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RELATIONSHIPS BETWEEN DIFFERENT TYPES OF SERVITIZATION AND OPERATIONAL PERFORMANCE: CONSIDERING THE EFFECT OF CROSS-FUNCTION INTEGRATION

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Relationships between Different Types of Servitization and Operational Performance: Considering the Effect of Cross-Function Integration

Xue-Liang PEI¹, Gu-Yang TIAN², David MCAVOY³

Abstract

There is fierce conflict between theoretical research of servitization which has high potential for manufacturing companies to build sustainable competitive advantages and the practice of manufacturing companies which invest a lot in servitization without getting the expected benefit. This study aimed at filling the aforementioned research gap to examine the relationship between servitization and operational performance. In line with the focus of information and knowledge within this study, we also examine the moderating effect of cross-function integration. Based on the IMSS-IV database, we test these relationships. The results showed the following: (1) The result suggests that service support products has a positive impact on operational performance while the relationship between service support clients' actions and operational performance is U-shaped; (2) the relationship between two types of service and operational performance is not moderated by cross-function integration. This study contributes to the current literature and practice on servitization and cross-function integration.

Keywords: servitization, service support, operational performance, Cross-Function Integration, social responsibility.

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Introduction

Increasingly, manufacturing companies are extending their offering portfolios from intangible products to “products and services” bundles for the purpose of differentiating from their competitors (Fang, Palmatier, & Steenkamp, 2008; Vandermerwe & Rada, 1988). Prior research suggested that the transition—termed as servitization—has high potential for manufacturing companies to build sustainable competitive advantages. However, in practice, a lot of manufacturing companies suffered from a “service paradox”—manufacturing companies invested a lot in service related activities without getting the expected benefit (Brax, 2005; Gebauer, Fleisch, & Friedli, 2005; Valtakoski, 2017). For example, Intel’s Web-based service, and more recently, Michelin’s Michelin Fleet Solutions (MFS) are notable examples of unsuccessful service transition. Empirical research regarding the relationship between servitization and firm performance also yield mixed results (Gebauer *et al.*, 2012; Kowalkowski *et al.*, 2017; Ambroise, Prim-Allaz, & Teyssier, 2018). Both positive (Eggert *et al.*, 2014), negative (Neely, 2008), and non-linear (Fang *et al.*, 2008; Suarez, Cusumano, & Kahl, 2013; Visnjic & Van Looy, 2013) relationships are presented. The mixed result yields several research gaps regarding the performance implication of servitization.

First, more empirical research is needed to examine how and why servitization impact firm performance (Eloranta & Turunen, 2015; Crozet, 2017). Current research regarding the relationship between servitization and firm performance are mostly qualitative and anecdotal. Of the few empirical research examining the relationship between servitization and firm performance, most research focuses on financial output and differentiates the various types of servitization of manufacturing companies. However, as proposed by Benedettini, Swink, Neely, Brown, and Brown (2015), the implementation of servitization need a long-term perspective, and need time to transfer to financial performance gain. Therefore, it’s more reasonable to examine the performance implication of the antecedents of financial performance, such as operational performance. In addition, manufacturing companies provided a wide range of services, and in each type of servitization, the role of service and operations realm are quite different, and therefore, have distinctive implications for performance. Hence, more research is needed to examine how different types of servitization, i.e. services support products (SSP) and services support clients (SSC), impact on operational performance.

Second, more research is needed to examine contingencies that help a firm to achieve performance gains from servitization strategies (Lightfoot, Baines, & Smart, 2013; Szasz, & Seer, 2018). The shift from selling pure products to service poses challenges to the firm operations, such as the design of offerings, organizational culture. Fang *et al.* (2008) proposed that the loss of strategic focus and organizational conflict mitigate the positive impact of service transition strategy. In order to attenuate the conflict coped with servitization, more cross-functional cooperation is needed. Cross-functional integration could help the firm

to reach an agreement on the balance between product and service and reduce conflict (Swink & Schoenherr, 2015). In addition, cross-functional integration could facilitate the development of service and product offerings. However, current research on cross-function integration mostly focuses on product manufacturing regime (Troy, Hirunyawipada, & Paswan, 2008), and little is known about the role of cross-function integration played in servitization context.

This study aimed at filling the aforementioned research gap to examine the relationship between servitization and operational performance. In line with the focus of information and knowledge within this study, we also examine the moderating effect of cross-function integration. Based on the IMSS-IV database, we test the hypothesis regarding (1) what is the relationship between servitization and operational performance? Specifically, does SSP and SSC have a different impact on operations performance? and (2) how would cross-function integration mitigate the relationship between servitization and operations performance?

Literature review and Hypothesis

Definition of Servitization

The concept of servitization was firstly proposed by Vandermerwe and Rada (1988) to illustrate the process of “creating value by adding services to products”. Vandermerwe and Rada (1988: 316) defined servitization as “the increased offering of fuller market packages or ‘bundles’ of customer focused combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings”. And then, while some focus on an integrated system of both goods and services (Vandermerwe & Rada, 1988; Wise, & Baumgartner, 1999; Robinson, Clarke-Hill & Clarkson, 2002; Tremblay *et al.*, 2018), others focus on create mutual value through a shift from selling product to selling Product Service Systems (PSS) by manufacturing companies (Desmet, van Dierdonck & van Looy, 2003; Neely, 2008; Baines *et al.*, 2009; Baines *et al.*, 2007; Barnett *et al.*, 2013). In addition, some emphasized the operational practice of servitization (Vandermerwe & Rada, 1988; Robinson, Clarke-Hill & Clarkson, 2002), others emphasized the strategic importance of servitization (Desmet, van Dierdonck & van Looy, 2003; Neely, 2008; Baines *et al.*, 2009; Baines *et al.*, 2007; Barnett *et al.*, 2013). With the intensify of competition in the product sector, servitization has become the “new growth trajectory” for traditional manufacturing companies, such as IBM, Rolls Royce, GE, etc.

We build upon the existing literature and its gaps to develop a integrated definition of servitization definition, define servitization as "both the strategic and operational capabilities and processes wherein manufacturing companies to better create mutual value through a shift from selling product to selling PSS". Regarding the typology of servitization, the most widely accepted categorization is Mathieu'

s (2001) categorization of service support products (SSP) and service support clients' actions (SSC). This study adopts this categorization of servitization.

Definition of Cross-functional integration

Cross-functional integration, also termed as internal integration, refers to “the mutual alignment of cross-functional interdependencies through interaction, information sharing, and collaboration (Swink & Schoenherr, 2015: 69)”. The core component of cross-functional integration involves interaction and communication, information sharing, coordination, and joint decision-making among different functions within a company. New product development literature has been repeatedly emphasized the benefit of cross-functional integration (Troy, Hirunyawipada, & Paswan, 2008).

In the context of servitization, CFI is more closely associated with success. Customers could recognize the inadequacy of coordination more easily because services are produced simultaneously with consumption, where the produce of services is exposed to the customers.

The effect of cross-functional integration was widely discussed in new product development literature. However, little attention was given to the role of cross-functional played in the servitization context. Given the importance of CFI in servitization context, how cross-functional integration mitigates the relationship between servitization and operational performance deserves more exploration.

Relationship between servitization and operational performance

Operational performance was defined as a manufacturing firm's excellence regarding quality, delivery, flexibility, cost efficiency, and more recently, service, product innovation, and sustainability. In this section, we develop hypothesis based on the difference between SSP and SSC.

A review of current research on servitization and firm performance yield several research gaps that need to be filled. First, current research on the relationship between servitization and firm performance are mostly qualitative and anecdotal. Of the few empirical research examining the performance implications of servitization, the results are quite inconclusive, which intensifies the “service paradox” argument. Second, current research on the performance implications of servitization mostly focuses on financial output. However, financial output is an external-oriented indicator that determined by multiple factors and take time to visualize, and therefore, too “far away” from a strategy that requires long-term planning, i.e. servitization. In this regard, a more internal-oriented indicator, such as operational performance, could better portray the impact of servitization. Also, for a manufacturing firm to achieve excellent financial performance, a satisfactory operational performance is a prerequisite. Therefore, more research is needed to examine how servitization impact operational performance to see if the

“service paradox” still holds. Finally, research into the performance implications of servitization is still emerging, yet lacking deep theoretical grounding. More understanding of the mechanism of how servitization impact performance differently is needed, particularly regarding their operational performance impact.

To address these research gaps, this study combine the knowledge-based view (KBV) and information-processing theory (IPT) to examine how different types of servitization impact operational performance, and how cross-functional integration moderate the relationship.

From a KBV perspective, servitized companies require two types of knowledge. The first is the existing product design and manufacturing related knowledge that supports the product. The second is the service operations-related knowledge that needs to be acquired from external sources. These two types of knowledge could complement each other and create competitive advantages for manufacturing companies. However, for manufacturing companies providing different types of service, the requirements for these two types of knowledge is different. For low levels of servitization, such as SSP, where the recipient of service is the core products, more existing product related knowledge is needed. In contrast, for high levels of servitization, such as SSC, where the recipient of service is customers, more service related knowledge is more important. Regarding the different knowledge needed for SSP and SSC, we propose that SSP and SSC have a different impact on operational performance.

SSP represent knowledge exploitation that adding product service to current business model, which is more routine. Existing knowledge of product design and manufacturing is the knowledge base, together with some service operation-related knowledge acquired from external sources for providing services (Zheng *et al.*, 2018). Therefore, at low level of SSP, the benefits overweight its cost. However, the margin of benefits declines, while the margin of cost increases. After a specific extent, their costs dominate its benefits. At a high level of SSP, the cost and risk associated with information-processing dominate due to the high cost associated with the intensive investments in under high level of SSP. Therefore, over some scale of SSP, the operational performance declines with the increase of SSP. We propose the following hypothesis:

Hypothesis 1a: SSP has an inverted U-shaped impact on operational performance, such that operational performance increases at the low level of SSP and declines after a certain point.

SSC is the exploration of current business, switching from product provider to service provider, which is non-routine, high level of complexity, and need more heterogeneous customer-related knowledge. The existing knowledge in product design and manufacturing is not sufficient for success operations, and service operations-related knowledge acquired from external source is the knowledge base. In this regard, knowledge exploration is needed. Therefore, the benefit of SSC can only be achieved when the scale and scope reach an extent.

Low level of SSC decreases operational performance. First, low level of SSC intensifies organizational conflict. Low level of SSC has high equivocality, where decision makers have different interpretations of the environment, resulting intense organizational conflict. Second, at a low level of SSC, the benefit associated with SSC may be restricted by the lacking for service operation-related knowledge. Manufacturing companies implement service infusion face both task-related and environmentally related uncertainty. For a manufacturing company with its knowledge base geared toward product manufacturing, service operations exceeded its boundary of the knowledge base. Third, service may substitute the product sales. Both product and service are geared toward the same customers, like the new product impair the market share of existing products; service may also cannibalize its current product market share. Although the KBV perspective proposed that the providing of SSC could help the firm to overcome bounded rationality in decision-making, at a low level of SSC, its cost would overweight its benefits and have an adverse impact on operational performance.

The cost and risk associated with information-processing are subject to decreasing margin due to the economies of scale and learning effect. For example, with the increase of SSC, organizations have a clearer emphasize of service. The combat for product and service will decrease, so as to reduce organizational conflict.

In contrast, the benefit associated with SSC is subject to increasing margin due to the economies of scope. The acquired knowledge enrich current knowledge repertory, and help the firm to increase operational performance. For example, a manufacturing company with both service and product knowledge can better cope with the change of environment, improving both innovation and flexibility. In addition, the acquired knowledge of service operations complements existing knowledge on product manufacturing, help the firm to achieve economies of scope and decrease cost. With the increase of SSC and broadening of the firm's knowledge base, the complement between service and product manufacturing become easier. As the increase of scale of SSC, its benefit will overweight its cost and risk. At a high level of SSC, the benefits associated with SSC dominate, and have a positive impact on operational performance.

Hypothesis 1b: SSC has a U-shaped impact on operational performance, such that operational performance decreases at a low level of SSC and increases after a certain point.

The role of cross-functional integration

Also, we expect the relationship between two types of service and operational performance to be contingent upon the level of cross-functional integration. As discussed, SSP has a positive impact on operational performance because the service operations-related knowledge enhances the design of offerings. However, SSP negatively impacts operational performance because of the lack of information-

processing capability. Under a high level of CFI, the benefit was strengthened, while the cost was weakened. First, within an integrated organizational structure, knowledge could be used more efficiently. The intensive information sharing and coordination between the design and marketing department could generate a better understanding of the customer needs, which is crucial for the design and delivery of offerings (Wu, Tsai, & Tai, 2016; Potocnik & Anderson, 2016).

Second, CFI provide additional information processing capability for organization to deal with the uncertainty, and mitigate the negative impact of servitization (Tushman, & Nadler, 1978). For example, the participation of decision makers with different background could mitigate bounded rationality in decision process. In addition, high level of CFI helps the firm to attenuate organizational conflict. With intensive communication and coordination, organizational members could reach an agreement on the balance between services and products, mitigating the intense combat of resource between product and service department. Therefore, we propose the following hypothesis.

Hypothesis 2a: Cross-functional integration positively moderation the relationship between SSP and operational performance such that under high level of SSP, manufacturing companies adopt high level of CFI outperform companies adopt low level of CFI.

From the IPT perspective, cross-functional integration represents capability to improve the information-processing capability for servitized manufacturing companies, which can exacerbate the benefit of knowledge and attenuate the cost. First, with intensive coordination between departments, knowledge related to product manufacturing and service operations are easier to complement each other to achieve economies of scope.

Second, information sharing between different departments could facilitate organizational learning, and mitigates the conflict associated with servitization. CFI help the decision makers from different backgrounds to reach a shared understanding of the external environment. In this regard, the cost associated with service will drop more sharply.

Hypothesis 2b: Cross-functional integration positively moderation the relationship between SSC and operational performance such that under high level of SSC, manufacturing companies adopt high level of CFI outperform companies adopt low level of CFI.

Methodology

Sample

This study used the 6th round of International Manufacturing Strategy Survey (IMSS-VI) database. The IMSS project aimed at investigating the strategy, practice, and performance of manufacturing firms. The IMSS project was originated in 1992 and was conducted for every four years. The IMSS-VI used in this study was started in 2013 and was finalized in 2014. Data were collected from 22 countries (both developed and developing countries), with 931 plants participated in the survey. Respondents are the senior manager of the plant and have an average work period in that plant for three years. Regarding non-response bias, the IMSS team compared the early and late samples, no significant difference was detected.

Measurement of Servitization

The IMSS-VI questionnaire listed eight types of service typically offered by manufacturing companies. We conducted an exploratory factor analysis to extract two factors. The cumulative variance explained is 61.45%. According to the results, factor 1 has high loadings at “Maintenance and repair of products sold to customers”, “Installation/implementation services”, and “Spare-parts/consumables provision for customers”, all of which are closely related to service that supports the use of the product. Factor 2 has high loadings at “Rental/lease of products (with responsibility for maintenance, repair, and operation)”, “Product upgrades (software, product modifications)”, “Help-desk/customer support centre”, “Training in using the products”, and “Consultancy services”, all of which are geared toward supporting customer’s behavior. Therefore, factor 1 was named as SSP, while factor 2 was named as SSC. Our measurement of SSP and SSC is similar to Kah (2013) and He & Lai (2012).

Measurement of Operational performance

Operational performance is a multi-dimensional concept. The traditional dimension of operational performance included cost, quality, delivery, and flexibility. However, with the evolution of competition, more dimensions, such as service, product innovation, environment, and social responsibility, are added. In this study, we take a holistic view of operational performance and measure operational performance along cost, quality, delivery, flexibility, service, product innovation, environment, and social responsibility. We used a five-point Likert scale based on the performance improved compared to three years ago, where 1 represents, 3 represent, and 5 represent. Also, we weighted them on the competitive priorities of each company. A weighted performance index yields a better representation of a company’s operational performance since it takes the importance of winning

orders into account. We calculate a weighted index for operational performance according to the following equation:

$$\text{Operational Performance} = \text{CPCost} \times \text{OPCost} + \text{CPQuality} + \text{CPDelivery} \times \text{OPDelivery} + \text{CPFlexibility} \times \text{OPFlexibility} + \text{CPService} \times \text{OPService} + \text{CPIInnovation} \times \text{OPIInnovation} + \text{CPEEnvironment} \times \text{OPEEnvironment}$$

Our measurement of operational performance is similar with Zhang (2012). Among the measurement of competitive priorities, two of these dimensions were measured by single items, while the others are measured by two items. We averaged their score and then calculate the weighted performance.

Measurement of Cross-function integration

Cross-function integration refers to the degree of information sharing, joint decision making, interaction and coordination within the different department within the company. We used a four-item to measure CFI, which is similar to the item used by Koufteros, Vonderembse & Jayaram (2005) and Swink & Schoenherr (2015). Respondents are asked to indicate their current implementation of internal integration within the plants based on a five-point Likert-scale. We averaged all the items as the proxy of CFI.

Control variables

We also include some control variables to exclude the “noise” of the study. First, we control for country and industry difference. We calculated 21 country dummies and five industry dummies. Second, we control for firm size, because firms size has an impact on the propensity to servitize and degree of performance. We calculate the natural log of the employees of each plant as the measurement of firm size. Third, firm age was suggested to have the impact on a firms’ servitization strategy, because aged firms are more likely to subject to the decrease of profit margin and take service extension as a new growth point. We use the natural log of the years since the plant have been started as the proxy for firm age. Finally, we control for the competitive environment because the competitive environment has an impact on both the propensity to servitize and its operational performance. We measure competitive environment based on Porter’s (1985) five source of competitive force, including competitive rivalry within the industry, market entry, the threat that your products will become substituted, bargaining power of suppliers, bargaining power of customers, each was measured by a five-point Likert scale. Due to the low correlation between these five variables, we estimate them separately.

Reliability and Validity

The IMSS questionnaire was designed by a group of operations management experts based on existing literature and have been pre-tested by practical managers. Moreover, the IMSS have been conducted for six rounds, and the main structure of the questionnaire has been maintained, represent a mature questionnaire, which could ensure the content validity of the scales.

Both competitive priority and operational performance are multi-dimensional constructs. To test the unidimensionality of the scales, we conducted an exploratory factor analysis on the competitive priorities and operational performance. We exacted eight factors based on a principle component factor analysis combined with varimax rotation approach. All the items have high loadings (over 0.5) on the specific factor they intended to measure and have low loadings (blow 0.5) on other factors, except for one item of competitive priorities to measure flexibility-wider product range-also have high loadings on innovation (0.514). The result is understandable because of the close relationship between flexibility and innovation. The result supported the unidimensionality of the scale.

We assess the reliability of the scale based on Cronbach's alpha coefficients. We calculated Cronbach's alpha coefficients for all the variables, including the dimensions of competitive priorities and operational performance. All Cronbach's alpha and composite reliability coefficients are greater than the suggested cut point of 0.60, indicating the scales are reliable.

To assess the convergent validity of the scale, we conducted a conformity factor analysis (CFA). The exploratory variables, including SSP, SSC, and cross-function integration are included in a measurement model. The goodness-of-fit are as follows: RMSEA=0.065, CMIN/df=4.878, CFI=0.941, NFI=0.927, IFI=0.941, indicating the measurement model is acceptable. Also, the factor loadings of items on the intended variables exceeded 0.5, which ensure the convergent validity.

To assess the discriminant validity of the scales, we calculate the average variance extracted (AVE) of each exploratory variable and compare the square root of its AVE with its correlation with other variables.

Common method bias

This study control for common method bias in two ways. First, at the research design stage, we adopt suggestions from existing literature to ensure the anonymity of the respondents. In addition, the variables used in this study are from the different section of the questionnaire. Second, we conducted a Harmon's single factor analysis to detect potential common method bias. An exploratory factor analysis was conducted with all the perception-based items included. The first factor only explained 20% of the total variance. Although Harmon's single factor analysis could not entirely eliminate the CMV concern, it could largely mitigate it.

Multicollinearity

The variables in this study are medium correlated (between 0.2 and 0.6). Therefore, multicollinearity is not a primary concern for this study. In the regression section, we also detected the underlying multicollinearity based on the variance inflation factor (VIF).

Results

Endogeneity test

The endogeneity concern of this study originates from two sources. The first source is the possible simultaneous causality between servitization and operational performance. As the threat-rigidity hypothesis suggest, well-performed companies are more likely to choose service that is more risky, such as SSC. In contrast, poorly performed companies are more apt to choose service that is less risky, i.e., SSP. Therefore, operational performance might have a reverse impact on the choice of service type. The second source is the omitted variables, such as managerial skills, that correlate to both the propensity of servitization and degree of operational performance. However, managerial skills are an unobservable variable. Therefore, endogeneity could lead to both Type I and Type II error.

In order to test the underlying endogeneity problem, we chose strategic investment and service revenue as the instrumental variables of SSP and SSC. Strategic investment was measured by “the average percentage of total sales invested in strategic initiatives such as sustainability, globalization, and servitization”. Service revenue was measured by the percentage of service revenue in total revenue. We conducted two stage instrumented regression and Dublin-Wu-Hausman test to detect whether these two variables are exogenous. The insignificant Wu-Hausman F-statistic of SSP (Wu-Hausman $F=0.86$, $p=0.36$) and SSC (Wu-Hausman $F=0.03$, $p=0.87$) indicate that the OLS regression is more efficient than instrumented regression.

Findings

This study used hierarchical ordinary least square multi-regression analysis to test the hypothesis. The regression coefficients are presented in *Table 1*. Model 1 includes all the control variables. In model 2, the independent variable - SSP and SSC - are added. In model 3, the squared term of SSP and SSC are added. In model 4, CFI is added. In model 5, the interaction term of SSP, SSC and CFI are added. In model 6, the interaction term between the squared term SSP and SSC and CFI are added. The regression coefficients are presented in *Table 1*.

We begin with the VIF and impact of control variables. The VIF of all the variables is lower than 6, which further exclude the multicollinearity concern. Regarding the control variables, only one of them is relevant. Consistent with prior research, the operational performance of manufacturing companies is partially depended on the competitive environment. However, we find opposite results. In our study, we find both competition within the industry ($\beta = 2.81, p < 0.01$) and bargain power from the customers ($\beta = 1.78, p < 0.05$) are positively related to operational performance, indicating that in industries with intensive competition and firms with higher customer bargain power have higher operational performance. This counter-intuitive finding could be understood by the dependent variable we use. Intensive competition and bargain power from the customers set a higher industrial standard, urging the firms to continuously improve their efficiency to win orders.

Hypothesis 1a predicts an inverted U-shaped relationship between SSP and operational performance. This hypothesis is not supported since the coefficient of the squared term of SSP is not significant. Whereas Hypothesis 1b predicts a U-shaped relationship between SSC and operational performance. We obtain preliminary support for it since the quadratic effect of SSC is positive and significant ($\beta = 1.15, p < 0.1$).

Hypothesis 2a and 2b pertain the moderating effect of cross-function integration on the relationship between two types of servitization and operational performance. In support of this hypothesis, the coefficients of the interaction terms of CFI and the squared SSP and squared SSC should be significant and at right sign (positive for SSP and negative for SSC). In this regard, we do not find support for H2a and h2B because the interaction terms between CFI and SSP are not significant.

However, as suggested by Haans, Pieters, & He, (2016), there are two types of moderation in U-shaped and inverted U-shaped relationships. The first type is steeping or flatting the shape, where as we proposed in H2a and H2b, which is not supported due to the insignificant coefficients of the interaction of the moderator and the quadratic terms. In order to explore the role of CFI further, we follow the steps proposed by Haans, Pieters, & He (2016) by testing a compound parameter composed of the coefficient of SSC, squared SSC, interaction of SSC and CFI, and interaction term of squared SSC and CFI (see equation (11) in Haans Pieters, & He (2016). However, the compound parameters are not significantly different from zero, indicating both relationships are not moderated by CFI.

In summary, the result suggests that SSP has a positive impact on operational performance while the relationship between SSC and operational performance is U-shaped. In addition, the relationship between two types of service and operational performance is not moderated by CFI.

Robustness test

We conduct further robustness test to ensure the robustness of the results in the following ways. First, we include the cubic terms of SSP and SSC in the regression

model to detect the possibility of an S-shaped relationship. However, both the change of R square of the equation and cubic terms are not significant, ruling out the possibility of an S-shaped relationship. Second, we use the implementation of cross-functional integration in the past three years as a proxy for the level of cross-functional integration of manufacturing companies. The signs and significance of the regression are the same as the model we used.

Table 1: OLS regression coefficients

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	52.95**	58.19**	56.54**	41.09**	39.34**	40.88**
CD included	Yes	Yes	Yes	Yes	Yes	Yes
ID included	Yes	Yes	Yes	Yes	Yes	Yes
FirmAge	0.10	0.43	0.59	0.76	0.66	0.63
FirmSize	0.64	0.32	0.37	-0.44	-0.39	-0.40
CWI	3.61**	3.55**	3.33**	2.73**	2.73**	2.81**
ME	-0.82	-1.01	-1.06	-0.76	-0.82	-0.83
ST	0.18	-0.24	-0.24	-0.26	-0.14	-0.11
BPS	2.63**	1.51+	1.44+	1.29	1.36+	1.30
BPC	2.06*	2.19**	2.22**	1.72*	1.78*	1.78*
SSP		2.68**	2.42**	1.60*	1.60*	1.57*
SSC		5.55**	5.35**	3.47**	3.18**	3.36**
SSP^2			-0.51	-0.48	-0.46	-0.40
SSC^2			1.49*	1.48**	1.04+	1.15+
CFI				8.46**	8.85**	8.22**
SSP × CFI					-0.31	-0.11
SSC × CFI					1.98*	2.08*
SSP^2 × CFI						0.98
SSC^2 × CFI						-0.49
R2	0.21	0.28	0.29	0.36	0.37	0.37
Adj-R2	0.17	0.25	0.25	0.32	0.33	0.33
△R2	0.21	0.07	0.01	0.07	0.01	0.00
F-statistics	5.53	7.48	7.31	9.58	9.30	8.92

Notes: (1) CD=country dummies, ID=industry dummies, CRI = competitive rivalry within the industry, ME = market entry, ST = substitution threat, BPS = bargaining power of suppliers, BPC = bargaining power of customers; (2) T-statistics in parentheses; 3. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

Discussion

This study how SSP and SSC separately impact operational performance, as well as the moderating effect of CFI. By drawing upon the important role information and knowledge played in servitization, we offer a more theoretically grounded explanation of the dual effect of servitization based on the knowledge-based view of the firm and information-processing theory (Grant, 1996). We suggest that servitization, on the one hand, enriches the knowledge base of manufacturing companies and complement existing knowledge repertory on product manufacturing to improve efficiency. On the other hand, the processing of service-related information and knowledge pose challenge the manufacturing companies' information-processing capability with their knowledge base geared toward product manufacturing, which jeopardizes the efficiency. Our research offers some theoretical and practical implications.

Theoretical implications

This study makes two theoretical contributions to servitization and cross-functional integration literature. First, we offer a more detailed picture of the intricate relationship between servitization and performance. Current empirical research on the non-linear relationship between servitization and performance yield both U-shaped, inverted U-shaped relationships. The conflicting result is due to the lacking of consideration on the different types of service provided by manufacturing companies. By differentiate SSP from SSC, our research seem to make a synergy between those two streams of research. In addition, current research mostly focus on financial performance, we focus on its prerequisite and more internal-oriented indicator of efficiency-operational performance. Of the four hypotheses we proposed, only the U-shaped relationship between SSC and operational performance was validated. The finding is consistent with Fang (2008). Low level of SSC jeopardizes operational performance because of the heterogeneous knowledge needed for services operations. As the scope of SSC increases, due to the economies of scale and learning effect, manufacturing companies accumulate information-processing capability. SSP have an inverted U-shaped impact on operational performance, which confirmed Visnjic (2013) in some extent. Low level of SSP can enrich the information source and improve operational performance. However, when the level of SSP exceed to some extent, the associated information-processing challenge mitigate the benefit of SSP. From the IPT perspective, the inverted U-shaped relationship between SSP and operational performance arises from and illustrates a critical hidden trade-off between service as a source of information to make better decision and the operational performance of servitized manufacturing companies increase at low levels of SSP (due to the enrichment of information for decision making), yet recedes after a certain level of SSP is passed and more adverse effects (associated

with the insufficient information-processing capabilities) dominate. In our sample, the relationship between SSP and operational performance is not significant. This could be explained by the learning effect and economies of scale. When a manufacturing company providing SSP, its cost in information-processing may be attenuated by the learning effects and economies of scale.

Second, we offer a contingent view on the relationship between servitization and operational performance. In this study, the moderating effect of CFI was not validated. This is due to the industry evolution of manufacturing industry (Valtakoski, 2017). At the present stage, the cross-functional integration of manufacturing industry has developed to a mature stage, and the gap between enterprises is not obvious. However, the relationship between CFI and operational performance is significant. Manufacturing companies implementing servitization should also implement cross-functional integration to improving operational performance.

Practical implications

This work also deliveries some important implications for the managers for servitized manufacturing companies.

First, different logic in managing SSP and SSC. Taken from an information and knowledge perspective, SSP represent knowledge exploitation while SSC represent knowledge exploration. This study indicates distinctive perspective toward SSP and SSC. When managing SSP, managers should avoid “too much of a good thing”. Therefore, managers should control the scale of SSP to balance the benefit and cost associated with SSP. In contrast, managers handling SSC should increase the scale of SSC to achieve economies of scale. Managers should focus on improving the information-processing capability.

Second, CFI could mitigate the negative impact of servitization. Cross-functional integration provides manufacturing firms additional information-processing theory. Managers handling SSC should also implement cross-functional integration to avoid organizational conflicts.

Conclusions

In summary, our study indicates that SSP and SSC have distinctive impact on operational performance. Although intensive qualitative-based research proposed the importance for a manufacturing company to achieve competitive advantages, little is known about whether, what types, and in what conditions can servitization help firm to achieve performance gains. Although extensive research has examined how servitization impact the external-oriented financial performance, its impact on the internal-oriented operational performance is less developed.

This study examined how servitization impact operational performance and how cross-functional integration mitigates the relationship based on an information-processing approach. The results indicate that SSP have a U-shaped impact on operational performance, while SSC have an inverted U-shaped impact on operational performance. In addition, under high level of cross-functional integration, the relationship between SSC and operational performance is stronger. The result yield implications for both servitization researchers and practitioners.

Limitations and future research

The limitation of this research mainly originated from the cross-sectional, survey-based, and single respondent approach to test the hypothesis. First, this study could not completely eliminate common method bias due to the single respondent-based survey design. Despite we make efforts to control for the common method variance issues. Second, this study is cross-sectional in nature. Future research could contribute more by a longitudinal design. Finally, only eight types of service are presented in the questionnaire. Although these service are typically provided by manufacturing companies, they are not complete enough to portray the whole picture of servitization. Future research should rely on more service type to develop a more comprehensive typology of servitization.

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