, and therefore credibility is determined by the richness of information gathered and the analytical abilities of the research (Creswell, 2007; Patton, 1990). The case studies in this paper are compiled using a between-method triangulation approach, thus enhancing the credibility of the study. Richness of the data was ensured through integrated use of in-depth interviewing, observation, and documentation analysis. As advised by the literature, "member checks" also were used, in which participants in the study were asked to corroborate findings at various stages (Guba & Lincoln, 1985). As stated in Vreede (2014), we evaluated the experiences in

the case organization to identify insights and recommendations for future service innovation efforts.

3.3 DATA COLLECTION AND ANALYSIS

The data for this study was collected using multiple sources and methods including: observation, in-depth semi-structured interviews, and corporate documents. Pilot interviews and access to organizational documents provided a context to develop a set of questions and probes for the interviews. Interviews lasted from 30 to 90 minutes and were recorded and transcribed. They took place over all levels of experience at all three companies as outlined in Table 1. Permission to record was sought and anonymity was assured before each interview. While Walsham (1995) argues that recording results in interviewees being less frank, this was not found to be the case in this research.

TABLE 1: Respondent Description

	CoA	Co. B	Co. C
Manager	4	2	3
Shift/Team Leader	2	6	3
Experienced 'Knowledge Workers'	13	4	12
Novice 'Knowledge Workers'	3	2	5
Total (59)	22	14	23

Organizational documents relating to formal work practices were made available and were compared with interviewees' accounts of how they worked. Another valuable source of data was access to the various information systems, created and used by the three case-study companies. These documents were useful in seeking to identify how information systems were used to formalize clients' problems and structure interactions. Inductive qualitative techniques were employed for data analysis similar to Orlikowski (2002). Data was iteratively coded as the research developed a number of themes and as concepts emerged (Silverman, 2000; Coffey & Atkinson, 1996; Klein & Myers, 1999; Walters et al., 2007). As with Riege and O'Keeffe (2007: 362), interviewing ceased when a "stable pattern of clear agreements and disagreements on core issues" was reached.

4.0 DISCUSSION

4.1 SERVICE STANDARDIZATION MODULARITY VERSUS UNIQUENESS

Case A

This company interacted with its clients during new-product development, which involved the internal redesign of processes to provide more efficient client interaction. There were

three primary drivers that prompted Case A to begin the process of codifying knowledge: (1) the need to quickly locate specialists' tacit knowledge in response to customer needs, (2) to make its product-development process in the innovation center more efficient, and (3) to achieve savings associated with the replication and reuse of codified knowledge.

A challenge for the firm was that 60% of employees in the innovation center were contracted for short periods of time, so that when that portion of the project is completed, the expert leaves and "that knowledge is gone" (Experienced Knowledge Worker).

> "It would save myself time, trying to track down whoever I could ask about that, or will save them time as well" (Novice Knowledge Worker).

The company developed the "Talent Navigator" and "Link" information systems to codify and categorize tacit knowledge present, increase expert visibility, and locate specialists possessing such tacit knowledge. Talent Navigator was a web-based knowledge-location tool used in the innovation center to provide individuals with a way to explore gaps that existed between the current level of skills, qualification, and experience and those required by the role or by the customer. Link was a web-based system that acted as a social network, similar to Facebook or LinkedIn. "This kind of knowledge network, the kind of sharing ideas – people post things on there. If you say, 'I've got a problem with X, can anyone help?'" (Experienced Knowledge Worker).

Given the need to develop and deliver new products to the customer, Case A was very procedural in the way it dealt with the client-provider relationship. Internal organizational processes were supported by two additional systems: "Agile," which was used to document procedural knowledge, and "Compliance Wire" for training employees on existing procedures. In the early stages of product development, some interaction between client and organization took place; but as the products needed more and more "in-house" expertise, the knowledge asymmetries became more pronounced. There was very little interaction between Case A and its customers during product development, especially the latter stages when products were "delivered" to customers.

Systems to support knowledge reuse existed but were in the early stages of development. "We don't have a proper system for knowledge sharing" (Experienced Knowledge Worker), but Agile provided basic capabilities and was "very handy for certain things. Like for me, all the raw material specs for R&D are up there. [However] you kind of need to know where to look. ... It's a bit convoluted" (Experienced Knowledge Worker). It also provided access to "standard operating procedures that they need to understand" (Manager). Case A employees do not necessarily see Agile as a long-term solution to documenting, but it is the system that enabled knowledge reuse at the time.

Case B

This company wanted to speed up the delivery of its services to the same standard without needing to involve knowledge specialists to the same extent. It faced three main barriers to meeting this objective: (1) Needing to improve confidence in their clients regarding the company's supply chain, particularly in inventory, (2) locating specific knowledge and (3) reusing knowledge.

Customer interaction at Case B involved dealing with new and varying requirements from customers. Its effectiveness at tracking materials through their full evolution, from concept generation to volume production and final product, was tenuous, particularly at the concept generation stage, which required a much higher level of traceability; there were an abundance of cumbersome administrative tasks involved, which led to a negative experience for Case B. To overcome this, they sought to improve confidence in their supply-chain management through the creation of a "Case B" label when improving their inventory-management process.

Employees, even when searching for a particular piece of explicit knowledge, were at times not able to locate the information. Case B wanted to standardize knowledge when it became clear that newer employees could not locate specific knowledge. Many of the engineers claim as much: "They find it difficult to find out ... who knows about molding? Who's our molding guy?" (Manager). Standardization would aid in making this critically held tacit knowledge available across the organization. "If you have a database full of solutions, and people even know what kind of things you're looking for … they wouldn't even know where to begin to look right now" (Shift Lead). For the clients, the procedures at Case B are available in an explicit format. "But you'd have to know the procedure number or do a word search and be lucky with your word search" (Novice Knowledge Worker). As a consequence, a disproportionate amount of time was spent searching by prototyping engineers, R&D engineers, inspection staff, and stores staff.

Case B also needed to improve in the area of knowledge reuse so the system then "gives you the process overview in a flow chart that's standardized amongst all the areas," which provides the employee with a catalogue of who knows what and where they are. "The guys who are given the job would be able to up-skill themselves on the particular knowledge that they may not have, but if it was done before here, we would have had a lessons-learned database" (Manager). This was the beginning of a shift in management practice throughout Case B; "inventory is just one step on the whole changing the practice" (Experienced Knowledge Worker). There are many more areas of the organization that are going to be analyzed and possibly restructured.

The knowledge-management system used by Case B was called "User Productivity Kit" (UPK): It began as with the standardization of unique knowledge and developed into a system that was used to capture problems and process, locate tacit knowledge and solutions, and document these centrally to enable reuse. As a result, knowledge to solutions was standardized and was available more quickly; employees were able to locate and reuse knowledge as required, some of which had been hidden, did not have designated ownership,

or was not known. These changes led to clients having increased confidence in the service delivered to them.

Case C

The company environment in which services were provided involved problems arising from clients' implementation of both Case C's and external vendors' new products, which gave rise to new and unique sets of circumstances. As technical problems were recurrent across the service provider's client base, a key objective of knowledge management for Case C was to benefit from economies of scale by firstly developing and then reusing explicitly codified solutions of how to resolve clients' problems. This moved the focus from a client's novel situation, requiring a bespoke interaction and service development, to a focus on how to represent the problem and its context in more general, reusable terms. A key capability here was to develop a solution for the specific problem presented, a short-term goal, and to then document this as a more universally applicable solution that could be reused in the long term. A large proportion of the technical knowledge about problems with the firm's products were codified using reusable action sets, taxonomies of errors, and technical configurations that defined the contexts in which they arose.

> "If you go putting in text, it can throw anything back at you, you know, but if you're putting in a specific error code it will take you there ... it will actually bring you up the exact solution." (Experienced Knowledge Worker)

That client situations and problems were definable to such a degree they acted to increase the knowledge asymmetries between client and service provider and were supported through the use of information systems.

The essential elements of a client problem could be codified to enable diffusion through the use of information systems that defined circumstances, problems and fixes in a structured solution. Elements of solutions could then be reused as new, similar contexts emerged enabling modularity.

> "It definitely gives you a head start. It will point you in the right direction and a lot of the solutions are written up anyway and have links to documentation in the interface and even sometimes looking at [Knowledge Management Solution Repository] will give you an idea and point you in a specific area." (Team Lead)

Reusing existing solutions was supported by the structured nature of the knowledge-management repository and standardized taxonomy of errors and client configurations. Employees were often able to identify if parts of existing solutions could be applied to the current problem. Typically, this involved checking if a set of actions would work with a

different client hardware or software environment. Because the firm's knowledge repository provided discrete parts and the "fix" section outlined a series of discrete actions, it was possible for workers to recombine components of solutions.

4.2 CUSTOMER-PROVIDER INTERACTION

The results of using information systems was that existing knowledge asymmetries between service provider and client, that existed as a result of knowledge intensity and specialization of labor, were increased with the relevant knowledge increasingly possessed by the service provider.

Case A

As outlined earlier, Case A developed various formal systems to locate expertise and individualize and eventually standardize knowledge. If an environment fosters an informal approach and relies on knowing who knows what, employees in this environment for a longer period have an advantage. "I'm here seven years, so … I know who's who" (Shift Lead). This poses its own problems as it is difficult and inefficient to identify who knows who or what, especially as the asymmetries increase between the company and its customers. Much of the knowledge is learned from people in an informal way, and thus the interpersonal network is very informal so that time is wasted in locating expertise; and, secondly, there is a lack of proper use of some of the formal systems provided. Many employees end up spending much of their "work time" navigating the informal network, only to lose sight of the knowledge they seek to acquire and thus delayed in the task of acquiring it; and, third, this leads to further knowledge asymmetry between company and client as the knowledge becomes more entrenched and tacitly held. At Case A, greater credibility with customers is established through improved efficiency as a result of expert location.

Case A knew more than any individual client and was able to provide its services without a great deal of client interaction. After the implementation of information systems, the relationship between organization and client changed and led to the automation of interaction between them. In some instances, product problems would be solved completely in house without any need to consult with the client.

Case A was largely dependent on a small group of employees. This meant engineers could deal with a problem without properly documenting their actions. Though expert location – using the Talent Navigator and Link systems – had improved, a challenge faced by Case A was that large portions of its knowledge was tacitly held by individual experts. This provided the impetus for the move toward standardization of knowledge within information systems.

Case B

Customer-provider interaction has changed for Case B as a result of an increasing level of knowledge asymmetries. Case B was further along its implementation of knowledge-

management systems and was successful in developing systems to locate specialists using UPK and also in capturing expertise explicitly to form a body of standardized knowledge in the organization. Many employees used these systems as a way of moving toward a more standard approach to meeting client requirements. Management had acknowledged that the lack of knowledge standardization is "definitely a problem for us" (Experienced Knowledge Worker).

For the client, it becomes the problem of "lacking ... daily knowledge. No, it's probably not real clear to them" (Experienced Knowledge Worker). For the client, the context is often lost; "Without taking the procedure and putting it into a real-time environment, you won't really get a true understanding of it" (Team Lead). The end result is that the engineers at Case B, through the dissemination and retention of informal knowledge, knew more than the client. Standardization, by increasing knowledge asymmetry, acts to increase epistemic boundaries between service provider and client, which make interactions more standardized and increasingly difficult for types of interaction that lead allow co-production to occur.

For Case B, its information systems improved the reuse of past knowledge around a particular procedure or problem to avoid losing tacit knowledge that was becoming increasingly embedded in informal employee networks. "It's not exactly a very good way of doing it because ... it's just word of mouth" (Shift Lead). In the future, this reliance on standardization could be problematic as there was the potential to use standard solutions for more complex problems when the development of customized solutions was more appropriate.

Case C

The use of the three information systems resulted in increased automation of the interaction between the service provider and its customers. To a large extent, the analysis of clients' needs was completed by the case company's monitoring software. While problem analysis and categorization of errors had a high level of knowledge intensity, it could be codified using taxonomies within the monitoring software due to its structured nature. The result of this system was to reduce the client's knowledge about their own support needs as well as automating the needs assessment task previously assigned to product support employees.

> "There are dial homes that people outside wouldn't actually know anything about that at the time you know." (Experienced Knowledge Worker)

In some cases, the information collected by the monitoring software was sufficient to identify a solution. Even when this was not the case, client interaction was minimal and typically consisted of requesting computer files that had recorded relevant information. Depending on the sensitivity of the data being stored, clients could give permission to the case company to take control of their hardware and software. Product support personnel could then take actions and make changes to resolve the client's problem remotely without client interaction. In this situation, the only interaction was with the client's information systems. At the

extreme end of the spectrum, a potential problem with a client's system could be identified, analyzed and resolved without the knowledge of the client. A result of the implementation of information systems was to increase client-provider systems integration.

In situations where clients' staff were required to carry out tasks in conjunction with the product-support staff, the tasks tended to be highly automated and defined, such as installing a piece of additional software or following a series of actions.

Co-production was predicated on the basis that customers knew what they required. The work of the service provider was to apply its knowledge to meet client requirements. For Case C, knowledge regarding clients' needs, as well as the context in which they arose, were codified and available through information systems. For standard situations, the entire interaction was formalized and automated. Key factors supporting this were the procedural nature of the problem and the defined and structured way in which the problem was communicated to specialized workers. While the firm did use and transfer knowledge, it provided clients with the output of a knowledge process rather than seeking their active participation co-producing a solution.

When the case company was satisfied that the knowledge about the errors, causes, and solution processes were sufficiently defined, they made the solution available on a customer-support website. The use of this product-support website had a number of effects. It provided clients with some understanding of the knowledge-intensive service provided by the case company. This acted as a method of providing credibility by the service provider. In addition, when a client's staff unsuccessfully tried to solve a problem, they only contacted the service provider having already looked for a solution on the support site.

5. ANALYSIS AND RESEARCH SYNTHESIS

In Table 2, we outline a cross-case comparison of our three case companies against four key concepts in the service literature: knowledge asymmetry, service standardization, service customization, and the service-provider interaction. The empirical evidence from our case studies both agreed and disagreed with the existing literature in all four areas. Of particular interest was the complete cross-case consistency among the empirical findings regarding how these concepts were present in our three knowledge-intensive firms.

TABLE 2: Empirical Cross Case Analysis

Concept	Literature	Co. A.	Co. B.	Co. C.	Cross-Case
Knowledge Asymmetry	Specialisation of knowledge may result in knowledge asymmetries (Tuli et al., 2007b)	**Agree**	**Agree**	**Agree**	**Agree**
	Situations where this knowledge cannot be easily transferred then decision rights must move (Kogut and Zander, 1992) to the service provider.	**Agree**	**Agree**	**Agree**	**Agree**
	Asymmetries may be reinforced by the underlying degree of knowledge intensity required. While a key characteristic of knowledge intensive services is client participation the resultant interaction may also reflect issues around the balance of knowledge asymmetry between parties (Gallouj, 2002)	**Disagree**	**Disagree**	**Disagree**	**Disagree**
Standardisation of Service	Firm may not be able to create products that are perfectly codified or standardised, (Gallouj and Weinstein, 1997a)	**Disagree:**	**Disagree**	**Disagree**	**Disagree**
	Davis et al. (2006) Firms that reused knowledge were better at converting what they learnt from service interactions into components that could be re-used, making future activities more simple	**Agree**	**Agree**	**Agree**	**Agree**
	Chances of improving efficiency through codification to achieve standardization are reduced where there is 'bespoke service provision', (Bettiol et al., 2012)	**Disagree**	**Disagree**	**Disagree**	**Disagree**
	Service provider can use codification to exploit high levels of reuse of knowledge developed through standard codified services, (Bettiol et al., 2012)	**Agree**	**Agree**	**Agree**	**Agree**
Customised Services	Providing highly customised solutions requires providers to have a better understanding of their customers	**Agree**	**Agree**	**Agree**	**Agree**
	High degrees of interaction with clients can lead to the development of customised products, (Vence and Trigo, 2009a)	**Agree**	**Agree**	**Agree**	
	Less complex services require exploitation while new process orientated solutions require exploration, (Kowalkowski et al., 2011a)	**Agree**	**Agree**	**Agree**	**Agree**
Service Provider – Client Interaction	The very nature of services according to Cheng and Krumwiede (2012) necessitates establishing greater credibility with customers	**Agree**	**Agree**	**Agree**	**Agree**
	Rare that firms organise service provision only in-house, (Kowalkowski et al., 2011b)	**Agree**	**Agree**	**Agree**	**Agree**
	Degree of interaction between service provider and client has been identified as a key difference between services and manufacturing activities (Gallouj and Weinstein, 1997a)	**Disagree**	**Disagree**	**Disagree**	**Disagree**
	Close and continuous interaction between client and provider are required due to the intangible nature of services, (Miles, 1993)	**Disagree**	**Disagree**	**Disagree**	**Disagree**
	There is more interaction and feedback from customers (Kindstrom and Kowalkowski, 2009)	**Disagree**	**Disagree:**	**Disagree**	**Disagree**

Knowledge asymmetries between clients and service providers were, like Tuli et al. (2007b), due to the specialization of knowledge by service providers who applied this over their client base to reap economies of scale. As a result, it moved decision rights (Kogut & Zander, 1992) to the service provider. Gallouj (2002) argues that a key characteristic of knowledge-intensive services is client participation; however, we found that as knowledge asymmetries increased and decision rights moved, service providers relied increasingly less on participation with their clients.

Our findings with respect to the standardization of services were consistent with Davis et al. (2006) in that those who reused knowledge were better at converting knowledge from service interaction into reusable components that simplified future activities, and the codification of standard services could be employed when there were high levels of knowledge reuse (Bettiol et al., 2012). Our findings differed from those arguing that it was not possible to completely codify or standardize services (Gallouj & Weinstein, 1997a) with the ability to improve efficiency via standardization having reduced where there was bespoke service provision

(Bettiol et al., 2012). The reasons for these differences is the deterministic nature of the contexts in which our case companies were located, which were more amenable to precise codification as well as the reliance on information systems to support service delivery.

For customized services, our firms did, like Kowalkowski et al. (2011a), seek to exploit less complex services and explore new process-orientated solutions. The results of exploration were to be codified and seen as a precursor to exploitation. It was possible to achieve highly customised solutions for clients without, as argued by Vence and Trigo (2009a), high degrees of interaction with clients. This was facilitated as a result of knowledge asymmetries, specialization of labor, and modularity in the information systems of Case C.

For our case companies, it was possible to gain a detailed understanding of their customers' needs without an intensive level of interaction. They could also develop customized solutions based on what they know about what was happening across their client base and on having a better understanding of how to develop service provision. A distinction can be drawn for Case C, the firm with the most developed information systems, regarding the nature of client interaction. While it did not require much interaction with clients' personnel, it engaged in very detailed interaction between the knowledge-management systems and those of its clients to determine very detailed requirements.

We agree with Kowalkowski et al. (2011b) that it is rare for firms to only achieve service provision in-house. The companies we examined were examples of clients choosing to outsource service provision due to efficiencies from provider economies of scale, making outsourced service provision more cost-effective. We also agree with Cheng and Krumwiede (2012) that the nature of services requires credibility to be established with customers. For our firms, credibility was primarily achieved through information systems for service provision. We do not agree with these authors that argue that the degree of interaction with clients is a key distinction between services and manufacturing (Gallouj & Weinstein, 1997) and, consistent with our earlier findings, more close and continuous interaction (Miles, 1993; Kindstrom & Kowalkowski, 2009) was not required. Thus, the knowledge intensity of the firms having specialized knowledge, giving rise to knowledge asymmetries, had identical effects on all three firms in terms of how standardization and customization, and ultimately client interactions, were concerned.

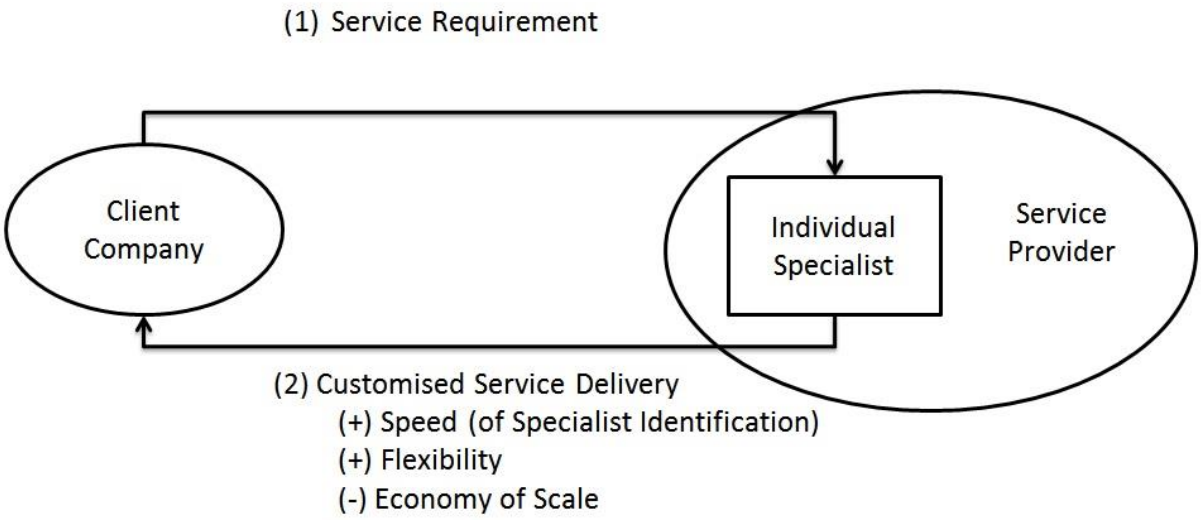
Though there were consistencies across the firms, it was clear from our research that while all three companies were seeking to develop information systems to support their activities, they were at different stages of development. As a consequence, and based on the data collected, we developed a three-stage model, as outlined next, to aid an understanding of how information technology supported knowledge-intensive service firms.

STAGE 1: Individualization

Company A is a good example of a firm at the earliest phase of development. Specialization of labor was present in the service company, giving rise to knowledge asymmetries but with little use of information systems to support service provision. The immediate challenge was to match client requirements to the specialized knowledge tacitly held by its employees. This meant that, from a knowledge-management perspective, the key issue was first to classify the types of knowledge tacitly held by employees and then to identify what knowledge was held by whom. This was achieved through its "Talent Navigator" and "Link" systems. This enabled the firm to understand the tacit knowledge it possessed and where it was located, increasing the visibility of both. A consequence of this was to increase the speed at which an expert was identified to respond to clients, leaving the rest of the process unaffected. This enabled Company A to improve its ability to respond to changing client needs flexibly and somewhat more quickly. An important similarity between the case-companies context was that they were all involved in work/industries, where work undertaken for one client could be utilized across the client base. By starting from a position where a large degree of knowledge was tacitly held then, in the short-term, a first step was to identify what knowledge existed and where it was located. This was particularly problematic in cases where there were high levels of contract specialists, as shown in Company A.

However, in the long run, both service provider and clients were unable to take advantage of the economies of scale available by the provider leveraging initially customized solutions for one client across the entire client-base. The current individualized system meant that where another client has a similar need, the system could identify the most suitable employee to meet it. While this system improved knowledge reuse, it did so only at an individual level and increased the danger of losing knowledge as staff left. This was of particular concern to Company A as it had a high number of contracted staff.

FIGURE 1: Stage 1 – Individualization



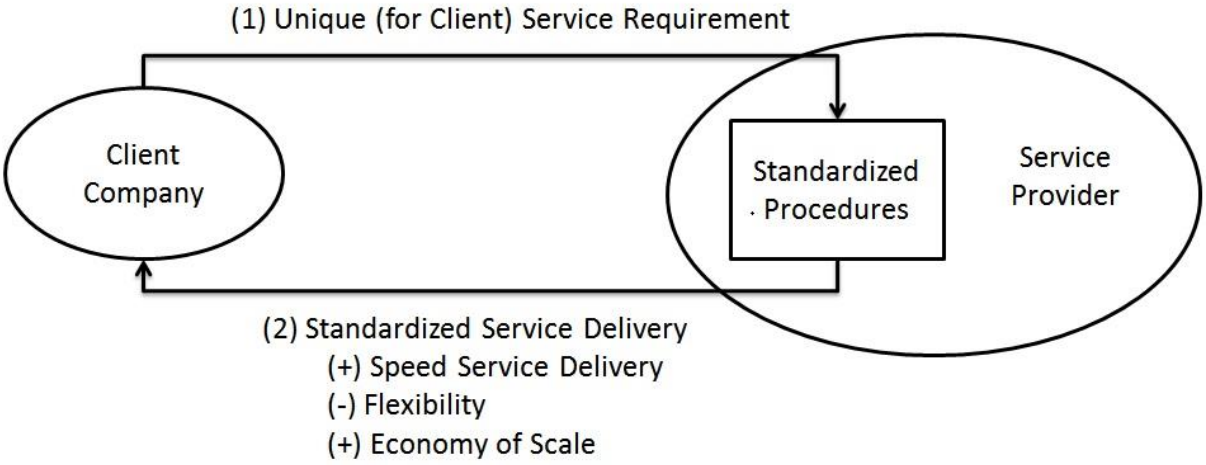
STAGE 2: Standardization

At the time this research was being conducted, Company A was beginning to move from the individualization stage to take advantage of the economies of scale and opportunities for knowledge reuse by codifying its catalogued tacit knowledge into a more explicit form using its Agile system, resulting in less reliance on specialists and more on standardized procedures that outlined the steps to be taken for service delivery now codified within an information system.

This changed the nature of the client-provider interaction. While a requirement was novel to a client, the need and appropriate standard response were known to the provider. This was also present in Company B's "User Productivity Kit," which stored knowledge in a standardized form. Such codification and system facilitation allowed client requirements to be served by less-specialized employees. A key role for specialist was to identify how best to solve novel client needs and then convert these into standardized procedures.

The procedural nature of the client interaction, coupled with the value to the company of leveraging solutions to client problems or providing knowledge about new knowledge requirements across the client base meant that these became drivers of codifying some of the experts' tacit knowledge that had been made more visible at the individualization stage. The focus of this stage then is at the procedural rather than individual level. The effect of this codification of procedures was to improve the use of past knowledge and the speed at which services could be provided to clients. It also ensured these services were delivered to a consistent standard. Thus, the firm's reliance on information systems increased while specialist roles were modified, and recurrent client needs were delivered in a consistent and standardized way. This allowed less-skilled employees to become more involved in the service-delivery process. There was an inherent danger at this stage: that a less-than-optimal standard procedure would be employed as it was easier and cheaper than developing a customized service.

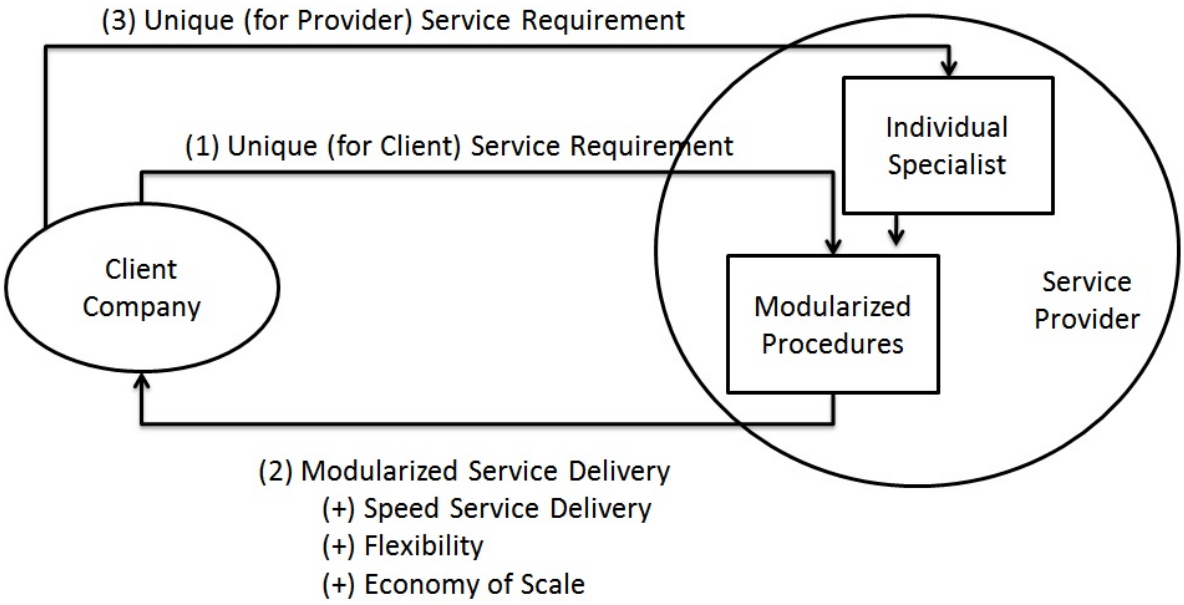
FIGURE 2: Stage 2 - Standardization



STAGE 3: Modularization

In order to overcome the risk of using a standardized service when a customized option was more appropriate, and still seeking the benefits conferred through codification of knowledge within information systems, a modularization of service elements was employed. This was useful in situations where service interactions were procedural, and it was possible to clearly define the sets of actions to be taken. If similar needs required similar but distinct action sets, then it was important that the differences in both contexts were defined. The knowledge-management system used in Company C was able to develop fine-grained context definitions as well as codifying sequences of actions in the fix section. These action sets were modular, parts of which could, with appropriate modifications, be reused in codifying similar problems. The outcome was to have several variants of an interaction available to service-provider staff, each with an appropriate-use context defined. While some extra time was required in selecting the most suitable alternative, this was outweighed by the ability to more closely align service provision to client needs. Another consequence was that codifying knowledge was not only useful for direct reuse, but as the basis for developing modular sets of actions that could be drawn upon as the basis for developing alternative client interactions.

FIGURE 3: Stage 3 – Modularization



Our view is that the model presented shows:

TABLE 3: Summary of Stages

	Stage 1: Individualized	**Stage 2: Standardized**	**Stage 3: Modularized**
Cause/Trigger	Specialisation of Labour (needed to meet requirements)	Problem/Requirement Recurrence	Non-Standard but similar problems/issues occurring
Challenge Presented	Find relevant Expert	Re-Use Knowledge already developed. Deliver consistent service.	Deliver not standardized but customised/multiple variants of service.
Focus of Activity	Individual (Specialist) involved in interaction	Procedure used to complete interaction	Choice of alternative interactions
Use of Information Systems	Expertise Mapping Expert Identification	Codify service delivery interaction as procedures.	Support alternative interactions in a modular format
Result	Speed matching specialist to new customer requirement	Consistent level of standardised client interaction provided.	Interaction involves choosing (assembling) from available alternatives (or adding new)

6. CONCLUSION

The objective of this paper is to examine the effects of increasing knowledge intensity and the use of information systems by service firms in response to differing views in the literature. While some argue that service firms are involved in increasing levels of client interaction and participation (Xie et al., 2016; Vence & Trigo, 2009a; Nordin et al., 2011b; Miles, 1993; Bitner et al. 2008) while others (Sundbo, 1994, 2008; Rust & Miu, 2006; Davis et al. 2007; Den Hertog et al., 2007) suggest that information systems are being used to standardize and leverage, or modularize (Peters & Saidin, 2000; Sundbo, 2002; Nordin et al., 2011b, Burton, 2017) what were initially unique customer interactions. We draw on case studies of service-focused departments of three knowledge-intensive multi-national firms to examine whether information systems were used to provide unique or standardized services to clients, and to examine the impact of such use on client interaction. The empirical data analyzed shows how knowledge specialization and knowledge asymmetries changed the dynamics of how knowledge was managed and the nature of client interaction. A key driver, identified across all three cases, was the high degree of knowledge asymmetry that existed between service provider and its clients, which had the effect of reducing clients into recipients rather than co-creators of knowledge.

A cross-case analysis enabled a broad developmental trajectory to be identified across the three companies, resulting in the development of a three-stage model through which firms were seen to move as they implemented more complex information systems. The proposed model contributes to the literature on service firms in several ways. It outlines how the increasing specialization of labor and knowledge-intensity of service providers leads to increased knowledge asymmetries between providers and clients. It illustrates not only how different types of information systems can be used to support different types of knowledge, but also suggests how associated problems, encountered with each phase, can be overcome as more sophisticated systems are implemented. The model as presented suggests that while a consequence of using information systems is the standardization of service elements to leverage existing knowledge, that this need not be an end in itself. Firms can use information systems to modularize and segment knowledge, elements of which can subsequently be combined to take account of unique client circumstances while also leveraging existing knowledge.

6.1 RESEARCH LIMITATIONS AND REFLECTIONS FOR FURTHER RESEARCH

We believe that this paper provides an added dimension to the existing literature in terms of (1) its focus on knowledge-intensive firms and (2) on their use of information systems. However, our research is limited to three case companies and, therefore, the model outlined is exploratory and would benefit from additional research in other industries. As the firms chosen in this study were dealing with very deterministic knowledge, research in industries where the underlying knowledge is more socially constructed would be beneficial. This research opens some additional avenues for future studies. Research in this area could benefit

from a more explicit treatment of knowledge as an organizational resource that is drawn upon for service provision. Following that, more quantitative studies would be beneficial as qualitative studies have obvious generalizability limitations – Qu et al. (2016) also made this recommendation. As Burton et al (2017) point out, future research could also test the impact of the themes and challenges identified by analyzing the types of strategic responses adopted by a large sample of manufacturing organizations and other industrial case studies (Lindstrom et al., 2015). Also, the role of information systems in codifying knowledge, its use by the service provider, and how it might provide a computer mediated environment through which customer interactions take place could be included in future work. We agree with (Shi et al., 2017) that little work has explored gamification in service innovation research. In addition, Xie et al. (2016: 1046) state that "in the digital era, firms should be more concerned with cooperative assets created through firm and customer interactions and the different values from different types of interactions. … Competitive advantages, such as better products or lower prices, may no longer be effective in addressing issues like customer defection due to low switching costs and numerous alternatives." Indeed, this paper also contends that a stable cooperative relationship can be established only when firms engage in value co-creation with customers through service exchanges and mutual support.

6.2 MANAGERIAL IMPLICATIONS:

The conceptual model we outline requires more empirical testing and elucidation before being used as a prescriptive tool by managers. Nonetheless, even at this stage, we believe that some managerial implications can be drawn out from the research. As a starting point, firms can use the model to identify and evaluate their current stage of development and suggest associated problems as well as potential system configurations that would support future developmental activities. While management may increase its specialization of labor for immediate operational benefits, this paper can bring awareness of some of the wider, long-term consequences of such an action. This is particularly important in situations where clients are currently engaged in co-production, and activity which could be rendered more difficult by the presence of knowledge asymmetries. In addition, as posited by Lindstrom et al. (2015), as these systems become ever more complex, as evidenced by the cases, additional training – and likely substantially more training – will be required of operators. A critical issue for managers in knowledge-intensive firms is the importance of understanding how to manage the role played by information systems in delivering the benefits of leveraging knowledge, and of the value added by efficiently recombining codified knowledge modules to efficiently construct service responses to clients' needs.

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