THE RELATIONSHIP BETWEEN SERVITIZATION AND FIRM PERFORMANCE IN MANUFACTURING FIRMS: AN EMPIRICAL STUDY BASED ON PANEL DATA

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The Relationship Between Servitization and Firm Performance in Manufacturing Firms: An Empirical Study Based on Panel Data

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CERTITICATE OF ORIGINITY

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Abstract

Over the recent decades, with the development of globalization and information technology, the academic and business worlds have realized that manufacturing firms are faced with the increasing commoditization, convergence and homogenization of goods' characteristics and attributes, such that differentiation is severely diminished or even disappears. In order to acquire competitive advantage amid such fierce competition, manufacturing firms have gradually shifted from the manufacture of physical products to service offering, which is termed as "servitization". Since servitization can create differentiation and boost customer satisfaction and loyalty, it is often regarded as an effective means for manufacturing firms to obtain greater competitive edge than with physical goods alone.

However, the relationship between servitization and firm performance in manufacturing firms is still ambiguous. Prior research on the servitization-firm performance link has shown that the effect of servitization on firm performance is positive, negative, non-linear and even insignificant. Therefore, more empirical research on the relationship between servitization and firm performance is needed. Since firm performance is a multi-dimensional construct and the extant literature focuses on the relationship between servitization and firms' profitability indicators concerning financial performance, Study 1 of this thesis extends the performance dimensions and explores the relationship between servitization and multiple performance indicators (namely, operating margin, sales growth, operating efficiency and the asset-liability ratio). The regression results of this thesis show that there is a U-shaped curvilinear relationship between servitization and two performance indicators (namely, operating margin and operating efficiency), while there is a negative linear relationship between servitization and sales growth, and no significant relationship between servitization and the asset-liability ratio.

Due to the fact that the research findings on the servitization-firm performance relationship in different research contexts are inconsistent and even contradictory, there could be some external and internal contingency factors affecting this relationship. Extant studies categorize these contingency factors into environmental and firm-specific variables, while the majority of the relevant research concentrates on the moderating effect of firm-specific variables such as organizational design factors and

organizational capabilities. However, there is a little research into the moderating effect of environmental variables on the servitization-firm performance relationship. In order to narrow this gap, Study 2 of this thesis examines how industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) moderate the performance effect of servitization. Based on the regression results, this thesis presents some significant findings: industry clockspeed significantly moderates the U-shaped relationship between servitization and operating margin, industry maturity moderates the U-shaped relationship between servitization and operating efficiency and the negative relationship between servitization and sales growth, whereas industry concentration has no significant moderating effect on the servitization-firm performance relationship.

Moreover, despite the fact that the extant literature has proposed some important firm-specific factors (including organizational design factors and capabilities) moderating the servitization-firm performance relationship, these research has not provided a reasonable theoretical lens or perspective to explain the confounding effect of multiple moderators. This in turn calls for a clear and systematic theoretical framework to articulate the moderating effect of multiple firm-specific factors on this relationship. Therefore, Study 3 of this thesis investigates how some firm-specific variables moderate the relationship between servitization and firm performance in terms of strategic coherence and resource allocation.

Specifically, strategic coherence is demonstrated in terms of service relatedness and research and development (R&D) intensity, while the resource allocation mode is formed from marketing resources, absorbed resource slack and unabsorbed resource slack. Based on an empirical analysis, this thesis presents some conclusions from the perspectives of strategic coherence and resource allocation. On the one hand, this thesis finds that service relatedness significantly moderates the U-shaped relationship between servitization and operating efficiency, while R&D intensity significantly moderates the U-shaped relationship between servitization and operating margin; on the other, marketing intensity has no impact on the performance effect of servitization and absorbed resource slack significantly moderates the U-shaped relationship between servitization and operating efficiency, while unabsorbed resource slack moderates the U-shaped relationships between the servitization-operating margin and servitization-operating efficiency.

Overall, this thesis enriches and extends the research theories on the relationship between servitization and firm performance and the moderating factors affecting this relationship, as well as provides some significant theoretical and managerial implications. First, this thesis offers a clear and intensive research framework on the relationship between servitization and firm performance, explores the specific effect of servitization on multiple firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio), and provides great theoretical significance by answering the question as to whether it is worth making huge investments when implementing servitization. Second, this thesis examines the moderating effect of industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) on the performance effect of servitization, which offers a better and deeper understanding of the industry environment, where it is more suitable for manufacturing enterprises to implement servitization. In addition, this thesis discusses the moderating effect of strategic coherence on the relationship between servitization and firm performance in terms of two strategic supporting activities (namely, service relatedness and R&D intensity), which answers the question as to how manufacturing firms acquire great success in servitization through strategic supporting activities. In addition, this thesis investigates the impact of resource allocation on the relationship between servitization and firm performance, based on three categories of resources (namely, marketing resources, absorbed resource slack and unabsorbed resource slack), which confirms the importance of resource allocation and provides effective guidance for the selection of resource allocation mode by which manufacturing firms can readily achieve successful servitization.

Keywords: Servitization; Operating Margin; Sales Growth; Operating Efficiency; Asset-liability Ratio; Industry Clockspeed; Industry Concentration; Industry Maturity; Strategic Coherence; Resource Allocation

Publications arising from the thesis

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Working Papers

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1 Introduction

1.1 Research background

1.1.1 Practical background

Over the recent decades, with the development of globalization and information technology, firms have been confronted with increasingly fierce competition and engaged in finding new ways to survive in an intensely competitive market. Manufacturing firms also realize that they cannot gain and maintain competitive advantage through pure traditional product manufacturing, as well as need to make great reforms if they want to stand out from the competition (Gebauer, 2008). Since it was first termed by Vandermerwe & Rada (1988) to delineate manufacturing firms' shift from pure product manufacturers to service providers, servitization has been considered as an effective means for manufacturing firms to acquire growth, profitability and economic stability (Neely, 2008). Both academics and practitioners have focused on the performance effect of servitization in manufacturing firms, while anecdotal evidence from the business world indicates that the impact of servitization on firm performance is still ambiguous (Visnjic et al., 2012).

Servitization has been carried out by an increasing number of manufacturing firms all over the world and many leading product manufacturing companies have achieved success in their implementation (Lay et al., 2010; Neely, 2008). These successful business cases, such as ABB, Caterpillar, GE, IBM, Xerox and Rolls-Royce, are significant in terms of the performance effect of servitization (Cohen et al., 2006; Kastalli & Van Looy, 2013). For example, IBM has made significant achievements by offering service business. Specifically, during the period between 1992 and 2008, the proportion of IBM's revenue from service business (e.g., software, maintenance and finance) to total operating revenue increased from 48% to 82% while the corresponding operating margin in the service business also rose from 52% to 91%. Rolls-Royce is another representative manufacturing firm with successful servitization, having developed itself from solely selling jet engines into offering maintenance and overhaul services, especially the 'power by the hour' Total Care solution package, which distinguishes Rolls-Royce from other manufacturers and by which customers procure the capability delivered by its engines whereas the company assumes responsibility for engines' maintenance and risk (Kastalli & Van Looy, 2013).

These successful business cases involving the implementation of servitization emphasize the great potential offered by servitization in promoting firm performance. However, there is more failure among manufacturing firms in implementing servitization. Intel is a prominent example of such failure. The company invested up to 1.5 billion US dollars in the construction of a data center, but was forced to close this programme after three years since the data center did not produce the expected profit growth (Fang et al., 2008). In a similar vein, Dürr, the leading German manufacturer of paint finishing systems, changed its business model and introduced the first pay-per-use services, enabling carmakers to pay for each car painted, rather than investing in equipment. However, it was difficult for Dürr to estimate an optimal pay-per-use fee by predicting the level of equipment usage. Therefore, the revenue from these services did not come close to the firm's expected financial targets and eventually this service division was obliged to be sold to Voith Industrial Services (Kowalkowski et al., 2017). These failures indicate that servitization may not generate the expected increased performance, even though manufacturing firms may make huge investments in service business; this is referred to as "service paradox" (Gebauer et al., 2005). The findings reported by researchers also confirm this phenomenon (Baveja et al., 2004; Stanley & Wojcik, 2005). Baveja et al.'s (2004) survey finds that only 21% of firms succeed in the implementation of servitization. Accordingly, Stanley & Wojcik (2005) report that around 50% of all solution providers enjoy modest gains, while nearly 25% suffer losses in the provision of added-value services and solutions.

"Service paradox" suggests the negative effect of servitization on firm performance, which is contrary to the belief that servitization can effectively facilitate firm performance. Subsequently, researchers ask the questions: can servitization in manufacturing firms really generate increased firm performance? If so, how does servitization influence firm performance? Could all manufacturing firms acquire better performance by means of servitization? If not, which contextual factors (including industry-specific and firm-specific factors) will affect the relationship between servitization and firm performance?

1.1.2 **Theoretical background**

The theoretical research on servitization has evolved from descriptive or normative studies into empirical studies over the past three decades. Vandermerwe &

Rada (1988) first propose the construct "servitization" and define it as "the tendency to offer fuller market packages or bundles of customer-focused combinations of goods, services, support, self-service, and knowledge". Many scholars subsequently focus on servitization, and define and delineate this construct using many synonymous terminologies, including service innovation (Eggert et al., 2014b), service orientation (Homburg et al., 2003), service offering (Szász et al., 2017), service infusion (Kowalkowski et al., 2012), service-dominant logic (Vargo & Lush, 2008) and product service system (Tukker, 2010).

In the infancy of servitization theory development, researchers focused on the definition, drivers and evolution of servitization, and the challenges faced in the implementation of servitization and corresponding measurements, among other issues (Jacob & Ulaga, 2008; Mathieu, 2001; Vandermerwe & Rada, 1988). Gradually, the majority of recent literature in the servitization field focuses more on the relationship between servitization and firm performance, which could offer significant practical and theoretical guidelines for manufacturing firms' business practice (Fang et al., 2008; Neely, 2008; Szász et al., 2017).

Extant research on the relationship between servitization and firm performance can be roughly divided into the following four categories. (1) Some scholars' findings indicate that servitization can positively promote firm performance. Quinn et al. (1990) and Fry et al. (1994) support this point. Quinn et al. (1990) suggest that successfully managing service activities can help acquire competitive advantage while Fry et al. (1994) elaborate on how service-based strategies result in manufacturing firms' success. Most of this early research on the performance effect of servitization is normative or descriptive (Jacob & Ulaga, 2008). Recently more empirical studies have confirmed the positive relationship between servitization and firm performance. Homburg et al. (2002) empirically investigate the association between the business strategy's service orientation and company performance from the perspective of organizational strategy, and conclude that service orientation positively affects firm performance (financial and non-financial). Antioco et al. (2008) also verify a positive effect of service business orientations on firm performance based on 137 European manufacturing firms. (2) Although much of the literature finds a positive effect of servitization on firm performance, there is another view that servitization in manufacturing firms has a negative influence in this regard (Neely, 2008). This corresponds with "service paradox", where major investments in service business fail to generate the

corresponding returns (Gebauer et al., 2005). Neely (2008) confirms the existence of "service paradox" and first empirically explores the negative association between servitization and financial performance based on secondary data. Specifically, Neely (2008) reports that, despite the significant growth in total firm sales in servitized firms, these firms in this context acquire lower profit margins than pure product manufacturers, especially large firms. Besides, servitized firms are more likely to declare bankruptcy than pure manufacturing firms (Neely 2008). (3) In contrast to the linear (positive or negative) relationship proposed in the first two categories of studies (Antioco et al., 2008; Homburg et al., 2002; Neely, 2008), recent research indicates that the performance effect of servitization is far from simple and may be non-linear (Fang et al., 2008; Kastalli & Van Looy, 2013; Kohtamäki et al., 2013b). Fang et al. (2008) idenfity a U-shaped association between service strategies and firm value based on longitudinal and aggregated firm data, with the critical point between 20% and 30%. Specifically, the effect of manufacturing firms' service transition on firm value is negative until the ratio of service sales to total sales reaches the critical value (20%-30%), after which this effect will gradually keep increasing. Suarez et al. (2013) argue that sales from services have non-linear impact on operating margins using data on the pre-packaged software products industry, while Kohtamäki et al. (2013b) also propose a non-linear relationship between service offering and sales growth using data from 91 Finnish manufacturing companies. Besides, Kastalli & Van Looy (2013) demonstrate a positive but non-linear effect of the scale of service activities on firm profitability. Specifically, in the initial stage of servitization, there is a steep positive relationship between service scale and profit margin; after reaching a critical point, service scale shows a relative decrease in profit margin; then the positive relationship between service scale and profit margin re-emerges when the economies of scale are achieved. (4) Apart from the significant relationship between servitization and firm performance identified in prior research, a minority of studies propose that the performance effect of servitization is insignificant. Eggert et al. (2014b) suggest that there is no significant relationship between service innovation and profitability growth while Samarrokhi et al. (2014) propose that service differentiation is limited in its contribution to achieving sustainable competitive advantage in manufacturing companies.

Despite the volume of available literature on the relationship between servitization and firm performance, the research results are inconsistent and even contradictory. In addition, the performance measurement adopted in the extant research is simplistic. For

example, Neely (2008) adopts operating revenue and net profit to measure firm performance, Antioco et al. (2008) select product sales and service volume as firm performance indicators, and Fang et al. (2008) measure firm value with Tobin's Q. Overall, the majority of the extant research has focused on firm profitability to represent the firm performance, but ignores other effective performance indicators, which suggests that few empirical studies have explored the performance effect of servitization from multiple performance perspectives. In brief, firm performance can be measured as financial and non-financial, and financial performance can be measured with multiple measurement indicators including operating margin, sales growth, operating efficiency and asset-liability ratio (Filer & Golbe, 2003; Gedajlovic & Shapiro, 2002; Stratopoulos & Dehning, 2000). Thus, firm profitability as performance measurement is relatively simple, meaning that it cannot fully represent the relationship between servitization and firm performance. In order to offer a deep understanding of the servitization-firm performance relationship, there is much need to construct a more comprehensive and accurate framework to analyse the specific relationship between servitization and firm performance by covering multiple performance indicators, namely, operating margin, sales growth, operating efficiency and asset-liability ratio.

Research gap 1: Since prior research offers mixed evidence regarding the effect of servitization on firm performance and mainly focuses on the relationship between servitization and firm profitability, the thesis aims to narrow this research gap by presenting a more comprehensive and accurate study on the relationship between servitization and firm performance based on multiple performance indicators, namely, operating margin, sales growth, operating efficiency and asset-liability ratio.

Considering these mixed findings on the relationship between servitization and firm performance, we speculate that there could be some contextual factors affecting the servitization-firm performance relationship. Prior research has explored the moderating effect and the moderating factors can be roughly categorized into two types, namely, industry characteristics and firm characteristics (Eggert et al., 2011). Firm characteristics include the variables related to organizational structure, organizational capability and organizational resource, such as service relatedness, resource slack, service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services and service training (Antioco et al., 2008; Donaldson, 1995; Fang et al., 2008; Gebauer, 2007; Gebauer, 2008; Homburg et al., 2003; Jia et al., 2016). Fang et al. (2008) identify

a positive moderating role of service relatedness and resource slack on the relationship between service strategies and firm value, while Antioco et al. (2008), Donaldson (1995), Gebauer (2008) and Homburg et al. (2003) propose additional firm characteristics including service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services and service training as positive moderating factors of the servitization-performance relationship. Moreover, some other firm characteristics, such as relational capital, network capabilities and product innovation activities, have been identified as significant moderators influencing the association between servitization and firm performance (Eggert et al., 2011; Kohtamäki et al., 2013a, 2013b).

In contrast, there are few studies exploring the moderating impact of industry characteristics on the servitization-firm performance link. Fang et al.'s (2008) findings suggest that industry growth negatively affects the relationship between service strategies and firm value, while industry turbulence positively moderates this relationship. However, other industry characteristics as moderators of the servitization-performance link have not been examined to date. Therefore, this thesis attempts to narrow this gap by exploring the moderating effect of some industry characteristics on the relationship between servitization and firm performance in manufacturing firms.

Research gap 2: The majority of the literature on the servitization-performance link focuses on these moderating variables associated with organizational structure, capability and resource, but few studies explore the moderating impact of industry characteristics. This thesis fills this gap by deeply exploring the moderating role of some common industry characteristics on the servitization-performance link.

Based on the literature review above, it can be seen that previous studies have proposed some firm characteristics as moderating factors of the relationship between servitization and firm performance, and that these moderators are closely associated with organizational structure, capability and resource, including service relatedness, resource slack, service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services, service training, relational capital and network capabilities (Antioco et al., 2008; Fang et al., 2008; Donaldson, 1995; Gebauer, 2007; Gebauer, 2008; Homburg et al., 2003; Jia et al., 2016). However, there is still no clear and systematic theoretical framework demonstrating how multiple firm characteristics affect the relationship between servitization and firm performance in manufacturing firms.

Since the introduction of service business has enabled manufacturing firms to shift their strategic focus from being product manufacturers to "product and service" package providers, the service outcome of manufacturing firms is the unbalance of firms' strategic focus and resource allocation (Cook et al., 2006; Fang et al., 2008). The mismatch between servitization and manufacturing firms' strategic supporting activities and resource allocation may result in "service paradox" (Josephson et al., 2016; Mathieu, 2001). Hence, this thesis aims to enrich the servitization literature by examining the moderating impact of firm characteristics on the performance effect of servitization in terms of strategic coherence and resource allocation (Argote & Greve, 2007; Josephson et al., 2016).

Research gap 3: Despite the research identifying the moderating effect of firm characteristics on the servitization-performance link such as moderators related to organizational structure, capability and resource, a clear and systematic theoretical framework, which shows how firm characteristics influence the association between servitization and firm performance, is still lacking. The thesis aims to address this gap by exploring the moderating role of firm characteristics in the servitization-performance relationship from the perspective of strategic coherence and resource allocation.

1.2 Research questions

In order to fill the gap in the literature, this thesis further investigates the servitization research from the three perspectives discussed below in order to identify new insights into the servitization-firm performance relationship.

First, the thesis aims to offer a deeper understanding of the servitization-firm performance relationship. The research findings on the impact of servitization on firm performance in prior research are still ambiguous, and thus more empirical research is needed to test and support them. As previous research has mainly focused on the impact of servitization on firm profitability, this thesis aims to present a more comprehensive and accurate study on the servitization-firm performance relationship from the perspective of multiple performance indicators including operating margin, sales growth, operating efficiency and asset-liability ratio.

Second, the thesis explores the moderating effect of industry characteristics on the relationship between servitization and firm performance. Extant studies have seldom

concentrated on the impact of industry-level moderating factors on the relationship between servitization and firm performance. However, some scholars have found that the difference in the servitization-firm performance relationship in different industries is significant (Fang et al., 2008), indicating that industry characteristics may significantly affect the relationship between servitization and firm performance. Thus, this thesis explores, in detail, how industry characteristics influence the servitization-firm performance relationship in order to fill the gap in the literature.

Third, this thesis explores the moderating effect of strategic coherence and resource allocation on the relationship between servitization and firm performance. Although prior research on the servitization-firm performance relationship has identified some moderating factors related to organizational structure, organizational resource and organizational capability, there is still a lack of a clear and systematic theoretical framework to demonstrate how firm characteristics influence the relationship between servitization and firm performance. Hence, this thesis examines the moderating effect of firm-level factors on the servitization-firm performance relationship to further enrich the servitization theories.

Overall, the thesis mainly seeks to answer the following three research questions:

Q1: Is there a significant relationship between servitization and the four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) in manufacturing firms? Are they linearly or non-linearly related?

Q2: Do industry characteristics significantly moderate the relationship between servitization and the four firm performance indicators? If so, how?

Q3: Do firm characteristics significantly moderate the relationship between servitization and the four firm performance indicators from the perspectives of strategic coherence and resource allocation? If so, how?

To answer these broad research questions, we set the following objectives to guide our investigation.

1.3 Research objectives

The objective of this thesis is to provide a more holistic and comprehensive research framework explaining the relationship between servitization and multiple firm performance indicators, and investigate the moderators in the servitization-performance

relationship at a greater depth in terms of industry-level and firm-level factors. Specifically, our research mainly aims to achieve the following specific objectives:

1. Establish a more holistic and comprehensive research framework to analyse the specific relationship between servitization and firm performance.
2. Develop and empirically test a set of hypotheses on the links between servitization, industry characteristics and firm performance, and validate the moderating effect of industry-level factors on the servitization-performance relationship.
3. Develop and empirically test a set of hypotheses on the links between servitization, firm characteristics and firm performance, and validate the moderating effect of firm-level factors on the servitization-performance relationship.
4. Advance knowledge for manufacturing firms on whether and, if so, how the implementation of servitization is beneficial for their profitability, sales growth, operating efficiency, and reduces asset-liability ratio.
5. Advance knowledge for manufacturing firms on how to plan and implement servitization, considering their industry environment for better performance outcomes in terms of multiple performance indicators, including operating margin, sales growth, operating efficiency and asset-liability ratio.
6. Advance knowledge for manufacturing firms on how to design and plan organizational integration or rearrangements including organizational strategic supporting activities and resource allocation when implementing servitization.

1.4 Significance of the research

Our research contributes to the literature in several ways. First, we attempt to empirically validate the relationship between servitization and firm performance based on multiple performance indicators, which could provide a deeper and more comprehensive understanding of the servitization-firm performance relationship and extend servitization research by modelling the performance contingencies in relation to firm- and industry-level factors. Towards this end, we explore the moderating effect of industry-level factors on the relationship between servitization and firm performance, which should enrich the research area on the alignment of manufacturing firms' servitization with the external industry environment on firm performance. Furthermore,

we investigate the moderating effect of firm characteristics on the servitization-firm performance relationship in terms of strategic coherence and resource allocation, providing a more holistic and systematic theoretical framework, which will complement extant research on the firm-level moderators of the servitization-firm performance relationship.

1.5 Structure of the thesis

This thesis includes seven chapters: Introduction, Literature review, Methodology, Study 1, Study 2, Study 3, and Conclusion and limitations, respectively. The specific contents are as follows:

The first chapter introduces the thesis, elaborating on the practical and theoretical background, proposing the research questions, and introducing the structure of this thesis.

The second chapter presents a comprehensive literature review in order to effectively answer the research questions and provide a theoretical basis for the three studies in the thesis. The relevant literature can be roughly divided into two types, namely, literature on servitization and relevant management theories. The literature on servitization mainly consists of definitions of servitization, the relationship between servitization and firm performance, and the moderating effect of servitization on firm performance, while relevant management theories involve the resource-based view (RBV), contingency theory and the behavioral theory of the firm (BTF).

Chapter 3 describes the research methodology used, including sample data collection procedures, descriptive statistics of sample data, and the measurements of constructs involved in the thesis.

Chapter 4 examines, in detail, Study 1, which looks at the relationship between servitization and firm performance in manufacturing firms. We introduce four firm performance indicators, namely, operating margin, sales growth, operating margin and asset-liability ratio, to further analyse the non-linear relationship between servitization and firm performance. Based on these hypotheses, we elaborate on the data source of this study and the descriptive statistical analysis, summarize the construct measurements, test the hypotheses based on Stata 14 statistical software, interpret the data results, and present the theoretical and managerial implications.

Chapter 5 explores Study 2, which investigates the moderating effect of industry

characteristics on the relationship between servitization and firm performance, and in detail analyses the impact of industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) on the relationships between servitization and the four firm performance indicators stated above. Study 2 also introduces the data sample, construct measurements and selected model estimation methods, applies Stata 14 to hypotheses testing, and discusses the research results.

Chapter 6 discusses Study 3, which consider the moderating role of strategic coherence and resource allocation on the performance effect of servitization in manufacturing firms. We use service relatedness and R&D intensity to represent strategic coherence, while marketing resources, absorbed resource slack and unabsorbed resource slack can be used to reflect resource allocation. Study 3 also introduces the process of data collection, construct measurements and selected model estimation methods, tests hypotheses based on Stata 14, and discusses the research results.

The last chapter summarizes the dissertation's findings, the evaluation of the achievement of research objectives, the theoretical and managerial implications, limitations and future directions, ending with concluding remarks.

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2 Literature review

2.1 Review on servitization

Since servitization was first termed by Vandermerwe & Rada (1988) to delineate manufacturing firms' shift from pure product manufacturers to service providers, the research development of servitization has lasted for nearly 30 years. Currently both academics and practitioners pay great attention to servitization, which has been regarded as an effective means for manufacturing firms to acquire competitive advantage. However, despite some studies having explored the performance effect of servitization, the inconsistent research findings suggest that the relationship between servitization and firm performance is still ambiguous, which in turn prompts calls for further investigation. Since this thesis attempts to further explore the relationship between servitization and performance and the moderating effect of some contextual factors on this primary relationship, in the following sections, we present a literature review concerning the definitions of servitization, the relationship between servitization and firm performance and the moderating effect on this relationship.

2.1.1 Definitions of servitization

Clear definitions are the starting point for all research and in our thesis, the term product and service are intrinsically related to discussions on servitization. Researchers have shown a good and deep understanding of product terminology, whereas the term "services" is still more contentious (Baines et al., 2009a). In this section, we first elaborate on the major definitions of servitization based on some prior literature review on servitization (Baines et al., 2009a; Lightfoot et al., 2013; Luoto et al., 2017). Vandermerwe & Rada (1988) first propose the term servitization and defined it 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". In turn, they present the point that services are performed and not produced and are essentially intangible (Baines et al., 2009a). Besides, other important definitions of servitization in the wider literature are summarized in Table 2.1.

Table 2. 1 Definitions of servitization

Source	Definition
Vandermerwe & Rada (1988)	"The increased offering of fuller market packages or bundles of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings"
Tellus Institute (1999)	"The emergence of product-based services which blur the distinction between manufacturing and traditional service activities"
Desmet et al. (2003)	"A trend in which manufacturing firms adopt more and more service components in their offerings"
Lewis et al. (2004)	"Any strategy that seeks to change the way in which a product functionality is delivered to its markets"
Ward & Graves (2005)	"Increasing the range of services offered by a manufacturer"
Ren & Gregory (2007)	"A change process wherein manufacturing companies embrace service orientation and/or develop more and better services, with the aim to satisfy customer's needs, achieve competitive advantages and enhance firm performance"
Baines et al. (2009a)	"The innovation of an organization's capabilities and processes to better create mutual value through a shift from selling product to selling product service system"
Martinez et al. (2010)	"The journey or transformation process whereby an organization enables its product-service offerings"
Visnjic et al. (2012)	"A business model innovation whereby existing product offerings are extended through related services"

Source: Adapted from Baines et al. (2009a)

Overall, as shown in Table 2.1, some scholars emphasize a combination of services and products when defining servitization (Desmet et al., 2003; Tellus Institute, 1999; Vandermerwe & Rada, 1988), while some regard servitization as a business model or strategy (Baines et al., 2009a; Lewis et al., 2004; Ren & Gregory, 2007; Visnjic et al., 2012). Although scholars define servitization from various perspectives, most agree that the essence of servitization involves the process of firms' transformation. Specifically, the research defining servitization as a combination of services and products describes the shift from offering products to product service systems while the studies regarding servitization as a business model or strategy concentrate on the change in firms' strategic focus (from a product-oriented strategy to a service-oriented

strategy). The former type of definition emphasizes the servitization result as adding more services to existing products while the latter highlights the shift of strategic focus. Both definitions reflect a firm's transformation from goods-dominant logic to service-dominant logic. Briefly, goods-dominant logic emphasizes value-in-exchange and views services as a special type of goods while service-dominant logic denotes a new perspective of value creation focusing on value-in-use in customer's own context (Gebauer et al., 2010; Vargo & Lusch, 2008). In this study, we define servitization as a transformational process of adding services to products with a strategic transition from goods-dominant logic to service-dominant logic. Accordingly, servitization involves a redefinition of the firm's mission, a redeployment and reconfiguration of organizational resources, capabilities and structures, and a renewal of organizational routines, shared norms and values (Kindström & Kowalkowski, 2014; Kowalkowski et al., 2017). This implies that the relationship between servitization and firm performance depends on the reconfiguration of organizational resources, capabilities and structures, and a renewal of organizational routines, shared norms and values between new coalitions (namely, service and product businesses). Next, we will review the literature on the relationship between servitization and firm performance and the moderating effect on this relationship.

2.1.2 **The relationship between servitization and firm performance**

The existing servitization research presents some evidence on the relationship between servitization and firm performance. Overall, the research findings on the servitization-performance relationship can be roughly divided into the following four categories. (1) Some scholars' findings indicate that servitization can positively promote firm performance. Quinn et al. (1990) and Fry et al. (1994) support this point. Quinn et al. (1990) suggest that successfully managing service activities can help acquire competitive advantage while Fry et al. (1994) elaborate on how service-based strategies result in manufacturing firms' success. Most of this early research on the performance effect of servitization is normative or descriptive (Jacob & Ulaga, 2008). Recently more empirical studies have confirmed the positive relationship between servitization and firm performance. Homburg et al. (2002) empirically investigate the association between the business strategy's service orientation and company performance from the perspective of organizational strategy, and conclude that service

orientation positively affects firm performance (financial and non-financial). Antioco et al. (2008) also verify a positive effect of service business orientations on firm performance based on 137 European manufacturing firms.

(2) Although much of the literature finds a positive effect of servitization on firm performance, there is another view that servitization in manufacturing firms has a negative influence in this regard (Neely, 2008). This corresponds with "service paradox", where major investments in service business fail to generate the corresponding returns (Gebauer et al., 2005). Neely (2008) confirms the existence of "service paradox" and first empirically explores the negative association between servitization and financial performance based on secondary data. Specifically, Neely (2008) reports that, despite the significant growth in total firm sales in servitized firms, these firms in this context acquire lower profit margins than pure product manufacturers, especially large firms. Besides, servitized firms are more likely to declare bankruptcy than pure manufacturing firms (Neely 2008).

(3) In contrast to the linear (positive or negative) relationship proposed in the first two categories of studies (Antioco et al., 2008; Homburg et al., 2002; Neely, 2008), recent research indicates that the performance effect of servitization is far from simple and may be non-linear (Fang et al., 2008; Kastalli & Van Looy, 2013; Kohtamäki et al., 2013b). Fang et al. (2008) idenfity a U-shaped association between service strategies and firm value based on longitudinal and aggregated firm data, with the critical point between 20% and 30%. Specifically, the effect of manufacturing firms' service transition on firm value is negative until the ratio of service sales to total sales reaches the critical value (20%-30%), after which this effect will gradually keep increasing. Suarez et al. (2013) argue that sales from services have non-linear impact on operating margins using data on the pre-packaged software products industry, while Kohtamäki et al. (2013b) also propose a non-linear relationship between service offering and sales growth using data from 91 Finnish manufacturing companies. Besides, Kastalli & Van Looy (2013) demonstrate a positive but non-linear effect of the scale of service activities on firm profitability. Specifically, in the initial stage of servitization, there is a steep positive relationship between service scale and profit margin; after reaching a critical point, service scale shows a relative decrease in profit margin; then the positive relationship between service scale and profit margin re-emerges when the economies of scale are achieved.

(4) Apart from the significant relationship between servitization and firm

performance identified in prior research, a minority of studies propose that the performance effect of servitization is insignificant. Eggert et al. (2014b) suggest that there is no significant relationship between service innovation and profitability growth while Samarrokhi et al. (2014) propose that service differentiation is limited in its contribution to achieving sustainable competitive advantage in manufacturing companies.

Overall, despite some studies having explored the relationship between servitization and firm performance, these research findings are inconsistent and even contradictory. These mixed findings may be caused by differences in regions, industries and organizational parameters. Servitized firms in different contexts may perform differently. Therefore, in order to further explore the relationship between servitization and firm performance in manufacturing firms, researchers subsequently have examined the moderating impact of some industry-level and firm-level factors on this primary relationship.

2.1.3 **The moderating effect of the servitization-firm performance relationship**

Prior research has explored the moderating effect of the servitization-performance relationship, and the moderating factors reported in the relevant literature can be roughly categorized into two types, namely, industry characteristics and firm characteristics (Eggert et al., 2011).

Firm characteristics include variables related to organizational structure, organizational capability and organizational resource, such as service relatedness, resource slack, service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services and service training (Antioco et al., 2008; Donaldson, 1995; Fang et al., 2008; Gebauer, 2007; Gebauer, 2008; Homburg et al., 2003; Jia et al., 2016). Specifically, Antioco et al. (2008) highlight the moderating effects of several organizational parameters on the performance effect of service business orientations including top management's commitment to and visionary leadership of services, service rewards, service technology, cross-functional communication of service employees, service training and customer treatment by conducting an empirical survey of 137 companies in the Netherlands. Fang et al. (2008) identify the positive moderating role of service relatedness and resource slack on the relationship between service strategies and firm

value by using secondary data pertaining to 477 publicly traded manufacturing companies from 1990 to 2005, while Eggert et al. (2011) find that manufacturers' product innovation activity significantly moderates the relationship between service offering and firm profitability based a longitudinal study with panel data on 414 German manufacturing firms. Besides, Kohtamäki et al. (2013a) identify the critical role of relational capital in the relationship between suppliers' R&D services and profit performance in customer relationships based on 91 firms in the machine and equipment manufacturing industries in Finland, while Kohtamäki et al. (2013b) explore the moderating impact of network capabilities on the relationship between industrial service offering and sales growth by using data from 91 Finnish manufacturing firms.

However, except that Fang et al. (2008)'s finding suggests that industry growth negatively affects the relationship between service strategies and firm value while industry turbulence positively moderates this relationship, few studies have explored the moderating impact of industry characteristics on the servitization-firm performance link.

Overall, the majority of studies focus on the moderating effect of firm-level factors associated with organizational structure, organizational resource and capability while there is still a lack of the research on the impact of industry-level factors on the relationship between servitization and firm performance. Moreover, despite many studies exploring the moderating effect of firm-level factors on the servitization-firm performance relationship, there remains no relatively holistic and systematic theoretical framework to demonstrate how firm characteristics affect the relationship between servitization and firm performance in manufacturing firms.

2.1.4 **Summary**

Although prior research has explored many characteristics, drivers and performance outcomes of servitization (Baines et al., 2009a; Baines et al., 2009b; Lightfoot et al., 2013; Luoto et al., 2017), there is no widely accepted view on how servitization affects firm performance. The literature review, as stated earlier, shows that the relationship between servitization and firm performance is still ambiguous, and that contextual factors, such as region, industry or organizational parameters, could influence the servitization-performance relationship. In order to further understand the relationship between servitization and firm performance, we still need to conduct

research on how manufacturing firms' contextual factors (either industry-level or firm-level) affect this relationship. The limitations of existing research on the servitization-performance relationship are summarized as follows:

First, the majority of these prior research focuses on the relationship between servitization and firm profitability, which constrains the generalizability of the extant findings. However, firm performance is a multidimensional construct, which consists of financial and non-financial performance (Berman et al., 1999; Dossi & Patelli, 2010; Fullerton & Wempe, 2009; Huselid, 1995). Non-financial performance indicators involve customer satisfaction, customer loyalty and relationship performance (Gebauer and Putz, 2007; Oliva et al., 2012), while financial performance indicators include profits, sales, costs, cash flow, turnover, and asset-liability ratio (Homburg et al., 2002; Kastalli et al., 2013; Kamboj and Rahman, 2015; Rasool and Shah, 2015). Prior research has also suggested that the provision of basic services has no significant effect on firms' sales, but does have a negative effect on profitability (Sousa & Silveira, 2017). This implies that servitization research with different performance indicators may result in different research findings. Considering that our research is not involved in the non-financial performance effect of servitization, we could further extend our research by exploring the relationship between servitization and multiple financial performance indicators.

Besides, few studies examine the contingency effect of industry-level factors on the relationship between servitization and firm performance, which implies a great need for research on the moderating effect of industry characteristics on the servitization-performance relationship.

Additionally, although many studies have explored the moderating effect of firm-level factors on the servitization-firm performance relationship, there is still a lack of a relatively holistic and systematic theoretical framework to demonstrate how firm characteristics affect the relationship between servitization and firm performance in manufacturing firms.

Overall, since extant literature shows the inconsistent and even contradictory findings on the servitization-performance relationship and the majority of these research is based on small sample size, it is still essential for researchers to conduct further empirical studies based on large sample data and thus our thesis adopts the panel data to overcome this limitation.

2.2 Review of related management theories

Recently, academics have paid increasingly close attention to servitization in manufacturing firms, as well as made relatively remarkable achievements. However, to date, there is a lack of an appropriate theoretical perspective to support or explain the specific performance effect of servitization. Therefore, in this section, our research will review some of the theories related to servitization, including the resource-based view (RBV), the contingency theory and the behavioral theory of the firm (BTF), in order to formulate the theoretical base for the relationship between servitization and firm performance, establish theoretical foundations for the three studies in this thesis, and provide effective guidelines for the implementation of servitization.

2.2.1 Relevant theory of Study 1 – The resource-based view

The RBV theory indicates that a firm's competitive advantage primarily depends on the application of a bundle of disposable valuable resources (Barney, 1991). The RBV implies the identification of valuable resources from two aspects. First, valuable resources should be heterogenous in nature and not perfectly mobile (Barney, 1991). Second, valuables resources should meet the so-called VRIN requirements (namely, valuable, rare, inimitable and non-substitutable) (Crook et al., 2008). Prior empirical studies have shown that key valuable resources help firms to acquire competitive advantages, such as performance outcomes (Kraaijenbrink et al., 2010; Van de Ven, 2007).

Specifically, the RBV perceives a firm as an idiosyncratic bundle of resources and capabilities, which are available for deployment, but very hard for competitors to duplicate (Amit & Schoemaker, 1993). In terms of a dynamic perspective, the most crucial drivers of firms' competitive edge are the dynamic capabilities, namely, the ability to build, integrate or reconfigure internal and external competencies (Teece et al., 1997). Hence, Eisenhardt & Martin (2000) extend the dynamic perspective of the RBV on the premise that firms can acquire competitive advantage only in the case of great coincidence between dynamic capabilities and environmental conditions.

Manufacturing firms' servitization means that they must shift from prouct manufacturing to service offerings (Wise & Baumgartner, 1999). Servitization could help improve firms' competitive position, especially under the condition of highly

competitive markets and increasing commoditization or homogenization (Sawhney et al., 2004; Vargo & Lusch, 2004). This argument mainly lies in the important benefits derived from the innate characteristics of services (Fang et al., 2008). Specifically, in contrast with products, services enable manufacturers' total offering to be more intangible, more difficult to standardize, more knowledge-intensive, more difficult to duplicate, more likely to require coproduction, and more demanding of direct sales contact (Fang et al., 2008). That is, the implementation of servitization encourages manufacturing firms to offer "product and service" bundles, which are characterized as more unique, more difficult to imitate and more valuable to customers (Gebauer et al., 2010), in turn satisfying the identification requirement of the RBV's valuable resources. Therefore, in Study 1, we investigate the performance effect of servitization within the RBV theoretical framework. Based on the dynamic perspective of the RBV, as proposed by Eisenhardt & Martin (2000), we speculate that the impact of firms' strategic efforts (e.g., servitization in our study) on firm performance should consider how these efforts promote the integration, combination and utilization of firms' resources and capabilities over time, and within firms' organizational and environmental context. Following this logic, we explore the effect of servitization on firm performance by assessing how firms' servitization could affect their abilities to configure their tangible and intangible resources within changing market environments.

By evaluating the manufacturers' shift from products to services, we identify two critical types of mechanisms (including positive and negative) through which servitization affects firm performance. The influence of these mechanisms on the relationship between servitization and firm performance is specified as follows.

(1) Positive mechanisms of the servitization-firm performance relationship

The first type of mechanism shows positive effects on the relationship between servitization and firm performance as follows.

First, services can improve firms' total offering's differentiation (Lusch et al., 2007). The characteristics inherent in services include high intangibility, uniqueness and complexity, which enable the total offering with services to be more durable, unique and more difficult to duplicate or substitute customers (Gebauer et al., 2010). This innate nature of services makes servitized manufacturers to be extremely hard for rivals to imitate, improve differentiation and finally generate additional avenues for future sales revenue (Eggert et al., 2014a). Overall, service provisions help satisfy diversified customer needs, make manufacturing firms differentiate and compete with competitors,

deliver greater value to customers and generate increased revenue, which positively affects the relationship between servitization and firm performance.

Second, servitization can strengthen buyer-supplier relationships. Service offerings require coproduction between customers and manufacturers and are more demanding of direct sales contact (Fang et al., 2008). These service attributes can effectively improve customer satisfaction and servitized manufacturers have a greater possibility to acquire and maintain their customers. Besides, the greater durability and longevity of "product and service" packages increase switching costs for customers, which diminishes customer defection and creates longer buyer-supplier relationships (Gebauer et al., 2010; Josephson et al., 2016). Longer relationships between customers and manufacturers represent firms' potential increase in future sales revenue, which implies a positive effect on the servitization-performance relationship.

Third, additional services can lead to the synergies between services and products in manufacturing firms. On the one hand, manufacturing firms can apply their resources and knowledge accumulated from original products to service extensions, namely, the so-called "resource and knowledge spillover" (Markides & Williamson, 1996). The spillover from product to service domains can help firms achieve cost and efficiency advantages over their rivals by sharing both tangible (e.g., local offices, personnel) and intangible resources (e.g., brand reputation, customer relationships). On the other hand, this resource spillover from service to product could effectively increase the total offering's complexity and diversity, hereby helping to attract and retain more customers and protect the total offering from duplication by competitors (Reed & DeFillippi, 1990). Overall, this reciprocal spillover between service and product helps firms exploit synergies between manufacturing and services, which in turn positively impacts the servitization-performance relationship.

(2) Negative mechanism of the servitization-firm performance relationship

The other type of mechanism indicates negative effects on the relationship between servitization and firm performance as follows.

First, the introduction of servitization may lead to a loss of strategic focus for manufacturing firms. A firm's strategic focus relies on its core competencies (Porter, 1985). A manufacturing firm's strategic focus is its product, with the core competencies associated with its product-based offering. The adoption of servitization may require the sacrifice of resource inputs originally applied to a firm's core product and manufacturing competencies (Bourgeois, 1981). Under resource constraints, service

business may dilute firm resources. Thus, servitization breaks away from the firm's primary product-oriented strategic focus. Overall, a firm's resource spread between an existing business and a new business involving new skills, new capabilities and new competencies, may negatively affect the performance effect of servitization, at least in the short term. This negative effect may remain in place until the firm's service-specific resources, capabilities and competencies are competitive.

Second, the implementation of servitization may lead to resource competition. The effective implementation of servitization requires substantial resource commitments to support it (Bolton et al., 2007). However, a manufacturing firm's resources are often product-oriented. Under resource constraints, firms must either acquire additional resources (e.g., excess slack resources) or "steal" existing resources from other functional areas to support servitization's implementation (Josephson et al., 2016). This resource competition between service and product businesses may create internal confusion and even outright conflict (Krishnamurthy et al., 2003), which in trun has negative impact on the servitization-performance relationship.

Third, the implementation of servitization may result in organizational rearrangements. Service and product businesses require different organizational arrangements, including organizational structures, processes, cultures, personnel and leadership (Vargo & Lusch, 2004). The effective implementation of servitization requires significant intrafirm cooperation. However, in the initial phase of servitization, manufacturing firms often have no separate service-centric department, which implies that they integrate mixed organizational elements such as personnel and processes for both service and product businesses. The mismatch between new strategic initiatives (e.g., servitization) and organizational arrangements may cause political tension and strife (Argote & Greve, 2007), which also exert a negative effect on the servitization-performance relationship. This negative effect may remain until firms achieve effective organizational rearrangements for both product and service businesses.

Overall, the RBV and its extended theories support the claim that the performance effect of manufacturing firms' servitization depends on how a shift from products to services influences their ability to configure their tangible and intangible resources under changing market conditions. These identified different (either positive or negative) mechanisms imply a non-linear effect of servitization on firm performance; and, as shown above, these major mechanisms can provide an appropriate framework for understanding the relationship between servitization and firm performance.

2.2.2 **Relevant theory of Study 2 – The contingency theory**

According to the literature review as mentioned previously, the major empirical studies on the relationship between servitization and firm performance can be roughly classified into two categories. The first category includes studies showing the linear association (positive or negative) between servitization and firm performance (Antioco et al., 2008; Neely, 2008; Skaggs & Droege, 2004; Visnjic et al., 2012) whereas the second consists of research exploring the nonlinear performance effect of servitization (Fang et al, 2008; Kohtamäki et al., 2013b; Visnjic & Van Looy, 2013). These mixed results (particularly negative and non-linear effect) corroborate the existence of "service paradox" (Gebauer et al., 2005). Thus, an increasing number of scholars has been engaged in exploring the reasons why "service paradox" happens in servitized manufacturing firms, in an attempt to find the hidden contingency factors affecting the relationship between servitization and firm performance.

One perspective in the literature that has been considered to be effective in explaining the nature of organizational strategy is contingency theory (Hambrick, 1983). A basic proposition of this theory is that organizational effectiveness is acquired by matching organizational characteristics to contingencies (Lawrence & Lorsch, 1967b). Contingency represents any factor moderating the impact of organizational characteristics on organizational performance, with the identified underlying contingencies are technology, innovation, environment, size, diversification, etc. Some strategic contingency theorists' findings have confirmed that an organization's performance is a function of the congruency between organizational characteristics or behaviors and contingencies (Donaldson, 2001; Lee & Miller, 1996). Manufacturing firms' servitization can be considered as a business development behavior or organizational characteristic such as the provision of bundles of products and services. Scholars have examined certain contingencies that moderate the effect of servitization on organizational performance (Antioco et al., 2008; Eggert et al., 2011; Fang et al., 2008; Kohtamäki et al., 2013b). Fang et al. (2008) propose the factors moderating the impact of service transition on firm value in terms of industry characteristics (i.e., industry growth and industry turbulence) and firm characteristics (i.e., the relatedness between product and service businesses and the availability of slack resources). At the firm level, the moderating role of product innovation, service-oriented human resource

management and corporate culture have also attracted strong attention in the management literature (Antioco et al., 2008; Eggert et al., 2011; Homburg et al., 2003). In addition, Kohtamäki et al. (2013b) identify the moderating effect of network capabilities (from among organizational service capabilities) on the non-linear relationship between industrial service offering and sales growth based on the strategic capability view.

However, the contingency factors discussed in these studies have been dominated by firm-level factors (i.e., product innovation, human resource management, corporate culture, networking capabilities, etc.), while firms' external or environmental factors, such as industry-level contingency factors, have been overlooked. Except for industry growth and industry turbulence, as explored by Fang et al. (2008), there is no other research examining the influence of the match between servitization and manufacturing firms' external environmental characteristics on firm performance. On the basis of the contingency theory, external environmental factors may play a pivotal role in the association between business strategies or practices and firm performance (Sun et al., 2009; Wong et al., 2011). For example, Souder et al. (2010) identify the importance of the alignment between organizational integration and environmental uncertainty in new product development effectiveness while Wong et al. (2011) reveal the contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance, based on the analysis of Thai automotive manufacturing plants. Hence, in the view of contingency theory, matching organizational strategic orientations or behaviors to environmental factors predicts performance (Buttermann et al., 2008).

Overall, the contingency theory suggests that there is no ideal way to manage an organization, and that the effectiveness of firms' business or management practice is contingent on the contextual environment of the organization concerned (Tosi & Slocum, 1984). Thus, in Study 2, we contemplate how a servitized manufacturer adapts to the industry environment in order to achieve superior firm performance.

2.2.3 **Relevant theory of Study 3 – Behavioral theory of the firm**

Previously, RBV researchers have proposed that the effect of a firm's strategic choice (e.g., servitization in our thesis) on firm performance relies on the match between the strategic choice and the firm's underlying competencies, resource levels

and market position (Black & Boal, 1994). In line with this argument, we speculate that a manufacturing firm should align servitization to its firm-specific factors in order to acquire enhanced firm performance. Thus, in Study 3, we explore how firm-specific factors affect the relationship between servitization and firm performance, using the BTF as our theoretical lens.

The BTF suggests that a firm is involved in a collection of coalitions or departments aligned to achieve certain goals, such as revenue, profits and market share (Cyert & March, 1963). As new participants or coalitions enter the firm, goals change, and the accompanying initial conflicts must be addressed in terms of goal alignment (Cyert & March, 1963). To achieve goal alignment, firms' decision-making involves two primary tasks, namely, to determine overall strategic choice, and to allocate resources and strategic efforts in pursuit of that choice (Argote & Greve, 2007).

Specifically, the implementation of servitization represents the introduction of a new coalition to the originally product-oriented firm structure (Neu & Brown, 2005). The success of this new coalition requires sufficient organizational resources and capabilities to support it (Bolton et al., 2007). Researchers have asserted that a firm comprising a collection of coalitions or departments needs to align these coalitions to achieve certain goals (Cyert & March, 1963). The introduction of new coalitions causes conflicts which should be addressed in terms of goal alignment between different coalitions (departments). To achieve firm goals, firms' decision-making involves two primary aspects, namely to determine overall strategic choice or action and to assign resources and strategic efforts in pursuit of that choice (Argote & Greve, 2007). Firms' strategic choices are determined according to their expectations, inferences from available information, market competition, performance aspirations and referent firm performance (Cyert & March, 1963). Accordingly, as manufacturing firms suffer from product commoditization and homogenization, they adopt strategic choices such as transitioning into servitization in order to counter the threats (Carter, 1971). To ensure the success of the strategic choice (namely, servitization), firms need to make ancillary strategic choices in conjunction with servitization (Argote & Greve, 2007). When these ancillary strategic choices and the strategic efforts are made in conjunction and support of manufacturing firms' servitization, they are likely to influence the relationship between servitization and firm performance.

3 Methodology

3.1 Sample collection

In order to test the hypotheses proposed in the study, we select US-based and publicly listed manufacturing firms with primary Standard Industrial Classification (SIC) codes ranging from 20 to 39 over a 27-year period, from 1990 to 2016, as our data sample. These SIC codes cover a wide range of manufacturing industries, including food and kindred products, tobacco products, textile mill products, apparel and other finished products, chemical products, electronic equipment, industrial machinery, and transportation equipment. We collect the data from the Compustat database.

Compustat has multiple datasets, including North America and Global. The data used in this thesis come from the subsets of North America, namely, Compustat Industrial Annual and Compustat Business Segments. Although the Global dataset contains the data on global regions, it does not include an independent data subset on different business segments for every firm. Therefore, we cannot obtain the sales revenue data on service and product businesses from Global, which results in the failure of our research objectives. Overall, we gather our data from the North America dataset of Compustat.

The specific data collection and treatment procedures are as follows. First, we download basic information on all publicly traded firms between 1990 and 2016 from Compustat Industrial Annual and firms' business segments' information for the same period from Compustat Business Segments, then we extract the information on these firms with SIC codes ranging from 20 to 39, and finally acquire the corresponding data on different business segments by matching Compustat Industrial Annual with Compustat Business Segments, based on the company identifier or name. Compustat Business Segments mainly include three kinds of business segments, namely, service business, product business and others. The classification of service and product business is based on the description of these business segments and their respective SIC codes. If the description of the business segments exactly matches the SIC code, it is easy to make classifications; for instance, when the business segment is described as a "financial service" with a SIC code of 6153 or a "global service" with a SIC code of 7379. However, in some cases, the business segments' description does not exactly match the SIC code; thus, two independent researchers are invited to judge both the

description and the SIC code until the disagreement is resolved, and then we categorize each business operating segment. To maintain a conservative measure, business segments that cannot be definitively classified appear as non-service businesses, since the research purpose of this thesis is to explore the impact of servitization on firm performance and the conservative measure of service businesses contributes to a reduction in errors in the research results (Fang et al., 2008).

By matching these two data subsets, Compustat Industrial Annual and Compustat Business Segments, we finally get 5,557 sample observations covering 928 firms between 1990 and 2016. These original 5,557 sample observations have some missing values in the case of certain variables, and these missing data can be filled up based on a particular criterion. Specifically, we categorize these samples according to the company identifier and year, and then fill in the missing data by averaging the remaining firms, but excluding firms with missing values for all variables in every observation. Besides, the main variables, such as independent and dependent variables, involve the transformation of the initial data from original sample observations, based on some criteria or formula, which enables some samples to be invalid. For example, if the net assets are equal to 0, when subtracting total liabilities from total assets (total liabilities and total assets are the raw data of sample observations), then the desired value of the return on equity (ROE) is invalid (ROE = net profits/net assets); thus, we need to eliminate this sample observation. Another example is that, if the ratio of service revenue to total revenue is greater than 1 or smaller than 0 in some samples, these kinds of sample should also be deleted because a ratio greater than 1 means that manufacturing firms obtain larger sales revenue from service business than firms' total revenue, while a ratio of less than 0 indicates that manufacturing firms obtain larger sales revenue from product business than firms' total revenue. By dropping these samples, 5,535 sample observations remain. Moreover, due to the lagged dependent variables included in our research models, the samples that cannot provide the lagged variables should also be excluded, such that we eventually acquire 4,451 valid sample observations from 808 manufacturing firms with which to test the research models in this thesis. Overall, as we have time series of observations for multiple firms, our selected valid data show an unbalanced panel structure.

3.2 Descriptive statistics of sample data

Table 3.1 displays the basic descriptive statistics for the valid sample observations, including the selected samples' distribution in the industry, employee number, annual sales and total asset.

Specifically, in terms of firms' annual sales and total assets, 27.7% of firms generate annual sales less than $100 billion, 21.9% generate annual sales ranging from $100 to $500 billion, and 50.4% generate annual sales more than $500 billion; firms with total assets greater than $1,000 billion account for 39.4%, followed by firms with total assets between $100 and $1,000 billion (32.1%); firms with total assets less than $100 billion have the least percentage (28.6%). From the perspective of the number of employees, the sample observations are relatively evenly distributed, where firms with fewer than 250 employees take up 19.0%, while 17.0%, 36.3% and 15.7% have employee numbers in the range of 250-1000, 1000-10,000 and 10,000-50,000, respectively; 12.0% of firms have employee numbers exceeding 50,000.

Additionally, manufacturing industries' distribution in this thesis with SIC codes ranging from 20 to 39 includes food and kindred products (6.5%), tobacco products (0.5%), textile mill products (0.8%), apparel and other textile products (3.8%), lumber and wood products (2.8%), furniture and fixtures (0.5%), paper and allied products, printing, publishing and allied industries (1.7%), chemical and allied products (3.0%), petroleum and coal products (12.1%), rubber and miscellaneous plastic products (2.1%), leather and leather products (1.7%), stone, clay and glass products (1.1%), primary metal industries (2.6%), fabricated metal products (2.9%), industrial machinery and equipment (14.1%), electronic and other electronic equipment (15.4%), transportation equipment (10.3%), instruments and related products (10.9%), and miscellaneous manufacturing industries (3.0%). This industry distribution suggests that, despite a relative large share in the samples from chemical and allied products, industrial machinery and equipment, electronic and other electronic equipment, transportation equipment, and instruments and related products, the sample observations in this thesis are relatively evenly distributed in terms of all industries.

Overall, as the distribution of the sample observations in this thesis in terms of firm size and industry is relatively even, the selected samples are representative for testing the research models.

Table 3. 1 Samples' descriptive statistics

Characteristics	Classification standard	Sample size	Percentage (%)
Annual sales (million dollars)	Annual sales >=500	2788	50.4
	100=< Annual sales <500	1213	21.9
	Annual sales <100	1534	27.7
Total asset (million dollars)	Total asset >=1000	2180	39.4
	100=< Total asset <1000	1774	32.1
	Total asset<100	1581	28.6
Employee number	Employee number>=50,000	665	12.0
	10,000=< Employee number<50,000	869	15.7
	1000=< Employee number<10,000	2007	36.3
	250=< Employee number<1000	942	17.0
	Employee number <250	1052	19.0
Industry (SIC codes)	20 Food and kindred products	358	6.5
	21 Tobacco products	27	0.5
	22 Textile mill products	42	0.8
	23 Apparel and other textile products	208	3.8
	24 Lumber and wood products	154	2.8
	25 Furniture and fixtures	30	0.5
	26 Paper and allied products	96	1.7
	27 Printing, publishing and allied industries	168	3.0
	28 Chemical and allied products	667	12.1
	29 Petroleum and coal products	238	4.3
	30 Rubber & miscellaneous plastic products	116	2.1
	31 Leather and leather products	96	1.7
	32 Stone, clay and glass products	61	1.1
	33 Primary metal industries	145	2.6
	34 Fabricated metal products	158	2.9
	35 Industrial machinery and equipment	779	14.1
	36 Electronic and other electronic equipment	850	15.4
	37 Transportation equipment	572	10.3
	38 Instruments and related products	603	10.9
	39 Miscellaneous manufacturing industries	167	3.0
Total sample size		5535	100

3.3 Construct measurement

The main purpose of this thesis is to investigate the relationship between servitization and firm performance and the moderating impact of contingency factors on this primary relationship. The constructs involved in the three studies of the thesis are specified as follows.

3.3.1 **The construct measurement of Study 1**

Dependent variable. Firm performance is the dependent variable in Study 1, which has been investigated and comprises multiple dimensions and measurements (Kastalli & Van Looy, 2013). This thesis focuses on multiple measurement indicators of firm performance, including operating margin, sales growth, operating efficiency and asset-liability ratio (Filer & Golbe, 2003; Gedajlovic & Shapiro, 2002; Stratopoulos & Dehning, 2000). Specifically, operating margin reflects the firm's profitability and is measured as the ratio of a firm's operating income to total sales (Suarez et al., 2013); sales growth is the change rate in the case of a firm's yearly sales over the yearly sales amount of the base year, and calculated as a firm's sales for the current period minus its sales from the previous year and then divided by last year's sales (Kohtamäki et al., 2013b); operating efficiency captures how efficiently management utilized assets to generate sales, and this variable's proxy is total assets turnover, which is assessed with the ratio of a firm's net sales to total assets (Stratopoulos & Dehning, 2000); finally, asset-liability ratio for a firm is calculated as total liabilities divided by total assets, which shows the proportion of a company's assets financed through debt (Bookstaber & Gold, 2015).

Independent variable. Servitization is the independent variable in Study 1, which has involved multiple measurements in prior empirical studies. First, the majority of these studies adopt the survey method to measure servitization (Antioco et al., 2008; Homburg et al., 2002; Kohtamäki et al., 2013b). Homburg et al. (2008) first measured servitization, based on the survey, in terms of service broadness, number of services and emphasis on services. Antioco et al. (2008) also chose this measurement. Besides, some researchers have proposed another questionnaire, which measures servitization in terms of service offering (Kohtamäki et al., 2013b; Kohtamäki et al., 2015). In addition,

some studies have focused on servitization measurement based on secondary data (Fang et al., 2008; Neely, 2008; Skaggs & Droege, 2004). Specifically, Neely (2008) employed the number of services as a proxy for servitization, while other scholars have used the ratio of service revenue to total sales as servitization's proxy (Fang et al., 2008; Josephson et al., 2016; Kastalli & Van Looy, 2013; Neely, 2008; Skaggs & Droege, 2004; Suarez et al., 2013). This thesis also adopts the ratio of a firm's revenue from service business to total revenue in order to measure servitization.

Control variable. In order to deliver on the research purpose, namely, investigate the influence of servitization on firm performance, we need to control for some other variables, which may significantly affect firm performance, in order to exclude the performance effect of these control variables. First, firm size is an important control variable because a considerable body of literature has shown that firm size can greatly affect firm performance (Boyer et al., 1996; Koufteros et al., 2007). Larger firms can acquire enhanced performance by better utilizing various firm resources, such as financial and human resources; therefore, larger firms can also take advantage of economies of scale in their business activities, helping them perform better in the market (Kim & Lee, 2010). Firm size is measured by the log-transformation of a firm's total assets. Second, industry is also considered as another factor affecting firm performance because firms in different industries generate different performance (Wiengarten et al., 2014). Therefore, we control for industry concentration in this thesis. A firm's market share is also controlled, since market share represents a firm's market position, which is related to firm performance (Suarez et al., 2013). Finally, we control for a set of year dummy variables to capture the effect of time, since our data were collected during a 27-year period, which may have greatly impacted firm performance.

Table 3.2 shows the specific definitions and measurements of constructs involved in Study 1 of this thesis.

Table 3. 2 Construct measurement of Study 1

		Proxy	Variables' abbreviations	Measurement
Dependent variable	Operating margin		Operatingmargin	A firm's operating income / total sales
	Sales growth		Growth	(A firm's sales for the current period - its sales

				from last year) / last year's sales
	Operating efficiency	Total assets turnover	Turnover	A firm's net sales / total assets
	Asset-liability ratio		Debt	A firm's total liabilities / total assets
Independent variable	Servitization	Service ratio	Serviceratio	A firm's revenue from service business / total revenue
Control variable	Firm size	Total assets	Firmsize	The log-transformation of a firm's total assets
	Industry	Industry concentration	Industryconcen	The sum of the square of each firm's market share in core product industry
	Market share		Marketshare	A firm's overall sales revenues / the sales revenues of all firms in the same SIC code industry
	Time	Year	Year	Set of year dummy variables

3.3.2 **The construct measurement of Study 2**

Study 2 presents the same dependent and independent variables (namely, firm performance and servitization) as Study 1, such that the specific construct measurements of Study 1 can also refer to those of Study 1.

Moderator variable. Industry characteristics are the moderators for Study 2, including industry clockspeed, industry concentration and industry maturity (Fines, 1998; Melville et al., 2007; Mendelson & Pillai, 1998; Suarez et al., 2013).

Industry clockspeed has been applied in prior literature to describe the rate of change within an industry sector or change that is endogenous to a particular industry (Fine, 1998). Fine (1998) first proposed industry clockspeed and suggested that each industry evolves at a different rate depending on the type of industry clockspeed. In previous studies, industry clockspeed can be measured in terms of the rate of change for products, processes and organizational structure (Fernández & Kekäle, 2005; Fines,

1998; Guimaraes et al, 2002; Meijboom et al., 2007; Mendelson, 2000; Mendelson & Pillai, 1999; Nadkarni & Narayanan, 2007; Perrons & Platts, 2005). In fact, product change could account for most of the changes in industry clockspeed (Chavez et al., 2012). Many studies measure industry clockspeed from the perspective of product change and have developed a measurement for it, which captures the change speed in the product market in terms of change in input prices, product life and product-line freshness (Mendelson, 2000; Mendelson & Pillai, 1998, 1999). Given the accessibility and availability of data used in the thesis, we measure industry clockspeed in terms of product change rate. For the three proxies of product change rate, product life is defined as the duration of the product life cycle, product-line freshness is measured by the share of total revenues that come from products introduced within the previous year, and change in input prices may classify industry as slow-cycle, standard-cycle or fast-cycle depending on whether product price change is positive, close to zero, or negative, respectively (Mendelson & Pillai, 1998, 1999; Williams, 1992). Since it is difficult to obtain corresponding secondary data directly from the databases for the former two, we adopt the third measurement, change in input prices, as a proxy of industry clockspeed in this thesis.

Industry concentration reflects firms' market competitiveness and implies the distribution of firms within an industry sector. It can be captured by the Herfindahl-Hirschman Index (HHI), which is calculated as the sum of the squares of each firm's market share in the firm's core product industry (Bellamy et al., 2014; Hou & Robison, 2006; Kacperczyk et al., 2005).

Industry maturity captures the maturity level of the industry in terms of the number of remaining competitors (Suarez et al., 2013). Prior studies suggest that the point where the total number of firms peaks often corresponds to the emergence of a major change in industry dynamics, which leads to a "shakeout" announcing the onset of maturity (Agarwal et al., 2002; Utterback & Suarez, 1993). The specific calculation is as follows. First, we determine a figure based on year and the corresponding number of firms in each year for the specific industry, before finding the "peak year" in which the total number of firms reaches the peak, thus representing the onset of maturity. Finally, we calculate industry maturity based on the number of firms in a certain industry in year t ($Number_t$) and the peak year of the onset of maturity. When t > peak year, $Industrymaturity = (1/Number_t)*100$; and when t =< peak year, $Industrymaturity = (-1)*(1/Number_t)*100$. Therefore, we take negative and decreasing values for points

before the onset of maturity and positive and increasing values for points after the onset of maturity (Suarez et al., 2013).

Control variable. We employ firm size, market share and year as the control variables in Study 2, with the corresponding measurements having been proposed and specified as per Study 1's control variables.

Table 3.3 shows the specific definitions and measurements of constructs involved in Study 2 of this thesis.

Table 3. 3 Construct measurement of Study 2

		Proxy	Variables' abbreviations	Measurement
Dependent variable	Operating margin		Operatingmargin	A firm's operating income / total sales
	Sales growth		Growth	(A firm's sales for the current period - its sales from last year) / last year's sales
	Operating efficiency	Total assets turnover	Turnover	A firm's net sales / total assets
	Asset-liability ratio		Debt	A firm's total liabilities / total assets
Independent variable	Servitization	Service ratio	Serviceratio	A firm's revenue from service business / total revenue
Moderator variable	Industry clockspeed	Product price change	Pricechange	Set of dummy variables, including Fast-cycle, Standard-cycle and Slow-cycle
	Industry concentration	Herfindahl-Hirschman Index	HHI	The sum of the squares of each firm's market share in core product industry
	Industry maturity		Industrymaturity	When t > peak year, Industrymaturity = $(1/Number_t)*100$; When t =< peak year, Industrymaturity

				= (-1)*(1/Number$_t$)*100
Control variable	Firm size	Total assets	Firmsize	The log-transformation of a firm's total assets
	Market share		Marketshare	A firm's overall sales revenues / the sales revenues of all firms in the same SIC code industry
	Time	Year	Year	Set of year dummy variables

3.3.3 **The construct measurement of Study 3**

Study 3 presents the same dependent and independent variables (namely, firm performance and servitization) as Study 1 and Study 2; thus, the specific construct measurements of Study 3 can refer to those of Study 1 and Study 2.

Moderator variable. Firm characteristics are the moderator variables of Study 3, including service relatedness, R&D intensity, marketing intensity, absorbed resource slack and unabsorbed resource slack (Fang et al., 2008; Josephson et al., 2016).

Service relatedness involves the extent of closeness between service business and the firm's core goods business, while service is labelled as "related" and "unrelated". Two independent judges are invited to categorize service business as related or unrelated to the core product business by evaluating each business segment (Fang et al., 2008). Differences are resolved through discussion. For instance, the business segments described as "product service", "maintenance and repair" and "integrated solutions" are classified as related services, while those labelled as "credit", "financial service" and "retail and distribution" are categorized as unrelated services. To be more specific, firms with service business segments are assigned as "1" (related) or "0" (unrelated) in relation to the firms' core product business.

R&D intensity reflects the extent of firms' financial resources devoted to R&D (Josephson et al., 2016). We measure R&D intensity with the ratio of R&D expenditures to total revenue (Dutta et al., 1999).

Marketing intensity refers to the level of resources a firm commits to marketing activities or programmes, and is operationalized as the ratio of advertising expenses to total revenue (Dutta et al.,1999; Fang et al., 2008; Nath et al., 2010; Yu et al., 2014).

Resource slack reflects the degree to which firms can utilize excess resources, such as financial and human resources, in a discretionary manner (Bourgeois, 1981). Bourgeois (1981) suggested that resource slack consists of absorbed and unabsorbed components. Absorbed resource slack consists of firms' excessive resources devoted to existing operations, which can in fact involve the costs of firms and tends to be difficult or even hard to redistribute, such as product inventory. In contrast, unabsorbed resource slack refers to firm resources that are relatively free of commitments, readily available and deployable as necessary, including cash, credit lines and capabilities. Overall, absorbed resource slack is the amount of resources linked to current operations and operationalized as the ratio of a firm's total inventory to cash, while unabsorbed resource slack refers to firms' disposable resources and is calculated as retained earnings divided by total assets (Fang et al., 2008; George, 2005; Josephson et al., 2016).

Control variable. We employ firm size, market share and time as the control variables in Study 3, with the corresponding measurements having been proposed and specified as per Study 2's control variables.

Table 3.4 shows the specific definitions and measurements of constructs involved in Study 3 of this thesis.

Table 3. 4 Construct measurement of Study 3

		Proxy	Variables' abbreviations	Measurement
Dependent variable	Operating margin		Operatingmargin	A firm's operating income / total sales
	Sales growth		Growth	(A firm's sales for the current period - its sales from last year) / last year's sales
	Operating efficiency	Total assets turnover	Turnover	A firm's net sales / total assets
	Asset-liability ratio		Debt	A firm's total liabilities / total assets
Independent variable	Servitization	Service ratio	Serviceratio	A firm's revenue from service business / total revenue
Moderator	Service		Relatedness	Set of dummy variable,

variable	relatedness			the value is 1 when service is labelled as related and 0 when service is labelled as unrelated
	R&D intensity		R&Dintensity	R&D expenditures / total revenue
	Marketing intensity		Marketintensity	Advertising expenses / total revenue
	Absorbed resource slack		Abresource	Total inventory / total assets
	Unabsorbed resource slack		Unabresource	Retained earnings / total assets
Control variable	Firm size	Total assets	Firmsize	The log-transformation of a firm's total assets
	Industry	Industry concentration	Industryconcen	The sum of the square of each firm's market share in core product industry
	Market share		Marketshare	A firm's overall sales revenues / the sales revenues of all firms in the same SIC code industry
	Time	Year	Year	Set of year dummy variables

4 Study 1: The research on the relationship between servitization and firm performance in manufacturing firms

4.1 Introduction

Over the recent decades, servitization has received increasing attention from both practitioners and scholars, and evolved from a niche topic into a broad cross-disciplinary research area (Baines et al., 2011; Oliva & Kallenberg, 2003; Wise & Baumgartner, 1999). Since the term 'servitization' was first coined by Vandermerwe & Rada (1988) to delineate the process of creating value by adding services to products, there has been a growing body of research in this field. Many manufacturing enterprises regard servitization as an important route on which to acquire growth, profitability and economic stability (Bandinelli & Gamberi, 2011; Spohrer & Maglio, 2008). Neely (2008) reports that globally over a third of manufacturing firms have servitized. Increasingly, firms recognize and utilize servitization as a viable means of creating value and making profits. For example, IBM generated around 60% of its total revenues from services in 2013, up from about 35% in 1996. Rolls-Royce's annual report in 2015 revealed that more than half of its total revenues were generated from maintenance of its engine products.

However, manufacturing firms are still confronted with huge challenges when implementing servitization (Mont, 2002; Oliva & Kallenberg, 2003; Vandermerwe & Rada, 1988). These challenges prevent manufacturing firms from easily acquiring positive firm performance, and even result in negative performance (Fang et al., 2008). This suggests that servitized manufacturing firms may not generate corresponding returns; this is termed "service paradox" (Gebauer et al., 2005). Much anecdotal evidence, such as the failure of Intel's data center, confirms this phenomenon. Overall, despite many successful business cases using servitization, such as GE, IBM, OTIS and Siemens, more firms fail at the implementation stage (Benedettini et al., 2013). Therefore, can manufacturing firms enhance performance by means of servitization?

The existing servitization research presents some evidence on the relationship between servitization and firm performance. Overall, the research findings on this relationship can be roughly divided into the following four categories. (1) Some scholars' findings indicate that servitization can positively promote firm performance. Quinn et al. (1990) and Fry et al. (1994) support this point. Quinn et al. (1990) suggest

that successfully managing service activities can help acquire competitive advantage while Fry et al. (1994) elaborate on how service-based strategies result in manufacturing firms' success. Most of this early research on the performance effect of servitization is normative or descriptive (Jacob & Ulaga, 2008). Recently more empirical studies have confirmed the positive relationship between servitization and firm performance. Homburg et al. (2002) empirically investigate the association between the business strategy's service orientation and company performance from the perspective of organizational strategy, and conclude that service orientation positively affects firm performance (financial and non-financial). Antioco et al. (2008) also verify a positive effect of service business orientations on firm performance based on 137 European manufacturing firms.

(2) Although much of the literature finds a positive effect of servitization on firm performance, there is another view that servitization in manufacturing firms has a negative influence in this regard (Neely, 2008). This corresponds with "service paradox", where major investments in service business fail to generate the corresponding returns (Gebauer et al., 2005). Neely (2008) confirms the existence of "service paradox" and first empirically explores the negative association between servitization and financial performance based on secondary data. Specifically, Neely (2008) reports that, despite the significant growth in total firm sales in servitized firms, these firms in this context acquire lower profit margins than pure product manufacturers, especially large firms. Besides, servitized firms are more likely to declare bankruptcy than pure manufacturing firms (Neely 2008).

(3) In contrast to the linear (positive or negative) relationship proposed in the first two categories of studies (Antioco et al., 2008; Homburg et al., 2002; Neely, 2008), recent research indicates that the performance effect of servitization is far from simple and may be non-linear (Fang et al., 2008; Kastalli & Van Looy, 2013; Kohtamäki et al., 2013b). Fang et al. (2008) idenfity a U-shaped association between service strategies and firm value based on longitudinal and aggregated firm data, with the critical point between 20% and 30%. Specifically, the effect of manufacturing firms' service transition on firm value is negative until the ratio of service sales to total sales reaches the critical value (20%-30%), after which this effect will gradually keep increasing. Suarez et al. (2013) argue that sales from services have non-linear impact on operating margins using data on the pre-packaged software products industry, while Kohtamäki et al. (2013b) also propose a non-linear relationship between service offering and sales

growth using data from 91 Finnish manufacturing companies. Besides, Kastalli & Van Looy (2013) demonstrate a positive but non-linear effect of the scale of service activities on firm profitability. Specifically, in the initial stage of servitization, there is a steep positive relationship between service scale and profit margin; after reaching a critical point, service scale shows a relative decrease in profit margin; then the positive relationship between service scale and profit margin re-emerges when the economies of scale are achieved.

(4) Apart from the significant relationship between servitization and firm performance identified in prior research, a minority of studies propose that the performance effect of servitization is insignificant. Eggert et al. (2014b) suggest that there is no significant relationship between service innovation and profitability growth while Samarrokhi et al. (2014) propose that service differentiation is limited in its contribution to achieving sustainable competitive advantage in manufacturing companies.

Overall, despite some studies on the relationship between servitization and firm performance, these research findings are inconsistent and even contradictory. Therefore, Study 1 attempts to further explore the relationship between servitization and firm performance in manufacturing firms based on the Compustat database.

In addition to the mixed research findings on the servitization-firm performance relationship, as mentioned above, the majority of extant research simply focuses on a simple measurement of firm performance. For example, Neely (2008) adopts operating revenue and net profit to measure firm performance, Antioco et al. (2008) select product sales and service volume as firm performance indicators, and Fang et al. (2008) measure firm value with Tobin's Q. Overall, the majority of extant studies concentrate on the firm's profitability to represent the firm performance while ignoring other effective performance indicators, which suggests that few empirical studies have explored the performance effect of servitization from multiple performance perspectives. In brief, firm performance can be measured as being financial and non-financial, and financial performance can be measured with multiple measurement indicators, including operating margin, sales growth, operating efficiency and asset-liability ratio (Filer & Golbe, 2003; Gedajlovic & Shapiro, 2002; Stratopoulos & Dehning, 2000). Thus, firm profitability as a performance measurement is relatively simple, meaning that it cannot fully represent the relationship between servitization and firm performance.

Prior research has suggested that the provision of basic services has no significant effect on firms' sales, but has a negative effect on profitability (Sousa & Silveira, 2017). This implies that servitization research with different performance indicators may result in different research findings. Therefore, in order to facilitate a deep understanding of the servitization-firm performance relationship, it is of great necessity to construct a more comprehensive and accurate framework in order to analyse the specific relationship between servitization and firm performance by covering multiple performance indicators, namely, operating margin, sales growth, operating efficiency and asset-liability ratio. The hypotheses development can be based on the analytical framework of major positive and negative mechanisms in the servitization-firm performance context, as discussed in the literature review in Chapter 2.

4.2 Hypotheses development

4.2.1 The relationship between servitization and operating margin

In the era of economic globalization, firms are faced with increasingly fierce competition, and the basis of competition is changing fast. Manufacturing firms are finding that they must compete by selling services (Hobday et al., 2006). Servitization has been considered as the optimum means for manufacturing firms in developed countries to reorganize industry structure in order to enhance profitability (Porter & Ketels, 2003).

However, for many companies, it may be an "unintended strategy" to focus on services, at least initially (Mintzberg, 1987). In their infancy, product firms tend to regard services as vehicles to promote product selling, which is a sort of "necessary evil" and not a source of profits in itself (Morgenson, 2004; Suarez et al., 2013). Hence, at first, firms may pay relatively little attention as to how services contribute to firms' profitability. With the penetration of servitization in product firms, firms gradually realize the importance of services in improving revenue and start paying more attention to the management of service production and margins, such as offering more effective routines for service design and delivery (Nelson & Winter, 1982). As a result, the relationship between servitization and operating margin is non-linear.

Specifically, in the initial phase, firms do not focus on services because they cannot generate great revenue from service business. With the development of

servitization in product firms, firms start to make huge investments in service business in order to create a service-oriented environment, such as service-oriented corporate culture, service-oriented human resources and separate service businesses. However, in this stage, firms are faced with issues arising from the merger of different businesses (service and product businesses), including loss of strategic focus, organizational conflict and huge investment, directly leading to a decline in firms' profits (Fang et al., 2008). Based on economies of scale, with the further development of servitization and the greater extent of services offered, the investment in service business can be shared by more customers. Economies of scale increase as product firms offer services for their entire installed base, while a single customer would need to invest in service resources and capabilities for a much smaller number of machines (Kastalli et al., 2013). Once the extent of servitization reaches a certain point (threshold) where the service business and product business achieve effective integration, firms' operating margin will rebound (Akan et al., 2011; Priem, 2007; Ye et al., 2012).

Overall, at a low level of servitization, the relationship between servitization and operating margin is negative; as the extent of servitization increases beyond a critical value, where the effect of servitization on operating margin is minimal, the effect of servitization on the operating margin becomes increasingly positive. Therefore, we propose the following hypothesis:

H1: The relationship between servitization and operating margin is U-shaped.

4.2.2 **The relationship between servitization and sales growth**

Currently product markets are characterized by commoditization, convergence and homogenization of goods, so that differentiation severely diminishes or even disappears (Antioco et al., 2008). To acquire a competitive advantage in the marketplace, manufacturing firms create product differentiation in relation to competitors by offering add-on services (Oliva & Kallenberg, 2003). That is, the provisions of "product and service" bundles could satisfy diversified customer needs, and help firms differentiate themselves from and compete with their peers, thus promoting product and service revenue and sales growth (Gebauer & Fleisch, 2007).

However, the different levels of servitization could exert different influences on sales growth, because, in a manufacturing industry context, a greater level of servitization comprises a more complex and more integrated bundles of services and

products, such as integrated solutions, which are more valuable than individual add-on services or pure products, suggesting an opportunity for greater sales growth (Meier et al., 2011). At low and moderate levels of servitization, individual add-on services are equal to low-value service offerings, whereas, at intermediate to high levels of servitization, a complex bundle of services and products represents a high-value service offering (Kohtamäki et al., 2013b). This implies that a weak add-on service, such as one comprising just product warranty or product demonstrations, is most unlikely to generate the expected level of sales growth of products, compared with offering total care solutions, such as guaranteed availability for the duration of the contract.

Moreover, the introduction of servitization makes the market structure and the key drivers of revenue for manufacturing firms changed. The ratio of revenue from service business to total revenue becomes increasing larger (Wise & Baumgartner, 1999). Service provisions help prolong product life cycles, and the introduction of servitization may unexpectedly result in the decline of firms' product sales (Sawhney et al., 2004). However, value-added services could create benefits for manufacturing firms, with the greater extent of servitization representing higher value. This indicates that low to moderate levels of servitization are not enough to boost sales growth, while the presence of a very strong or superior extent of servitization is likely to positively affect sales growth. Therefore, we propose the following hypothesis:

H2: The relationship between servitization and sales growth is U-shaped.

4.2.3 **The relationship between servitization and operating efficiency**

When manufacturing firms extend into service business, they can leverage the knowledge and resources accumulated from manufacturing products (Buchanan & Huczynski, 1997). The knowledge and resource spillovers result in synergies between product business and service business. On the one hand, this resource spillover between product and service offerings enhances the ambiguity and complexity of resource endowments, thus facilitating differentiation and preventing imitation from competitors (Reed & DeFillippi, 1990). On the other hand, manufacturing firms transitioning to service domains, such as after-sales services and integrated solutions, can share tangible resources (e.g., local offices and plants) and intangible resources (e.g., brand image and customer relationships) originally from product domains (Fang et al., 2008). The "product and service" bundle enables manufacturers to utilize resources and knowledge

more effectively. Therefore, the synergies between manufacturing and services can contribute to firms' management of operations and production.

However, due to significant differences in the management of production and operations between service business and product business, the effect of servitization on firms' operating efficiency is very complex. Besides the benefits generated from servitization (e.g., increased loyalty and leverage of resources), servitization involves several fundamental weaknesses including loss of strategic focus and organizational conflicts (Fang et al., 2008). In the initial phase, to assure the operation of service business, manufacturing firms make great investments in organizational change, such as training new service personnel and establishing separate service businesses (Cook et al., 2006). However, as in the case of low and moderate levels of servitization, manufacturing firms' organizational structure, process, culture, leadership and resources are still product-oriented, which hinders the service business operations (Gebauer et al., 2010). Moreover, given that service business requires enormous resources originally used for product business, the introduction of services could lead to unbalanced resource distribution and internal conflicts between different divisions. Furthermore, the introduction of service business represents a more complicated organizational structure of manufacturing firms, which directly increases the difficulty of firms' operation management and coordination (Mathieu, 2001).

Overall, the implementation of servitization in manufacturing firms has some drawbacks, which could reduce employee motivation, cause confusion between resource deployment and configuration, and undermine resource utilization and productivity rates, which in turn undermine firms' operating efficiency. Considering the synergies between manufacturing and services, this negative effect of servitization on operating efficiency is gradually weakened and finally neutralized until firms reach a critical level of servitization, after which point they have an increasingly positive effect, because, from a moderate to a high degree of servitization, manufacturers have overcome the difficulties arising from the integration of product and service businesses, and may acquire great operating efficiency through synergies between these two businesses. Therefore, we propose the following hypothesis:

H3: The relationship between servitization and operating efficiency is U-shaped.

4.2.4 **The relationship between servitization and asset-liability ratio**

When manufacturing firms implement servitization, in order to guarantee the operation of service business, they need to make great investments in organizational change including organizational structure, process and culture (Gebauer et al., 2005). However, due to the increased management cost and complexity generated from the introduction of servitization, firms may not acquire the corresponding high returns (Gebauer et al., 2005). Therefore, for low and moderate levels of servitization, while manufacturing firms' investment in service business is most likely to be acquired via loans from financial institutions, they cannot be offset in a timely manner by the returns, which directly results in an increase in these firms' asset-liability ratio and even lead to bankruptcy. However, once firms reach a certain critical level of servitization, the returns from service business become increasing higher with the extent of servitization ranging from medium to high, which could effectively repay the loan. This implies that firms' asset-liability ratio gradually decreases with an increase in the extent of servitization. Overall, we propose the following hypothesis:

H4: The relationship between servitization and asset-liability ratio is inverse and U-shaped.

4.3 Research model

4.3.1 **Research model**

Based on the hypotheses development, we propose the conceptual model for Study 1, as shown in Figure 4.1.

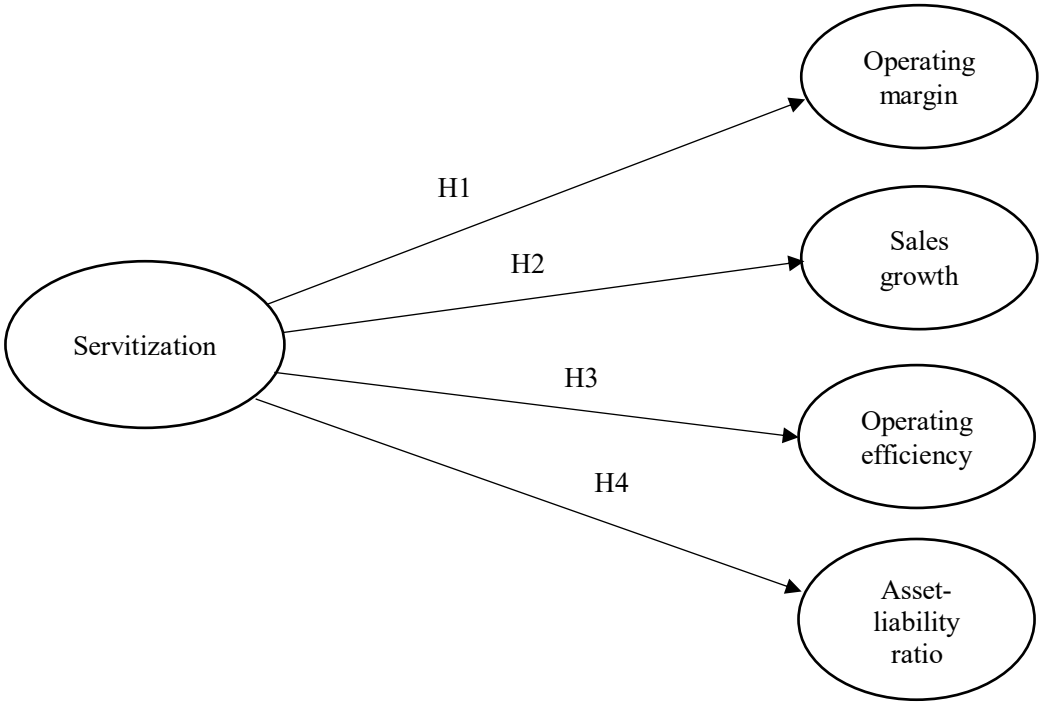

Figure 4. 1 The conceptual model of Study 1

4.3.2 **Model specification**

Based on the research model above, Study 1 constructs the econometric model by using firm performance as the dependent variable, servitization as the independent variable, and firm size, industry concentration, market share and year as control variables. Firm performance is measured in terms of multiple indicators, including operating margin, sales growth, operating efficiency and asset-liability ratio. Considering the broad time span ranging from 1990 to 2016 during which we collected the research sample, we conjecture that the customary presence of a lagged dependent variable in the panel data may affect the current value, which can give rise to autocorrelation (Suarez et al., 2013). Therefore, we introduce lagged dependent variables (namely, indicators of firm performance) in the econometric model and construct the following dynamic panel data (DPD) models (as shown in Equations 4-1, 4-2, 4-3 and 4-4):

$$\text{Operatingmargin}_{i,t} = \alpha_0 + \alpha_1 \text{Serviceratio}_{i,t} + \alpha_2 \text{Serviceratio}^2_{i,t} + \alpha_3 \text{Firmsize}_{i,t} + \alpha_4 \text{Industryconcen}_{i,t} + \alpha_5 \text{Marketshare}_{i,t} + \alpha_6 \text{Year}$$

$$+ \alpha_7 \text{Operatingmargin}_{i,\,t-1} + \varepsilon_{1i} + v_{1i,\,t} \tag{4-1}$$

$$\text{Growth}_{i,\,t} = \beta_0 + \beta_1 \text{Serviceratio}_{i,\,t} + \beta_2 \text{Serviceratio}^2_{i,\,t} + \beta_3 \text{Firmsize}_{i,\,t} + \beta_4 \text{Industryconcen}_{i,\,t} + \beta_5 \text{Marketshare}_{i,\,t} + \beta_6 \text{Year} + \beta_7 \text{Growth}_{i,\,t-1} + \varepsilon_{2i} + v_{2i,\,t} \tag{4-2}$$

$$\text{Turnover}_{i,\,t} = \lambda_0 + \lambda_1 \text{Serviceratio}_{i,\,t} + \lambda_2 \text{Serviceratio}^2_{i,\,t} + \lambda_3 \text{Firmsize}_{i,\,t} + \lambda_4 \text{Industryconcen}_{i,\,t} + \lambda_5 \text{Marketshare}_{i,\,t} + \lambda_6 \text{Year} + \lambda_7 \text{Turnover}_{i,\,t-1} + \varepsilon_{3i} + v_{3i,\,t} \tag{4-3}$$

$$\text{Debt}_{i,\,t} = \mu_0 + \mu_1 \text{Serviceratio}_{i,\,t} + \mu_2 \text{Serviceratio}^2_{i,\,t} + \mu_3 \text{Firmsize}_{i,\,t} + \mu_4 \text{Industryconcen}_{i,\,t} + \mu_5 \text{Marketshare}_{i,\,t} + \mu_6 \text{Year} + \mu_7 \text{Debt}_{i,\,t-1} + \varepsilon_{4i} + v_{4i,\,t} \tag{4-4}$$

where each variable is as defined in Chapter 3 and summarized in Table 3.2, (*i, t)* refers to firm *i* in year *t*, α_0, β_0, λ_0 and μ_0 are a set of constant terms, α_n, β_n, λ_n, μ_n (n=1, 2, 3, …, 7) are a set of regression coefficients for independent variables, ε_{1i}, ε_{2i}, ε_{3i} and ε_{4i} are firm-specific constant terms for individual effects, and $v_{1i,\,t}$, $v_{2i,\,t}$, $v_{3i,\,t}$ and $v_{4i,\,t}$ are error terms.

4.3.3 **Estimators, model corrections and diagnostic checks**

Since we have time series of sample observations for multiple firms, and given that some firms do not provide corresponding data in some years, our data in the study show an unbalanced panel structure. This requires great attention to be paid to several estimation issues.

First, in order to avoid the biased estimates, we use the Dicker-Fuller unit root to test whether these variables in our study are stationary (Choi, 2001). In our sample, a significant panel unit root test confirms the stationarity of variables (four test indexes, i.e., inverse chi-squared, inverse normal, inverse logit t, and modified inverse chi-squared, reject the null hypothesis, $p < 0.01$). Second, the Wooldridge test is used to identify the existence of serial correlation in panel data (Wooldridge, 2015), with the test result rejecting the null hypothesis that there is no first-order autocorrelation. This

suggests that, in our sample, autocorrelation is an important issue, which may bias the parameter estimates. Therefore, to cope with this issue, we introduce lagged dependent variables in our econometric models. Besides, the Wald test is applied to identify the heteroscedasticity arising from our sample, while we use the cluster robust standard error to reduce the effect of heteroscedasticity on research results (Cameron & Trivedi, 2005).

In addition, endogeneity is a common issue that may bias the parameter estimates, which in turn affect the main effects in the research models. Despite a large body of research exploring the effect of servitization on firm performance, some studies report that firm performance may also influence servitization (Benedettini et al., 2017; Han et al., 2013). This indicates that the causal relationship between servitization and firm performance is ambiguous and even simultaneous. The presence of simultaneous causality is a common cause behind the violation of the standard regression analysis assumption with regard to the absence of correlation between the error terms and independent variables; this is known as endogeneity (Stock & Watson, 2003; Wooldridge, 2002). To avoid biased estimates caused by endogeneity, econometricians suggest the introduction of instrumental variables in econometric models explains the independent variable, but is unrelated to the dependent one (Wooldridge, 2015). Since our study data have a panel structure and our econometric models introduce lagged dependent variables, we adopt system generalized method of moments (GMM) dynamic panel methods (Arellano & Bover, 1995; Blundell & Bond, 1998). The system GMM is an instrumental variable methodology designed to precisely cope with endogeneity and dynamic panel bias, since it can automatically generate corresponding instrumental variables based on dependent variables (Arellano & Bond, 1991; Blundell & Bond, 1998).

4.4 Data analysis and results

4.4.1 **Descriptive statistics**

Table 4.1 presents descriptive statistics and the corresponding correlation matrix for all variables (except instrumental variables and year dummies), pooled across firms and time. The variance inflation factor (VIF) scores for all variables in the table (VIFs < 4) suggest no major collinearity issue in our data (Farrar & Glauber, 1967). In order

to avoid collinearity, Serviceratio^2 is calculated with the squared value of the centred Serviceratio (Aiken & West, 1991).

Table 4. 1 Descriptive Statistics and Correlations of Study 1

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	VIF
1. Operatingmargin	-146.101	0.676	-0.030	2.660	1									
2. Growth	-0.975	36.191	0.115	0.711	-0.056***	1								
3. Turnover	0.004	6.378	1.148	0.658	0.061***	-0.098***	1							
4. Debt	0.139	44.062	2.439	2.095	-0.071***	0.048***	-0.137***	1						
5. Serviceratio	0.000	0.998	0.223	0.205	-0.037**	0.031**	0.094***	0.008	1					2.03
6. Serviceratio^2	0.000	0.997	0.092	0.157	-0.049***	0.022	0.086***	0.011	0.935***	1				1.99
7. Firmsize	-1.546	12.829	6.352	2.651	0.123***	-0.106***	-0.024	-0.303***	-0.227***	-0.216***	1			1.48

Table 4.1

(Continued)

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	VIF
8. Marketshare	0.000	1.000	0.125	0.203	0.037**	-0.055***	-0.025**	-0.191***	-0.118***	-0.111***	0.477***	1		1.84
9. Industryconcen	0.048	1.000	0.283	0.200	0.027	-0.024*	-0.008	-0.083	-0.042***	-0.052***	0.002***	0.480	1	1.43
Average VIF														1.75

Notes: (1) The sample size is 4451; (2) *** p < 0.01, ** p < 0.05, * p < 0.1.

4.4.2 **Data results**

We use the routine Xtabond2 in Stata 14.0 to run the system GMM to test the proposed hypotheses. Table 4.2 shows the regression results pertaining to the testing of the hypotheses, with four models' results in this table corresponding to the model specifications in Equations 4-1, 4-2, 4-3 and 4-4. It is noteworthy that the four dependent variables are significantly correlated with their lagged values (beta = 1.028 for Operatingmargin, beta = -0.964 for Growth, beta = -0.167 for Turnover, and beta = -0.242 for Debt), which provides support for the inclusion of the lagged dependent variables in the regression models and the adoption of the system GMM estimator for data analysis.

Table 4. 2 Regression Results for Hypotheses in Study 1

Variables	Model 4-1 Operatingmargin	Model 4-2 Growth	Model 4-3 Turnover	Model 4-4 Debt
Serviceratio	-5.442***	-2.634**	-1.556***	0.389
	(1.536)	(1.117)	(0.483)	(1.583)
$Serviceratio^2$	5.498***	1.575	1.962**	0.175
	(1.520)	(1.288)	(0.758)	(1.751)
Firmsize	0.189	1.012***	0.278***	-0.223*
	(0.153)	(0.159)	(0.047)	(0.114)
Marketshare	0.124	-0.041	-0.172	0.083
	(0.702)	(0.268)	(0.206)	(0.432)
Industryconcen	0.317	-0.042	0.063	-0.513
	(0.238)	(0.161)	(0.109)	(0.385)
L.Operatingmargin	1.028***			
	(0.125)			
L.Growth		-0.964***		
		(0.027)		
L.Turnover			-0.167***	
			(0.030)	
L.Debt				-0.242**
				(0.117)
Year				
Year1991	0.072		0.091**	
	(0.053)		(0.038)	
Year1992	0.046		0.069**	-0.293
	(0.044)		(0.030)	(0.521)
Year1993		2.452***		-0.323
		(0.323)		(0.497)
Year1994	-0.132***	2.386***	-0.005	-0.253
	(0.040)	(0.305)	(0.034)	(0.485)
Year1995	-0.167***	2.306***	-0.027	-0.133
	(0.055)	(0.293)	(0.049)	(0.469)
Year1996	-0.245**	2.124***	-0.053	-0.152
	(0.101)	(0.271)	(0.058)	(0.457)

Table 4.2

(Continued)

Variables	Model 4-1 Operatingmargin	Model 4-2 Growth	Model 4-3 Turnover	Model 4-4 Debt
Year1997	-0.283**	2.006***	-0.130**	-0.047
	(0.116)	(0.253)	(0.064)	(0.427)
Year1998	-0.402***	1.858***	-0.224***	-0.017
	(0.137)	(0.244)	(0.077)	(0.416)
Year1999	-0.397***	1.768***	-0.323***	-0.129
	(0.137)	(0.241)	(0.079)	(0.379)
Year2000	-0.504***	1.602***	-0.319***	-0.335
	(0.150)	(0.221)	(0.082)	(0.381)
Year2001	-0.649***	1.496***	-0.294***	-0.284
	(0.173)	(0.204)	(0.085)	(0.353)
Year2002	-0.766***	1.379***	-0.336***	-0.283
	(0.188)	(0.192)	(0.089)	(0.334)
Year2003	-0.817***	1.193***	-0.369***	-0.342
	(0.203)	(0.180)	(0.090)	(0.301)
Year2004	-0.910***	1.171***	-0.348***	-0.273
	(0.244)	(0.185)	(0.096)	(0.278)
Year2005	-0.990***	1.136***	-0.352***	-0.058
	(0.264)	(0.168)	(0.100)	(0.261)
Year2006	-1.102***	0.996***	-0.406***	0.048
	(0.301)	(0.157)	(0.114)	(0.241)
Year2007	-1.161***	0.827***	-0.435***	0.023
	(0.328)	(0.153)	(0.120)	(0.214)
Year2008	-1.143***	0.781***	-0.409***	0.006
	(0.334)	(0.160)	(0.121)	(0.200)
Year2009	-1.102***	0.624***	-0.498***	0.153
	(0.335)	(0.147)	(0.123)	(0.195)
Year2010	-1.095***	0.504***	-0.557***	0.011
	(0.322)	(0.134)	(0.126)	(0.191)
Year2011	-1.178***	0.475***	-0.551***	0.086
	(0.348)	(0.153)	(0.132)	(0.163)
Year2012	-1.224***	0.469***	-0.545***	0.057
	(0.362)	(0.091)	(0.136)	(0.154)

Table 4.2

(Continued)

Variables	Model 4-1 Operatingmargin	Model 4-2 Growth	Model 4-3 Turnover	Model 4-4 Debt
Year2013	-1.234***	0.300***	-0.609***	0.107
	(0.370)	(0.071)	(0.136)	(0.121)
Year2014	-1.348***	0.088*	-0.660***	0.060
	(0.380)	(0.050)	(0.140)	(0.107)
Year2015	-1.332***	0.049	-0.791***	0.054
	(0.379)	(0.033)	(0.156)	(0.076)
Year2016	-1.358***		-0.852***	
	(0.379)		(0.161)	
Instrumental variables	GMM instruments	GMM instruments	GMM instruments	GMM instruments
Number of observations	3529	2224	3529	2782
Number of firms	669	418	669	520
Number of instruments	78	95	103	75
AR(1)-p	0.056	0.013	0.472	0.011
AR(2)-p	0.268	0.169	0.256	0.185
Hansen-p	0.032	0.066	0.395	0.107

Notes: (1) L.Operatingmargin, L.Growth, L.Turnover, and L.Debt are the lagged values of four performance indicators, and Year* denotes year dummies; (2) AR(1)-p and AR(2)-p are p-values of AB Statistic while Hansen-p is the p-value of Hansen's J statistic; (3) Robust standard errors are in parentheses, except where indicated; (4) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Before analysing the regression results for the proposed hypotheses, we first need to test whether it is appropriate for these models to use system GMM estimation. The highly popular Arellano-Bond (AB) test and the Hansen test are used to examine the applicability of the system GMM in our data. Specifically, in order to check the autocorrelation in the idiosyncratic disturbances, the first-order autocorrelation, namely, AR(1), should be significant in terms of construction. Considering that, in Table 4.2, the first-order autocorrelations for some models are statistically significant ($p < 0.1$), we need to further test the second-order autocorrelation in differences, namely, AR(2), to determine the first-order autocorrelation across levels (Roodman, 2009). The statistical insignificance of AR(2) across the models in Table 4.2 ($p > 0.1$) indicates that we cannot reject the null hypothesis that there is no serial correlation in the idiosyncratic disturbances. However, the p-values of Hansen's J statistic in Model 4-1 and Model 4.2 are less than 0.1, which suggests a result contrary to the AB test. Considering the limitation of the Hansen test in GMM estimation, that is, this test is more applicable to panel data with a large N and a small T (N is the cross-sectional sample size while T is the period), it is more reliable to adopt the AB test to perform the estimations for these models (Roodman, 2009). Overall, the AB test suggests that there is no evidence that our models are misspecified (Tuli et al., 2010).

The regression results for four models, which test four proposed hypotheses with four different performance indicators (namely, Operatingmargin, Growth, Turnover and Debt), are presented in Table 4.2. The results for Model 4-1 indicate that the relationship between Serviceratio and Operatingmargin is significantly negative, while the relationship between $Serviceratio^2$ and Operatingmargin is significantly positive ($z = -3.540$, $p = 0.000$; $z = 3.620$, $p = 0.000$), which supports H1, that there is a U-shaped relationship between servitization and firms' operating margin.

The results for Model 4-2 reject H2. Specifically, in spite of the significant negative relationship between Serviceratio and Growth ($z = -2.360$, $p = 0.018$), there is no significant relationship between $Serviceratio^2$ and Growth ($z = 1.220$, $p = 0.221$). Hence, the relationship between servitization and sales growth is negative, but not U-shaped.

In addition, the results for Model 4-3 are analogous to those for Model 4-1, namely, there is a significant negative relationship between Serviceratio and Turnover, and a positive relationship between $Serviceratio^2$ and Turnover ($z = -3.220$, $p = 0.001$; $z = 2.590$, $p = 0.010$), which supports H3, that there is a U-shaped relationship between

servitization and firms' operating efficiency.

However, the results for Model 4-4 suggest an insignificant relationship between Serviceratio, Serviceratio^2 and Debt (z = 0.250, p = 0.806; z = 0.100, p = 0.921), which rejects H4, that there is a U-shaped relationship between servitization and firms' asset-liability ratio.

4.5 Discussion and conclusion

4.5.1 **Theoretical implications**

This study examines the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) based on the Compustat database; the testing results for the proposed hypotheses are shown in Table 4.3. Overall, this study extends the research on the performance effect of servitization (Fang et al., 2008; Gebauer et al., 2012). The specific contributions of this study are as follows:

First, this study confirms a U-shaped relationship between servitization and firms' operating margin. At the low level of servitization, manufacturing firms require great investments to support the operation of service business, which may result in the decline of their operating margin. As the level of servitization increases, this negative effect of servitization on firms' operating margin will be attenuated, until a critical level of servitization is reached (namely, the critical point), after which firms will gradually generate an increasingly positive effect. According to the formula ($\frac{\partial Operatingmargin_{i,t}}{\partial Serviceratio_{i,t}} = \alpha_1 + 2\alpha_2 Serviceratio_{i,t}$), the critical point is 49.5%. This finding is consistent with some prior research evidence (Fang et al., 2008; Suarez et al., 2013) and further supports the non-linear performance effect of servitization on firms' profitability.

Second, the data results reject the U-shaped relationship between servitization and sales growth, but verify the significant negative effect of servitization on firms' sales growth. This finding contradicts that reported by Kohtamäki et al. (2013b), who find a positive, but non-linear relationship between service offering and sales growth. However, the relationship between service offering and sales growth is only significant at moderate and high levels of service offering, but insignificant at low to medium levels. Kohtamäki et al. (2013b) employ survey data with a multidimensional firm-level

measurement of industrial services whereas our results are based on secondary data. Hence, our study enriches the findings on the performance effect of servitization.

Moreover, our study demonstrates a U-shaped relationship between servitization and firms' operating efficiency. At a low level of servitization, the emergence of new business (namely, service business) easily enables originally product-oriented manufacturing firms to encounter the loss of strategic focus and organizational conflicts, which may lead to decreased firms' operating efficiency. As the level of servitization increases, the benefits from synergies between service and product businesses will be increased, which could effectively attenuate the negative effect of servitization on operating efficiency. Until the level of servitization increases beyond a critical point (namely, the critical point), the effect of servitization on firms' operating efficiency becomes increasingly positive. Based on the calculation formula of the critical point mentioned above, the critical point is 39.7%. With few studies of late having explored the relationship between servitization and operating efficiency, this study makes an important contribution to this area.

Finally, our results suggest that both a main effect and a quadratic effect of servitization on firms' asset-liability ratio are insignificant, indicating that the implementation of servitization in manufacturing firms cannot cause a significant decline in asset-liability ratio.

Table 4. 3 Hypotheses testing results of Study 1

	Hypotheses	Outcome
H1	The relationship between servitization and operating margin is U-shaped	Supported
H2	The relationship between servitization and sales growth is U-shaped	Rejected
H3	The relationship between servitization and operating efficiency is U-shaped	Supported
H4	The relationship between servitization and asset-liability ratio is U-shaped	Rejected

4.5.2 **Managerial implications**

This study has several important managerial implications for manufacturing firms. First, our finding that there is a U-shaped relationship between servitization and firms'

operating margin suggests that, once manufacturing firms reach a critical level of servitization (namely, 49.5%), the positive effect of servitization on firms' operating margin becomes pronounced. This implies that servitization is not a short-term strategy, but a long journey to success. In the initial phase of servitization, firms require great investments to support service business, which easily results in the emergence of service paradox (Gebauer et al., 2005), that is, firms' great investments cannot necessarily generate expected returns. However, as the extent of servitization increases beyond a critical point, servitization will positively affect the operating margin. Overall, servitization is not a remedy for how manufacturing firms should respond to highly competitive markets, because firms at low and medium levels of servitization often suffer from difficulties resulting from the introduction of new coalitions (namely, service businesses), such as loss of strategic focus and resource competition. This means that servitization not only represents opportunities but also threats; thus, firms with no capabilities to cope with challenges posed by servitization may have decreased profits. Therefore, manufacturing firms should take effective measures to respond to these challenges if they want to acquire increased profitability by the servitization route.

Second, our finding suggests there is a negative effect of servitization on firms' sales growth. This means that an increased level of servitization may even lead to a decrease in firms' sales growth. However, Kohtamäki et al. (2013b) indicate that the relationship between service offering and sales growth is only positively significant at moderate and high levels of service offering. Therefore, we speculate that the observed negative relationship between servitization and sales growth may be due to the relatively low level of servitization among firms distributed in manufacturing industries. Despite a prevailing tendency towards servitization in manufacturing firms, the majority of these firms' servitization are at the elementary stage and thus remain to be further developed. For servitized manufacturers, the negative effect of servitization on sales growth emerges in the early stage of servitization. Specifically, the introduction of servitization improves the product life cycle and in turn decreases product revenue. Besides, services are characterized as intangible, hard to imitate and often based on long-term contracts and customer relationships (Josephson et al., 2016), and these characteristics inherent in service business may mean that the increase in service revenue cannot offset the loss of product revenue. Therefore, it is a long journey for manufacturing firms to acquire enhanced total revenue by means of servitization, especially for ones in particularly sophisticated and costly product industries.

Moreover, the U-shaped relationship between servitization and operating efficiency suggests that manufacturing firms will expect enhanced operating efficiency after the critical point of servitization (namely, 39.7%), before generating a negative effect on operating efficiency. This indicates that, at low and medium levels of servitization, manufacturing firms tend to evolve from a product-oriented organizational structure into an organizational structure, separating service from manufacturing divisions (Slack, 2005). The organizational change may cause the emergence of some major issues, such as department function confusion, human resource reorganization and other internal conflicts, which may adversely affect organizational operating efficiency, even in the case of synergies between service and product businesses. Once the changed organizational arrangements are matched with firms' new coalitions, the effect of synergies between manufacturing and service could be further strengthened, which in turn will lead to increased operating efficiency. Overall, besides the positive benefits, the implementation of servitization also poses some new challenges. Firms may fail in implementing servitization if they cannot effectively respond to these challenges. Therefore, servitized manufacturing firms should pay great attention to the integration of mixed organizational elements between service and product businesses (e.g., process, culture and structure).

Finally, the rejected hypothesis about the effect of servitization on asset-liability ratio indicates that the implementation of servitization in manufacturing firms will not lead to a significant decline in asset-liability ratio. This implies that it is not a feasible method for manufacturing firms with high debt to lower their leverage by adopting servitization.

5 Study 2: The moderating effect of industry characteristics on the relationship between servitization and firm performance

5.1 Introduction

Since servitization was first termed by Vandermerwe & Rada (1988) to delineate the process of creating value by adding services to products, the impact of servitization on firm performance has attracted considerable attention from the business and academic communities (Oliva & Kallenberg, 2003; Wise & Baumgartner, 1999).

As the latest trend in servitization, some studies have explored the relationship between servitization and firm performance, while showing inconsistent results (Brax, 2005; Fang et al., 2008; Gebauer et al., 2005; Lapré, 2011; Neely, 2008; Neu & Brown, 2005; Oliva & Kallenberg, 2003; Suarez et al., 2013). Study 1 has reported on the literature concerning these mixed findings and empirically investigated the U-shaped relationship between servitization and four performance indicators, based on data from Compustat database during the period 1990-2016. The results of Study 1 indicate that the relationships between servitization and two performance indicators (operating margin and operating efficiency) are U-shaped, which is in accordance with some researchers' findings (Fang et al., 2008; Li et al., 2015; Suarez et al., 2013).

These non-linear effects of servitization on firm performance may, in part, be due to contextual differences associated with servitization practices. Therefore, it would be productive to further investigate the specific contextual factors affecting the relationship between servitization and firm performance.

Prior research has explored the moderating effect and the moderating factors, which can be roughly categorized into two types, namely, industry characteristics and firm characteristics (Eggert et al., 2011). Firm characteristics include variables related to organizational structure, organizational capability and organizational resource, such as service relatedness, resource slack, service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services and service training (Antioco et al., 2008; Donaldson, 1995; Fang et al., 2008; Gebauer, 2007; Gebauer, 2008; Homburg et al., 2003; Jia et al., 2016). Fang et al. (2008) identify the positive moderating role of service relatedness and resource slack on the relationship between service strategies and firm value, while Antioco et al. (2008), Donaldson (1995), Gebauer (2008) and Homburg et

al. (2003) propose further firm characteristics, including service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services and service training as positive moderating factors of the servitization-performance relationship. Moreover, other firm characteristics, such as relational capital, network capabilities and product innovation activities have been identified as significant moderators influencing the association between servitization and firm performance (Eggert et al., 2011; Kohtamäki et al., 2013a; Kohtamäki et al., 2013b).

In contrast, there are few studies exploring the moderating impact of industry characteristics on the servitization-firm performance link. Fang et al. (2008) suggest that industry growth negatively affects the relationship between service strategies and firm value, while industry turbulence positively moderates this relationship. However, certain other industry characteristics as moderators of the servitization-performance link have not been examined to date. Based on the literature review as mentioned previously, the contingency theory suggests that there is no ideal way to manage an organization, and that the effectiveness of firms' business or management practice is contingent on the contextual environment of the organization concerned (Tosi & Slocum, 1984). Considering the importance of the coalignment between external environment and firms' business strategy or practice on performance implications (Venkatraman & Prescott, 1990), it is essential to explore how this co-alignment between servitization and industry environment affects firm performance. Therefore, this study attempts to narrow this gap by exploring the moderating effect of some industry characteristics on the relationship between servitization and firm performance in manufacturing firms. For this purpose, the selected common industry characteristics, which have not explored yet in prior literature, are industry clockspeed, industry concentration and industry maturity (Melville et al., 2007; Mendelson & Pillai, 1999; Suarez et al., 2013).

5.2 Hypotheses development

5.2.1 **Moderating effect of industry clockspeed**

Prior research has identified environmental dynamism as an important contingency factor shaping the selection of the employed strategy (Bensaou &

Venkatraman, 1995; Eisenhardt & Martin, 2000; Lawrence & Lorsch, 1967a; Teece et al., 1997). Industry clockspeed, closely related to environmental dynamism, is most likely to affect firms' strategy choice (Mendelson & Pillai, 1998, 1999). Fine (1998) defines industry clockspeed as the change rate within an industry sector and identifies several important conceptual measures of industry clockspeed, including the change rate of products, process and organizational structure. Industry clockspeed can be categorized as slow-cycle, standard-cycle and fast-cycle, depending on whether the product price change is positive, close to zero, or negative, respectively (Mendelson & Pillai, 1999; Williams, 1992). Each industry evolves at a different rate and relies on the pertinent type of industry clockspeed (Fine, 1998).

Industries with fast industry clockspeed are characterized by rapid updating speed of products and high-level process innovation, such as electronic devices (Mendelson & Pillai, 1998; Williams, 1992). These kinds of industries tend to thrive for differentiation by developing and selling innovative products among competitors. Servitization is also an effective tactic by which manufacturing firms differentiate and compete (Eggert et al., 2011). Compared with the rapidly updating products in industries with fast industry clockspeed, services have some important innate characteristics, such as intangible, knowledge-intensive, and hard-to-imitate and -standardize (Fang et al., 2008). These characteristics, inherently derived from services, encourage more firms to pursue benefits by implementing servitization. However, besides these stated characteristics above, service offerings involve an important attribute, namely, acquiring competitive edge based on long-term buyer-supplier relationships; that is, the transaction between service providers and customers is not a one-off but often based on a long-term contract. Service provisions are often accompanied by core products. However, service sales based on long-term contracts cannot effectively match the sales pattern of products with a high updating speed. Therefore, firms in industries with fast industry clockspeed cannot acquire higher firm performance by means of servitization.

In contrast, for industries with slow industry clockspeed such as medical equipment manufacturing, the change rate for products and technology is relatively slow, while the product life cycle is relatively long, which better matches with the characteristics of service offerings and enables manufacturers to focus on service business.

Overall, we speculate that industry clockspeed has moderating effect on the

relationship between servitization and firm performance and as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H1: Industry clockspeed moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

5.2.2 **Moderating effect of industry concentration**

Industry concentration reflects the extent of firms' competitiveness within a particular industry sector (Hou & Robinson, 2006). Low industry concentration represents a highly competitive market and *vice versa*. Firms in the case of low industry concentration are often faced with intense competition. In order to stand out from competitors, firms need to adopt innovative strategies to acquire competitive advantage (Porter, 2008). Prior studies have proposed that differentiation is the optimal strategy for firms in a highly competitive industry environment to enhance firm performance (Christensen & Montgomery, 1981; Rumelt, 1974). For manufacturing firms, the introduction of servitization provides customers with "product and service" packages, which help firms differentiate and compete (Eggert et al., 2011). Therefore, when industry concentration is lower, industry competition becomes higher, and the need for a differential competitive edge derived from unique or hard-to-imitate tangible and intangible products (e.g., services) is greater (Gebauer, 2008).

In contrast, firms in an industry with high concentration are in a relatively low competitive business environment and often occupy a relatively large market share (Hou & Robinson, 2006). This suggests that such firms are dominant in the field and have a relatively competitive advantage over competitors. In this case, manufacturing firms have no urgent need or motivation to transition to service business, because corporate transformation is not only an opportunity but a challenge. Hence, as industry concentration increases, industry competition decreases, and firms are less motivated to transition to servitization in order to acquire competitive edge.

Overall, we conjecture that industry concentration has a moderating effect on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H2: Industry concentration moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

5.2.3 **Moderating effect of industry maturity**

A large body of literature has described industry maturity as the emergence of a major change in industry dynamics, which causes a shake-out representing the onset of maturity (Agarwal et al., 2002; Utterback & Suarez, 1993). Prior research has highlighted the importance of services to product firms in mature industries. For example, Teece (1986) maintains that, in the early stages of an industry, services do not loom large. Once the onset of industry maturity starts, products become commoditized and homogenous, enabling firms to suffer from increased pricing pressure. Services characterized as difficult to duplicate and unique may not be susceptible to product commoditization and homogenization. As a result, services primarily play an important role in mature or maturing product industries (Reinartz & Ulaga, 2008; Teece, 1986). Thus, we speculate that, in industries with different levels of maturity, the effect of firms' servitization on firm performance may significantly differ.

Specifically, in immature industries, manufacturing firms thrive at differentiation by offering innovative products and focusing on products as the main source of revenue. This implies that the relative contribution of services to total revenue is low, with additional services often impairing firms' operating margins (Suarez et al., 2013). Consequently, firms in the early stage of an industry tend to be less motivated towards servitization in order to acquire greater firm performance. However, as product industries reach maturity, product firms' innovation focus may shift away from product to process innovation (Abernathy & Utterback, 1978). Once commoditization and homogenization of products in mature industries occur, firms no longer concentrate on product differentiation, but differentiate and compete by offering additional services. Thus, services become the main revenue streams for product firms in mature industries.

Overall, we propose that industry maturity has a moderating effect on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H3: Industry maturity moderates the relationship between servitization and four

firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

5.3 Research model

5.3.1 **Research model**

Based on the hypotheses development, we propose the conceptual model for Study 2, as shown in Figure 5.1.

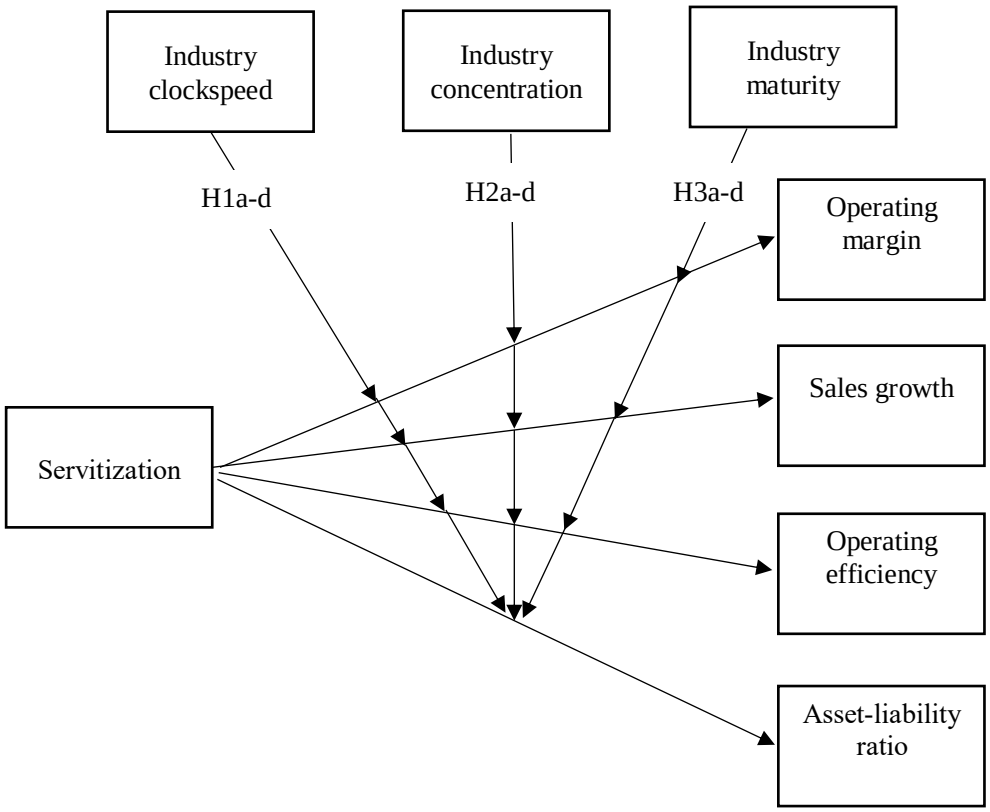

Figure 5. 1 The conceptual model of Study 2

5.3.2 **Model specification**

Based on the research model above, Study 2 constructs the econometric model by using four indicators of firm performance (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) as dependent variables, servitization as an independent variable, industry clockspeed, industry concentration and industry maturity as moderator variables, and firm size, market share and year as control variables. Given the broad time span ranging from 1990 to 2016, during which we

collected the research sample, we conjecture that the customary presence of a lagged dependent variable in the panel data may affect the current value, which can give rise to autocorrelation (Suarez et al., 2013). Therefore, we introduce lagged dependent variables (namely, indicators of firm performance) in the econometric model and construct the following DPD models (as shown in Equations 5-1, 5-2, 5-3 and 5-4):

$$\begin{aligned}\text{Operatingmargin}_{i,t} &= \alpha_0 + \alpha_1\text{Serviceratio}_{i,t} + \alpha_2\text{Serviceratio}^2_{i,t} + \alpha_3\text{Pricechange}_{i,t} \\ &+ \alpha_4\text{HHI}_{i,t} + \alpha_5\text{Industrymaturity}_{i,t} + \alpha_6\text{Serviceratio}_{i,t} \times \text{Pricechange}_{i,t} \\ &+ \alpha_7\text{Serviceratio}^2_{i,t} \times \text{Pricechange}_{i,t} + \alpha_8\text{Serviceratio}_{i,t} \times \text{HHI}_{i,t} \\ &+ \alpha_9\text{Serviceratio}^2_{i,t} \times \text{HHI}_{i,t} + \alpha_{10}\text{Serviceratio}_{i,t} \times \text{Industrymaturity}_{i,t} \\ &+ \alpha_{11}\text{Serviceratio}^2_{i,t} \times \text{Industrymaturity}_{i,t} + \alpha_{12}\text{Firmsize}_{i,t} + \alpha_{13}\text{Marketshare}_{i,t} \\ &+ \alpha_{14}\text{Year} + \alpha_{15}\text{Operatingmargin}_{i,t-1} + \varepsilon_{1i} + \nu_{1i,t}\end{aligned} \tag{5-1}$$

$$\begin{aligned}\text{Growth}_{i,t} &= \beta_0 + \beta_1\text{Serviceratio}_{i,t} + \beta_2\text{Serviceratio}^2_{i,t} + \beta_3\text{Pricechange}_{i,t} + \beta_4\text{HHI}_{i,t} \\ &+ \beta_5\text{Industrymaturity}_{i,t} + \beta_6\text{Serviceratio}_{i,t} \times \text{Pricechange}_{i,t} \\ &+ \beta_7\text{Serviceratio}^2_{i,t} \times \text{Pricechange}_{i,t} + \beta_8\text{Serviceratio}_{i,t} \times \text{HHI}_{i,t} \\ &+ \beta_9\text{Serviceratio}^2_{i,t} \times \text{HHI}_{i,t} + \beta_{10}\text{Serviceratio}_{i,t} \times \text{Industrymaturity}_{i,t} \\ &+ \beta_{11}\text{Serviceratio}^2_{i,t} \times \text{Industrymaturity}_{i,t} + \beta_{12}\text{Firmsize}_{i,t} + \beta_{13}\text{Marketshare}_{i,t} \\ &+ \beta_{14}\text{Year} + \beta_{15}\text{Growth}_{i,t-1} + \varepsilon_{2i} + \nu_{2i,t}\end{aligned} \tag{5-2}$$

$$\begin{aligned}\text{Turnover}_{i,t} &= \lambda_0 + \lambda_1\text{Serviceratio}_{i,t} + \lambda_2\text{Serviceratio}^2_{i,t} + \lambda_3\text{Pricechange}_{i,t} \\ &+ \lambda_4\text{HHI}_{i,t} + \lambda_5\text{Industrymaturity}_{i,t} + \lambda_6\text{Serviceratio}_{i,t} \times \text{Pricechange}_{i,t} \\ &+ \lambda_7\text{Serviceratio}^2_{i,t} \times \text{Pricechange}_{i,t} + \lambda_8\text{Serviceratio}_{i,t} \times \text{HHI}_{i,t} \\ &+ \lambda_9\text{Serviceratio}^2_{i,t} \times \text{HHI}_{i,t} + \lambda_{10}\text{Serviceratio}_{i,t} \times \text{Industrymaturity}_{i,t} \\ &+ \lambda_{11}\text{Serviceratio}^2_{i,t} \times \text{Industrymaturity}_{i,t} + \lambda_{12}\text{Firmsize}_{i,t} + \lambda_{13}\text{Marketshare}_{i,t} \\ &+ \lambda_{14}\text{Year} + \lambda_{15}\text{Turnover}_{i,t-1} + \varepsilon_{3i} + \nu_{3i,t}\end{aligned} \tag{5-3}$$

$$\begin{aligned}\text{Debt}_{i,t} &= \mu_0 + \mu_1\text{Serviceratio}_{i,t} + \mu_2\text{Serviceratio}^2_{i,t} + \mu_3\text{Pricechange}_{i,t} + \mu_4\text{HHI}_{i,t} \\ &+ \mu_5\text{Industrymaturity}_{i,t} + \mu_6\text{Serviceratio}_{i,t} \times \text{Pricechange}_{i,t} \\ &+ \mu_7\text{Serviceratio}^2_{i,t} \times \text{Pricechange}_{i,t} + \mu_8\text{Serviceratio}_{i,t} \times \text{HHI}_{i,t} \\ &+ \mu_9\text{Serviceratio}^2_{i,t} \times \text{HHI}_{i,t} + \mu_{10}\text{Serviceratio}_{i,t} \times \text{Industrymaturity}_{i,t} \\ &+ \mu_{11}\text{Serviceratio}^2_{i,t} \times \text{Industrymaturity}_{i,t} + \mu_{12}\text{Firmsize}_{i,t} + \mu_{13}\text{Marketshare}_{i,t} \\ &+ \mu_{14}\text{Year} + \mu_{15}\text{Debt}_{i,t-1} + \varepsilon_{4i} + \nu_{4i,t}\end{aligned} \tag{5-4}$$

where each variable is as defined in Chapter 3 and summarized in Table 3.3, (*i, t)* refers to firm *i* in year *t*, α_0, β_0, λ_0 and μ_0 are a set of constant terms, α_n, β_n, λ_n, μ_n (n=1, 2, 3, …, 7) are a set of regression coefficients for independent variables, ε_{1i}, ε_{2i}, ε_{3i} and ε_{4i} are firm-specific constant terms for individual effects, and $v_{1i,t}$, $v_{2i,t}$, $v_{3i,t}$ and $v_{4i,t}$ are error terms.

5.3.3 **Estimators, model corrections and diagnostic checks**

Since we have time series of sample observations for multiple firms, and given that some firms do not provide corresponding data in some years, our data in the study show an unbalanced panel structure. This requires great attention to be paid to several estimation issues.

First, in order to avoid the biased estimates, we use the Dicker-Fuller unit root to test whether these variables in our study are stationary (Choi, 2001). In our sample, a significant panel unit root test confirms the stationarity of variables (four test indexes, i.e., inverse chi-squared, inverse normal, inverse logit t, and modified inverse chi-squared, reject the null hypothesis, $p < 0.01$). Second, the Wooldridge test is used to identify the existence of serial correlation in panel data (Wooldridge, 2015), with the test result rejecting the null hypothesis that there is no first-order autocorrelation. This suggests that, in our sample, autocorrelation is an important issue, which may bias the parameter estimates. Therefore, to cope with this issue, we introduce lagged dependent variables in our econometric models. Besides, the Wald test is applied to identify the heteroscedasticity arising from our sample, while we use the cluster robust standard error to reduce the effect of heteroscedasticity on research results (Cameron & Trivedi, 2005).

In addition, endogeneity is a common issue that may bias the parameter estimates, which in turn affect the main effects in the research models. Despite a large body of research exploring the effect of servitization on firm performance, some studies report that firm performance may also influence servitization (Benedettini et al., 2017; Han et al., 2013). This indicates that the causal relationship between servitization and firm performance is ambiguous and even simultaneous. The presence of simultaneous causality is a common cause behind the violation of the standard regression analysis assumption with regard to the absence of correlation between the error terms and

independent variables; this is known as endogeneity (Stock & Watson, 2003; Wooldridge, 2002). To avoid biased estimates caused by endogeneity, econometricians suggest the introduction of instrumental variables in econometric models explains the independent variable, but is unrelated to the dependent one (Wooldridge, 2015). Since our study data have a panel structure and our econometric models introduce lagged dependent variables, we adopt system generalized method of moments (GMM) dynamic panel methods (Arellano & Bover, 1995; Blundell & Bond, 1998). The system GMM is an instrumental variable methodology designed to precisely cope with endogeneity and dynamic panel bias, since it can automatically generate corresponding instrumental variables based on dependent variables (Arellano & Bond, 1991; Blundell & Bond, 1998).

5.4 Data analysis and results

5.4.1 **Descriptive statistics**

Table 5.1 presents descriptive statistics and the corresponding correlation matrix for all variables (except instrumental variables and year dummies), pooled across firms and time. The VIF scores for all variables in the table (VIFs < 4) suggest no major collinearity issue in our data (Farrar & Glauber, 1967). In order to avoid collinearity, $Serviceratio^2$ is calculated with the squared value of the centred Serviceratio (Aiken & West, 1991).

Table 5. 1 Descriptive Statistics and Correlations of Study 2

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	VIF
1. Operatingmargin	-146.1	.676	-.03	2.66	1										
2. Growth	-.975	36.191	.115	.711	-.056***	1									
3. Turnover	.004	6.378	1.148	.658	.061***	-.098***	1								
4. Debt	.139	44.062	2.439	2.095	-.071***	.0488***	-.137***	1							
5. Serviceratio	.000	.998	.223	.205	-.037**	.031**	.094***	.008	1						2.03
6. Serviceratio^2	.000	.997	.092	.157	-.049***	.022	.086***	.011	.935***	1					1.99
7. HHI	.048	1.000	.283	.200	.027*	-.024	-.008	-.083***	-.042***	-.052***	1				1.45

Table 5.1

(Continued)

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	VIF
8. Industrymaturity	-100.0	100.00	2.576	14.764	.0004	-.007	-.082***	.028*	-.044***	-.054***	.122***	1			1.02
9. Firmsize	-1.546	12.829	6.352	2.651	.123***	-.106***	-.024	-.303***	-.227***	-.216***	.002	-.018	1		1.48
10. Marketshare	.000	1.000	.125	.203	.037**	-.055***	-.025*	-.191***	-.118***	-.111***	.480***	.014	.477***	1	1.02
Average VIF															1.64

Notes: (1) The sample size is 4451; (2) *** p < 0.01, ** p < 0.05, * p < 0.1.

5.4.2 **Data results**

We use the routine Xtabond2 in Stata 14.0 to run the system GMM to test the proposed hypotheses. Table 5.2 shows the regression results pertaining to the testing of the hypotheses, with four models' results in this table corresponding to the model specifications in Equations 5-1, 5-2, 5-3 and 5-4. It is noteworthy that the four dependent variables are significantly correlated with their lagged values (beta = 1.031 for Operatingmargin, beta = -0.959 for Growth, beta = -0.169 for Turnover, and beta = -0.275 for Debt), which provides support for the inclusion of the lagged dependent variables in the regression models and the adoption of the system GMM estimator for data analysis.

Table 5. 2 Regression Results for Hypotheses in Study 2

Variables	Model 5-1 Operatingmargin		Model 5-2 Growth		Model 5-3 Turnover		Model 5-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Serviceratio	-4.291***	1.188	-3.126*	1.305	-1.508***	0.484	1.245	1.567
$Serviceratio^2$	5.060***	1.416	1.985	1.537	1.695**	0.800	-0.396	1.622
Pricechange								
Fast	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)
Standard	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)
Slow	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)
HHI	0.190	0.238	0.047	0.165	0.034	0.125	-0.537	0.418
Industrymaturity	0.001	0.001	-0.001	0.001	-0.001	0.001	-0.002	0.003
Fast×Serviceratio	3.529*	2.140	1.509	2.101	0.048	0.772	-1.874	1.423
Fast×$Serviceratio^2$	-3.607	2.232	-3.677	3.202	-0.274	0.825	2.563	1.717
Slow×Serviceratio	3.510*	2.023	1.310	1.825	-0.181	0.865	-0.141	1.967
Slow×$Serviceratio^2$	-3.671*	2.143	-1.298	2.021	-0.148	0.896	0.546	2.929
HHI×Serviceratio	0.469	2.672	-1.032	2.184	-0.599	1.458	5.309*	3.113
HHI×$Serviceratio^2$	-2.491	3.375	0.447	2.952	-0.813	1.793	-1.194	3.464
Industrymaturity×Serviceratio	0.018	0.024	0.059**	0.029	0.021*	0.012	-0.012	0.035
Industrymaturity×$Serviceratio^2$	-0.022	0.034	-0.078*	0.041	-0.038*	0.020	0.042	0.054
Marketshare	-0.016	0.592	-0.130	0.253	-0.174	0.218	0.191	0.397
Firmsize	0.170	0.138	1.018***	0.163	0.295***	0.047	-0.234**	0.104

Table 5.2

(Continued)

Variables	Model 5-1 Operatingmargin		Model 5-2 Growth		Model 5-3 Turnover		Model 5-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
L.Operatingmargin	1.031***	0.123						
L.Growth			-0.959***	0.027				
L.Turnover					-0.169***	0.030		
L.Debt							-0.275***	0.097
Year								
Year1991	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)	0.000	(omitted)
Year1992	-0.022	0.032	0.000	(omitted)	-0.024	0.028	0.000	(omitted)
Year1993	-0.070	0.049	2.620***	0.428	-0.096***	0.037	-0.028	0.081
Year1994	-0.206***	0.071	2.575***	0.409	-0.097*	0.051	0.045	0.106
Year1995	-0.244***	0.084	2.507***	0.395	-0.124**	0.062	0.205	0.137
Year1996	-0.313***	0.090	2.299***	0.372	-0.148**	0.070	0.250	0.180
Year1997	-0.344***	0.097	2.154***	0.348	-0.227***	0.077	0.364*	0.208
Year1998	-0.421***	0.113	1.998***	0.321	-0.319***	0.087	0.377	0.241
Year1999	-0.437***	0.131	1.918***	0.313	-0.418***	0.091	0.237	0.287
Year2000	-0.531***	0.147	1.750***	0.286	-0.412***	0.093	0.038	0.314
Year2001	-0.651***	0.163	1.612***	0.244	-0.383***	0.096	0.103	0.362
Year2002	-0.756***	0.177	1.478***	0.226	-0.426***	0.100	0.143	0.408

Table 5.2

(Continued)

Variables	Model 5-1 Operatingmargin		Model 5-2 Growth		Model 5-3 Turnover		Model 5-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Year2003	-0.791***	0.183	1.297***	0.218	-0.465***	0.104	0.083	0.419
Year2004	-0.847***	0.202	1.243***	0.206	-0.441***	0.112	0.185	0.445
Year2005	-0.897***	0.219	1.188***	0.179	-0.447***	0.115	0.396	0.468
Year2006	-0.987***	0.237	1.035***	0.161	-0.499***	0.125	0.531	0.514
Year2007	-1.022***	0.264	0.838***	0.155	-0.522***	0.133	0.498	0.499
Year2008	-1.010***	0.257	0.798***	0.162	-0.499***	0.134	0.443	0.501
Year2009	-0.994***	0.272	0.619***	0.151	-0.589***	0.135	0.626	0.496
Year2010	-1.023***	0.310	0.520***	0.135	-0.651***	0.137	0.444	0.466
Year2011	-1.090***	0.332	0.519***	0.150	-0.645***	0.142	0.494	0.481
Year2012	-1.124***	0.336	0.481***	0.091	-0.645***	0.148	0.498	0.487
Year2013	-1.147***	0.352	0.310***	0.072	-0.708***	0.148	0.535	0.497
Year2014	-1.240***	0.362	0.096*	0.055	-0.758***	0.152	0.490	0.528
Year2015	-1.215***	0.360	0.047	0.038	-0.886***	0.166	0.483	0.528
Year2016	-1.228***	0.355	0.000	(omitted)	-0.945***	0.171	0.446	0.545

Table 5.2

(Continued)

Variables	Model 5-1 Operatingmargin		Model 5-2 Growth		Model 5-3 Turnover		Model 5-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	
Instrumental variables	GMM instruments		GMM instruments		GMM instruments		GMM instruments	
Number of observations	3529		2224		3529		2782	
Number of firms	669		418		669		520	
Number of instruments	87		104		112		84	
AR(1)-p	0.054		0.016		0.431		0.010	
AR(2)-p	0.222		0.189		0.273		0.119	
Hansen-p	0.029		0.025		0.252		0.100	

Notes: (1) L.Operatingmargin, L.Growth, L.Turnover, and L.Debt are the lagged values of four performance indicators, Pricechange is the dummy variable of industry clockspeed (including Fast, Standard and Slow), and Year* denotes year dummies; (2) AR(1)-p and AR(2)-p are p-values of AB Statistic while Hansen-p is the p-value of Hansen's J statistic; (3) Coefficient and SE respectively represent the regression coefficients and robust standard errors; (4) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As mentioned in Study 1, we first examine the applicability of the system GMM in our data by using the AB test. The results in Table 5.2 shows that the p-values of AR(2) in the AB test exceed 0.1 for all four models, which indicates that there is no evidence that our models are misspecified (Tuli et al., 2010).

The regression results for the four models, which test the proposed hypotheses of Study 2, namely, H1a-d, H2a-d and H3a-d, are shown in Table 5.2. Specifically, the dependent variables are four different performance indicators (namely, Operatingmargin, Growth, Turnover and Debt), while the independent variables include Serviceratio and Serviceratio^2, and the moderator variables include industry clockspeed, industry concentration and industry maturity. The specific regression results are as follows:

(1) Moderating effect of industry clockspeed

As can be seen from Table 5.2, the interaction terms between two dummies for industry clockspeed (namely, Fast and Slow) and Serviceratio or Serviceratio^2, are significantly related to Operatingmargin. Specifically, the beta coefficient for Fast × Serviceratio and Operatingmargin is 3.529 (z = 1.650, p = 0.099), while the beta coefficients for Slow × Serviceratio and Operatingmargin and Slow × Serviceratio^2 and Operatingmargin are 3.510 (z = 1.740, p = 0.083) and -3.671 (z = -1.710, p = 0.087), respectively. Therefore, H1a is supported, but H1b, H1c and H1d are not.

In order to clearly demonstrate the moderating role of industry clockspeed on the relationship between servitization and operating margin, we perform regression results for the relationship between servitization and operating margin in different categories of industry clockspeed, including Fast, Slow and Standard (shown in Table 5.3).

It can be seen from Table 5.3 that there are some significant differences in the relationship between servitization and operating margin in different categories of industry clockspeed. Specifically, Model 1 shows the regression results of the relationship between servitization and operating margin in the case of fast industry clockspeed. The relationships for Serviceratio and Operatingmargin, and Serviceratio^2 and Operatingmargin, are significantly negative with a beta coefficient of -1.282 (z = -1.710, p = 0.088) and a positive with beta coefficient of 1.290 (z = 1.850, p = 0.064). Therefore, it can be concluded that a U-shaped relationship exists between servitization and operating margin in the case of fast industry clockspeed and the critical point is 49.7% ($\frac{\partial Operatingmargin_{i,t}}{\partial Serviceratio_{i,t}} = \alpha_1 + 2\alpha_2 Serviceratio_{i,t}$). Model 2 shows the regression

results of the relationship between servitization and operating margin in the case of slow industry clockspeed. The relationship between Serviceratio and Operatingmargin is significantly negative with beta coefficient of -0.578 (z = -1.860, p = 0.062), while the relationship between Serviceratio^2 and Operatingmargin is insignificant (z = 1.120, p = 0.264), which implies that the relationship between servitization and operating margin in the case of slow industry clockspeed is negative, but not U-shaped. Model 3 shows the regression results of the relationship between servitization and operating margin in the case of standard industry clockspeed. The relationship between Serviceratio and Operatingmargin is significantly negative with a beta coefficient of -4.387 (z = -2.820, p = 0.005), while the relationship between Serviceratio^2 and Operatingmargin is significantly positive with a beta coefficient of 6.732 (z = 2.480, p = 0.013). Therefore, it can be concluded that a U-shaped relationship exists between servitization and operating margin in the case of standard industry clockspeed and the critical point is 32.6%. To further clarify the results, we plot the relationship between servitization and operating margin for the fast, standard and slow industry clockspeed conditions, as shown in Figure 5.2.

Overall, H1a is supported, that is, industry clockspeed has a significant moderating effect on the relationship between servitization and operating margin.

Table 5. 3 Regression results in different kinds of industry clockspeed

Variables	Model 1 (Fast)		Model 2 (Slow)		Model 3 (Standard)	
	Operatingmargin		Operatingmargin		Operatingmargin	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Serviceratio	-1.282*	0.751	-0.578*	0.310	-4.387***	1.553
Serviceratio^2	1.290*	0.697	0.572	0.512	6.732**	2.711
HHI	0.032	0.172	-0.071	0.081	0.205	0.366
Industrymaturity	0.062	0.088	0.000	0.001	0.001	0.001
Marketshare	-0.047	0.270	0.095	0.064	0.169	0.733
L.Operatingmargin	-0.404**	0.189	-0.642***	0.087	1.111***	0.039
Year						
Year1991	0.000	(omitted)	0.013	0.010	-0.002	0.096
Year1992	0.000	(omitted)	0.000	(omitted)	0.006	0.080
Year1993	-0.072	0.103	-0.018	0.018	0.000	(omitted)
Year1994	-0.047	0.102	-0.024	0.030	-0.051	0.067
Year1995	-0.058	0.117	-0.017	0.026	-0.074	0.069
Year1996	-0.137	0.151	-0.011	0.030	-0.086	0.102
Year1997	-0.122	0.145	-0.025	0.030	-0.148	0.108
Year1998	-0.330	0.247	-0.034	0.040	-0.147	0.111
Year1999	-0.083	0.239	-0.065	0.054	-0.115	0.148
Year2000	-0.196	0.270	-0.057	0.056	-0.138	0.145
Year2001	-0.590	0.669	-0.104*	0.057	-0.273	0.182
Year2002	-0.588	0.648	-0.124**	0.057	-0.446*	0.240
Year2003	-0.613	0.696	-0.125*	0.065	-0.440**	0.223
Year2004	-0.644	0.690	-0.134*	0.071	-0.478**	0.226
Year2005	-0.654	0.718	-0.129*	0.074	-0.505*	0.304
Year2006	-0.738	0.756	-0.149**	0.073	-0.670*	0.389
Year2007	-0.767	0.781	-0.160**	0.072	-0.764*	0.452
Year2008	-0.789	0.768	-0.203***	0.074	-0.740*	0.385
Year2009	-0.796	0.750	-0.205***	0.075	-0.845*	0.434
Year2010	-0.831	0.812	-0.175**	0.084	-0.920*	0.516
Year2011	-0.789	0.760	-0.159**	0.084	-0.923*	0.533
Year2012	-0.813	0.783	-0.141	0.086	-0.909*	0.526
Year2013	-0.867	0.788	-0.140	0.089	-0.921*	0.558

Table 5.3 (Continued)

Variables	Model 1 (Fast)		Model 2 (Slow)		Model 3 (Standard)	
	Operatingmargin		Operatingmargin		Operatingmargin	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Year2014	-0.879	0.745	-0.172*	0.095	-0.962	0.606
Year2015	-0.870	0.734	-0.162*	0.098	-0.981	0.615
Year2016	-0.914	0.794	-0.147	0.106	-0.988	0.607
Instrumental variables	GMM instruments		GMM instruments		GMM instruments	
Number of observations	618		1081		1655	
Number of firms	115		194		322	
Number of instruments	75		78		78	
AR(1)-p	0.307		0.078		0.084	
AR(2)-p	0.323		0.146		0.449	
Hansen-p	0.933		0.775		0.277	

Notes: (1) Model 1, 2 and 3 show the regression results in different kinds of industry clockspeed (including Fast, Slow and Standard), L.Operatingmargin is the lagged Operatingmargin, and Year* denotes year dummies; (2) AR(1)-p and AR(2)-p are p-values of AB Statistic while Hansen-p is the p-value of Hansen's J statistic; (3) Coefficient and SE respectively represent the regression coefficients and robust standard errors; (4) *** p < 0.01, ** p < 0.05, * p < 0.1.

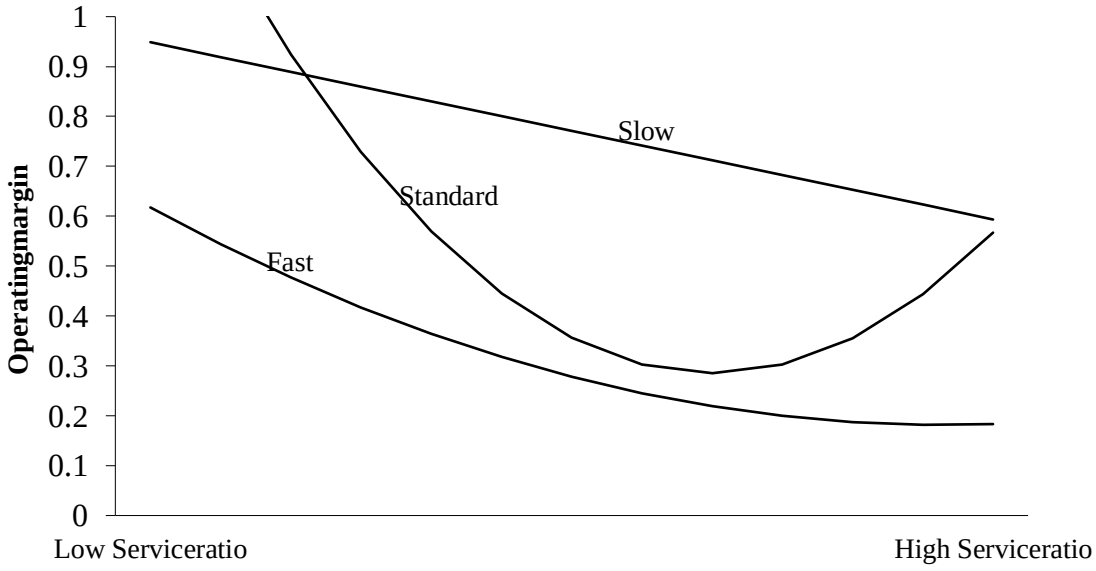

Figure 5. 2 Moderating effect of Industry Clockspeed on Servitization-Operating Margin Relationship

(2) Moderating effect of industry concentration

The regression results in Table 5.2 suggest that there is no significant relationship between the interaction terms (HHI × Serviceratio and HHI × Serviceratio^2) and three performance indicators (Operatingmargin, Growth and Turnover), which rejects H2a-c. Besides, despite the significant relationship between the interaction term (HHI × Serviceratio) and Debt (beta = 5.309, z = 1.710, p = 0.088), the relationships between Serviceratio and Debt, and Serviceratio^2 and Debt, are insignificant. Hence, H2d is also not supported. Overall, industry concentration is suggested to insignificantly moderate the relationship between servitization and firm performance.

(3) Moderating effect of industry maturity

The regression results in Table 5.2 indicate that the relationship between interaction terms (namely, Industrymaturity × Serviceratio and Industrymaturity × Serviceratio^2) and two performance indicators (namely, Growth and Turnover) are significant, whereas the relationship between interaction terms (namely, Industrymaturity × Serviceratio and Industrymaturity × Serviceratio^2) and two other performance indicators (namely, Operatingmargin and Debt) is insignificant, which supports H3b and H3c, but does not support H3a and H3d. Specifically, in Model 5-2, the beta coefficients of the relationships between Industrymaturity × Serviceratio and Growth, and Industrymaturity × Serviceratio^2 and Growth, are 0.059 (z = 2.040, p = 0.041) and -0.078 (z = -1.890, p = 0.059), respectively. Given the insignificant relationship between Serviceratio^2 and Growth, the results support the claim that Industrymaturity significantly moderates the negative relationship between Serviceratio and Growth. In contrast, in Model 5-3, the significant interaction terms for Industrymaturity × Serviceratio (beta = 0.021, z = 1.800, p = 0.073) and Industrymaturity × Serviceratio^2 (beta = -0.038, z = -1.920, p = 0.055) indicate that Industrymaturity significantly moderates the U-shaped relationship between Serviceratio and Turnover.

To clarify the results, we plot Figure 5.3 and Figure 5.4, which describe the moderating effect of industry maturity on the relationship between servitization and sales growth, and the relationship between servitization and operating efficiency. Figure 5.3 reveals the relationships between servitization and sales growth for the two industry maturity moderators, while Figure 5.4 duplicates this scenario for the industry maturity moderators, which strongly supports H3b and H3c.

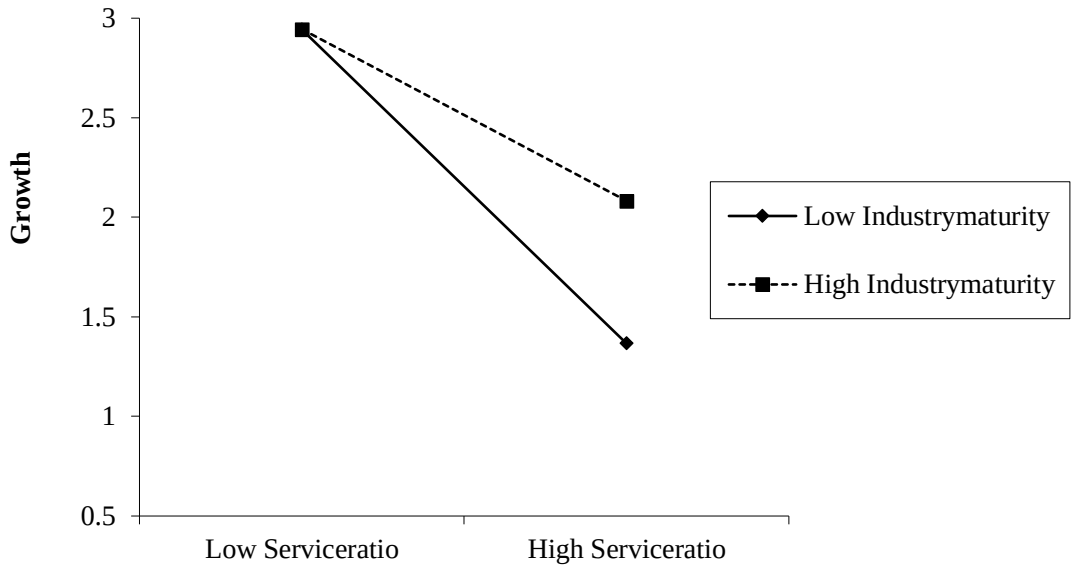

Figure 5. 3 Moderating effect of Industry Maturity on Servitization-Sales Growth Relationship

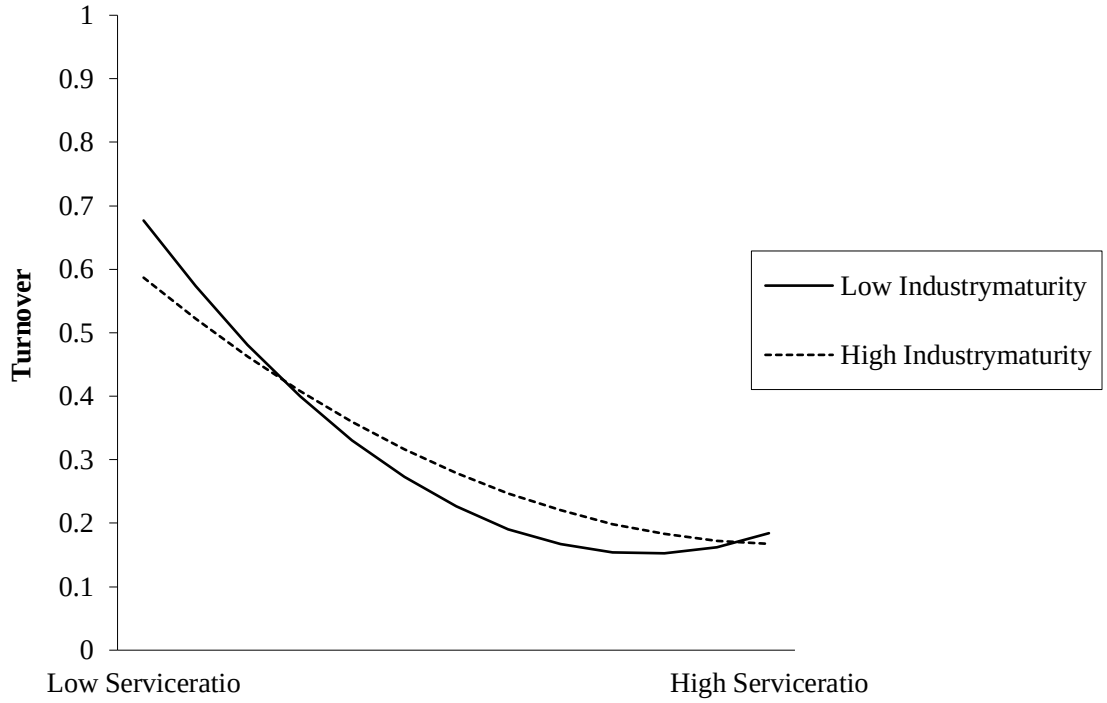

Figure 5. 4 Moderating effect of Industry Maturity on Servitization-Operating Efficiency Relationship

5.5 Discussion and conclusion

5.5.1 **Theoretical implications**

This study examines the moderating effect of industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) on the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio), based on the Compustat database; the testing results for the proposed hypotheses are shown in Table 5.4. Overall, this study extends the research on moderators of the servitization-firm performance relationship (Eggert et al., 2011; Fang et al., 2008). The specific contributions of this study are as follows:

First, this study confirms the significant moderating effect of industry clockspeed on the relationship between servitization and operating margin. Specifically, in the context of fast industry clockspeed, there is a significant U-shaped relationship between servitization and firms' operating margin, whereas, in the context of slow industry clockspeed, the relationship between servitization and operating margin is negative, but not U-shaped. Besides, for manufacturing firms in the context of standard industry clockspeed, despite a significant U-shaped relationship between servitization and operating margin, this relationship curve is steeper and has a smaller critical point of 32.6% than in the context of fast industry clockspeed, where the critical point is 49.7%. As few previous studies have explored industry clockspeed as the moderator of the servitization-performance link, our study enriches this research area.

Moreover, our study suggests an insignificant moderating effect of industry concentration on the relationship between servitization and four firm performance indicators. This finding is consistent with Fang et al.'s (2008) argument that industry competition insignificantly affects the effect of service transition on firm value, with our study further supporting this point in terms of multiple firm performance dimensions.

Finally, this study demonstrates that industry maturity could significantly moderate the relationship between servitization and two performance indicators, including sales growth and operating efficiency. Specifically, given the negative relationship between servitization and sales growth, industry maturity could effectively attenuate the negative effect of servitization on sales growth. In contrast, considering the U-shaped relationship between servitization and operating efficiency, firms in the context of high industry maturity have a flatter relationship curve and a larger critical point than in the context of low industry maturity. Hence, this study contributes to the discussions on industry characteristics as moderators in the relationship between

servitization and firm performance.

Table 5. 4 Hypotheses testing results of Study 2

	Hypotheses	Outcome
H1a	Industry clockspeed moderates the relationship between servitization and operating margin	Supported
H1b	Industry clockspeed moderates the relationship between servitization and sales growth	Rejected
H1c	Industry clockspeed moderates the relationship between servitization and operating efficiency	Rejected
H1d	Industry clockspeed moderates the relationship between servitization and asset-liability ratio	Rejected
H2a	Industry concentration moderates the relationship between servitization and operating margin	Rejected
H2b	Industry concentration moderates the relationship between servitization and sales growth	Rejected
H2c	Industry concentration moderates the relationship between servitization and operating efficiency	Rejected
H2d	Industry concentration moderates the relationship between servitization and asset-liability ratio	Rejected
H3a	Industry maturity moderates the relationship between servitization and operating margin	Rejected
H3b	Industry maturity moderates the relationship between servitization and sales growth	Supported
H3c	Industry maturity moderates the relationship between servitization and operating efficiency	Supported
H3d	Industry maturity moderates the relationship between servitization and asset-liability ratio	Rejected

5.5.2 **Managerial implications**

This study has several important managerial implications for manufacturing firms. First, our finding on the significant moderating effect of industry clockspeed on the relationship between servitization and operating margin suggests that manufacturing firms should effectively implement servitization according to their corresponding industry clockspeed. Specifically, firms in the context of slow industry clockspeed reveal a negative effect of servitization on operating margin, while those in the context of fast and standard industry clockspeed show a U-shaped relationship between servitization and their operating margin. However, this relationship curve in the context of standard industry clockspeed is steeper and has a smaller critical point than that in the context of fast industry clockspeed. Besides, when further comparing these two relationship curves, the curve in the context of standard industry clockspeed is above the curve in the context of fast industry clockspeed: that is, at a given level of servitization, firms with standard industry clockspeed generate a slightly higher operating margin. Overall, firms with standard industry clockspeed have greater possibility to succeed in the implementation of servitization. Firms with fast industry clockspeed have a very rapid product updating speed. which contradicts the service characteristics of long-term contracts and relationships, whereas firms with slow industry clockspeed should invest much more than other industries and generate products with a relatively long life cycle and relatively smaller quantities sold, as this will result in a relatively longer period when servitization negatively affects firms' operating margin. Therefore, when deciding on the overall strategic trajectory, firms should first consider carefully their characteristics concerning industry clockspeed (e.g., product life cycle, product technical sophistication, product costs).

Moreover, our finding on the insignificant moderating effect of industry concentration on the servitization-firm performance relationship suggests that intense industry competition is an important encouragement of servitization, but not an essential factor, as it cannot significantly affect the impact of servitization on firm performance.

Finally, the finding that industry maturity significantly moderates the relationship between servitization and two performance indicators (namely, sales growth and operating efficiency) offers some managerial insights. On the one hand, industry maturity could effectively mitigate the negative linear effect of servitization on sales

growth. On the other, industry maturity significantly affects the U-shaped relationship between servitization and operating efficiency. Specifically, this relationship curve for firms in the context of low industry maturity is steeper and has a smaller critical point than those in the context of high industry maturity. This finding is in conflict with the prevailing perception that services primarily play an important role in mature or maturing product industries (Reinartz & Ulaga, 2008; Teece, 1986). This is mainly because services, as mechanisms by which manufacturing firms are able to transfer product knowledge to new customers as well as new product developers, particularly in situations of high uncertainty, are more significant (Suarez et al., 2013). Firms in immature industries are situated in a more complicated and uncertain market environment, where services can be easily introduced to attract new customers and greatly affect firms' operating efficiency by exploiting the synergies between service and product businesses.

6 Study 3: The moderating effect of firm characteristics on the relationship between servitization and firm performance

6.1 Introduction

Over the recent decades, many leading product firms have gradually shifted from being purely product manufacturers to product-service package providers (Neely, 2008; Baines et al., 2011). For instance, GE, Rolls-Royce, Caterpillar and ABB have increasingly highlighted the importance of this service transition (Kohtamäki et al., 2013b). This transition is delineated as "servitization" (Vandermerwe & Rada, 1988). Given the benefits acquired from servitization including enhanced customer loyalty, increased pricing power, and improved resistance to outsourcing, it has been regarded as an effective means for manufacturing firms to acquire competitive advantage (Fang et al., 2008). However, the large proportion of firm failures in adopting servitization suggests that the effect of servitization on firm performance is still vague. For example, a Bain & Co. study reports that only 21% succeed with service strategies (Baveja et al., 2004), while Stanley & Wojcik (2005) suggest that around 50% of all solution providers enjoy modest gains, and nearly 25% even suffer losses in the provision of added-value services and solutions.

Previous studies have shown mixed evidence on the relationship between servitization and firm performance (Brax, 2005; Fang et al., 2008; Gebauer et al., 2005; Lapré, 2011; Neely, 2008; Neu & Brown, 2005; Oliva & Kallenberg, 2003; Suarez et al., 2013).). Study 1 has reviewed the literature concerning these mixed findings and empirically investigated the U-shaped relationship between servitization and four performance indicators based on the data from the Compustat database during the period 1990-2016. The results of Study 1 indicate that the relationships between servitization and two performance indicators (operating margin and operating efficiency) are U-shaped, which is in accordance with some researchers' findings (Fang et al., 2008; Li et al., 2015; Suarez et al., 2013).

These non-linear effects of servitization on firm performance may, in part, be due to contextual differences associated with servitization practices. Therefore, it would be productive to further investigate the specific contextual factors affecting the relationship between servitization and firm performance. Extant research has explored the moderating effect on this relationship and the contextual factors can be roughly

categorized into two types, namely, industry characteristics and firm characteristics (Eggert et al., 2011). Study 2 has examined the moderating effect of some industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) on the relationship between servitization and firm performance.

In contrast, firm characteristics as moderating factors of the relationship between servitization and firm performance, as presented in prior studies, consist of service relatedness, resource slack, service orientation of human resource management, service orientation of corporate culture, top management's commitment to and visionary leadership of services, service training, relational capital and network capabilities (Antioco et al., 2008; Fang et al., 2008; Donaldson, 1995; Gebauer, 2007; Gebauer, 2008; Homburg et al., 2003; Jia et al., 2016). However, there is still a lack of a clear and systematic theoretical framework demonstrating how firm characteristics affect the relationship between servitization and firm performance in manufacturing firms.

The introduction of service business enables manufacturing firms' strategic focus to shift from product manufacturing to "product and service" bundle offerings. This may result in a loss of strategic focus and a redistribution of firm resources, which implies that the implementation of servitization requires corresponding reorganization of organizational structure and redeployment of organizational resources and capabilities (Cook et al., 2006; Fang et al., 2008; Shepherd & Ahmed, 2000). The mismatch between servitization and manufacturing firms' strategic supporting activities and resource allocation may lead to the emergence of "service paradox" (Josephson et al., 2016; Mathieu, 2001). Hence, this study aims to enrich the servitization research by examining the moderating impact of firm characteristics on performance effect of servitization from the perspective of strategic coherence and resource allocation (Argote & Greve, 2007; Josephson et al., 2016).

6.2 Hypotheses development

A significant body of literature has suggested that the effective implementation of servitization not only requires managerial motivations, but also matched organizational arrangements to support it (Gebauer et al., 2005). The mismatch between service strategy and organizational arrangements may lead to the emergence of "service paradox"; put another way, high investment in service business extensions results in enhanced service provisions and higher costs, but does not create the expected

correspondingly greater returns (Gebauer et al., 2005, 2010). Acknowledging that there is great need to investigate the effect of the match between servitization and organizational arrangements on firm performance, this study explores this moderating effect in terms of primary organizational factors, namely, strategic coherence and resource allocation (Argote & Greve, 2007; Josephson et al., 2016).

Specifically, the implementation of servitization represents the introduction of a new coalition into the originally service-oriented firm structure (Neu & Brown, 2005). The success of this new coalition requires sufficient organizational resources and capabilities to support it (Bolton et al., 2007). Researchers have asserted that a firm comprising a collection of coalitions or departments needs to align these coalitions in order to agree on certain goals, such as revenue, market share and profits (Cyert & March, 1963). The introduction of new coalitions causes conflicts, which should be addressed in terms of goal alignment between different coalitions (departments). To achieve their goals, firms' decision-making involves two primary aspects, namely, to determine the overall strategic choice or action, and to assign resources and strategic efforts in pursuit of that choice (Argote & Greve, 2007). Firms' strategic choices are determined according to their expectations, inferences from available information, market competition, performance aspirations and referent firm performance (Cyert & March, 1963). Accordingly, as manufacturing firms suffer from product commoditization and homogenization, they adopt strategic choices, such as transitioning to servitization in order to counter the threat (Carter, 1971). To ensure the success of their strategic choice (namely, servitization), firms also require ancillary strategic choices in conjunction with servitization (Argote & Greve, 2007). When these ancillary strategic choices are made in conjunction and support of manufacturing firms' servitization, they are likely to influence the relationship between servitization and firm performance.

In this study, the ancillary strategic choices made to support servitization entail strategic coherence and resource allocation. Strategic coherence refers to the commitment, congruency and complementarity of a firm's offering strategy (Katsikeas et al., 2006), and is investigated from the perspective of R&D intensity and service relatedness in this study. Resource allocation involves a firm's ability to offer and assign sufficient resources to support strategic activities (Chen & Hsu, 2010; Hutchisonkrupat & Kavadias, 2010), and is investigated in terms of marketing intensity and resource slack (including absorbed and unabsorbed) in this study.

6.2.1 **Moderating effect of strategic coherence**

(1) Moderating effect of service relatedness

Service relatedness, as an important measurement of strategic coherence, indicates the extent of congruence between a firm's service offerings and its core physical goods, and reflects how closely its products and services are linked (Fang et al., 2008; Josephson et al., 2016). Manufacturing firms offer different categories of services, which in turn have different degrees of closeness with core products. Certain service offerings (e.g., installation, repair and maintenance) are more closely related to core products than other services (e.g., consulting services and financial services) (Eggert et al., 2014a; Mathieu, 2001).

When service relatedness is high, manufacturing firms provide services that re highly related to their core products. Given that such services reflect firms' commitment to maintaining their core competences and strategic coherence (Neu & Brown, 2005), high service relatedness weakens the possibility of the potential loss of strategic focus. It is easier to help firms exploit synergies between their service and product businesses (Fang et al., 2008). Specifically, the resources and knowledge accumulated from product business can be leveraged to service extensions. This resource spillover between manufacturing and services means that service business can effectively share both tangible resources, such as local offices and call centers, and intangible resources, such as firm reputation and customer relationship. That is, high service relatedness improves the possibility of customer acceptance regarding services. Therefore, in the case of high service relatedness, the spillover benefits and synergies between services and manufacturing enable firms to acquire enhanced firm performance more easily.

In contrast, firms in the case of low service relatedness cannot effectively utilize the resources and knowledge derived from product business in service extensions. To offer services that are not closely connected to the core product business, firms primarily require service-specific resources and competences, which greatly differ from those of products (Kowalkowski et al., 2009). Therefore, the provision of services that are not closely linked to products requires an extensive change process for manufacturing firms, which improves the possibility of the potential loss of strategic focus (Eggert et al., 2011). Overall, firms in the case of low service relatedness may not generate greater firm performance by servitization compared with the case of high

service relatedness.

Overall, we conjecture that service relatedness has a moderating impact on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H1: Service relatedness moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

(2) Moderating effect of R&D intensity

R&D intensity refers to the level of financial resources owned by a firm dedicated to R&D; and, as another important measurement of strategic coherence, it signals firms' commitment to continually innovate and improve its offering (Gebauer et al., 2011). R&D intensity has a significant impact on firms' new offering development and critical firm innovation outcomes (Raassens et al., 2012; Swaminathan et al., 2008).

Specifically, strong R&D intensity represents firms' significant commitment to and engagement in the maintenance and improvement of their offerings, which can undermine the possibility of the loss of strategic focus for product firms (Josephson et al., 2016). That is, product firms with strong R&D intensity show their commitment to existing product-oriented knowledge and competences (Neu & Brown, 2005). As a result, strong R&D intensity helps manufacturing firms to develop innovative products, services and marketing channels, which improves their diversification and differentiation abilities and thus generates increased market goodwill (McAlister et al., 2007). Therefore, when firms have strong R&D intensity, they have greater abilities to innovate in many areas, such as products, services and trading platforms for product or service marketing, which may better satisfy diverse customer requirements (Neu & Brown, 2005; Vargo & Lusch, 2004). This implies that strong R&D intensity significantly affects firms' total offering (product and service bundles), and helps manufacturing firms differentiate themselves from and compete with other competitors, thereby generating larger firm performance.

In contrast, firms with weak R&D intensity have no sufficient resources to commit to existing product-oriented business, which may lead to an increase in the potential loss of strategic focus between service and product businesses. Therefore, in the case of weak R&D intensity, firms will not be able to provide such overall offerings (product and service bundles), which are more difficult for competitors to duplicate or imitate.

Consequently, low R&D intensity cannot create a favourable environment for the implementation of servitization, and firms with weak R&D intensity may not be able to generate greater firm performance by servitization than those with strong R&D intensity.

Overall, we speculate that R&D intensity has a moderating impact on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H2: R&D intensity moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

6.2.2 **Moderating effect of resource allocation**

(1) Moderating effect of marketing intensity

Marketing intensity indicates the extent of firms' financial resources devoted to marketing activities, which in turn determines their commitment to offer adequate marketing resources and efforts to support their offering (Anderson, 1982; Moorman & Rust, 1999). Strong marketing intensity may have a positive influence on service offerings, while prior research has recognized the importance of marketing resources in the success of servitization implementation (Neu & Brown, 2005). Adequate investments in marketing resources help firms exploit potential market opportunities for service and product offerings (Bolton et al., 2007). For example, firms make investments in the establishment of new distribution channels for service offerings and advertisements to attract potential customers of services. A failure to provide marketing resources may lead to the loss of potential customers and hinder the potential performance gains for service offerings. Hence, these marketing activities are essential to improve customer utility regarding service offering (Bolton et al., 2007). Since increased customer utility resulting from service offerings can generate potential performance gains, manufacturing firms with strong marketing intensity could more easily acquire improved firm performance by implementing servitization.

In contrast, firms with weak marketing intensity do not have enough resources to exploit new markets for service business, because their existing resources are mainly used to market product offerings and thus cannot be effectively utilized in the marketing

of service offerings. Therefore, firms with weak marketing intensity may not acquire potential customers and generate greater firm performance by servitization than those with strong marketing intensity.

Overall, we assume that marketing intensity has a moderating impact on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H3: Marketing intensity moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

(2) Moderating effect of absorbed resource slack

Absorbed resource slack involves excessive resources that firms devote to current operations (Singh, 1986). Since these resources include excess production capability, physical plant or equipment, specialized skilled labour, etc., it is very difficult or even impossible to redistribute and redeploy them (Greve, 2003). Therefore, as absorbed resource slack represents firms' costs, to some extent, the impact of high absorbed resource slack may be undesirable. High levels of absorbed resource slack can constrain firm reactions and responses, and result in poor flexibility and financial performance, which may in turn influence the exploitation of new opportunities (i.e., service offering) (Greve, 2003). In contrast, firms with low levels of absorbed resource slack have greater flexibility to respond to market changes with resource deployments, which improves their ability to move resources to support alternative strategic initiatives (i.e., the implementation of servitization). Therefore, in the case of low levels of absorbed resource slack, firms' flexibility is not constrained, meaning that they can quickly respond to market changes with resource deployments, allowing servitization to be implemented more easily.

Overall, we speculate that absorbed resource slack has a moderating impact on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H4: Absorbed resource slack moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

(3) Moderating effect of unabsorbed resource slack

Unabsorbed resource slack refers to excessive resources, which firms can utilize in a discretionary manner (Bourgeois, 1981). Firms can repeatedly redistribute and redeploy these spare resources to new market opportunities or needs without stealing resources for another use (Sharfman et al., 1988). These resources consist of cash, credit lines, capabilities, etc. (Josephson et al., 2016). A sufficient reservoir of spare resources ensures effective resource redistribution and redeployment for certain new coalitions without hindering other firm activities (Sharfman et al., 1988). Therefore, when implementing servitization, manufacturing firms with high unabsorbed resource slack could support their new investment in service business without constraining existing product business, which in turn effectively mitigates the organizational conflicts between service and product businesses that are inherent in the competition for scarce resources (Bourgeois, 1981; Fang et al., 2008).

In contrast, in the case of low unabsorbed resource slack, the implementation of servitization enables manufacturing firms' departments to compete for limited spare resources, which easily leads to organizational conflicts and thus adversely affects firm performance (Fang et al., 2008; Josephson et al., 2016).

Overall, we consider that unabsorbed resource slack has a moderating impact on the relationship between servitization and firm performance, and, as mentioned in Study 1, firm performance indicators include operating margin, sales growth, operating efficiency and asset-liability ratio. The specific hypothesis is as follows:

H5: Unabsorbed resource slack moderates the relationship between servitization and four firm performance indicators, namely, (a) operating margin, (b) sales growth, (c) operating efficiency and (d) asset-liability ratio.

6.3 Research model

6.3.1 **Research model**

Based on the hypotheses development, we propose the conceptual model for Study 3, as shown in Figure 6.1.

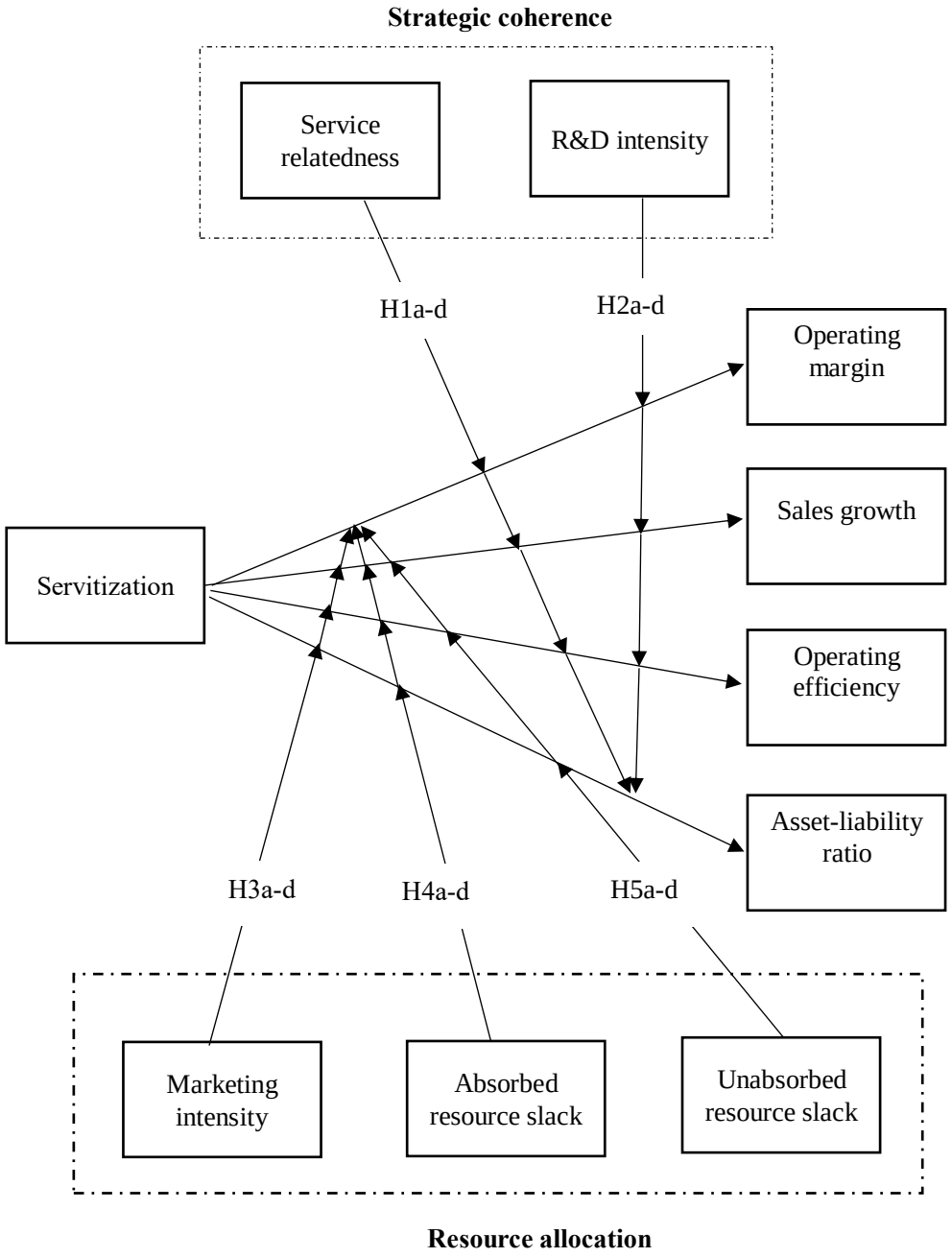

Figure 6. 1 The conceptual model of Study 3

6.3.2 **Model specification**

Based on the research model above, Study 3 constructs the econometric model by using four indicators of firm performance (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) as dependent variables, servitization as an independent variable, service relatedness, R&D intensity, marketing intensity, absorbed resource slack and unabsorbed resource slack as moderator variables, and firm size,

industry concentration, market share and year as control variables. Given the broad time span ranging from 1990 to 2016 during which we collected the research sample, we conjecture that the customary presence of a lagged dependent variable in the panel data may affect the current value, which can give rise to autocorrelation (Suarez et al., 2013). Therefore, we introduce lagged dependent variables (namely, indicators of firm performance) in the econometric model and construct the following DPD models (as shown in Equations 6-1, 6-2, 6-3 and 6-4):

$$\begin{aligned}\text{Operatingmargin}_{i,t} &= \alpha_0 + \alpha_1\text{Serviceratio}_{i,t} + \alpha_2\text{Serviceratio}^2_{i,t} + \alpha_3\text{Relatedness}_{i,t} \\ &+ \alpha_4\text{R\&Dintensity}_{i,t} + \alpha_5\text{Marketintensity}_{i,t} + \alpha_6\text{Abresource}_{i,t} + \alpha_7\text{Unabresource}_{i,t} \\ &+ \alpha_8\text{Serviceratio}_{i,t} \times \text{Relatedness}_{i,t} + \alpha_9\text{Serviceratio}^2_{i,t} \times \text{Relatedness}_{i,t} \\ &+ \alpha_{10}\text{Serviceratio}_{i,t} \times \text{R\&Dintensity}_{i,t} + \alpha_{11}\text{Serviceratio}^2_{i,t} \times \text{R\&Dintensity}_{i,t} \\ &+ \alpha_{12}\text{Serviceratio}_{i,t} \times \text{Marketintensity}_{i,t} + \alpha_{13}\text{Serviceratio}^2_{i,t} \times \text{Marketintensity}_{i,t} \\ &+ \alpha_{14}\text{Serviceratio}_{i,t} \times \text{Abresource}_{i,t} + \alpha_{15}\text{Serviceratio}^2_{i,t} \times \text{Abresource}_{i,t} \\ &+ \alpha_{16}\text{Serviceratio}_{i,t} \times \text{Unabresource}_{i,t} + \alpha_{17}\text{Serviceratio}^2_{i,t} \times \text{Unabresource}_{i,t} \\ &+ \alpha_{18}\text{Industryconcen}_{i,t} + \alpha_{19}\text{Firmsize}_{i,t} + \alpha_{20}\text{Marketshare}_{i,t} \\ &+ \alpha_{21}\text{Year} + \alpha_{22}\text{Operatingmargin}_{i,t-1} + \varepsilon_{1i} + \nu_{1i,t}\end{aligned} \tag{6-1}$$

$$\begin{aligned}\text{Growth}_{i,t} &= \beta_0 + \beta_1\text{Serviceratio}_{i,t} + \beta_2\text{Serviceratio}^2_{i,t} + \beta_3\text{Relatedness}_{i,t} \\ &+ \beta_4\text{R\&Dintensity}_{i,t} + \beta_5\text{Marketintensity}_{i,t} + \beta_6\text{Abresource}_{i,t} + \beta_7\text{Unabresource}_{i,t} \\ &+ \beta_8\text{Serviceratio}_{i,t} \times \text{Relatedness}_{i,t} + \beta_9\text{Serviceratio}^2_{i,t} \times \text{Relatedness}_{i,t} \\ &+ \beta_{10}\text{Serviceratio}_{i,t} \times \text{R\&Dintensity}_{i,t} + \beta_{11}\text{Serviceratio}^2_{i,t} \times \text{R\&Dintensity}_{i,t} \\ &+ \beta_{12}\text{Serviceratio}_{i,t} \times \text{Marketintensity}_{i,t} + \beta_{13}\text{Serviceratio}^2_{i,t} \times \text{Marketintensity}_{i,t} \\ &+ \beta_{14}\text{Serviceratio}_{i,t} \times \text{Abresource}_{i,t} + \beta_{15}\text{Serviceratio}^2_{i,t} \times \text{Abresource}_{i,t} \\ &+ \beta_{16}\text{Serviceratio}_{i,t} \times \text{Unabresource}_{i,t} + \beta_{17}\text{Serviceratio}^2_{i,t} \times \text{Unabresource}_{i,t} \\ &+ \beta_{18}\text{Industryconcen}_{i,t} + \beta_{19}\text{Firmsize}_{i,t} + \beta_{20}\text{Marketshare}_{i,t} \\ &+ \beta_{21}\text{Year} + \beta_{22}\text{Growth}_{i,t-1} + \varepsilon_{2i} + \nu_{2i,t}\end{aligned} \tag{6-2}$$

$$\begin{aligned}\text{Turnover}_{i,t} &= \lambda_0 + \lambda_1\text{Serviceratio}_{i,t} + \lambda_2\text{Serviceratio}^2_{i,t} + \lambda_3\text{Relatedness}_{i,t} \\ &+ \lambda_4\text{R\&Dintensity}_{i,t} + \lambda_5\text{Marketintensity}_{i,t} + \lambda_6\text{Abresource}_{i,t} + \lambda_7\text{Unabresource}_{i,t} \\ &+ \lambda_8\text{Serviceratio}_{i,t} \times \text{Relatedness}_{i,t} + \lambda_9\text{Serviceratio}^2_{i,t} \times \text{Relatedness}_{i,t} \\ &+ \lambda_{10}\text{Serviceratio}_{i,t} \times \text{R\&Dintensity}_{i,t} + \lambda_{11}\text{Serviceratio}^2_{i,t} \times \text{R\&Dintensity}_{i,t} \\ &+ \lambda_{12}\text{Serviceratio}_{i,t} \times \text{Marketintensity}_{i,t} + \lambda_{13}\text{Serviceratio}^2_{i,t} \times \text{Marketintensity}_{i,t} \\ &+ \lambda_{14}\text{Serviceratio}_{i,t} \times \text{Abresource}_{i,t} + \lambda_{15}\text{Serviceratio}^2_{i,t} \times \text{Abresource}_{i,t}\end{aligned}$$

$$+ \lambda_{16}\text{Serviceratio}_{i,t} \times \text{Unabresource}_{i,t} + \lambda_{17}\text{Serviceratio}^2_{i,t} \times \text{Unabresource}_{i,t}$$
$$+ \lambda_{18}\text{Industryconcen}_{i,t} + \lambda_{19}\text{Firmsize}_{i,t} + \lambda_{20}\text{Marketshare}_{i,t}$$
$$+ \lambda_{21}\text{Year} + \lambda_{22}\text{Turnover}_{i,t-1} + \varepsilon_{3i} + v_{3i,t} \quad (6\text{-}3)$$

$$\text{Debt}_{i,t} = \mu_0 + \mu_1\text{Serviceratio}_{i,t} + \mu_2\text{Serviceratio}^2_{i,t} + \mu_3\text{Relatedness}_{i,t}$$
$$+ \mu_4\text{R\&Dintensity}_{i,t} + \mu_5\text{Marketintensity}_{i,t} + \mu_6\text{Abresource}_{i,t} + \mu_7\text{Unabresource}_{i,t}$$
$$+ \mu_8\text{Serviceratio}_{i,t} \times \text{Relatedness}_{i,t} + \mu_9\text{Serviceratio}^2_{i,t} \times \text{Relatedness}_{i,t}$$
$$+ \mu_{10}\text{Serviceratio}_{i,t} \times \text{R\&Dintensity}_{i,t} + \mu_{11}\text{Serviceratio}^2_{i,t} \times \text{R\&Dintensity}_{i,t}$$
$$+ \mu_{12}\text{Serviceratio}_{i,t} \times \text{Marketintensity}_{i,t} + \mu_{13}\text{Serviceratio}^2_{i,t} \times \text{Marketintensity}_{i,t}$$
$$+ \mu_{14}\text{Serviceratio}_{i,t} \times \text{Abresource}_{i,t} + \mu_{15}\text{Serviceratio}^2_{i,t} \times \text{Abresource}_{i,t}$$
$$+ \mu_{16}\text{Serviceratio}_{i,t} \times \text{Unabresource}_{i,t} + \mu_{17}\text{Serviceratio}^2_{i,t} \times \text{Unabresource}_{i,t}$$
$$+ \mu_{18}\text{Industryconcen}_{i,t} + \mu_{19}\text{Firmsize}_{i,t} + \mu_{20}\text{Marketshare}_{i,t}$$
$$+ \mu_{21}\text{Year} + \mu_{22}\text{Debt}_{i,t-1} + \varepsilon_{4i} + v_{4i,t} \quad (6\text{-}4)$$

where each variable is as defined in Chapter 3 and summarized in Table 3.4, (*i, t)* refers to firm *i* in year *t*, α_0, β_0, λ_0 and μ_0 are a set of constant terms, α_n, β_n, λ_n, μ_n (n=1, 2, 3, …, 7) are a set of regression coefficients for independent variables, ε_{1i}, ε_{2i}, ε_{3i} and ε_{4i} are firm-specific constant terms for individual effects, and $v_{1i,t}$, $v_{2i,t}$, $v_{3i,t}$ and $v_{4i,t}$ are error terms.

6.3.3 **Estimators, model corrections and diagnostic checks**

Since we have time series of sample observations for multiple firms, and given that some firms do not provide corresponding data in some years, our data in the study show an unbalanced panel structure. This requires great attention to be paid to several estimation issues.

First, in order to avoid the biased estimates, we use the Dicker-Fuller unit root to test whether these variables in our study are stationary (Choi, 2001). In our sample, a significant panel unit root test confirms the stationarity of variables (four test indexes, i.e., inverse chi-squared, inverse normal, inverse logit t, and modified inverse chi-squared, reject the null hypothesis, $p < 0.01$). Second, the Wooldridge test is used to identify the existence of serial correlation in panel data (Wooldridge, 2015), with the test result rejecting the null hypothesis that there is no first-order autocorrelation. This

suggests that, in our sample, autocorrelation is an important issue, which may bias the parameter estimates. Therefore, to cope with this issue, we introduce lagged dependent variables in our econometric models. Besides, the Wald test is applied to identify the heteroscedasticity arising from our sample, while we use the cluster robust standard error to reduce the effect of heteroscedasticity on research results (Cameron & Trivedi, 2005).

In addition, endogeneity is a common issue that may bias the parameter estimates, which in turn affect the main effects in the research models. Despite a large body of research exploring the effect of servitization on firm performance, some studies report that firm performance may also influence servitization (Benedettini et al., 2017; Han et al., 2013). This indicates that the causal relationship between servitization and firm performance is ambiguous and even simultaneous. The presence of simultaneous causality is a common cause behind the violation of the standard regression analysis assumption with regard to the absence of correlation between the error terms and independent variables; this is known as endogeneity (Stock & Watson, 2003; Wooldridge, 2002). To avoid biased estimates caused by endogeneity, econometricians suggest the introduction of instrumental variables in econometric models explains the independent variable, but is unrelated to the dependent one (Wooldridge, 2015). Since our study data have a panel structure and our econometric models introduce lagged dependent variables, we adopt system generalized method of moments (GMM) dynamic panel methods (Arellano & Bover, 1995; Blundell & Bond, 1998). The system GMM is an instrumental variable methodology designed to precisely cope with endogeneity and dynamic panel bias, since it can automatically generate corresponding instrumental variables based on dependent variables (Arellano & Bond, 1991; Blundell & Bond, 1998).

6.4 Data analysis and results

6.4.1 **Descriptive statistics**

Table 6.1 presents descriptive statistics and the corresponding correlation matrix for all variables (except instrumental variables and year dummies), pooled across firms and time. The VIF scores for all variables in the table (VIFs < 4) suggest no major collinearity issue in our data (Farrar & Glauber, 1967). In order to avoid collinearity,

Serviceratio^2 is calculated with the squared value of the centred Serviceratio (Aiken & West, 1991).

Table 6. 1 Descriptive Statistics and Correlations of Study 3

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	VIF
1. Operatingmargin	-146.101	0.676	-0.031	2.778	1													
2. Growth	-0.975	36.191	0.117	0.735	-0.055***	1												
3. Turnover	0.004	6.378	1.166	0.659	0.060***	-0.096***	1											
4. Debt	0.139	44.062	2.457	2.097	-0.068***	0.046***	-0.137***	1										
5. Serviceratio	0.000	0.998	0.212	0.199	-0.042***	0.041***	0.111***	0.030*	1									2.06
6. Serviceratio2	0.000	0.997	0.084	0.148	-0.056***	0.031*	0.099***	0.034**	0.932***	1								2.01

Table 6.1

(Continued)

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	VIF
7. R&Dintensity	0.000	117.309	0.115	2.204	-0.983***	0.029*	-0.062***	0.056***	0.037**	0.050***	1							1.77
8. Marketintensity	0.000	2.619	0.015	0.072	0.000	0.134	-0.003**	0.033**	0.017	0.016	-0.003	1						1.61
9. Abresource	-2285.735	1364.316	1.393	49.461	0.001	-0.007	0.032**	-0.010	-0.007	-0.008	-0.002	0.001	1					1.41
10. Unabresource	-38.967	11.428	-0.290	2.074	0.089***	-0.052***	0.001	0.050***	-0.096***	-0.097***	-0.054***	-0.005	0.015	1				1.15
11. Industryconcen	0.048	1.000	0.282	0.201	0.027*	-0.026	-0.005	-0.076***	-0.028*	-0.032**	-0.030*	0.027*	-0.005	0.004	1			1.01

Table 6.1

(Continued)

Variables	Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	VIF
12. Firmsize	-1.546	12.829	6.342	2.589	0.118***	-0.105***	-0.009	-0.301***	-0.218***	-0.202***	-0.081***	-0.070***	0.011	0.358***	-0.028*	1		1.01
13. Marketshare	0.000	1.000	0.121	0.199	0.034**	-0.054***	-0.009	-0.188***	-0.116***	-0.101***	-0.025	-0.026*	0.014	0.148***	0.463***	0.454***	1	1.00
Average VIF																		1.45

Notes: (1) The sample size is 4053; (2) *** p < 0.01, ** p < 0.05, * p < 0.1.

6.4.2 **Data results**

We use the routine Xtabond2 in Stata 14.0 to run the system GMM to test the proposed hypotheses. Table 6.2 shows the regression results pertaining to the testing of the hypotheses, and four models' results in this table correspond to the model specifications in Equations 6-1, 6-2, 6-3 and 6-4. It is noteworthy that the four dependent variables are significantly correlated with their lagged values (beta = 0.166 for Operatingmargin, beta = -0.893 for Growth, beta = -0.136 for Turnover, and beta = -0.327 for Debt), which provides support for the inclusion of the lagged dependent variables in the regression models and the adoption of the system GMM estimator for data analysis.

Table 6. 2 Regression Results for Hypotheses in Study 3

Variables	Model 6-1 Operatingmargin		Model 6-2 Growth		Model 6-3 Turnover		Model 6-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Serviceratio	-0.126	0.523	-5.488***	2.115	-1.812***	0.498	-2.182	2.497
Serviceratio^2	1.549*	0.923	4.820	3.250	2.062***	0.721	3.025	3.533
Relatedness	-0.050	0.096	0.343	0.796	0.069	0.213	-0.281	0.948
R&Dintensity	-1.691***	0.221	-0.577**	0.285	0.007	0.023	0.268	0.364
Marketintenstiy	-0.959	0.970	-7.270	8.775	0.059	0.335	1.937	1.785
Abresource	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.001
Unabresource	0.036	0.034	0.049	0.046	-0.059***	0.012	0.212***	0.060
Relatedness×Serviceratio	0.743	0.678	3.346	3.726	1.314*	0.692	-0.530	3.822
Relatedness×Serviceratio^2	-2.367	1.602	-1.134	3.649	-0.764	0.718	1.443	4.370
R&Dintensity×Serviceratio	1.063	1.084	-0.182	2.450	0.082	0.135	-0.202	1.885
R&Dintensity×Serviceratio^2	-1.481*	0.770	-0.482	1.607	-0.214	0.299	-1.469	1.478
Marketintensity×Serviceratio	-4.996	12.074	-165.216	122.528	1.939	3.300	30.855	23.143
Marketintensity×Serviceratio^2	-3.025	12.165	168.123	127.919	-1.968	4.207	-31.812	25.614
Abresource×Serviceratio	0.000	0.003	0.001	0.010	-0.004**	0.002	0.020	0.020
Abresource×Serviceratio^2	0.000	0.006	0.000	0.022	0.007**	0.003	-0.050	0.050
Unabresource×Serviceratio	0.392	0.249	0.304	0.442	0.135	0.173	-0.117	0.489
Unabresource×Serviceratio^2	-0.402*	0.233	-0.334	0.424	-0.293*	0.163	-0.008	0.515

Table 6.2

(Continued)

Variables	Model 6-1 Operatingmargin		Model 6-2 Growth		Model 6-3 Turnover		Model 6-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Industryconcen	0.056	0.098	0.023	0.335	0.022	0.107	-0.166	0.374
Marketshare	-0.158	0.242	-0.449	0.722	-0.258	0.183	0.123	0.474
Firmsize	0.184*	0.100	0.806***	0.185	0.289***	0.050	-0.454**	0.203
L.Operatingmargin	0.166**	0.076						
L.Growth			-0.893***	0.048				
L.Turnover					-0.136***	0.030		
L.Debt							-0.327*	0.175
Year								
Year1991	0.000	(omitted)	0.000	(omitted)	0.124***	0.038	0.000	(omitted)
Year1992	0.337**	0.131	0.000	(omitted)	0.085***	0.030	0.000	(omitted)
Year1993	0.340***	0.131	-0.078	0.110	0.000	(omitted)	-0.072	0.108
Year1994	0.322**	0.125	-0.187	0.132	0.000	0.039	0.014	0.120
Year1995	0.300***	0.116	-0.376**	0.189	-0.020	0.054	0.093	0.153
Year1996	0.285**	0.112	-0.564**	0.223	-0.036	0.063	0.139	0.198
Year1997	0.263**	0.109	-0.724***	0.256	-0.121*	0.068	0.168	0.220
Year1998	0.254**	0.107	-0.907***	0.306	-0.197**	0.081	0.206	0.252
Year1999	0.212**	0.099	-0.981***	0.335	-0.282***	0.085	0.289	0.290

Table 6.2

(Continued)

Variables	Model 6-1 Operatingmargin		Model 6-2 Growth		Model 6-3 Turnover		Model 6-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Year2000	0.180*	0.095	-1.109***	0.344	-0.305***	0.087	0.108	0.303
Year2001	0.167*	0.089	-1.350***	0.371	-0.301***	0.089	0.295	0.298
Year2002	0.180**	0.088	-1.565***	0.378	-0.361***	0.090	0.294	0.349
Year2003	0.155*	0.080	-1.599***	0.385	-0.396***	0.090	0.226	0.376
Year2004	0.130*	0.071	-1.660***	0.416	-0.393***	0.095	0.294	0.406
Year2005	0.090	0.069	-1.737***	0.436	-0.393***	0.097	0.414	0.422
Year2006	0.073	0.073	-1.970***	0.449	-0.438***	0.106	0.452	0.434
Year2007	0.068	0.077	-2.222***	0.493	-0.463***	0.111	0.519	0.465
Year2008	0.046	0.076	-2.315***	0.500	-0.431***	0.112	0.511	0.483
Year2009	0.044	0.068	-2.517***	0.496	-0.524***	0.114	0.549	0.466
Year2010	0.042	0.052	-2.537***	0.501	-0.560***	0.116	0.387	0.508
Year2011	0.006	0.039	-2.330***	0.516	-0.569***	0.123	0.391	0.521
Year2012	-0.006	0.027	-2.433***	0.541	-0.584***	0.128	0.410	0.533
Year2013	-0.011	0.025	-2.653***	0.559	-0.628***	0.127	0.452	0.538
Year2014	-0.003	0.020	-2.830***	0.574	-0.670***	0.129	0.380	0.573
Year2015	0.004	0.010	-2.868***	0.586	-0.846***	0.153	0.402	0.576
Year2016	0.000	(omitted)	-2.925***	0.600	-0.913***	0.159	0.388	0.576

Table 6.2

(Continued)

Variables	Model 6-1 Operatingmargin		Model 6-2 Growth		Model 6-3 Turnover		Model 6-4 Debt	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Instrumental variables	GMM instruments		GMM instruments		GMM instruments		GMM instruments	
Number of observations	2448		2448		3157		2448	
Number of firms	487		487		630		487	
Number of instruments	90		90		118		90	
AR(1)-p	0.265		0.716		0.243		0.018	
AR(2)-p	0.549		0.474		0.238		0.274	
Hansen-p	0.032		0.977		0.494		0.693	

Notes: (1) L.Operatingmargin, L.Growth, L.Turnover, and L.Debt are the lagged values of four performance indicators, Pricechange is the dummy variable of industry clockspeed (including Fast, Standard and Slow), and Year* denotes year dummies; (2) AR(1)-p and AR(2)-p are p-values of AB Statistic while Hansen-p is the p-value of Hansen's J statistic; (3) Coefficient and SE respectively represent the regression coefficients and robust standard errors; (4) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As mentioned in Study 2, we first examine the applicability of the system GMM in our data by using the AB test. The results in Table 6.2 show that the p-values of AR(2) in the AB test exceed 0.1 for all four models, which supports the claim that there is no evidence that our models are misspecified (Tuli et al., 2010).

The regression results of four models in Table 6.2 test the proposed hypotheses of Study 3, namely, H1a-d, H2a-d, H3a-d, H4a-d and H5a-d. Specifically, the dependent variables are four different performance indicators (namely, Operatingmargin, Growth, Turnover and Debt), while the independent variables include Serviceratio and Serviceratio^2, and the moderator variables include Relatedness, R&Dintensity, Marketintensity, Abresource and Unabresource. The specific regression results are as follows:

(1) Moderating effect of service relatedness

As can be seen from Table 6.2, the interaction term between Relatedness and Serviceratio (namely, Relatedness × Serviceratio) is significantly related to Turnover (beta = 1.314, z = 1.900, p = 0.058), but insignificantly related to the three other performance indicators (Operatingmargin, Growth and Debt), which supports H1c, but rejects H1a, H1b and H1d. Therefore, Relatedness significantly moderates the relationship between Serviceratio and Turnover.

To clarify the regression results, we plot the relationship between Serviceratio and Turnover for the high and low conditions of Relatedness shown in Figure 6.2. Overall, Figure 6.2 indicates that the relationship between Serviceratio and Turnover for the high and low conditions of Relatedness is U-shaped. However, in the condition of low Relatedness, the curve for the Serviceratio-Turnover relationship is steeper, and this curve's critical point is larger than that in the condition of high Relatedness. Hence, H1c is supported, that is, service relatedness significantly moderates the relationship between servitization and operating efficiency.

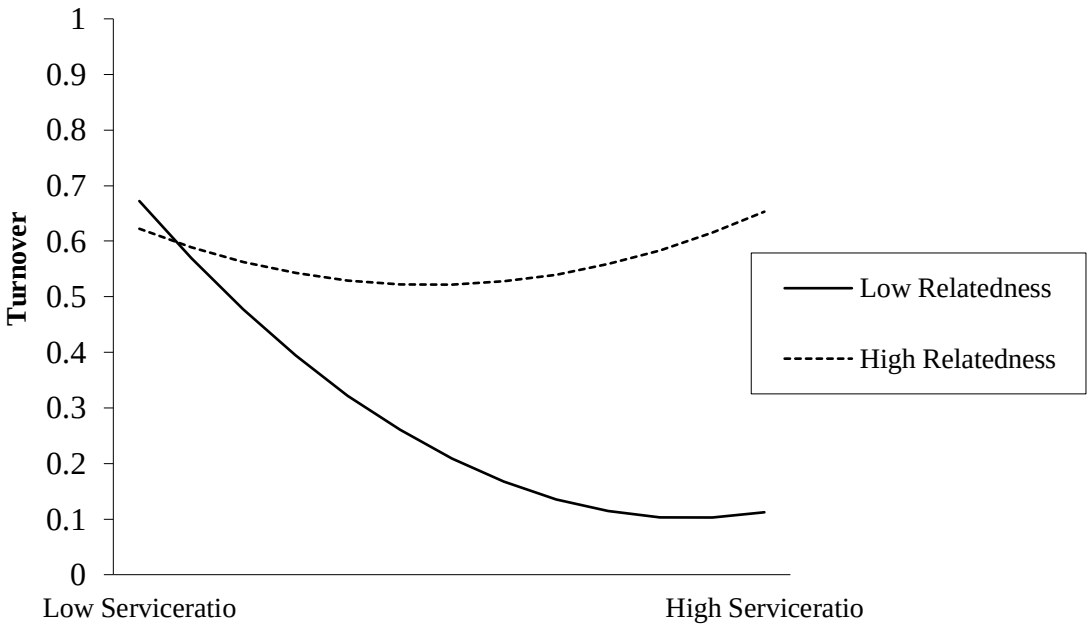

Figure 6. 2 Moderating effect of Service Relatedness on Servitization-Operating Efficiency Relationship

(2) Moderating effect of R&D intensity

The regression results in Table 6.2 show that the interaction term between R&Dintensity and Serviceratio^2 (namely, R&Dintensity × Serviceratio^2) is significantly related to Operatingmargin (beta = -1.481, z = -1.920, p = 0.055), but insignificantly related to the three other performance indicators (Growth, Turnover and Debt), which supports H2a, but rejects H2b, H2c and H2d. Therefore, R&Dintensity significantly moderates the relationship between Serviceratio and Operatingmargin.

To clarify the regression results, we plot the relationship between Serviceratio and Operatingmargin for the high and low conditions of R&Dintensity, as presented in Figure 6.3. Overall, Figure 6.3 indicates that the relationship between Serviceratio and Operatingmargin for the high and low conditions of R&Dintensity is U-shaped. However, in the condition of high R&Dintensity, the curve for the Serviceratio-Operatingmargin relationship is lower and has a smaller critical point than that in the condition of low R&Dintensity. Hence, H2a is supported, that is, R&D intensity significantly moderates the relationship between servitization and operating margin.

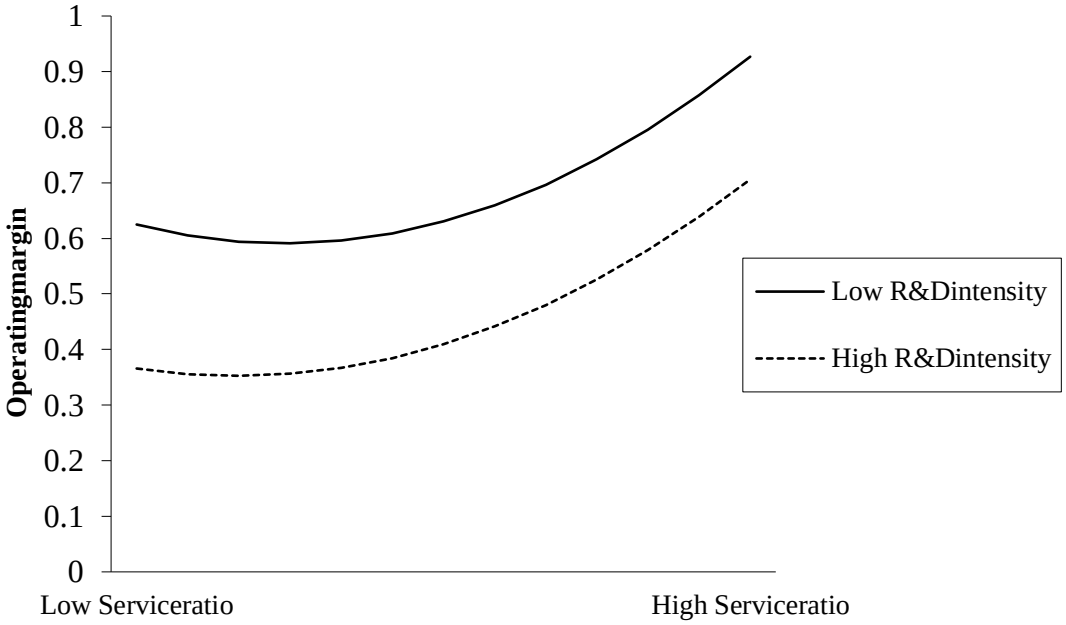

Figure 6. 3 Moderating effect of R&D Intensity on Servitization-Operating Margin Relationship

(3) Moderating effect of marketing intensity

Table 6.2 shows that the relationships between interaction terms (namely, Marketintensity × Serviceratio and Marketintensity × Serviceratio^2) and four performance indicators (namely, Operatingmargin, Growth, Turnover and Debt) are insignificant, which rejects H3a-d. Therefore, marketing intensity does not moderate the relationship between servitization and firm performance.

(4) Moderating effect of absorbed resource slack

From Table 6.2, we can see that the interaction terms (namely, Abresource × Serviceratio and Abresource × Serviceratio^2) are significantly related to Turnover (beta = -0.004, z = -2.560, p = 0.010; beta = 0.007, z = 2.250, p = 0.025), but insignificantly related to the three other performance indicators (Operatingmargin, Growth and Debt), which supports H4c, but rejects H4a, H4b and H4d. Therefore, Abresource significantly moderates the U-shaped relationship between Serviceratio and Turnover.

Figure 6.4 reveals the relationships between servitization and operating efficiency under two different conditions of high and low absorbed resource slack. Overall, Figure

6.4 indicates that the relationship between Serviceratio and Turnover for the high and low conditions of absorbed resource slack is U-shaped. However, in the condition of high Abresource, the curve for the Serviceratio-Turnover relationship is steeper, and this curve's critical point is smaller than that in the condition of low Abresource. Hence, H4c is supported, that is, absorbed resource slack significantly moderates the relationship between servitization and operating efficiency.

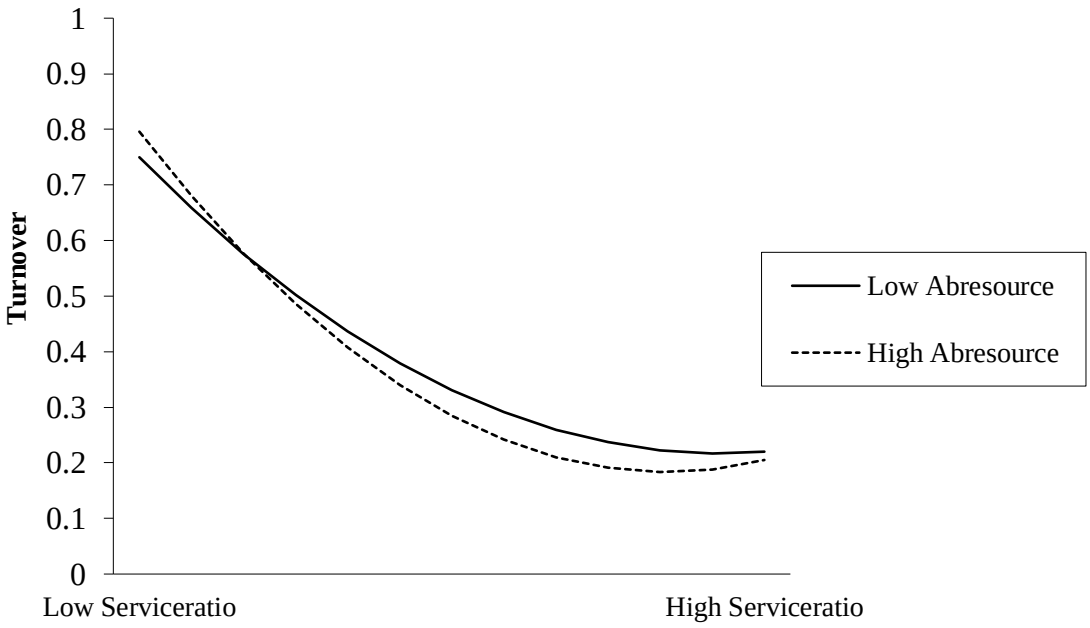

Figure 6. 4 Moderating effect of Absorbed Resource Slack on Servitization-Operating Efficiency Relationship

(5) Moderating effect of unabsorbed resource slack

We can see from Table 6.2 that the interaction term (namely, Unabresource × Serviceratio^2) is significantly related to two of the performance indicators (namely, Operatingmargin and Turnover) (beta = -0.402, z = -1.720, p = 0.085; beta = -0.293, z = -1.790, p = 0.073), but insignificantly related to the two other performance indicators (Growth and Debt), which supports H5a and H5c, but rejects H5b and H5d. Therefore, Unabresource significantly moderates the U-shaped relationships between Serviceratio and Operatingmargin, and between Serviceratio and Turnover.

Figure 6.5 and Figure 6.6 delineate the moderating effects of unabsorbed resource slack on the relationship between servitization and operating margin, and the relationship between servitization and operating efficiency. Figure 6.5 shows that, in the condition of low Unabresource, the curve for the Serviceratio-Operatingmargin relationship is steeper, and this curve's critical point is larger than that in the condition of high Unabresource. Hence, H5a is supported, that is, unabsorbed resource slack significantly moderates the relationship between servitization and operating margin. In contrast, Figure 6.6 duplicates this scenario for the moderating role of unabsorbed resource slack on the relationship between servitization and operating efficiency. In the case of low Unabresource, the curve for the Serviceratio-Turnover relationship is steeper, and this curve's critical point is smaller than that in the condition of high Unabresource. Overall, H5a and H5c are supported, that is, unabsorbed resource slack significantly moderates the relationship between servitization and operating margin, and the relationship between servitization and operating efficiency.

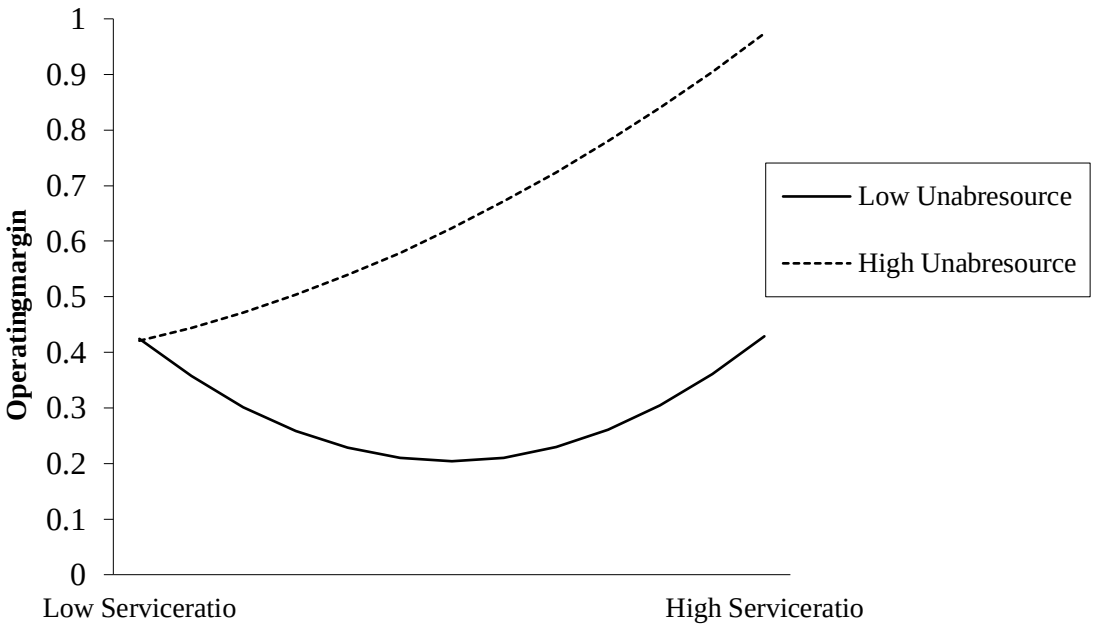

Figure 6. 5 Moderating effect of Unabsorbed Resource Slack on Servitization-Operating Margin Relationship

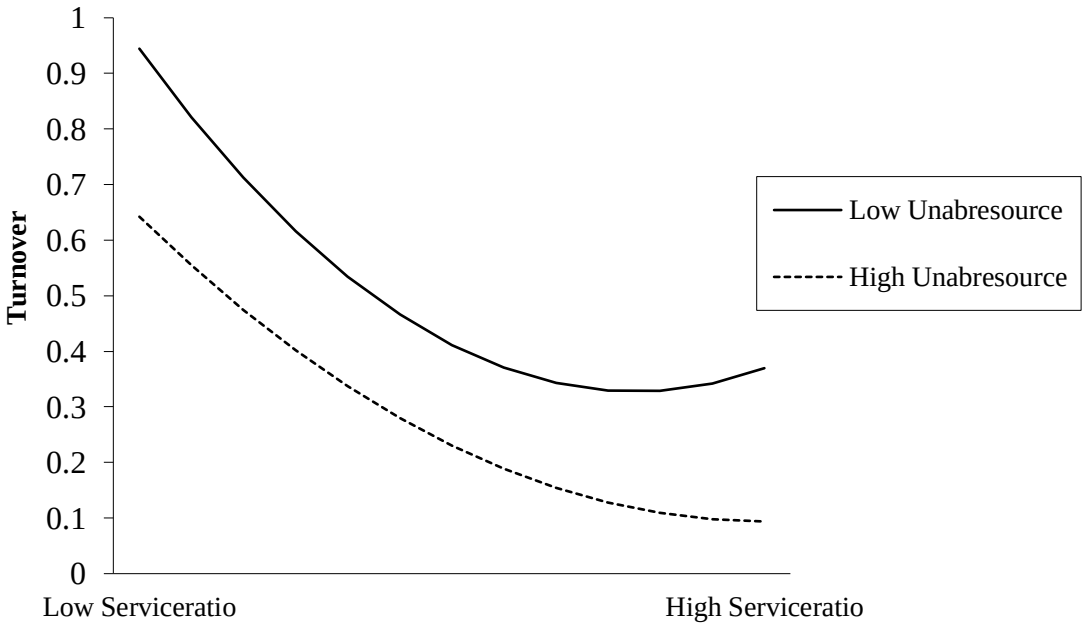

Figure 6. 6 Moderating effect of Unabsorbed Resource Slack on Servitization-Operating Efficiency Relationship

6.5 Discussion and conclusion

6.5.1 **Theoretical implications**

This study examines the moderating effect of firm characteristics on the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio), based on the Compustat database; the testing results for proposed hypotheses are shown in Table 6.3. The firm characteristics as moderators of the servitization-performance relationship in our study include service relatedness, R&D intensity, marketing intensity, absorbed resource slack and unabsorbed resource slack. Overall, this study contributes to the research on moderators of the servitization-firm performance relationship and thus expands the theoretical boundaries and understanding of servitization by uncovering key internal mechanisms, as well as important firm-level contextual factors (Eggert et al., 2011; Fang et al., 2008; Kohtamäki et al., 2013b). The specific contributions of this study are as follows:

First, this study confirms the significant moderating effect of service relatedness on the relationship between servitization and firms' operating efficiency. Specifically, given the U-shaped relationship between servitization and operating efficiency, in the case of low service relatedness, this relationship curve is steeper and has a larger critical point than that in the case of high service relatedness. In previous research, Fang et al. (2008) acknowledge the moderating impact of service relatedness on the effect of service transition on firm value, while Josephson et al. (2016) report that service relatedness negatively moderates the relationship between service transition and firm risk. This study presents a similar finding, which enriches this area of research.

Second, this study demonstrates the significant moderating impact of R&D intensity on the association between servitization and operating margin. Surprisingly, given the U-shaped relationship between servitization and operating margin, this relationship curve in the condition of high R&D intensity is lower and has a smaller critical point than that in the condition of low R&D intensity. In the extant servitization research, only one study has concluded that R&D intensity negatively affects the positive effect of service transition on firm risk (Josephson et al., 2016). Hence, our study contributes to the understanding of servitization.

Third, our study concludes that marketing intensity does not moderate the relationship between servitization and firm performance. Josephson et al. (2016) have suggested that marketing intensity significantly amplifies the effect of service transition on firm risk, whereas, in this study, we observe an insignificant moderating effect of marketing intensity on the relationship between servitization and four firm performance indicators.

Moreover, this study confirms that absorbed resource slack significantly moderates the relationship between servitization and firms' operating efficiency. Specifically, the relationship between servitization and operating efficiency is U-shaped. However, in the condition of high absorbed resource slack, the curve for this relationship is steeper and has smaller critical point than that in the condition of low absorbed resource slack. Prior literature has explored the moderating effect of resource slack on the relationship between service transition and firm value, but few studies have explored the differential effects of different types of resource slack (absorbed resource slack and unabsorbed resource slack) on the servitization-performance link. This study fills this gap and expands our understanding of the effect of firm-level factors on servitization.

Finally, this study finds that unabsorbed resource slack significantly moderates the relationship between servitization and two firm performance indicators (namely, firms' operating margin and operating efficiency). Specifically, the relationships between servitization and these two performance indicators are U-shaped. In the condition of low unabsorbed resource slack, the curve for the servitization-operating margin relationship is steeper and has a larger critical point than that in the condition of high unabsorbed resource slack. Besides, in the case of low unabsorbed resource slack, the curve for the servitization-operating efficiency relationship is steeper and has a smaller critical point than that in the condition of high unabsorbed resource slack. Prior servitization research has discussed the moderating effect of unabsorbed resource slack. For example, Fang et al. (2008) propose that resource slack moderates the effect of service transition on firm value, while Josephson et al. (2016) argue that unabsorbed resource slack exacerbates the relationship between service transition and firm risk. This study demonstrates a further contribution to this research area.

Table 6. 3 Hypotheses testing results of Study 3

	Hypotheses	Outcome
H1a	Service relatedness moderates the relationship between servitization and operating margin	Rejected
H1b	Service relatedness moderates the relationship between servitization and sales growth	Rejected
H1c	Service relatedness moderates the relationship between servitization and operating efficiency	Supported
H1d	Service relatedness moderates the relationship between servitization and asset-liability ratio	Rejected
H2a	R&D intensity moderates the relationship between servitization and operating margin	Supported
H2b	R&D intensity moderates the relationship between servitization and sales growth	Rejected
H2c	R&D intensity moderates the relationship between servitization and operating efficiency	Rejected
H2d	R&D intensity moderates the relationship between servitization and asset-liability ratio	Rejected
H3a	Marketing intensity moderates the relationship between servitization and operating margin	Rejected
H3b	Marketing intensity moderates the relationship between servitization and sales growth	Rejected
H3c	Marketing intensity moderates the relationship between servitization and operating efficiency	Rejected
H3d	Marketing intensity moderates the relationship between	Rejected

	servitization and asset-liability ratio	
H4a	Absorbed resource slack moderates the relationship between servitization and operating margin	Rejected
H4b	Absorbed resource slack moderates the relationship between servitization and sales growth	Rejected
H4c	Absorbed resource slack moderates the relationship between servitization and operating efficiency	Supported
H4d	Absorbed resource slack moderates the relationship between servitization and asset-liability ratio	Rejected
H5a	Unabsorbed resource slack moderates the relationship between servitization and operating margin	Supported
H5b	Unabsorbed resource slack moderates the relationship between servitization and sales growth	Rejected
H5c	Unabsorbed resource slack moderates the relationship between servitization and operating efficiency	Supported
H5d	Unabsorbed resource slack moderates the relationship between servitization and asset-liability ratio	Rejected

6.5.2 **Managerial implications**

This study has several important managerial implications for manufacturing firms. First, our finding on the significant moderating effect of service relatedness on the relationship between servitization and operating efficiency suggests that, as firms move into service business unrelated to the core product business, the negative effect of servitization on their operating efficiency will persist over a broad range of the level of servitization. However, if firms offer services closely linked to products, the negative effect will disappear relatively quickly and converted into a strong and increasingly positive effect after exceeding the critical level of servitization. This is mainly due to the synergies between service and product businesses, implying that the benefits from resource spillovers

or synergies help manufacturing firms mitigate difficulties, such as the loss of strategic focus, internal conflict and resource constraints, and thus generate improved operating efficiency. Without these spillover or synergistic benefits, it may be hard-pressed for product-oriented firms to compete against more focused, service-only firms. Therefore, the offering of services that is closely related to core products makes it easier for manufacturing firms to successfully implement servitization. Furthermore, it may be better for manufacturing firms to first provide services highly related to products in the initial phase of servitization.

Second, our finding that R&D intensity moderates the association between servitization and operating margin reveals that firms, under the conditions of both high and low R&D intensity, show similar relationship shapes. However, contrary to our expectation, the relationship curve in the condition of low R&D intensity is above that in the condition of high R&D intensity. Specifically, at a given level of servitization, lower R&D intensity generates higher levels of firms' operating margin. One possible explanation for this is that R&D resources are mainly devoted to product-centric activities, rather than service-oriented activities. In that case, strong R&D intensity demonstrates firms' strong commitment to their existing product-oriented resources and knowledge, which may be mismatched with their service transition and even hinder the implementation of servitization. Overall, servitized manufacturers should pay great attention to specific R&D activities, especially service-oriented activities, such as building platforms for service marketing, when investing in R&D.

Third, observing the insignificant impact of marketing intensity on the servitization-firm performance relationship is also contradictory to our expectation that greater investment in marketing activities could help to exploit new market opportunities and generate improved performance. One possible explanation for this could involve the service characteristics and perceptions of the marketing function in the firms. Specifically, services are intangible, harder to imitate, more likely to require coproduction, and more demanding of direct sales contact (Fang et al., 2008). Marketing intensity refers to firms' ability to communicate and exchange with the external environment (Anderson, 1982). The innate characteristics of services may greatly hinder the effects of firms' marketing, because, even in the condition of strong marketing intensity, customers may still be not

impressed with the "invisible" services. Therefore, marketing intensity is not an important moderator affecting the performance effect of servitization, and manufacturing firms should restrain resources in the course of marketing activities (especially in service-oriented activities) when implementing servitization.

Moreover, our finding that absorbed resource slack significantly moderates the relationship between servitization and operating efficiency indicates that similar shapes occur when comparing the servitization-operating efficiency relationship curves under the conditions of both high and low absorbed resource slack. Relatively, the curve in the condition of high absorbed resource slack is steeper and has a smaller critical point than that in the condition of low absorbed resource slack. However, over a broad range of service ratios, the curve in the condition of high absorbed resource slack is below that in the condition of low absorbed resource slack. Thus, mostly at a given level of servitization, lower absorbed resource slack produces slightly higher levels of firms' operating efficiency. Servitized manufacturers with abundant absorbed resource slack should first take measures to reduce absorbed resource slack in order to improve their operating efficiency.

Finally, our research recognizes the moderating effect of unabsorbed resource slack on the relationship between servitization and two firm performance indicators (namely, operating margin and operating efficiency). On the one hand, the significant moderating effect of unabsorbed resource slack on the servitization-operating margin relationship suggests that firms with high unabsorbed resource slack could generate a greater operating margin by servitization than those with low unabsorbed resource slack. Specifically, the curve for the servitization-operating margin relationship in the condition of high unabsorbed resource slack almost approaches a positive linear relationship and is well above that in the condition of low unabsorbed resource slack. Thus, higher unabsorbed resource slack helps servitized manufacturers acquire an enhanced operating margin. On the other hand, the finding on the significant moderating effect of unabsorbed resource slack on the servitization-operating margin relationship suggests that firms in the condition of low unabsorbed resource slack could, surprisingly, generate greater operating efficiency by servitization than those with high unabsorbed resource slack. Specifically, the curve for the servitization-operating efficiency relationship in the condition of high unabsorbed resource slack is very flat, and way below that in the condition of low unabsorbed resource

slack. Thus, higher unabsorbed resource slack causes decreased operating efficiency among servitized manufacturers. It is noteworthy that, by comparing these two types of conflicting (positive and negative, respectively) effects on the relationship between servitization and two performance indicators (operating margin and operating efficiency), we find that the positive effect of servitized manufacturers' high unabsorbed resource slack on operating margins surpasses the negative effect of servitized manufacturers' high unabsorbed resource slack on operating efficiency. Therefore, unabsorbed resource slack positively moderates the servitization-performance relationship, and manufacturers with adequate unabsorbed resource slack could perform better in the implementation of servitization.

Overall, in order to successfully transition to service business, manufacturing firms should first provide services more closely related to core products, constrain investment in these three categories of resources (namely, product-centric R&D, marketing resources for services and absorbed resource slack), and increase the resource reserve for unabsorbed resource slack.

7 Conclusion and limitations

This thesis explores the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio), with the aim of refining the existing research on the servitization-firm performance relationship. It also examines the moderating effect of industry characteristics on the servitization-firm performance relationship in terms of industry clockspeed, industry concentration and industry maturity, which enriches the research area on the moderators of this relationship. Lastly, it investigates the moderating effect of firm characteristics on this relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack), which in turn provides a relatively clearer and more systematic framework for firm-level characteristics as moderators in the servitization-firm performance relationship. The hypotheses of this thesis are tested, based on secondary data gathered from the Compustat database during the period 1990-2016. In this chapter, we offer a conclusion of the findings of Chapters 4, 5 and 6 by presenting their overall academic contributions, managerial insights and limitations, as well as suggesting directions for future research.

7.1 Summary of study findings

In our research work, we summarize some important conclusions based on the hypotheses testing from the three studies in this thesis; the main findings are as follows:

(1) Main findings of Study 1

Study 1 explores the relationships between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) and finds that they have significant differences. Specifically, the relationships between servitization and two performance indicators (namely, operating margin and operating efficiency) are U-shaped, whereas the relationship between servitization and sales growth is significantly negative. Besides, there is no significant relationship between servitization and firms' asset-liability ratio. The negative linear effect of servitization on sales growth may be due to the fact that the majority of manufacturing firms are still in the early stage of servitization; thus, we consider that sales growth will increase along with the

increased level of servitization in the long run. Overall, at low and moderate levels of servitization, manufacturing firms experience decreased performance. However, once they reach the critical level of servitization, their performance will rebound gradually; that is, when the critical point is reached and firms realize the right integration between service and product businesses in the organizational elements, such as organizational structure, process, culture and leadership, they will acquire enhanced performance and a competitive edge by means of servitization.

(2) Main findings of Study 2

Study 2 provides evidence of the moderating effect of industry characteristics on the servitization-firm performance relationship in terms of industry clockspeed, industry concentration and industry maturity. Briefly, Study 2 finds that industry clockspeed moderates the relationship between servitization and operating margin, while industry maturity moderates the relationship between servitization and two performance indicators (namely, sales growth and operating efficiency). However, industry concentration does not moderate the servitization-firm performance relationship.

Specifically, Study 2 confirms the significant moderating effect of industry clockspeed on the relationship between servitization and operating margin. In the context of fast industry clockspeed, there is a significant U-shaped relationship between servitization and firms' operating margin, whereas, in the context of slow industry clockspeed, the relationship between servitization and operating margin is negative, but not U-shaped. Besides, for manufacturing firms in the context of standard industry clockspeed, despite a significant U-shaped relationship between servitization and operating margin, this relationship curve is steeper and has a smaller critical point of 32.6% than in the context of fast industry clockspeed, which has a critical point of 49.7%. Overall, it may be most appropriate for manufacturing firms in the context of standard industry clockspeed to acquire competitive advantage by adopting servitization.

Study 2 also demonstrates that industry maturity could significantly moderate the relationship between servitization and two performance indicators, including sales growth and operating efficiency. Specifically, given the negative relationship between servitization and sales growth, industry maturity could effectively attenuate the negative effect of servitization on sales growth. In contrast, considering the U-shaped relationship between

servitization and operating efficiency, firms in the context of high industry maturity have a flatter relationship curve and a larger critical point than that in the context of low industry maturity. Therefore, servitized manufacturing firms may perform better in the context of low industry maturity.

(3) Main findings of Study 3

Study 3 investigates the moderating effect of firm characteristics on the servitization-firm performance relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack). Briefly, Study 3 shows that: (a) service relatedness significantly affects the relationship between servitization and firms' operating efficiency, while R&D intensity significantly affects the relationship between servitization and operating margin; (b) absorbed resource slack significantly moderates the relationship between servitization and firms' operating efficiency, whereas unabsorbed resource slack significantly moderates the relationship between servitization and two firm performance indicators (namely, firms' operating margin and operating efficiency); however, (c) marketing intensity does not moderate the relationship between servitization and firm performance.

On the one hand, in terms of strategic coherence, Study 3 identifies the significant moderating effects of service relatedness and R&D intensity on the servitization-firm performance relationship. Specifically, service relatedness significantly affects the relationship between servitization and firms' operating efficiency. Given the U-shaped relationship between servitization and operating efficiency, in the case of low service relatedness, this relationship curve is steeper and has a larger critical point than that in the case of high service relatedness: that is, as firms move into service business, which is unrelated to the core product business, the negative effect of servitization on firms' operating efficiency will persist over a broad range of the level of servitization. Therefore, when implementing servitization, it may be better for manufacturing firms to first provide services closely related to core products in the initial phase of servitization.

Study 3 demonstrates the significant moderating impact of R&D intensity on the association between servitization and operating margin. Surprisingly, given the U-shaped relationship between servitization and operating margin, this relationship curve in the

condition of high R&D intensity is lower and has a smaller critical point than that in the condition of low R&D intensity. Comparing these two relationship curves in both conditions reveals similar shapes: at a given level of servitization, lower R&D intensity generates higher levels of firms' operating margin, which means that low R&D intensity positively moderates the relationship between servitization and operating margin.

On the other hand, in terms of resource allocation, Study 3 identifies the significant moderating effects of resource slack (including absorbed resource slack and unabsorbed resource slack) on the servitization-firm performance relationship, but proposes the existence of an insignificant moderating effect of marketing intensity on this relationship. Specifically, absorbed resource slack significantly moderates the relationship between servitization and firms' operating efficiency. In the condition of high absorbed resource slack, the curve for this U-shaped servitization-operating efficiency relationship is steeper and has a smaller critical point than that in the condition of low absorbed resource slack. However, over a broad range of service ratios, the curve in the condition of high absorbed resource slack is below that in the condition of low absorbed resource slack. Thus, mostly at a given level of servitization, lower absorbed resource slack produces slightly higher levels of firms' operating efficiency.

Study 3 also recognizes the moderating effect of unabsorbed resource slack on the relationship between servitization and two firm performance indicators (namely, operating margin and operating efficiency). Specifically, the relationships between servitization and these two performance indicators are U-shaped. In the condition of low unabsorbed resource slack, the curve for the servitization-operating margin relationship is steeper and has a larger critical point than that in the condition of high unabsorbed resource slack. Besides, in the case of low unabsorbed resource slack, the curve for the servitization-operating efficiency relationship is steeper and has a smaller critical point than that in the condition of high unabsorbed resource slack. Therefore, the curve for the servitization-operating margin relationship in the condition of high unabsorbed resource slack almost approaches a positive linear relationship and is well above that in the condition of low unabsorbed resource slack. However, higher unabsorbed resource slack enables servitized manufacturers to generate decreased operating efficiency. It is noteworthy that, by comparing these two types of conflicting (positive and negative, respectively) effects on

the relationship between servitization and two performance indicators (operating margin and operating efficiency), we find that the positive effect of servitized manufacturers' high unabsorbed resource slack on operating margin surpasses the negative effect of servitized manufacturers' high unabsorbed resource slack on operating efficiency. Overall, unabsorbed resource slack positively moderates the servitization-performance relationship.

7.2 Evaluation of the achievement of research objectives

In order to achieve the research objectives, as stated in Chapter 1, this thesis presents three empirical studies. Study 1 examines the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio); Study 2 evaluates the moderating effect of industry characteristics on the servitization-firm performance relationship in terms of industry clockspeed, industry concentration and industry maturity; and Study 3 evaluates the moderating effect of firm characteristics on the servitization-firm performance relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack).

The findings of these three studies confirm that the research objectives of this thesis are satisfactorily achieved. First, Study 1 constructs a relatively holistic and accurate theoretical model to explain the relationship between servitization and firm performance by covering multiple performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio). This study's findings also verify the significant U-shaped relationships between servitization and the two performance indicators (operating margin and operating efficiency), the negative linear effect of servitization on sales growth, and the insignificant relationship between servitization and asset-liability ratio, this extending knowledge on the servitization-firm performance relationship, with insights for manufacturers on how to acquire a competitive edge by means of servitization. Specifically, once the critical level of servitization is reached, manufacturers are more capable of gaining profitability and operating efficiency, as well as leading the competition, by implementing servitization.

Second, Study 2 empirically evaluates the moderating impact of industry

characteristics on the association between servitization and firm performance. In doing so, a set of hypotheses on the links between servitization, industry characteristics (namely, industry clockspeed, industry concentration and industry maturity) and firm performance (namely, operating margin, sales growth, operating efficiency and asset-liability ratio) are empirically tested. The findings from this study indicate that: (a) industry clockspeed significantly moderates the relationship between servitization and operating margin, whereby manufacturing firms in the context of standard industry clockspeed perform better than those in in the context of fast and slow industry clockspeed; (b) industry maturity moderates the relationship between servitization and two performance indicators (sales growth and operating efficiency), whereby manufacturing firms in the condition of low industry maturity show a stronger positive relationship between servitization and firm performance, that is, high industry maturity attenuates the effect of servitization on sales growth and weakens the U-shaped relationship between servitization and operating efficiency; and (c) industry concentration has no effect on the relationship between servitization and firm performance. Further to enriching the research area on the industry-level moderators of the servitization-firm performance relationship, this study also provides managerial insights into how manufacturers' industry environment influences this relationship. Manufacturing firms should better plan and implement servitization according to their corresponding industry clockspeed, as it is both an opportunity and a threat in terms of competition. Meanwhile, servitization is more favourable for manufacturing firms under the condition of low industry maturity for enhanced performance. One possible explanation is that firms in immature industries operate under a more complicated and uncertain market environment, whereby services can be easily introduced to attract new customers and greatly affect firms' operating efficiency by exploiting the synergies between service and product businesses. In addition, the insignificant moderating effect of industry concentration on the servitization-firm performance relationship indicates that intense industry competition may encourage servitization to be implemented, while making no enhancement in the servitization-performance relationship for the implementing manufacturers.

Finally, Study 3 develops and empirically tests a set of hypotheses on the links between servitization, firm characteristics and multiple firm performance indicators in

terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack). The findings of this study indicate that: (a) service relatedness strengthens the servitization-operating efficiency relationship; (b) absorbed resource slack weakens the servitization-operating efficiency relationship; (c) R&D intensity weakens the effect of servitization on operating margin; and (d) marketing intensity has no significant effect on the servitization-firm performance relationship. Besides, unabsorbed resource slack weakens the relationship between servitization and operating efficiency, but strengthens the relationship between servitization and operating margin. Overall, the positive effect of servitized manufacturers' high unabsorbed resource slack on operating margin surpasses the negative effect of their high unabsorbed resource slack on operating efficiency. Thus, unabsorbed resource slack amplifies the servitization-performance relationship. Therefore, our research expands the investigation into firm-level moderators and their effects on the servitization-firm performance relationship, as well as identifies several managerial implications concerning how to provide supporting strategic activities and better utilize organizational resources to support the implementation of manufacturers' servitization. For a successful transition to service business, manufacturing firms are advised to provide services closely related to core products, constrain investment into these three categories of resources (namely, product-centric R&D, marketing resources for services and absorbed resource slack), and increase the resource reserve for unabsorbed resource slack.

In sum, the three empirical studies presented in this thesis provide a more holistic and comprehensive research framework for explaining the relationship between servitization and multiple firm performance indicators, while expanding the investigation into moderators in the servitization-performance relationship to a greater depth in terms of industry-level and firm-level factors, in turn achieving the research objectives of this thesis to a satisfactory extent.

7.3 Theoretical implications

The main theoretical contribution of this thesis is in enriching the research on the servitization-firm performance relationship and expanding the set of moderators in this

relationship in terms of industry characteristics and firm characteristics. The specific theoretical contributions are as follows:

(1) Theoretical implications of Study 1

The first theoretical contribution of this thesis is in facilitating a deeper understanding of the servitization-firm performance relationship. As the research findings on the impact of servitization on firm performance in prior research remain ambiguous, more empirical research is required to test and support them. With previous research having mainly focused on the impact of servitization on firm profitability, this thesis has aimed to provide a more comprehensive and accurate study on the servitization-firm performance relationship in terms of multiple performance indicators, including operating margin, sales growth, operating margin and asset-liability ratio. The findings of our research confirm the presence of significant U-shaped relationships between servitization and two performance indicators (operating margin and operating efficiency), a negative linear effect of servitization on sales growth, and an insignificant relationship between servitization and asset-liability ratio, all of which refines the existing literature on the servitization-firm performance relationship (Fang et al., 2008; Gebauer et al., 2012).

Specifically, first, this study confirms a U-shaped relationship between servitization and firms' operating margin. This finding is consistent with some prior research evidence (Fang et al., 2008; Suarez et al., 2013) and further supports the non-linear performance effect of servitization on firms' profitability. Besides, the data results reject the U-shaped relationship between servitization and sales growth, but verify the significant negative effect of servitization on firms' sales growth. This finding contradicts that reported by Kohtamäki et al. (2013b), who find a positive, but non-linear relationship between service offering and sales growth. However, the relationship between service offering and sales growth is only significant at moderate and high levels of service offering, but insignificant at low to medium levels. Kohtamäki et al. (2013b) employ survey data with a multidimensional firm-level measurement of industrial services whereas our results are based on secondary data. Hence, our study enriches the findings on the performance effect of servitization. Moreover, our study demonstrates a U-shaped relationship between servitization and firms' operating efficiency. With few studies of late having explored the relationship between servitization and operating efficiency, this study makes an important

contribution to this area. Finally, our results suggest that both a main effect and a quadratic effect of servitization on firms' asset-liability ratio are insignificant, indicating that the implementation of servitization in manufacturing firms cannot cause a significant decline in the asset-liability ratio.

(2) Theoretical implications of Study 2

The second theoretical contribution of this thesis is in clarifying the moderating effect of industry characteristics on the relationship between servitization and firm performance. Despite the majority of the literature in this area focusing on the moderating role of contextual factors in the servitization-performance relationship, few studies have examined the impact of industry-level moderating factors on this primary relationship. Indeed, servitization-performance relationships for firms in different industries differ significantly (Fang et al., 2008), which implies that industry characteristics may significantly affect the relationship between servitization and firm performance. Thus, this thesis, in detail, explores how industry characteristics (including industry clockspeed, industry concentration and industry maturity) influence the servitization-firm performance relationship in order to fill the relevant gap in the literature. Our findings show that industry clockspeed significantly moderates the relationship between servitization and operating margin, while industry maturity moderates the relationship between servitization and two performance indicators (sales growth and operating efficiency). However, there is no significant effect of industry concentration on the servitization-performance relationship. Overall, our thesis further enriches the research area on the industry-level moderators of the servitization-firm performance relationship (Fang et al., 2008; Suarez et al., 2013).

Specifically, first, this study confirms the significant moderating effect of industry clockspeed on the relationship between servitization and operating margin. As few previous studies have explored industry clockspeed as the moderator of the servitization-performance link, our study enriches this research area. Moreover, our study suggests an insignificant moderating effect of industry concentration on the relationship between servitization and four firm performance indicators. This finding is consistent with Fang et al.'s (2008) argument that industry competition insignificantly affects the effect of service transition on firm value, with our study further supporting this point in terms of multiple firm performance dimensions. Finally, this study demonstrates that industry maturity could

significantly moderate the relationship between servitization and two performance indicators, including sales growth and operating efficiency. Hence, this study contributes to the discussions on industry characteristics as moderators in the relationship between servitization and firm performance.

(3) Theoretical implications of Study 3

The third theoretical contribution of this research is in providing a more holistic and systematic framework for the moderating effect of firm characteristics on the relationship between servitization and firm performance. Although prior research on this relationship has identified some firm-level moderating factors related to organizational structure, organizational resource and organizational capability, there is still a lack of a clear and systematic theoretical framework to demonstrate how firm-level factors affect the relationship between servitization and firm performance. Hence, this thesis examines the moderating effect of firm characteristics on the servitization-firm performance relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack). The specific contributions are as follows:

First, this study confirms the significant moderating effect of service relatedness on the relationship between servitization and firms' operating efficiency. Specifically, given the U-shaped relationship between servitization and operating efficiency, in the case of low service relatedness, this relationship curve is steeper and has a larger critical point than in the case of high service relatedness. In previous research, Fang et al. (2008) acknowledge the moderating impact of service relatedness on the effect of service transition on firm value, while Josephson et al. (2016) report that service relatedness negatively moderates the relationship between service transition and firm risk. This study presents a similar finding, which enriches this area of research.

Second, this study demonstrates the significant moderating impact of R&D intensity on the association between servitization and operating margin. Surprisingly, given the U-shaped relationship between servitization and operating margin, this relationship curve in the condition of high R&D intensity is lower and has a smaller critical point than that in the condition of low R&D intensity. In the extant servitization research, only one study has concluded that R&D intensity negatively affects the positive effect of service transition on

firm risk (Josephson et al., 2016). Hence, our study contributes to the understanding of servitization.

Third, our study concludes that marketing intensity does not moderate the relationship between servitization and firm performance. Josephson et al. (2016) have suggested that marketing intensity significantly amplifies the effect of service transition on firm risk, whereas, in this study, we observe an insignificant moderating effect of marketing intensity on the relationship between servitization and four firm performance indicators.

Moreover, this study confirms that absorbed resource slack significantly moderates the relationship between servitization and firms' operating efficiency. Specifically, the relationship between servitization and operating efficiency is U-shaped. However, in the condition of high absorbed resource slack, the curve for this relationship is steeper and has smaller critical than that in the condition of low absorbed resource slack. Prior literature has explored the moderating effect of resource slack on the relationship between service transition and firm value, but few studies have explored the differential effects of different types of resource slack (absorbed resource slack and unabsorbed resource slack) on the servitization-performance link. This study fills this gap and expands our understanding of the effect of firm-level factors on servitization.

Finally, this study finds that unabsorbed resource slack significantly moderates the relationship between servitization and two firm performance indicators (namely, firms' operating margin and operating efficiency). Specifically, the relationships between servitization and these two performance indicators are U-shaped. In the condition of low unabsorbed resource slack, the curve for the servitization-operating margin relationship is steeper and has a larger critical point than that in the condition of high unabsorbed resource slack. Besides, in the case of low unabsorbed resource slack, the curve for the servitization-operating efficiency relationship is steeper and has a smaller critical point than that in the condition of high unabsorbed resource slack. Prior servitization research has discussed the moderating effect of unabsorbed resource slack. For example, Fang et al. (2008) propose that resource slack moderates the effect of service transition on firm value, while Josephson et al. (2016) argue that unabsorbed resource slack exacerbates the relationship between service transition and firm risk.

Overall, this study contributes to the research on moderators of the servitization-firm

performance relationship and thus expands the theoretical boundaries and understanding of servitization by uncovering key internal mechanisms, as well as important firm-level contextual factors (Eggert et al., 2011; Fang et al., 2008; Kohtamäki et al., 2013b).

7.4 Managerial implications

The findings of this thesis have several managerial implications for manufacturing firms.

(1) Managerial implications of Study 1

This thesis explores the relationship between servitization and four firm performance indicators (namely, operating margin, sales growth, operating efficiency and asset-liability ratio), while its findings the presence of significant U-shaped relationships between servitization and two performance indicators (namely, operating margin and operating efficiency). Overall, at low and moderate levels of servitization, the effect of servitization on firm performance is negative. Once the critical level of servitization is reached, the positive effect will gradually appear. When the critical point is successfully exceeded, whereby manufacturing firms realize the right integration between service and product businesses in organizational elements, such as organizational structure, process, culture and leadership, they will acquire enhanced performance by means of servitization. However, it is also noteworthy that servitization is not a panacea. As manufacturing firms cannot effectively respond to challenges resulting from the introduction of servitization, including loss of strategic focus and organizational conflict, they will be caught up in service paradox and even finally go bankrupt. Therefore, these firms should realize that servitization is a long-term initiative. If they have excess resources and capabilities to transform into other areas or have appropriate organizational arrangements for service business, they will successfully endure the more difficult times of servitization and finally gain competitive advantage.

(2) Managerial implications of Study 2

Our research examines the moderating effect of industry characteristics on the servitization-firm performance relationship in terms of industry clockspeed, industry concentration and industry maturity. The findings of this thesis show that industry

clockspeed significantly moderates the relationship between servitization and operating margin, while industry maturity can significantly moderate the relationship between servitization and two performance indicators (sales growth and operating efficiency). Besides, industry concentration does not moderate the servitization-firm performance relationship. These findings offer some important managerial insights into the effect of the fit between the implementation of servitization and manufacturers' industry environment on firm performance.

On the one hand, observing a significant moderating effect of industry clockspeed on the relationship between servitization and operating margin suggests that firms with standard industry clockspeed have a greater possibility to succeed in the implementation of servitization. The attributes of fast and slow industry clockspeed do not effectively match the innate characteristics of services, as manufacturing firms with both types of industry clockspeed will not perform better during the implementation of servitization. Overall, manufacturing firms should effectively implement servitization according to their corresponding industry clockspeed, as servitization is both an opportunity and a threat.

On the other hand, the findings that industry maturity significantly moderates the relationship between servitization and two performance indicators (namely, sales growth and operating efficiency) reveal some managerial insights. Specifically, industry maturity can effectively mitigate the negative linear effect of servitization on sales growth, while industry maturity significantly affects the U-shaped relationship between servitization and operating efficiency. This relationship curve for firms in the context of low industry maturity is steeper and has a smaller critical point than that in the context of high industry maturity. This finding is in conflict with the prevailing perception that services primarily play an important role in mature or maturing product industries (Reinartz & Ulaga, 2008; Teece, 1986). This is mainly because services, as mechanisms by which manufacturing firms can transfer product knowledge to new customers as well as new product developers, particularly in situations of high uncertainty, are more significant (Suarez et al., 2013). Firms in immature industries are situated in a more complicated and uncertain market environment, whereby services can be easily introduced to attract new customers and greatly affect firms' operating efficiency by exploiting the synergies between service and product businesses.

Moreover, observing an insignificant moderating effect of industry concentration on the servitization-firm performance relationship suggests that intense industry competition is an important driver of servitization, but not an essential factor as it cannot significant affect the impact of servitization on firm performance.

(3) Managerial implications of Study 3

As this thesis investigates the moderating effect of firm characteristics on the servitization-firm performance relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack), it involves several managerial implications concerning how to provide supporting strategic activities and optimize organizational resources to support the implementation of manufacturers' servitization. The findings on the effect of strategic coherence on the servitization-performance relationship reveals that service relatedness positively moderates the relationship between servitization and operating efficiency, while R&D intensity adversely affects the association between servitization and operating margin. Due to the positive moderating impact of service relatedness on the performance effect of servitization, the offering of services that are closely related to core products makes it easier for manufacturing firms to successfully implement servitization. Furthermore, it may be better for manufacturing firms to first offer services that are highly related to products in the initial phase of servitization.

Besides, given the negative moderating impact of R&D intensity on the performance effect of servitization, strong R&D intensity demonstrates firms' strong commitment to their existing product-oriented resources and knowledge, which may be mismatched to firms' service transition and even hinder the implementation of servitization. Thus, servitized manufacturers should pay great attention to specific R&D activities, especially service-oriented ones, such as building platforms for service marketing, when investing in R&D.

In contrast, observing a moderating effect of resource allocation on the servitization-performance relationship reveals that absorbed resource slack significantly moderates the relationship between servitization and operating efficiency, while unabsorbed resource slack moderates the relationship between servitization and two firm performance indicators (namely, operating margin and operating efficiency). However, there is no significant

impact of marketing intensity on the servitization-firm performance relationship. Specifically, on the one hand, the finding concerning the moderating effect of absorbed resource slack on the servitization-operating efficiency relationship suggests that, across a broad range of service ratios, the curve in the condition of high absorbed resource slack is below that in the condition of low absorbed resource slack. Thus, mostly at a given level of servitization, lower absorbed resource slack produces slightly higher levels of firms' operating efficiency. Servitized manufacturers with significant absorbed resource slack should first take measures to reduce this in order to improve their operating efficiency.

On the other hand, the findings on the moderating effect of unabsorbed resource slack on the relationship between servitization and two firm performance indicators (namely, operating margin and operating efficiency) indicate that firms with high unabsorbed resource slack could generate a greater operating margin by servitization than those with low unabsorbed resource slack, whereas higher unabsorbed resource slack decreases operating efficiency among servitized manufacturers. It is noteworthy that, by comparing these two types of conflicting (positive and negative, respectively) moderating effects on the relationship between servitization and two performance indicators (operating margin and operating efficiency), we find that the positive effect of servitized manufacturers' high unabsorbed resource slack on operating margin surpasses the negative effect of their high unabsorbed resource slack on operating efficiency. Therefore, as unabsorbed resource slack positively moderates the servitization-performance relationship, manufacturers with adequate unabsorbed resource slack should perform better in the implementation of servitization.

Overall, in order to successfully transition to service business, manufacturing firms should first provide services that are closely related to core products, constrain investment in product-centric R&D, marketing resources for services and absorbed resource slack, and increase the resource reserve for unabsorbed resource slack.

7.5 Research limitations and further research

There are several limitations of this study. First, our selected sample only consists of manufacturing firms reporting service revenue, which limits the generalizability of our

research findings. Besides, our sample data are taken from the Compustat database North America subset, which implies that using a sample of US firms also reduces the generalizability of our results. As different national cultures and economies could lead to differences in the servitization-performance relationship, further research should try to capture the performance effect of servitization from an international or cross-cultural perspective.

Further, despite the financial implications of servitization resulting from multiple performance indicators (including operating margin, sales growth, operating efficiency and asset-liability ratio) explored in our research, other important non-financial performance outcomes may be overlooked. Future research work could explore the comparison between the financial and non-financial performance effects of servitization by applying a longitudinal approach.

Moreover, secondary data could contain some limitations in construct measurement. The measurement of servitization in this thesis is taken from Fang et al. (2008). A more nuanced measurement approach could possibly uncover important underpinnings of servitization not gauged by a secondary measure (Eggert et al., 2014a).

Additionally, our research performs estimations by employing the suitable lagged dependent variables' levels and differences as instrumental variables, as derived from the system GMM approach. In addition to the GMM instruments (including lagged levels and differences), the instrument list may include other strictly exogenous regressors (Baum, 2006). Therefore, to enhance the robustness of the GMM estimation, further study could include other exogenous instrumental variables in our model and run several sensitivity analyses.

Finally, there may be other moderating factors affecting the servitization-firm performance relationship, which would require more detailed research involving more moderators in future work.

7.6 Concluding remarks

Today's business markets are confronted with fierce competition, characterized by the commoditization and homogenization of goods, while narrowing the differentiation or

even losing it totally. In order to respond to these challenges, manufacturing firms are increasingly considering servitization as an effective means to help them stand out from other rivals. A literature review on the relationship between servitization and firm performance suggests that the performance effect of servitization is still inconclusive, which in turn prompts calls for a deeper investigation into the topic. Considering that the majority of research studies are confined to exploring the relationship between servitization and firm profitability, and that firm performance is a multidimensional construct, this thesis investigates the relationship between servitization and multiple performance indicators (namely, operating margin, sales growth, operating margin and asset-liability ratio) based on the Compustat database, providing a more holistic and comprehensive theoretical framework for explaining the servitization-firm performance relationship.

Furthermore, the available literature on the servitization-performance relationship mainly focuses on firm-level moderating variables related to organizational structure, capability and resource. Few studies have investigated the moderating impact of industry-level factors on the relationship. The thesis fills this research gap by empirically evaluating the moderating role of industry-level characteristics, including industry clockspeed, industry concentration and industry maturity, on the servitization-performance link for manufacturing enterprises from the perspective of contingency theory.

Finally, despite an abundance of studies identifying some firm-level moderators in the servitization-performance relationship, there is still a lack of a clear and systematic theoretical framework to demonstrate how firm characteristics influence the association between servitization and firm performance. The thesis also fulfils this gap, based on an empirical study on the moderating role of firm characteristics in the servitization-performance relationship in terms of strategic coherence (service relatedness and R&D intensity) and resource allocation (marketing intensity, absorbed resource slack and unabsorbed resource slack).

Overall, our thesis is useful for scholars and practitioners striving to understand the performance outcomes of servitization, as well as contextual factors including industry-level and firm-level factors affecting the performance effect of servitization. We hope that our research will trigger a series of follow-up investigations into the application of servitization in manufacturing firms, especially Chinese manufacturing enterprises.

Currently, in the era of Industry 4.0, China is working on upgrading *Made in China* to *China Manufacturing 2025*, which aims to foster upgraded and technologically advanced manufacturing. As announced in the *China Manufacturing 2025* report, manufacturing firms' servitization is closely associated with manufacturing industries' transformation and upgrading, which is helping to facilitate the optimization of industrial structure, maintain the ecosystem for sustainable manufacturing operations and increase the productivity rate. Thus, servitization plays a pivotal role in the success of this new *China Manufacturing 2025* initiative. As our research has found evidence to confirm the importance of servitization in achieving enhanced performance outcomes for manufacturing firms, we offer several suggestions for Chinese manufacturing enterprises that are embracing servitization. First, since servitization is favourable for manufacturing firms seeking to improve performance, it is highly desirable for government entities to establish or improve the corresponding policy system (e.g., to narrow the differences in the tax rate between service and manufacturing industries) for servitization in order to promote integration between service and manufacturing. Additionally, in order to guarantee the success of servitization and reduce the risk of failure, pilot projects in certain manufacturing industries are encouraged. Based on our research findings, which show that manufacturing firms with different industry characteristics perform differently by means of servitization, we should select firms in different industries with greater success potential (e.g., equipment industry, electronic device, appliance industry) as pilots to implement servitization and observe whether it is effective in enabling the implementing manufacturer to attain the desired cost and service advantages.

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