



## Product and service development in a strategic alliance: A quantitative analysis

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### Abstract

There is a need for more research on how multinational corporations can effectively serve their customers. This study aims to see if Manufacturing Multinational Enterprises (MMNEs) will boost their servitization results by collaborating with Knowledge-Intensive Business Service (KIBS) firms and developing products and service in the strategic alliance. The study also discusses human resource management's centralized decision as a systemic method for addressing development and service unit alignment loss. Survey responses from about 260 MMNEs were gathered in collaboration with an industry partner for the preliminary research results. The findings revealed that cross-border strategic partnerships and knowledge policy centralization are crucial for product-service innovation.

**Keywords:** Captive sourcing, Cross-border partnership, development, domestic partnership, domestic, product, service, strategic alliance

### Introduction

Manufacturers worldwide are adopting new ways of manufacturing and customer engagement processes (Marsh, 2012) [28]. This is achieved by servitization, which involves delivering a range of resources and solutions to boost product experience at different product lifecycle stages (Cusumano *et al.*, 2015) [14]. Approximately 70% of manufacturers are implementing service business models, with the service segment accounting for about 30% of their overall sales. This is attributed to the creative ways in which businesses sell and service their goods (Crozet & Milet, 2017) [13]. The final innovation is distinct from the traditional product or process innovation in that it relies on servicing goods and services (Kastalli & Van Looy, 2013) [23]. Focusing on critical determinants of manufacturers' product-service innovation is essential, as it necessitates not just improving product capabilities but also a greater understanding and interaction with consumers (Bustinza *et al.*, 2019) [7].

The success in product-service innovation is said to be dependent on how companies handle three new complexities. First, manufacturing companies that are evolving product-service innovation must increasingly export their products to global markets (Parida *et al.*, 2015 [31]; Zhang *et al.*, 2016) [46]. This necessitates making rational decisions on the right way to enter international markets. Second, companies must determine whether to operate service functions in conjunction with internal business functions, establish a separate service agency, or outsource it to a service vendor to operationalize service-led development strategies (Rabetino *et al.*, 2017 [35]; Ho *et al.*, 2017). A Knowledge-Intensive Business Service (KIBS) company is a typical example of the above (Lafuente *et al.*, 2017) [25]. As a result, deciding whether to internalize or externalize the service role is a crucial business consideration.

To date, research has concentrated on internal service delivery (Baines *et al.*, 2017) [2]. A few studies consider the importance of external collaborators in improving product-service innovation, according to the comprehensive analysis

of the servitization literature (Durugbo & Erkoynucu, 2016 [15]; Bigdeli *et al.*, 2017 [4]; Bustinza *et al.*, 2017 [9]; Xing *et al.*, 2017) [45]. Furthermore, while recent studies have begun to look into how service provision can be expanded internationally by joint arrangements with KIBS companies and mergers and acquisitions, the cross-border aspect of those agreements is still understudied (Bustinza *et al.*, 2017 [9]; Xing *et al.*, 2017) [45].

There is a need to explore the product-market growth results of four distinct strategic alternatives for service provision in manufacturing multinational enterprises (MMNEs), including cross-border service partnerships, captive service offshoring, domestic strategic alliances, and domestic internal production to analyze these strategic choices. Some studies have looked at the effect of gaps in inner growth and external joint relationships on results (Stettner & Lavie, 2013). Examining the innovation implications of various exterior and cross-border service provisions in different foreign contexts is considered a significant contribution (Bustinza *et al.*, 2017) [9]. Moreover, responding to current demands for contextualizing international market research is possible by examining the importance of research results and existing and new hypotheses in different settings (Teagarden *et al.*, 2018) [40].

Human resource management has been described as another essential enabler of improved product-service innovation, as well as a central factor in explaining the success or lack of corporate partnerships, joint ventures, and mergers and acquisitions (Weber & Tarba, 2014 [43]; Aklamanu *et al.*, 2015 [1]; Prajogo & Oke, 2016 [34]; Vasilaki *et al.*, 2016) [41]. According to Kim *et al.* (2003) [24], servitized MMNEs that manage service and integrated solutions in-house need a central national production of service architecture and global configuration of organizational and structural decisions. Employees engaged with product-service innovation should report to a single administrator, referred to as competence judgment centralization (Brewster *et al.*, 2015) [5]. In a similar context, the present study aims to offer new scientific data on the association between organizational success and centralized knowledge-based

decisions and analyze the moderation of this association by KIBS.

The rest of the paper is organized as follows: Section 2 reviews the related literature and Hypothesis Development. In Section 3, the methodology the experimental setup, and the datasets used in this paper are discussed. In Section 4, the results of the experiments are analyzed and discussed, and general discussion of the approach and found results are presented. In Section 5. The conclusion, Managerial Implications and Limitations and Future Directions are discussed in Sections 6 and 7, respectively.

## Literature Review and Hypothesis Development Innovative Manufacturing Processes

The Fourth Industrial Revolution, also known as Manufacturing 4.0, is a modern manufacturing paradigm gaining momentum (Marsh, 2012) [28]. Smart manufacturing depends on technical advances and the rapid adoption of emerging technologies, all of which are reshaping the manufacturing industry (Porter & Heppelman, 2015) [33]. The companies with corporate customers aim to obtain more integrated products to deliver services that complement conventional product supply, including fully-fledged customizable solutions that meet individual consumer demands, should consider service-led growth strategies (Cusumano *et al.*, 2015) [14]. Many considerations affect the decision to adopt service-led growth strategies in manufacturing, including product sophistication, consumer proximity, and firm differentiation (Cusumano *et al.*, 2015 [14]; Raddats *et al.*, 2016) [36]. These methods reflect a change in commodity firms' underlying market structures to provide services, referred to as servitization and integrated solutions in the literature (Visnjic-Kastalli & Van Looy, 2013) [23]. To some point, more than two-thirds of corporate product vendors around the world are evolving service business models (Crozet & Milet, 2017) [13]. More stable sales, higher profitability, and firm growth are all predicted advantages of servitization approaches (Baines *et al.*, 2017) [2s].

Product-service innovation refers to the results of servitization's production (Bustinza *et al.*, 2017) [9]. The product-service invention's primary goal is to create added demand by bringing new service offerings to the market (Visnjic-Kastalli & Van Looy, 2013) [23]. Nonetheless, as in any other form of the invention, servitization is a complex procedure with several unknowns (Benedettini *et al.*, 2015) [3]. According to the literature, product development employees would otherwise risk enforcing their standards and guidelines on newly merged service development employees (Rabetino *et al.*, 2017) [35]. However, there is also no agreement about how the service unit should be run. There is a need to concentrate on central areas of service unit management in this report for ensuring effective coordination between service and product units and hence is a good tool for improving firms' product-service creativity.

## Ownership of Service's Functions

The servitization literature provides the tacit statement that the service role is built in-house (Cusumano *et al.*, 2015) [14]. This is particularly true for MMNEs, which are presumed to have ample internal capital to execute this role (Woerkom & Zeijl-Rozema, 2017) [44]. Ceci and Masini (2011) [11] published the first survey to look at a new strategic choice, observing that half of the producers

cooperate with tech companies to develop and optimize their products. Paiola *et al.* (2013) [30] built on this discovery by looking at the option to make or buy service capabilities. These investigators discovered that service capabilities could be purchased from external vendors or collaborators via case study research. Purchasing service capabilities from outside sources reduce the costs and uncertainty involved with implementing this role in-house (Durugbo & Erkoyuncu, 2016 [15]; Bigdeli *et al.*, 2017) [4]. If research on improving the service feature by collaborations with KIBS or other suppliers is minimal, research on how to internationalize this function is virtually non-existent, despite recent research highlighting the need to market services internationally (Parida *et al.*, 2015 [31]; Zhang *et al.*, 2016) [46].

According to Xing *et al.* (2017) [45], some emerging-market manufacturers are acquiring service capability through cross-border acquisitions. This pattern is significant because some businesses have built up a knowledge base over time, and companies in other countries may improve their service functions by pursuing cross-border strategic options. Internal service creation relates to a corporation's internal development without the need to outsource or contract with a third party. This is the most popular strategic option that has been studied in the literature. Captive service offshoring refers to service operations established in a company's wholly-owned service production unit outside of the country (Lewin & Volberda, 2011) [26].

To find and leverage prospects in domestic and foreign markets, serviced organizations must implement new technologies. This modern capability would necessitate a significant investment in both labor skills and technical infrastructure (Rabetino *et al.*, 2017) [35]. It is expected that collaborations with KIBS will be used to minimize financial investment and obtain access to qualified workers since this expertise and infrastructure are now in KIBS companies' hands. Furthermore, recent research shows that when servitized MMNEs form relationships with KIBS, their firm efficiency improves (Bustinza *et al.*, 2017) [9]. The advantages of outsourcing the service role (access to service capability without investment) outweigh the disadvantages (loss of ownership over a critical business function of servitized MMNEs).

Furthermore, economic geographers stress the importance of proximity in obtaining additional business capabilities from the service provider. Manufacturers can better recognize and coordinate with the externalized service role by forming alliances with domestic KIBS companies, allowing them to develop and stimulate their competition in the local field (Jacobs *et al.*, 2016 [20]; Lafuente *et al.*, 2017) [25]. Overall, the present study hypothesizes that businesses that shape domestic strategic KIBS alliances can attain higher levels of product-service innovation than companies that deliver services domestically.

Hypothesis 1a: Manufacturers who implement services through KIBS alliances' domestic strategies have increased product-service creativity levels compared to the ones offering domestic services.

Unlike conventional manufacturing firms that internationalize based on lower production costs, servitized firms with clients in other countries need physical presence to create service providers physically close to existing or new customers (Jones & Wren, 2016 [22]; Vendrell-Herrero *et al.*, 2017) [42]. This is significant because recent studies

show that companies providing services internationally will save a considerable amount of money by finding the client’s market service feature. (Peeters *et al.*, 2015 [32]; Ghauri *et al.*, 2016) [17]. As a result, it is expected that captive service offshoring will result in higher product-service innovation levels than domestic internal service supply.

Hypothesis 1b: Manufacturers who implement services through captive services have increased product-service creativity levels compared to the ones offering the internal provision of services.

The cross-border service relationships would benefit from being formed internationally and externalizing the service role (Bustinza *et al.*, 2015). Big producers will gain more technical expertise from top leading specialized firms through international joint ventures, which improves their productivity (Carnovale & Yenyurt, 2014) [10]. Based on this logic, it is predicted that cross-border service alliances would have increased creativity levels than companies rendering services domestically.

Hypothesis 1c: Manufacturers who implement services through cross-border service partnerships have increased levels of product-service creativity compared to the ones offering domestic services.

**Centralized Expertise Decision Coordinating Product and Service Development**

With the growth of global demand, more emphasis has been placed on human resource management in domestic and international subsidiaries. With the development of the worldwide market, more emphasis has been placed on human resource management in domestic and international subsidiaries. Previous studies have failed to focus on the topic that has received little attention in recent studies on the relationship between management decisions on human capital and product service innovation (Johnstone *et al.*, 2014 [21]; Prajogo & Oke, 2016) [34].

Standardization of operations is based on the codification of job practices and tasks. This integrative model typically provides subsidiaries with unique laws, regulations, and guides (Smale *et al.*, 2013) [38]. The focus of centralized decision-making is on human resources' proactive role in the transition process (Smale *et al.*, 2013) [38]. As a result of centralization, decision-making power is centralized at the organizational level, where a more detailed and foundational view of the market resides. In contrast, other business divisions are distributed across the globe.

According to recent studies, the role of knowledge decision centralization in manufacturing is increasing again. This

activity is expected to increase information inflows and, as a result, the collaboration between various business units (Brewster *et al.*, 2015 [5]; Reiche *et al.*, 2017) [37]. Improved collaboration between service and product units will lead to a deeper understanding of industrial customers and, as a result, more efficient production of integrated product and service solutions. Intelligent products and big data, which allow companies to develop their analytical skills in the head office, will help with this teamwork (Porter & Heppelman, 2015 [33]; Opresnik & Taisch, 2015) [29]. Therefore, the study hypothesizes:

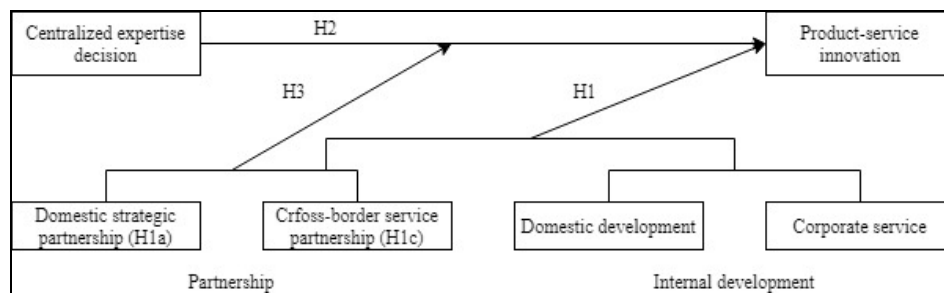
Hypothesis 2: Manufacturers who centralize their knowledge decision-making would reach higher levels of product-service innovation.

The value of making proper human resource management decisions has been described as a prerequisite for maximizing resource complementarity and realizing the future synergetic benefits expected from strategic alliances or mergers and acquisitions. In strategic partnerships, the synergetic results of competence decision centralization are conducive to increased organizational efficiency (Correia *et al.*, 2013) [12]. Despite this discovery's importance, there is no research on the correlation between knowledge decision centralization and product-service creativity in strategic partnerships. Strategic alliances are critical enablers of product-service innovation, and new analysis indicates that businesses that engage in strategic alliances do higher than companies with in-house service departments (Bustinza *et al.*, 2017) [9]. The reasoning behind this finding is that outsourcing the service function to external partners allows producers to gain know-how while limiting the internal transition required to get the service function in-house (Bustinza *et al.*, 2018). Indeed, one of the key triggers of the high bankruptcy rate observed in servitized manufacturers has been described as management of the internal organizational transition, suggesting that forming strategic relationships with KIBS decreases manufacturers' need for centralization to pursue product-service innovation (Benedettini *et al.*, 2015) [3]. Based on these arguments, it is posited that;

Hypothesis 3. The relationship between knowledge decision centralization and product-service creativity is moderated adversely by partnerships.

**Conceptual Framework**

Figure 1 illustrates the potentially expected relationship between related variables in a visual format.



**Fig 1:** Conceptual framework

**Methodology and Experimentation**

**Study Sample**

The present study has focused on an extensive survey of manufacturing processes, including detailed questions about

product service innovation and human capital management choices for a sample of servitized businesses. The survey was performed in conjunction with a major consulting company specializing in service management solutions by a

business partner. The population was characterized by the industry partner’s internal sector catalog, which included 7,000 manufacturing companies with annual sales of >\$1 billion. Before administration, the business partner used an advisory board comprised of external industry professionals to verify the desired sample size. The size for the target sample was calculated using the Gaussian distribution at a 95% confidence level. This experiment yielded a sample size of at least 365 MMNEs, which was the target sample size. The information was gathered using a recruited audience. The respondents were given a password through email to monitor access to the online survey. Companies were contacted via email and phone regularly. Some respondents were in charge of one or more expense or benefit centers within their company’s service sector.

**Study Variables**

**Strategic Option**

The study participants were asked to describe the country in which the MMNE’s headquarters are present and whether the company has existing relationships with domestic or international service providers. Captive service offshoring is considered the most prevalent practice of service provision in the present study.

**Innovation of Product-Service**

The study by Bustinza *et al.* (2017) [9] provided the term known as innovation of product-service. Product-service growth and customer experience dimensions, which are essential dimensions of servitization, are used to operationalize the component. Product-service growth and customer experience dimensions, which are critical servitization dimensions, are used to operationalize the part.

**Centralized Expertise Decision**

To match the things to the current analysis function, the variable of centralized expertise decision was adapted from Reiche *et al.* (2017) [37]. Unlike Reiche *et al.* (2017) [37],

which investigates who has decision-making power over recruiting and selection, preparation and advancement, performance assessment, pay, promotion, and general HR policy, the present study aims to concentrate on the centralization of decision-making in the specific unit. The centralization of competence decision is optimized by using three elements that focus on measuring whether decision making in architecture, 14 operations, and service provision structure are local or global, since servitized MMNEs both need a central global production of service design and customize institutional and systemic decisions globally.

**Control Variables**

The study aims to account for sector variations. The study companies are from seven different processing industries such as Aerospace and Defense, Commercial or Cargo Airlines, Heavy, Industrial Equipment, White Goods Manufacturing, Automotive and Transportation, Electronics High-Tech Equipment, and Medical Devices and Equipment. For each field, the study generated dummy variables. The survey had an equal distribution of areas.

**Results and Discussion**

According to the graphical exercise, top-performing companies tend to be externalizing and internationalizing the service role. The averages listed in Table 1 confirm this conclusion. The results of strategic options (H1) and knowledge decision centralization (H2) were studied using ordinary least squares (OLS) since the dependent variable (product-service innovation) is constant. Table 2 displays the implications of estimating the whole study model, including fixed effects for sample size, industry, and region. Interestingly, these effects do not seem to be important in understanding product-service innovation. There is a need to use sub-samples in OLS regressions because the countries chosen are supposed to have heterogeneous relationships between related variables.

**Table 1:** Descriptive statistics

	Sample (n=260)	Domestic (n=71)	Captive sourcing (n=150)	Domestic partnership (n=15)	Cross-border partnership (n=24)
Product-service innovation	-0.008	-0.221	0.002	0.135	0.407
Centralized expertise decision	-0.004	-0.056	0.003	-0.516	0.239
Aerospace	0.134	0.187	0.127	0.100	0.048
Automotive	0.137	0.138	0.133	0.000	0.216
Cargo	0.147	0.163	0.115	0.500	0.137
Electronics	0.137	0.138	0.140	0.100	0.018

**Table 2:** Effect of partnership strategy and centralized expertise decision on product-service innovation

	OLS of sample	Servitization US	Servitization UK	Servitization Germany	Servitization Japan	Servitization China
Domestic partnership (H1a)	0.447 (0.332)	0.00303 (0.534)	1.205* (0.678)		0.402 (0.589)	1.545 (1.124)
Captive service (H1b)	0.270 (0.150)	0.219 (0.314)	0.126 (0.444)	0.0460 (0.328)	0.379 (0.421)	0.600 (0.454)
Cross-border partnership (H1c)	0.551** (0.222)	1.288*** (0.247)	0.0378 (0.505)	0.859** (0.415)	0.864 (0.682)	0.204 (0.768)
Centralized expertise decision (H2)	0.352*** (0.0522)	0.325** (0.152)	0.554*** (0.103)	0.383 (0.151)	0.0326 (0.173)	0.421** (0.164)
UK	-0.231 (0.106)					
US	0.0841 (0.211)					
Japan	-0.122 (0.223)					
China	0.326 (0.222)					
Aerospace	-0.0521 (0.319)	0.0165 (0.501)	-0.679 (0.858)	0.258 (0.668)	0.722 (0.705)	-0.637 (0.579)
Automotive	0.132 (0.261)	-0.137 (0.500)	-0.202 (0.552)	-0.0551 (0.606)	1.332** (0.613)	0.0608 (0.840)
Cargo	0.0241 (0.259)	0.204 (0.623)	-0.630 (0.583)	0.330 (0.730)	0.469 (0.436)	-1.042 (1.162)
Electronics	-0.181 (0.307)	-0.00184 (0.605)	-0.082 (0.466)	-0.646 (0.623)	0.230 (1.754)	-1.471** (0.539)

The findings narrated that firms with domestic foreign alliances do not have higher product-service creativity levels than firms that offer domestic internal services, which rejects H1a. Although the parameter is positive and strong (0.457), it is not statistically significant. The number of companies' observations with domestic partnerships is minimal, which is one technical reason why this parameter is not found to be distinct from zero. Surprisingly, the parameter is positive and statistically relevant at 10% ( $p$ -value $<0.1$ ) when tested in the nation sub-sample performance. While only 2.9 percent of UK companies choose domestic partnership as a strategic choice for providing both services and goods, the finding suggests that this theory should be tested more thoroughly in a more significant number of cases.

According to the total sample's findings, firms with captive service offshoring have higher levels of product-service innovation than firms with domestic internal provision. Firms that use captive service offshoring have a higher index of product-service invention than firms that use domestic internal conditions. H1b is supported by this result, which is statistically relevant at 10% ( $p$ -value $<0.01$ ). Even if the gap is minor, it is notable that China is the nation where captive service offshoring continues to have more significant gains in product-service innovation. This result confirms Xing *et al.* (2017)<sup>[45]</sup>'s findings, indicating that Chinese MMNEs are investing in Germany to develop their service capability.

Another significant finding is that companies with cross-border service agreements have higher product-service creativity levels than companies that only have internal services within their own country. Their product-technology innovation index is higher on average than that of domestic internal service providers, supporting H1c.

Since knowledge decision centralization is positively related to product-service innovation, the findings strongly support H2. This finding is statistically vital at 1% ( $p$ -value $0.01$ ) and almost consistent overall sub-samples in the relationship between knowledge decision centralization and product-service creativity, whether domestic or multinational. While the data do not confirm the moderating effect in the whole study, H3 is rejected. Strategic alliances minimize the need for internal change in servitized companies by moderating the interaction between knowledge decision centralization and product-service innovation.

## Conclusion

### Theoretical Implications

This present study highlights the literature on strategic alliances and servitization to see how servitized MMNEs can help operationalize an autonomous service function through strategic collaborations and human resource management decisions. On the contrary, the present research contributes to increasing knowledge about cross-border and cross-sector strategic partnerships (Luo *et al.*, 2013<sup>[27]</sup>; Gomes *et al.*, 2016)<sup>[18]</sup>. It's one of the first studies to look at how the service mechanism can be externalized by partnerships or mergers and acquisitions, as well as the role of competence decision centralization in optimizing service-led growth strategies (Johnstone *et al.*, 2014<sup>[21]</sup>; Durugbo & Erkoyuncu, 2016<sup>[15]</sup>; Prajogo & Oke, 2016<sup>[34]</sup>; Bustinza *et al.*, 2017<sup>[9]</sup>; Xing *et al.*, 2017)<sup>[45]</sup>.

Furthermore, the present study findings support the hypothesis that cross-border service agreements and captive

service offshoring are competitive alternatives that provide better innovation results than internal 18 service provision. At the same time, domestic partnerships do not seem to be correlated with a premium for innovation. This result is notable because it supports the literature that stresses proximity to global clients and international information exchange, rather than proximity between output and suppliers to underline debates related to economic geography (Peeters *et al.*, 2015<sup>[32]</sup>; Jones & Wren, 2016<sup>[22]</sup>; Jacobs *et al.*, 2016<sup>[20]</sup>; Lafuente *et al.*, 2017)<sup>[25]</sup>.

Another interesting finding is that by having a central planning unit, the lack of coordination between service and product production units identified in previous research studies can be resolved (Einola *et al.*, 2016)<sup>[16]</sup>. This finding is consistent with the model presented by Kim *et al.* (2003)<sup>[24]</sup>, which indicates that knowledge centralization is critical for the decision-making process involved in developing collaborative strategies because it offers a stronger foundation for departmental collaboration. The findings support the hypothesis that knowledge judgment centralization is directly related to product-service innovation in this regard. Unlike the other countries studied, the present study found that knowledge decision centralization in Japan does not promote product-service innovation. This outcome's explanations remain unclear, and the data lacks the necessary details to provide a definitive response. However, one possible interpretation is that industrial models and corporate systems are distinct. This unique organizational environment can impact how businesses serve their customers and, more specifically, how skill decision centralization affects product-service innovation. A potential research direction may be to decode the country-specific conditions of Japanese MMNEs to provide a complete explanation for this intriguing finding.

### Managerial Implications

The current study has significant consequences for professionals, emphasizing manufacturers that are actively pursuing or planning to pursue service-led strategies. Managers of MMNEs must be mindful, according to the present study findings, that a transition would support the organization, especially in terms of centralization of knowledge inflows and service role decision-making. Employees engaged in service planning, structure, and procedures can report directly to the head office, as this structure allows for a deeper view of the industry's clients and their demands, as well as an increased service capability.

Manufacturing companies applying integrated technologies to their current goods face more significant complexities and threats and must therefore be vigilant about implementing disruptive operational improvements (Benedettini *et al.*, 2015)<sup>[3]</sup>. Organizational restructuring can be beneficial in terms of growth, but it can also be detrimental to a company's financial status in the near term. There is less need to manage information inflows for staff because half or more of the service function and client relationship is outsourced to a specialist associate. Another significant implication for managers is that, while international business expertise and excellent technical capabilities are available, they are unlikely to be placed next door. Captive service offshoring, which keeps the service role internal to the enterprise, could be a choice for managers with a global vision of the service unit. This

seems to be a better choice than domestic internal provision. However, the present study results suggest that the cross-border service relationship is the strategic choice with the highest innovation premium.

### Limitations and Future Directions

Several nation heterogeneities are found in the present study. For example, the study discovers that Japanese producers do not benefit from knowledge decision centralization in terms of creativity. Domestic strategic partnerships only have an innovation premium in the United Kingdom. One drawback of this research is that the dataset used did not detail the basic features of the negotiations or the country-specific aspects of decision-making processes. Collecting more data on these topics to achieve a deeper understanding of country heterogeneities is one future study path. The study of the internationalization of the service function is almost non-existent in the field of servitization analysis. An important avenue for future servitization research is to include the international angle by developing studies of how service provision is grown in countries other than the head office and the export gains of implementing service-led growth strategies. The present study is cross-sectional and does not allow for diverse strategic aspects, crucial in service industries. This suggests that other elements not considered in the new paradigm, such as organizational reform, may have a substantial effect. Validating the study in a longitudinal environment is, therefore, an essential potential research path.

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