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The Financial Impact of Applying the Servitization Business Model

An empirical research based on the residual income valuation model

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Abstract

As many manufacturing firms find servitization business model a trend, a need for investigating the firm value difference between this new business model and the traditional manufacturing business model has arisen. In this study, we examine the implied q-value in these two business models and consequently discuss the distinct business characteristics of transforming into a service-focused business model. In detail, the residual income valuation model is applied to imply the q-value with 48 companies in each group. A higher implied q-value is found in servitized companies and indicates a shifting focus from short-term physical assets to long-term knowledge resources. Moreover, we specifically explore the role intellectual capital plays in the servitization business model and find it explains much of the difference. Overall, this study contributes to quantify the financial impact of applying the servitization business model.

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Content

1. Introduction

How can manufacturing firms compete with their counterparts, secure their existing positions, and expand in business markets in today's global ecosystem? With increased industrialization and standardization, many manufacturing firms choose to innovate their offerings by adding services to their traditional core product solutions. This trend, known as "servitization", was first proposed by Vandermerwe and Rada (1988) to describe the suppliers' tendency of adding value by adding services. Mary Agler, director of the Large Corporates Division at EKN (Swedish Export Credit Agency), recognizes this trend and describes it as following:

> *"Many companies no longer wish to own expensive equipment, when it is cheaper to only pay for the time they are using it. This is a development we have seen in many industries… "*

Servitization is causing many companies to transform their business models.

> *"In a sense, the business model is being turned on its head. We are finding that customers do not necessarily want to own the machines any more. We believe that in a very few years about 30% of our big global customers will be using us as a provider of service. Although the normal, purchasing route will still be available of course."*
>
> Greger Svanström, Global Director of Trade & Customer Finance at Volvo CE

Since this research aims to shed light on whether applying the servitization business model will alter companies' firm value, we evaluated the transformation from a supplier's perspective. To be more specific, we focus on the benefits servitization bring to the manufacturing firms rather than to their customers. To understand and explain this trend better, we need to start by defining what a product and a service is. In this paper, a product is defined as a material artifact such as a bag, a vehicle, or an equipment (Goedkoop, 1999). On the contrary, a service is an economic

activity that does not result in ownership of a tangible asset (Baines et al., 2009). There are many different definitions of servitization. For example, some emphasis on the emergence of service in the offering of manufacturing firms (Vandermerwe and Rada, 1988; White et al., 1999; Verstrepen and Van Den Berg, 1999; Robinson et al., 2002; Lewis et al., 2004). Some underline the progress of increasing the range of services (Ward and Graves, 2005). Moreover, some describe it a change in business focus from product to the customer (Ren and Gregory, 2007; Baines et al., 2009). In this paper, we adopt the definition from Baines et al, that servitization epitomizes the trend that companies shift from a product-centered business model to a service-centered business model to better generate mutual value.

With the emergence of servitization business model, the boundary between manufacturing firms and service firms is no longer as clear, and companies focusing on specific products are gradually expanding their capabilities to provide a more thorough solution to customers (Neely, 2008). Previous research has highlighted the advantages of adopting the servitization business model, which mainly lies in intellectual capital. To give an example, by providing more customized and bundled solutions, servitized companies will be able to lock in customers and lock out competitors. This can leverage servitized firms' performance through higher and more stable revenue streams, profits, and cash flow (Vargo and Lusch, 2004; Vandermerwe and Rada, 1988).

Rolls-Royce, the classic car and engine manufacturer, is one of the most successful manufacturing firms transforming into a servitization business model. From being a pure manufacturer of aero engine, Rolls-Royce started offering a Total Care Package in the 2000s. In this business model, Rolls-Royce provides engine service and retains the engines' ownership, risk, and the responsibility to maintain the asset, meaning that customers buy the capability of aero engine instead of aero engine this product. Besides, since the Total Care Package contract normally lasts more than 20 years, Rolls-Royce sustain a relatively secured revenue stream over

the contract period and be able to access and collect the operational data that helped the company to repair the engine quickly. The accessibility of operational data is especially important for this business model since it enables Rolls-Royce to forecast engines' failure and conduct preventive maintenance, which results in fewer canceled flights and reduced incident-in-flights involving Rolls-Royce engines by 25% annually. The Total Care Package has proven to be a tremendous success and consequently inspired more manufacturers to embrace the servitization business model.

However, not all the companies adopting this business model reach a higher performance. A phenomenon called the "service paradox" is discussed extensively in previous research. The paradox implies that, in contrast to the financial benefit expected, a company value decline appears because of an implementation hurdle caused by adding services in the company offerings (Kastalli and Looy, 2013). Previous studies provide evidence that though firms may enjoy a higher revenue compared to traditional firms, a lower profit margin is observed at the same time (Neely, 2008; Eggert et al., 2014; Kastalli and Looy, 2013). Furthermore, servitization is found to have a positive effect on firm value only when a critical mass of service sales is reached (Fang et al., 2008). Thus, a short-term profit sacrifice is expected when applying this model.

Though there has been a range of studies discussing whether servitization increase company value, limited research was done from an accounting perspective and quantified the difference between servitized and traditional manufacturing firms. However, as more manufacturing firms notice the trend, the needs for quantifying the business model in terms of value creation, for measuring the monetary value of identified servitization characteristics, and for discussing the value drivers behind the model have increased. In order to respond to the needs, we conducted a quasi-experimental study and applied the concept of q-value to capture the difference. This study is designed to fill in the gap by addressing the following research question:

Does the servitization business model generate a different firm value compared to the traditional manufacturing business model?

This paper contributes in mainly three areas. First, we provide empirical research on the financial implications of the servitization business model, which is still at an early stage and needs more attention. Second, instead of analyzing from a marketing or strategic perspective, we quantify the business model from an accounting point of view. To be more specific, we use the RIV model in this study to capture the accounting effects brought by servitization, and the differences between market value and book value are illustrated by the implied q-value. Last of all, in order to explain the difference, we investigate the value drivers behind servitization and measure the q-value in regard to intellectual capital.

This paper proceeds as follows. The next section (Section 2) presents a literature review on business models, intellectual capital, and servitization in specific. Section 3 provides a methodology framework that describes how the study is conducted and the reasons for the approach and variables selected. After describing the methods, we conclude and discuss the empirical results of different business models' q-values (Section 4). Lastly, in the conclusion (Section 5), we propose the main theoretical implication of the study as well as the limitations and directions for future research.

2. Literature Review & Hypothesis

The literature review is divided into three parts. The first part is a general background about the business model and intellectual capital. The second part introduces the servitization business model and its characteristics such as generating intellectual capital and leading to a financial outcome known as the "service paradox". In the last part, we present our hypothesis for following testing and discussion.

2.1 A Literature Background in Business Model and Intellectual Capital

While physical assets and financial capital are currently recognized in the financial statements, there is a growing demand for a top-down, holistic nutshell of how the company acquires and utilizes resources to create value (Beattie and Smith, 2013). Therefore, the concept of a business model has entered into the discourse. A business model epitomizes the distinct tactic pattern that a company convert capital and capabilities into economic value (Teece, 2010). In other words, a business model provides a comprehensive view on describing how companies operate, create value, add value to customers, and capture valuable opportunities (Zott et al., 2010).

The business models are used to perform various roles (Baden-Fuller and Morgan, 2010, Beattie and Smith, 2013). One role is a fundamental classification role which provides a set of a generic level description of how a firm creates value and deliver value. More specific, each company is symbolized a particular form of behavior which has been observed and is often given in an overall impression along with the brand. For example, the "McDonalds business model" often leads to an impression of "the franchising model". Another role of a business model serves the function of model organisms and reveals a true story for stakeholders involved. From an internal perspective, a business model offers not only a description of where a company currently is but also a model for where it is heading. This function is especially important for a firm when planning to have a radical change since it offers a point of anchoring itself and rally the members of the firm.

The move to reporting on the business model is regarded as representing a stable anchor in the market valuation of a company to stakeholders (Holland, 1998). Providing a macro view of value creation and value delivery, a business model is highly related to a firm's sustainability. It is believed that a robust business model and a proactive strategy are the keys to keep sustainable competitive advantages for a firm in a changing environment (Teece, 2010). To be more specific, this requires both solution differentiation, strong innovation development, and

the fast time-to-market reaction (Beattie and Smith, 2013, Teece et al., 1997). Worth noticing, one of the identified crucial elements and key value drivers of the sustainable business models is intellectual capital (Beattie and Smith, 2013).

Beginning around the 1980s, with the rise of the Internet, the traditional economic theory of a firm is no longer valid to the whole market. Instead, a knowledge economy based on knowledge resources, also known as intellectual capital, is emerging (Roos et al., 1997; Stewart, 1997). Intellectual capital refers to intangible resources which increase company value by developing a long-term competitive edge (Edvinsson and Malone, 1997; Stewart, 1997). In other words, intellectual capital consists of knowledge, applied experience, organizational technology, customer relationships and professional skills that make a firm competitive in the market (Edvinsson and Malone, 1997).

Three main intellectual capital components and related elements were identified in the previous research (Boedker et al., 2008; Guthrie et al., 2007; Ricceri, 2008). 1. Human competencies, "the knowledge embedded in people" which refers to the firm's employees and their knowledge, skills, and capabilities; 2. Structural capital, "the knowledge embedded in the organization and its systems" such as documents, plans, and intellectual properties; and 3. Relational capital, "the knowledge embedded in the firm's external relationships" such as the connection with its customers, suppliers, partners, and society. (Guthrie et al., 2012, p.70; Inkinen, 2015).

Although intellectual capital is often regarded as a company value driver, it generally lies outside of the traditional accounting framework (Roos et al., 1997). This is because it does not meet the pre-requisites of an asset to be recognized in the balance sheet, which are (i) "it is probable that any future economic benefits associated with the item will flow to or from the entity" and (ii) "the item's cost or value can be measured with reliability" (International Accounting Standard). Besides, in order to be able to recognize an intangible asset, it has to be identifiable (International Accounting Standard 38), which is normally not the case for

intellectual capital. This underlies the limitations on financial statements in explaining company value when the economic value no longer lies in the product manufacturing but in the creation of intellectual capital (Chen et al., 2005).

In summary, though current accounting rules do not require companies to disclose their business model and intellectual capital, the literature on the subjects highlight the importance of reflecting value creation and value delivery in this knowledge and information-based age. This serves as a cornerstone for us to investigate the characteristics of an identified emerging business model known as Servitization.

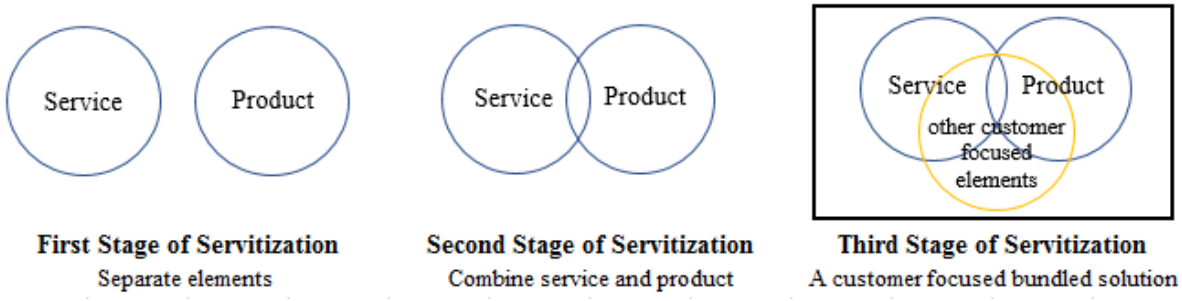
2.2 Servitization Business Model & Intellectual Capital

As the research from Zott and Amit (2007) illustrates, business model innovations reshape the value chain between firms, suppliers, and other stakeholders. One specific example of business model innovation in the manufacturing industry is servitization. Due to rapid technology development, diminishing product life cycles, fast time-to-market requirements, and price pressure from developing countries, product innovation by itself can no longer secure firms' value (Antioco et al., 2008). From a supplier's perspective, most of the added value in their offerings do not lie in the product but in the complementary role that the product plays (Vandermerwe and Rada, 1988). This is consistent with other research on business models that value is no longer created by firms acting autonomously but by firms acting in conjunction with other stakeholders (Beattie and Smith, 2013). Therefore, servitization is found to be a natural progression to companies in fast developing industries, and a differentiation tool to companies in more mature industries in regard to extend products' life cycle and keep business from receding (Vandermerwe and Rada, 1988; Fang et al., 2008; Neely, 2008; Gebauer et al., 2011).

Three stages of servitization have been identified in previous research (see Graph 1). The first stage is goods or service, in which a firm can clearly fit into one of the categories. Typical

examples are financial banks (service) and pure manufacturing firms (products). The second stage is goods and service, where manufacturers find inseparability of goods and services. For instance, many manufacturing firms provide not only products but also service options like maintenance and warranties. The last stage is a customer-focused combination of goods, services, support, and knowledge (Vandermerwe and Rada, 1988). In this stage, manufacturing firms bundle different elements and provide a customized integrated solution to customers. Like the case described in the introduction, Rolls-Royce provides a Total Care Package, which sells the capability of aero engines and bundles elements like leasing, maintenance, finance, etc. In order to amplify the differences between servitized and traditional manufacturing firms, we targeted servitized companies in the second and especially in the third stage.

Graph 1 Three Stages of Servitization



First Stage of Servitization
Separate elements

Second Stage of Servitization
Combine service and product

Third Stage of Servitization
A customer focused bundled solution

In order to verify this new business model, previous research mostly focuses on firm value changes. Servitization can impact companies' firm value in mainly two ways, generating intellectual capital and altering the financial outcome.

2.2.1 Servitization Intellectual Capital

In terms of intellectual capital, we find servitization mainly contribute to structural capital and relational capital. The absent of human competencies is because no specific complementary related to employee skills are identified in previous research when adopting the servitization business model. We believe that this is because a macro perspective is taken for business model innovation, and human competencies are a rather minor factor in such a transformation. Thus,

in this paper, we divided the intellectual capital generated from servitization into two groups: structural capital and relational capital. Intellectual capital identified in previous literature is presented in Table 1. Three kinds of intellectual capital are found in structural capital; differentiation, leverage knowledge and resources, and culture. Two kinds of intellectual capital are acknowledged in relational capital; customer loyalty and company reputation.

Table 1 Intellectual Capital Identified in Previous Servitization Literature

	Structual Capital					**Relational Capital**		
	Differentiation	**Leverage Knowledge and Resource**			**Culture**	**Customer Loyalty**		**Reputation**
Authors (Year)/ Descriptions	Enhance Competitiveness	Customer Knowledge	Co-create Value	Product Effectiveness	Organizational Reconfiguration	Long-term customer relationship	Higher Customer Satisfaction	Society and Environmental Benefit
Antioco et al (2008)	✓	✓	✓		✓	✓	✓	
Eggert et al (2014)	✓	✓			✓			
Kastalli and Looy (2013)	✓	✓	✓			✓	✓	✓
Neely (2008)	✓			✓				✓
Ambroise et al (2018)					✓		✓	
Visnjic et al (2016)		✓	✓	✓				
Fang et al (2008)	✓	✓		✓		✓		
He and Lai (2012)	✓	✓	✓	✓		✓	✓	

(i) Structural Capital

Differentiation

As Cova et al (2000, p.10) put in the paper presented in Industrial & Purchasing 2000 Conference,

> "*... in a logic of differentiation, industrial product companies have developed their offers by adding more and more services directly linked to products in order to help the implementation of the products by, and for, the customers. Such an approach has been at the centre of industrial marketing for a long time.*"

This clearly shows that much of the manufacturers' interest in service is based on the intention of differentiation.

In order to respond to commoditization and stay competitive, manufacturers can no longer

simply rely on product innovation but need to turn to service and customized solutions. This is because compared to products, services require more co-production, customization, and direct sales contact (Fang et al., 2008), and altogether makes it harder for other suppliers to provide same customer offerings. As a result, a servitized solution is often difficult to imitate and regarded as more unique (Fang et al., 2008; Ambroise et al., 2018; Eggert et al., 2014).

Leverage Knowledge and Resources

A positive value loop between products and service is expected to be developed based on accumulated experience from manufacturing products for specific customer applications, and this will help the company to generate a long-term benefit – customer knowledge (Markides and Williamson, 1996; Fang et al., 2008; Kastalli and Looy, 2013). During the information exchange process, suppliers and customers work closely together and create the solution. The co-creation is important because suppliers are able to know customer's needs and can actively impact their activity chain (Ambroise et al., 2018). For instance, instead of transferring the ownership of an asset, a servitized solution could be selling the availability of the asset. This kind of dynamic and flexible offerings can better respond to customer's need and create value for both parties.

Culture

As companies apply the servitization business model, an organizational reconfiguration is normally found within the firm (Antioco et al., 2008; Eggert et al., 2014; Ambroise et al., 2018). Many previous studies have shed light on the organizational configuration led by servitization, in which manufacturing firms change from product oriented to customer oriented. This change needs to be carried out with different organizational parameters such as service technology, top management's commitments and visionary leadership, and service reward (Antioco et al., 2008). Over time a customer-oriented culture is believed to be the key for companies to successfully

transform into a servitization business model (Eggert et al., 2014).

(ii) Relational Capital

Customer Loyalty

Because of the close interactivity among suppliers and customers, a servitized solution often better respond to customers' needs (Kastalli and Looy, 2013; Fang et al., 2008; Ambroise et al., 2018; Antioco et al., 2008; He and Lai, 2012). Besides, a long service contract period provides opportunities for companies to develop a more customized solution and establish a foundation of trust. (Morgan and Hunt, 1994; Antioco et al., 2008; Eggert et al., 2014; Ambroise et al., 2018). With trust and close cooperation, customer loyalty is expected to grow and hence enable the servitized company to sustain a competitive advantage in the long run.

Company Reputation

Servitization plays a particularly important role in building a company's reputation. Since this new business model revises the concept of asset ownership (Kastalli and Looy, 2013; Ambroise et al., 2018; Antioco et al., 2008; Neely, 2008), the supplier and customer are both incentive to minimize the environmental impact of the product (Neely, 2008). Take Rolls-Royce for instance, they are motivated to maximize assets' useful life in a service contract and develop higher quality aero engines to avoid maintenance cost and accident rate. At the same time, customers are also driven to optimize their use of the asset since they are charged by the engine hours. Considering this, servitization can have a positive effect on both environment and society, and therefore strengthen a servitized company's reputation.

Altogether, servitization stimulates intellectual capital by enhancing structural capital and relational capital. These different kinds of intellectual capital are considered to be the main drivers of a company's long-term success and hence contribute to a higher company value (Fang et al., 2008; Visnjic et al., 2016).

2.2.2 Servitization Financial Outcome

In addition to intellectual capital, servitization also affects firms' financial performance. In table 2, we presented previous empirical research on financial outcomes of servitization. Most of the early stage research emphasizes its positive influences on firm value. The positive influences mainly lie in the financial benefits constituted by service characteristics: a substantial potential revenue, higher profit margin, and a more stable source of revenue (Gebauer et al., 2005).

Table 2 Empirical Research on Financial Outcomes of Servitization

			Financial Performance Measurement		
Cluster	**Authors (Year)**	**Country & Data**	**Revenue**	**Profit**	**Firm Value, method**
Revenue	Antioco et al (2008)	Belgium, the Netherlands, and Denmark, 137 manufacturing firms	+		
Revenue & Profit	Eggert et al (2014)	German, 513 mechanical engineering companies	+	short term: − long term: +	
	Kastalli and Looy (2013)	Worldwide, 44 Atlas Copco's subsidiaris	short term: − long term: +	short term: − long term: +	
	Neely (2008)	25 Countries, 10,028 publicly traded manufacturing firms	+	−	
Profit	Ambroise (2018)	France, 184 manufacturing firms		+	
Profit & Firm Value	Visnjic et al (2016)	Developed countries, 133 publicly traded manufacturing firms		short term: − long term: +	short term: − long term: + Tobin's q
Firm Value	Fang et al (2008)	US, 477 publicly traded manufacturing firms			short term: − long term: + Tobin's q
	He and Lai (2012)	China, 229 publicly traded manufacturing firms			+, SERVQUAL model[a]

+: Increase, −: Decrease

[a] SERVQUAL model is developed by Parasuraman et al (1985, 1988). It contains 22 items for assessing customer perceptions and expectations regarding the quality of service.

However, a phenomenon called "service paradox" is found in a lot of previous empirical research, namely that it appears more difficult for firms to make incremental profits by adding services than what might be expected (Gebauer et al., 2005; Reinartz and Ulaga, 2008). This situation could be explained by the challenge of changing managers' mindset from offering a product to offering an integrated product and service solution (Ng et al., 2012). Kahneman et

al (1982) identified several difficulties in changing the mindset when adopting servitization business model. One difficulty is that manufacturers normally concentrate on tangible products since they are more concrete than services. Thus, generally speaking, manufacturers appear more reluctant to invest in expanding service business. Another significant difficulty lies in the risk aversion of managers in manufacturing firms. Since adding services is regarded as beyond the traditional business scope, it brings more uncertainty to the outcome of an investment and thus generates higher risk to the managers. Therefore, although many firms claim to adopt servitization, they are unprepared to solve the complication of extending into service business.

Furthermore, other studies find that servitization increases the revenues but simultaneously decreases the profit margin due to higher R&D expenses and labor costs (Neely, 2008; Antioco et al., 2008; Eggert et al., 2014, Kastalli and Looy, 2013). But this is not always the case. Since the degree of servitization and company performance is highly intervened, a positive result appears when the company achieves a critical mass of service (Fang et al., 2008; Suarez et al., 2013; Kastalli and Looy, 2013). The paper by Fang et al (2008) investigates the effectiveness of servitization for generating shareholder value by analyzing the financial performance of 477 publicly traded manufacturing firms during 1995 – 2005. Some managerial implications have been identified. For example, firm value remains relatively flat or slightly negative before the company build a critical mass of service sales, which is normally 20%-30% sales revenue. However, once a company reach a critical mass of service, an increasingly positive effect will show in company value. Besides, this model is more effective if the service offerings are strongly related to the company's core business, and this can be explained by the concept of cost-effectiveness: the financial outcome and intellectual capital gained from developing a new service business normally cannot exceed the investments.

Another study conducted by Visnjic et al., (2016) also supports the findings that servitization normally leads to a short-term performance sacrifice but brings in long-term performance

benefits. Based on data from 133 servitized listed companies in developed countries, the research indicates that a short-term profitability declined because of increased R&D investments in product innovation. However, since companies may develop long-term competitive edge generated by intellectual capital, servitization is believed to bring firm value growth in the long run.

In brief, moving towards service usually leads companies to a lower profitability margin in the beginning due to initial investments; overtime though, companies will realize financial advantages with intellectual capital, extensive industrial services offerings and growing profit (Vianjic et al., 2016; Eggert et al., 2014).

Collectively, these reviews provide a meaningful background knowledge regarding the characteristics of this model. However, we also identify a limitation in previous research. Although many researchers have studied the relationship between servitization and profitability, limited papers have focused on the relation of intellectual capital and firm value.

2.3 Hypothesis

As the implementation of the servitization business model normally relies heavily on long-term investments and intellectual capital, we argue that the differences between market value and book value will increase accordingly. To be more concrete, we believe that after reaching a critical mass of service revenue (20-30%), the firm value of a servitized company will increase. This lies mainly in realizing the financial interest of investments and intellectual capital. However, since intellectual capital generally does not fit into accounting rules and is not recognized as an asset in the balance sheet, the book value will not increase in conjunction with the market value. Therefore, a growing gap between market value and book value will appear and be reflected in a higher q-value.

Hypothesis: The implied q-value of servitized manufacturing firms is higher than the one of

traditional manufacturing firms.

3. Methodology

3.1 Research Design

Given the study aims to understand the different value of two manufacturing business models, a quasi-experimental design was deemed appropriate. Specifically, we are interested in the q-value of different business model, and therefore the RIV model was implemented as the foundation framework with financial data collected from the COMPUSTAT database for publicly listed North American manufacturing firms in 2017. Additionally, the traditional manufacturing firms were defined as the non-servitized firms in this study.

3.2 The Concept of q-value & Computation Approach

The q-value was first known as the expected goodwill to book ratio and could be seen as the valuation measurement bias of owners' equity (Skogsvik, 1998). The q-value is expected to capture various matching errors led by rather strict accounting assumptions regarding investment pattern and a constant inflation rate (Johansson and Östman, 1995). In detail, matching errors lie mainly in three aspects. First, non-liquid assets and capitalized expenses are normally recognized based on historical transaction prices or contractual obligation values instead of fair market value. Second, unrealized value changes of asset/liabilities are in general not recognized. Last, even in some cases, companies are allowed to recognize unrealized value changes, only value decrease in asset and value increase in liability can be recognized. In general, these matching errors are mainly due to the accounting principle of prudence. Thus, according to the study of Skogsvik (1998), the prediction of the expected q-value should be taken into account when discussing the connection between accounting numbers and stock market prices.

Generally speaking, the q-value can be separated into two parts: one is the relative business

goodwill of owners' equity and the other is the relative cost matching bias of owners' equity (Feltham and Ohlson, 1996). Since no company is expected to earn abnormal earnings in a perfectly competitive market, a reasonable statement is that relative business goodwill of owner's equity would recede to zero in the long-term (Skogsvik, 1998). However, the relative cost matching bias of owner's equity is expected to last even in a perfectly competitive market. Simply put, the prevailing accounting core principles rely on the notion of conservatism, where historical cost accounting standing as a cornerstone and realization principle guiding the revenue recognition. Thus, when companies reach the steady state, the relative cost matching bias are representative of the q-value, for which we are interested in this thesis.

There are two ways to obtain a firm's q-value. One way is to directly estimate the q-value by the formula: $\mathrm{q}(\mathrm{B}_T) = \frac{(V_T - B_T)}{B_T}$ (Skogsvik et al., 2010), which is defined as the estimated q-value. Another way is to imply the q-value by valuation models. For example, a q-value can be attained from computing all the other variables in the RIV model and imply the q-value accordingly. This kind of q-value is called the implied q-value. In this study, we used the second approach to imply the q-value in steady state and assumed it is equal to the one at valuation point.

Table 3 Comparison between Implied q-value and Estimated q-value

	If Efficient Market Theory Holds	**If Efficient Market Theory Doesn't Hold**
Implied q-value	Correct	Incorrect
Estimated q-value	1. Implied q-value = Estimated q-value, estimated q-value is correct. 2. If Implied q-value ≠ Estimated q-value, estimated q-value is incorrect	N/A

The reasons for choosing implied q-value can be explained by Table 3. On one hand, under the efficient market assumption that share prices reflect all information, implied q-value are considered superior in regard to objectivity. Implied q-value is believed to mirror the true differences between fair capital value and book value since it is built upon share price and

company residual value (the RIV model). Whereas, estimated q-value is more subjective and requires researchers to make their own assumptions. Simply put, there are three guidelines for estimating q-value. First, business characteristics of the company should be normalized in regard to profitability, real growth, and asset structure. Second, only normal rate of inflation exists when the company reaches the steady state. Third, asset values in current cost accounting are close to fair market values in a company steady state. Besides, subjective assumptions are required for non-liquid assets and capitalized expenses such as inventory, operating fixed assets, R&D and marketing expenses, and deferred tax liabilities. Therefore, although it is possible that the estimated q-value is equal to the implied q-value under an efficient market, we regarded the implied q-value as a more reliable choice to reflect the fair measurement bias.

On the other hand, when efficient market theory doesn't hold, we were well informed that the implied q-value would not indicate the real measurement bias. On the contrary, the estimated q-value, in this case, could be closer to or further away from the real measurement bias. We cannot say for sure since the estimated q-value highly depends on researchers' assumptions and prediction.

Altogether, although implied q-value has its limitation, we considered it a superior indicator compared to estimated q-value regarding reliability and objectivity. In this study, we introduced the RIV model as the fundamental framework to imply the q-value.

3.3 Residual income valuation model

Under the assumptions that the clean surplus relation[1] holds and that the discount rate is constant over time, the RIV model is written as:

[1] Clean surplus relation of accounting: $BV_t = BV_{t-} + E_t - D_t$. Assuming that all changes in the book value of equity other than transactions with owners are reflected in income, and therefore this concept enables users to calculate company value in terms of balance sheet and income statement components.

$$V_0 = BV_0 + \sum_{t=1}^{T} \frac{E_{(0)}[(ROE_t - \rho_E) \cdot BV_{t-1}]}{(1+\rho_E)^t} + \frac{E_{(0)}[q_T \cdot BV_T]}{(1+\rho_E)^T}$$

Where $V_0 =$ value of owners' equity at time t = 0,

$\mathrm{BV}_t =$ book value of owners' equity at time t,

$\rho_E =$ cost of owners' equity,

$ROE_t = I_t/BV_{t-1} =$ book return on owners' equity in period t,

$I_t =$ net income for period t,

$q_T =$ accounting measurement bias of owners' equity at time t = T,

$E_{(0)}(\ldots) =$ expectation operator, conditioned on available information at time t = 0.

The RIV model was developed by Ohlson from the dividend discount valuation model (DDM) and the concept of clean surplus relation of accounting in 1995. There were two main reasons why we decided to use the RIV model in our study. One was due to its theoretical advantages and the other was due to the implication advantages.

3.3.1 Theoretical Advantages of the RIV Model

According to prior research, we made a theoretical comparison between the RIV model and other valuation models (see Table 4). That being said, the study made by Francis et al (2000) showed that the RIV model is superior to DDM and the discounted cash flow model (DCF) because the intrinsic value estimates are based on reliable book value of equity, and abnormal earnings are believed to be more precise and predictable compared to a company's future dividends. Moreover, empirical research had found that the RIV model is less sensitive than Abnormal Earnings Growth model (OJ) to assumptions about the forecast horizon and future earnings growth, meaning that with different finite forecast horizons, the RIV model yields a closer valuation result. (Jorgensen et al., 2011).

Table 4 Comparison of valuation models

Panel A: Information from Francis et al.,(2000)			
	RIV	**DDM**	**DCF**
Measurement fundation	Residual income	Dividends	Free cash flow
Valuation accuracy	+++[a]	++	+
Panel B: Information from Jorgensen et al.,(2011)			
	RIV	**OJ**	
Measurement fundation	Residual income	Abnormal earnings growth	
Valuation accuracy	++[b]	+	
Assumption differences	Assumed an industry-specific earnings growth rate after forecaset horizon	Assumed an economy-wide earnings growth rate after forecast horizon	

[a] "+++" means the highest accuracy and "+" means the lowest accuracy.
[b] "++" means higher accuracy and has no relationship with the "+" in Panel A.

3.3.2 Implication Advantages of the RIV Model

The fundamental basis of the RIV model makes it much easier to apply in valuation and hence this model is often used to imply accounting variables such as market expected ROE and cost of capital (Skogsvik et al., 2010; Gebhardt et al., 2001). Implication advantages were found by comparing the calculation of different variables in the RIV model to other valuation models. For example, some variables in the RIV model can be obtained from companies' financial reports without making further assumptions, e.g. current book value and abnormal earnings. Besides, the constant growth rate of abnormal earnings is less abstract and easier to gauge compared to perpetuity expected dividend growth rate (Claus and Thomas, 2001).

After reasoning the choice of the RIV model, an application of the model and the computations of different variables are presented below.

3.4 Variables

We reasonably computed variables in the RIV model based on companies' public information and prior research (see Appendix A). Table 5 summarizes how we computed each variable in the RIV model.

Table 5 Variables in the RIV model

Panel A: Variables for RIV model				
Variables	**t=0**	**T**	**Required rate of return**	**Market value**
	End of May, 2017	12 years	CAPM	Assumed market values equal to stock prices multiply the total amount of outstanding shares
Variables	**ROE**	**Dividend policy**	**Book value**	**Pfail**
	Assumed the ROE trends linearly from the level implied by analysts' earnings forecasts for the end of the forecast horizon to the industry median in 12 years	Assumed dividends payout ratios are constant and equal to the average value of past five years' payout ratio.	Forecast book values related to ROE and dividend payout ratio	Estimated by O-score model and unbaised adjustment
Panel B: Variables for CAPM model				
Variables	**Market risk premium**	**Risk free rate**	**Beta**	
	5%	Ten-year U.S treasury-bill rates	Standard regressions of 36 months of historical market monthly data and S&P 500 index	

Valuation Point t = 0 & Explicit Forecast Period T

The end of May 2017 was taken as the valuation point t = 0 because most financial reports in the US are publicized by the end of May, and all public information for 2016 are expected to be accessible by the investors. Besides, 12 years was used as the forecast period T because of two reasons. One reason is that the explicit forecast period T in previous RIV model research varies from 3 to 12 years (see Appendix A) in consideration of different specifications. The other one is that it takes 12 to 17 years for servitized companies to reach a mature servitization phase based on a statistic research of 52 high-level managers (Martinez et al., 2017). Together, we considered it reasonable to take 12 years as the explicit forecast period T.

Market Value V_0

V_0 in this research is defined as the firm's market price at the end of May 2017. Generally, the market price of a firm is calculated by the stock price of that firm at time t = 0 multiplied number of shares outstanding (Skogsvik et al., 2010, Gebhardt et al., 2001). However, in order to have a more precise market value, we adjusted the market price for companies that did not declare

dividends in May but in other months in accordance with the required cost of capital.

Implied Cost of Capital – CAPM

The formula of CAPM[2] model is presented below:

$$\rho_E = r_f + \beta * rpm$$

Where ρ_E = cost of capital,

r_f = risk free rate,

rpm = risk premium.

Although researchers provided various methods (see Appendix A) to compute the implied cost of capital such as RI cross-sectional model, HVZ cross-sectional model, and CAPM model, we decided to use CAPM in regard to its universality and simplicity. In detail, we estimated the market beta for each company based on prior 36 monthly stock price returns and benchmarked it by the S&P 500 index. Besides, the US ten-year treasury-bill rate was taken as the risk-free rate, and a market premium rate of 5% was used in accordance with previous research.

Return on Equity (ROE)

The return on equity (ROE) forecasts from IEBS database were used to proxy for future ROE in steady state. To be more specific, analysts' forecasts of ROE for selected companies were found from the IBES database and the trend of ROE was assumed to be linearly depreciated to the ROE in steady state. Besides, for companies whose analysts' forecast of ROE could not be found from IBES, the average ROE over the past five years was taken as the forecast ROE for 2018. Subsequently, the forecasted ROE was assumed to increase or decrease linearly to steady state value. Lastly, the ROE of each company in the steady state was estimated based on the

[2] Capital Asset Pricing Model. This model is widely used to describe the relationship between systematic risks and expected return for assets.

median ROEs of each industry for the past five years[3]. If the median ROE was negative, we adjusted it to the first positive value closest to the median.

Book Value (BV_t)

The book value is estimated based on the "clean surplus relation". The formula is

$$\mathrm{BV}_t = BV_{t-1} * (1 + ROE_t * (1 - pr_t))$$

Where BV_t = book value of owners' equity at time t,

ROE_t = book return on owners' equity in period t

pr_t = dividend payout ratio at time t.

We assumed that the dividend payout ratio is constant and equal to the average dividend payout ratio of the past five years. Besides, in order to avoid extreme values, if the payout ratio was over 50%, we adjusted it to 50%. Likewise, if the payout ratio was below 0%, we regarded it as 0%.

Bankruptcy Rate (P_{fail})

In contrast to previous literature assuming company will continue to operate and meet going concern principle, we considered it reasonable to take bankruptcy rate into consideration since servitization is a rather new and riskier business model.

One-year O-score Model (Ohlson, 1980):

[3] The industry median ROE is based on S&P 500 and obtained from WRDS. Specifically, we combined SIC and Fama & French (1997) industry classification to define the right industry in S&P 500 and retrieve the ROE in steady state.

$$
\begin{aligned}
&\text{y} \\
&= -1.32 - 0.407(\text{Size}) + 6.03\left(\frac{Total\ liabilities}{Total\ assets}\right) - 1.43\left(\frac{Working\ capital}{Total\ assets}\right) \\
&+ 0.057\left(\frac{Current\ liabilities}{Current\ assets}\right) - 2.37\left(\frac{Net\ income}{Total\ assets}\right) \\
&- 1.83\left(\frac{Working\ capital\ flow\ from\ operations}{Total\ liabilities}\right) \\
&+ 0.285(1\ if\ net\ income\ was\ negative\ for\ the\ last\ two\ years, 0\ otherwise) \\
&- 1.72(1\ if\ total\ liabilities\ exceed\ total\ assets, 0\ otherwise) \\
&- 0.521\left(\frac{Change\ in\ net\ income}{Sum\ of\ absolute\ values\ of\ current\ and\ prior\ years'net\ incomes}\right)
\end{aligned}
$$

Where Size = log (total assets/GNP deflator). The deflator assumes a base value of 100 for 2015.

Working capital flow from operations = cash flow from operations + changes in other working capital items.

Then the probability of bankruptcy (P_{fail}) is transformed from y by the equation of:

$$\mathrm{P}_{fail} = \frac{1}{1 + e^{-y}}$$

Furthermore, in order to reduce bias in the bankruptcy rate, the following formula was used to adjust the bankruptcy rate:

$$\mathrm{P}_{fail(u)} = P_{fail} * [\frac{\phi(1 - prop)}{prop(1 - \phi) + P_{fail}(\phi - prop)}]$$

Where prop = Number of failed companies in relation to the total number of companies in the estimation sample;

Φ = Proportion of failed companies in the population of companies;

$\mathrm{P}_{fail(u)}$ = The unbiased probability of bankruptcy.

In this study, ϕ was assumed to be 1% based on an average percentage of bankruptcy in North America from 1980 to 2000 (Hillegeist et al., 2004). In order to ensure the validity of our study,

an adjustment based on Fama and French (1997) industry classification system was then applied to P_{fail}. For $P_{fail(u)}$ >5%, we assumed it is equal to the average industry bankruptcy rate conducted by Hillegeist et al, in 2004.

By carefully computing each variable, we were able to imply the q-value in selected firms, both servitized and non-servitized. Besides, in response to the validity of final q-value, we found it necessary to adjust the q-values larger than 10 to 10. Following the methodology, sample selection procedures and selected company samples are presented below.

3.5 Sample Selection

Manufacturing companies were selected from COMPUSTAT database and classified into two categories, servitized firms and non-servitized firms. Companies were selected based on their servitization degree at the valuation point. Below the steps were outlined and concluded in Table 6.

Table 6 Sample Selection

Panel A: Servitized Companies	
Selection Criterion	**Number of Companies**
All active North American manufacturing companies in 2017	2477
Companies with service segments	236
Companies with servitization ratio larger than 50%	53
Companies with positive book value of equity at valuation point	48
Panel B: Non-servitized Companies	
Selection Criterion	**Number of Companies**
All active North American manufacturing companies in 2017	2477
Companies without service segments	2241
Companies without service selected based on annual reports	48

Servitized manufacturing firms

To begin with, the standard industrial classification (SIC) code from 20-39 was used to find US manufacturing companies (see Appendix B). North American Industrial Classification System

(NAICS) code and segment name were then applied to distinguish service revenue from total revenue. For instance, revenue belongs to the NAICS code "541330" is "engineering service", which is related to a range of consulting and evaluation activities, and thus can be defined as service-related revenue. In short, manufacturing firms with revenue classified under the 541330 code were regarded as providing not only products but also services, and therefore have adopted servitization to some degree. To evaluate the servitization degree of a firm, the service-related revenue over total revenue (service revenue / total revenue) was taken as a determinant. Companies with a degree over 50% were classified as servitized companies. Furthermore, the ones with negative equity value were removed to increase the validity.

Generally speaking, 236 companies were found to contain service revenue based on NAICS revenue code. However, only 53 firms had a degree over 50% (half of the revenue comes from service), which we defined as the minimum degree to be classified as a servitized company. This ratio is set to amplify the differences between the two groups. In terms of the servitized samples, 67% (32) of the identified servitized firms had a degree higher than 80%, and 33% (16) of them were between 50% and 80%. This rather small sample confirmed that servitization is a relatively new business model and not so many firms have adopted it. Besides, another reason for a low number of servitized firms was that companies are not required to disclose their detailed revenue information. For instance, some companies might have provided some associated service along with their products, but we were not able to identify them if the company did not reveal them in their income statement and remark them as service revenue.

In addition, 33% (16) of identified firms were from SIC 27, *Printing, Publishing, and Allied Industries*. It was reasonable because most of the publishers provide subscription service and charge a monthly fee instead of per book's price. Besides, printing firms might also provide customized service and professional design service for customers. Surprisingly, the second highest percentage 23% was from SIC 20, *Food and Kindred Products*. This was because except

producing food, many identified servitized firms in this industry launched their own restaurants and provided distribution service.

Non-servitized manufacturing firms

Based on the identified servitized companies, the same number of non-servitized firms were identified from the 2241 zero-servitized-degree companies in the same SIC code industry with similar company size[4]. For example, as mentioned above, we found 16 servitized companies in SIC 27 with various company size. In order to keep consistency, we took 16 non-servitized manufacturing firms with similar company size under this code.

4. Findings & Discussions

4.1 Comparison of the Variables in the Residual Income Valuation Model

Table 7 RIV variables Summary

Panel A: Servitized companies					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
Cost of capital	9.31%	4.90%	32.56%	8.86%	0.87%
Probability of bankruptcy	1.42%	1.09%	4.85%	1.17%	0.07%
ROE[a]	0.79%	38.26%	46.80%	5.28%	-211.02%
Dividend payout ratio	22.29%	22.13%	50.00%	19.10%	0.00%
Book value (MUSD)[b]	6,954.08	28,212.93	189,362.44	850.50	2.46
Market value (MUSD)	9,366.08	22,396.44	115,785.13	1,797.69	2.75
Panel B: Non-servitized companies					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
Cost of capital	9.13%	4.37%	23.91%	8.42%	1.91%
Probability of bankruptcy	1.24%	1.23%	4.85%	0.67%	0.00%
ROE[a]	4.84%	33.27%	54.49%	8.73%	-177.48%
Dividend payout ratio	18.29%	21.16%	50.00%	2.90%	0.00%
Book value (MUSD)[b]	4,983.36	25,093.06	173,830.00	394.92	3.83
Market value (MUSD)	12,937.81	54,045.26	341,099.91	771.76	0.83

[a] Summary the value of company's ROE at the valuation point
[b] Summary the value of company's book value at the valuation point

In Table 7, we summarized the statistical data of key variables used in the RIV model. Specifically, in Panel A the key statistical data for servitized companies are presented and in Panel B the data related to non-servitized companies are reported. By comparing Panel A and B, we found that servitized companies have higher mean cost of capital and mean probability

[4] To ensure the validity of non-servitized sample, we went through their annual reports and websites to verify if they were really non-servitized companies.

of bankruptcy than non-servitized companies. This outcome is consistent with prior literature that servitization is a relatively new business model with higher risks.

In terms of ROE, the average ROE for servitized companies is 0.79%, while the average ROE for non-servitized companies is 4.84%. This substantial difference could be explained by the characteristics of servitized companies from two perspectives.

Firstly, servitized companies normally have a higher equity value. Based on the study of Fang et al., (2008), the profitability of servitized companies is highly influenced by the servitization degree, meaning that a positive effect appears only after companies reaching a critical mass of service. For the servitized companies in this study, they all have a servitized degree higher than 50%, which means they all reach the critical mass point (20-30%) and obtain a positive effect on their company value long before. Therefore, the lower ROE ratio can be explained partly by the higher equity value in servitized firms compared to non-servitized firms. Secondly, the annual revenue of servitized firms is normally lower than their counterparts considering service characteristics. Instead of selling one-time products to customers, servitized companies provide long-term services. As a result, the annual income of servitized companies could be more stable yet lower at the same time. In other words, servitized companies receive the total revenue over a longer period. Therefore, it is reasonable for servitized companies to have a lower ROE compared to non-servitized firms.

Besides, one might find the ROE in the table much lower than the normal ROE, which is around 12%[5]. The reason is that there were some companies with extremely low ROE in our sample and thus pulled down the average ROE value. For example, the minimum ROE for servitized and non-servitized companies are -211.02% and -177.48% respectively, whereas the maximum ROE for both groups are around 50%. Therefore, comparing the median ROE for servitized and

[5] Based on a statistic of average return on equity by sector in the US conducted by NYU Stern, http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/roe.html

non-servitized firms, 5.28% and 8.73% respectively, the value is much closer to the normal ROE.

Additionally, for book value and market value, some criteria were made in the sample selection to make two groups comparable. Due to this selection criteria, it is reasonable that the differences between two groups' mean book value and mean market value are mild. In general, it is logical to say that we alleviated the influence of these two factors by selecting comparable non-servitized companies.

4.2 Summary of q-values

Considering servitization is a rather new and transformative business model, we used the conditioned implied q-value (implied q-value with bankruptcy rate considered) as our main result. Since a company's bankruptcy rate is estimated based on its historical financial performance and business model characteristics, it is reasonable to say that applying servitization business model might impact a firm's bankruptcy rate and further affect its implied q-value. This is further supported by the study conducted by Neely in 2008 that a higher bankruptcy rate is found in servitized companies. Altogether, we found it logical to consider bankruptcy rate when computing the implied q-value in order to reflect the real consequences and effects of servitization.

4.2.1 Main result – Conditioned Implied q-value

Table 8 Implied q-value Statistic Summary

Panel A: Main result

	Mean	Std Deviation	Maximum	Median	Minimum
q-value (ser[a])	1.77	2.68	10.00	0.63	-0.88
q-value (nonser[b])	0.81	1.71	7.35	0.50	-1.12

Panel B: T-test and Wilcoxon test for main result

	T-test[c]		Wilcoxon test[d]	
	t-statistic	p-value	w-statistic	p-value
q-value	2.08	0.040*	934.00	0.111

*p < 0.05; **p < 0.01
[a] Servitized companies' implied q-value
[b] Non-servitized companies' implied q-value
[c] H_0: true difference in means is equal to 0; H_1: true difference in means is not equal to 0.
[d] H_0: true location shift is equal to 0; H_1: true location shift is not equal to 0.

In Table 8 we summarized our final results, the conditioned implied q-value, in Panel A, and presented the t-test and Wilcoxon test in Panel B. The result shows that the mean q^*_{ser} – henceforth denoted *the conditioned implied q-value for servitized companies* – is 1.77 and mean q^*_{nonser} – henceforth denoted *the conditioned implied q-value for non-servitized companies* – is 0.81. Meaning that a substantial difference is found under the two different business models. Moreover, a negative minimum q-value are found under both conditions. This is an uncommon result since market price is generally higher than company book value. The reason could be that these companies adopt aggressive accounting instead of conservative accounting, and therefore lead to a higher book value.

Panel B of Table 10 presents the results of t-test on mean implied q-value and Wilcoxon test on the median implied q-value. On one hand, the t-statistic is larger than 2 and p-value is lower than 0.05, demonstrating that the mean q-value between servitized and non-servitized companies is statistically different at the confidence level of 95%. On the other hand, the p-value of Wilcoxon test is 0.11 and larger than 0.05, meaning that the median of two groups is not statistically different at the confidence level of 95%. These results show that the difference

between q^*_{ser} and q^*_{nonser} might be induced by extreme values. Specifically, the maximum value of q^*_{ser} is 10, while q^*_{nonser} is only 7.35, and q^*_{ser} have higher standard deviation than q^*_{nonser}. In order to have a general view of the sample, we focused on the mean implied q-value in this study. Therefore, considering the outcome of t-test, the results support the hypothesis we put forward at the beginning that the q-value of servitized companies is higher than the q-value of non-servitized companies.

Runsten's research in 1988 is introduced to explain the higher q-value. According to his research (see Appendix B), the permanent measurement bias (PMB) in different industries various due to specific industrial characteristics and required cost of capital. To be more specific, industries which heavily rely on goodwill, intangible assets, or long-term investments are more likely to have a higher measurement bias, while those with current tangible assets normally have a lower measurement bias. For instance, a higher q-value (0,76) is found in the intensive-capital service industry to reflect the accounting conservatism. More specifically, intensive-capital service industry holding long economic life assets normally find a substantial earnings recognition lag and more difficult to capture short-term value creation (Runsten, 1998; Warfield and Wild, 1992), and thus lead to a higher measurement bias. On the other hand, for engineering firms, the q-value (0.33) is lower because they tend to hold a small amount of long-life assets and thus regarded as more liquid.

Some characteristics are identified in generating higher cost matching bias for a firm. Such characteristics include (1) Perpetual and considerable R&D investments. (2) Perpetual and considerable marketing expenditures. (3) Significant investments in specialized human capital. (4) Perpetual and considerable investments in assets with long economic life. (5) A significant inventory of ongoing projects with a long production cycle and a large cumulated income realized as project progress (Runsten, 1998). In short, firms with great potential value "investment" will normally have a higher q-value due to accounting limitation.

As manufacturers start to adopt servitization, retain assets, and provide an alternative solution to customers, they are considered gradually transforming from an engineering industry to a intensive-capital service industry and accordingly changing their business characteristics. For example, considerable investments in R&D and long economic life assets, a significant inventory of ongoing projects with a long production cycle, and a large cumulated income realized as project progress are found typical in servitized firms but not in non-servitized companies. Thus, our result is consistent with prior research that firms with greater long-life assets, investments, and long production cycle will lead to a higher implied q-value.

Apart from the cost matching principle resulting in measurement bias, we also took values that generally lie outside companies' book such as intellectual capital into account. In particular, servitization business model is found highly related to intellectual capital. Under an efficient market, in which investors realize intellectual capital brought by servitization and reflect them on the market share price, intellectual capital that is not recognized in companies' book might contribute to a higher implied q-value.

Altogether, considering these two accounting limitations, we find it reasonable to have a higher implied q-value for servitized manufacturing firms.

4.2.2 A Comparison with Runsten's Results

Although the result is consistent with the business characteristics that Runsten discussed in his research, one might find the mean q^*_{ser} and q^*_{nonser} surprisingly high compared to Runsten's results in 1988, where he found the q-value of different industries is between 0.28 and 1.74.

On one hand, the mean q^*_{ser} (1.77) is over the highest q-value (1.74) in Runsten's study which lies in the pharmaceutical industry. On the other hand, the mean q^*_{nonser} (0.81) is also higher than the q-value for manufacturing industries (approximately 0.30) reported by Runsten.

Generally speaking, the implied q-value in this study is much higher than Runsten's research, no matter the companies apply servitization or not. There are several justifications for the remarkably high mean q^*_{ser} and q^*_{nonser}. Firstly, as technology and business development, there is an increasing number of intangible assets and intellectual capital that do not fit into accounting regulations and cannot be recognized in financial statements. Therefore, assuming the market is efficient, the q-value will naturally increase in order to reflect accounting limitation. Secondly, different countries have different market efficiency level and thus lead to different q-value. The research of Runsten was based on the Swedish market while we focused on the North America market. Therefore, a higher measurement bias could be due to different regions and different market efficiency. Most importantly, we took the bankruptcy rate into consideration while Runsten's research targeted on going-concern companies. In order to examine the real driver of the higher q-value, we made a robust test to verify whether the significant high q-values are generated by the bankruptcy rate.

4.2.3 Robust Test – Unconditioned Implied q-value

Table 9 Robust Test for Unconditioned Implied q-value

Panel A: Robust test (exclude Pfail)					
	Mean	**Std Deviation**	**Maximum**	**Median**	**Minimum**
q-value (ser[a])	1.37	2.58	10.00	0.38	-0.88
q-value (nonser[b])	0.52	1.40	6.12	0.31	-1.13

Panel B: T-test and Wilcoxon test for robust test result				
	T-test[c]		**Wilcoxon test[d]**	
	t-statistic	**p-value**	**w-statistic**	**p-value**
q-value	2.02	0.047*	969.00	0.181

*p < 0.05; **p < 0.01
[a] Servitized companies' implied q-value
[b] Non-servitized companies' implied q-value
[c] H_0: true difference in means is equal to 0; H_1: true difference in means is not equal to 0.
[d] H_0: true location shift is equal to 0; H_1: true location shift is not equal to 0.

Panel A of Table 9 illustrates the outcome of the unconditioned q-value (the implied q-value without bankruptcy rate), where the mean q_{ser} – henceforth denoted *the unconditioned*

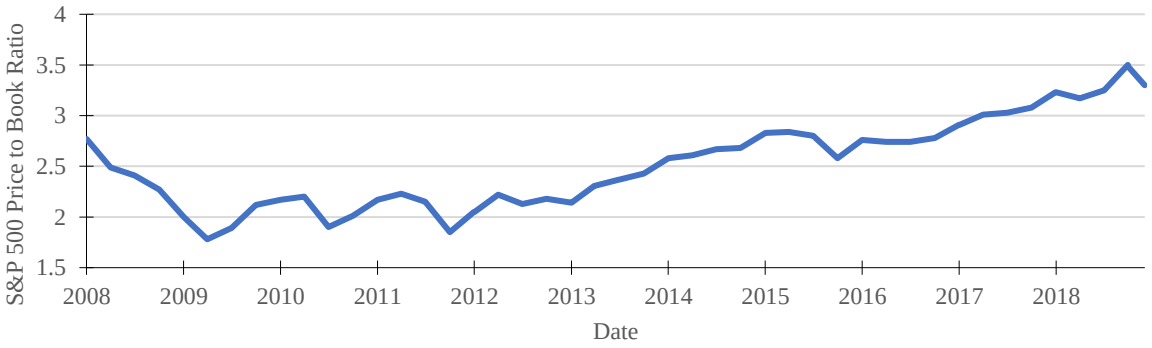
implied q-value for servitized companies – and mean q_{nonser} – henceforth denoted *the unconditioned implied q-value for non-servitized companies* – are 1.37 and 0.52 respectively. Panel B presents the results of t-test and Wilcoxon test for the unconditioned q-value. The outcome is consistent with the conditioned implied q-value. The mean value between q_{ser} and q_{nonser} is statistically different at the confidence level of 95%, while the median is not significantly different.

The mean q_{ser} and q_{nonser} are both lower than the conditioned ones. However, the mean q_{nonser} (0.52) is still larger than the q-value of the manufacturing industries (approximately 0.30) provided by Runsten's research. There are several possible explanations for this situation.

Firstly, the high mean q_{nonser} might be contributed by the outliers. This explanation is supported by the medium q-value. It is found that the median q_{nonser} presented in Table 9 is 0.31, and this value is located in the reasonable range provided by Runsten (1998).

Secondly, the higher q-value could be due to a general overpricing of the North American market. Graph 2 shows that the price to book value ratio (P/B) of S&P 500, which is taken as the proxy for the whole North American market, has been gradually increased over the past 10 years. As shown in the graph, the P/B ratio at the valuation point (May 30, 2017) of this study is higher than in the past. Hence, from a macroeconomic point of view, the generally increasing price in North American might contribute to the high mean q_{nonser} in this research.

Graph 2 Price to Book ration of S&P 500



Thirdly, the high q-value might be generated by the fundamental characteristics of the RIV model. The research of Jorgenson et al., (2011) shows that the ratio of equity value estimates to stock price based on the RIV model is lower than that ratio based on OJ model. Meaning that the equity value estimated by the RIV model might be lower than that estimated by OJ model, and thus indicating RIV model is a more conservative valuation method. Therefore, when we took the market price at the valuation point and used the RIV model to imply the q-value, the implied q-value might be higher than directly calculated by other valuation models.

Finally, another reason for a higher q-value lies in our sample selection. For example, some non-servitized companies selected in the sample might have provided product associated services that are not disclosed in their financial reports, and hence should not be classified as non-servitized companies but as semi-servitized companies. To verify whether the sample classification is valid, a statistical analysis was applied to the sample. Table 10 summarizes the results of the statistical analysis. One interesting outcome we found in the two identified groups of companies is that 52% of servitized companies put services as their main focus or main strategy on the company website's "About Us"-section, and another 34% do not directly mention service but have implied services such as consultancy and advertising (see Appendix D). In contrary, for the non-servitized companies, none of them has put service nor implied service on their websites' - "About Us"- section. Besides, 76% of servitized companies provide service as an independent business segment separated from products on their websites, while non-servitized firms focus more on advertising their products. Moreover, a terminology analysis of "service" is applied in companies' annual reports. A frequency of 1.1 "service" per page is found for servitized firms, while only 0.6 "service" per page for non-servitized firms. In general, we consider our sample selection valid in this study and the high q_{nonser} might not be a result of an invalid classification of non-servitized companies.

Table 10 Information comes from annual reports and websites

	Websites			Annual Reports
	About us		Offerings	
	"Service" metioned directly[a]	"Service" metioned indirectly[b]	"Services" offering ratio[c]	Indirectly descripions about service[d]
Servitized companies	0.52	0.34	0.76	1.12
Non-servitized companies	0	0	0	0.59

[a] "service" mentioned directly = the number of companies that mention the term "service" in the company "about" of their websites / total number of companies in that group
[b] "service" mentioned indirectly = the number of companies that indirectly mention services in the company "about" of their websites (e.g consultancy, marketing, and distribution) / total number of companies in that group
[c] services offering ratio = the number of companies put service-related offerings as one of their main business on their websites / total number of companies in that group
[d] "service" mentioned ratio = the number of the term "service" appeared in the annual report / the number of total pages of the annual report

4.3 Sensitivity Analysis

Several sensitivity analyses were made to test the validity of the main result (see Table 11).

Table 11 Sensitivity Analysis

Panel A: Main result					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
q-value (ser[a])	1.77	2.68	10.00	0.63	-0.88
q-value (nonser[b])	0.81	1.71	7.35	0.50	-1.12
Panel B: Extend explict forecast horizon					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
q-value (ser[a])	1.71	2.80	10.00	0.68	-1.00
q-value (nonser[b])	0.79	2.28	10.00	0.23	-1.18
Panel C: Change the forecast method of servitized companies' ROE					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
q-value (ser[a])	1.89	2.76	10.00	0.73	-1.01
q-value (nonser[b])	0.81	1.71	7.35	0.50	-1.12
Panel D: Change the benchmark index of Beta					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
q-value (ser[a])	1.62	2.56	10.00	0.50	-0.87
q-value (nonser[b])	0.80	1.72	7.35	0.48	-1.12

[a] Servitized companies' implied q-value
[b] Non-servitized companies' implied q-value

The first sensitivity analysis was made to extend the explicit forecast period from 12 years to 15 years. As shown in Panel B, the mean q-value of servitized companies is 1.71 and the mean of non-servitized companies is 0.79. These values are lower than those of our main result (1.77 and 0.81), but the changes are rather small and insignificant. This outcome is consistent with the empirical research by Jorgensen et al., (2011) that the valuation accuracy of the RIV model estimates will not improve much when the forecast horizon increases. This is likely because the

RIV model decreases the influence of future earnings expectation's noise contained in the current earnings by anchoring on the current book value of equity and thus reducing the benefit of extending the forecast horizon. In conclusion, our result is not sensitive to the explicit forecast period.

The second test was made on the forecast ROE trend for servitized companies during the explicit forecast horizon. For the main result presented before, we assumed companies' ROE linearly depreciated from the estimated ROE values[6] to industry median for both groups. While in the sensitivity analysis we adjusted this assumption with servitization characteristics. Based on the studies of Fang et al., (2008) and Kastalli and Looy (2013), an increasing customer loyalty will lock in customer, lock out competitors, and accordingly form an analogous monopoly market for the servitized firms. As a result, we assumed that the estimated ROE of servitized companies will keep constant for the next five years and subsequently depreciate linearly to industry median afterwards. In contrary, the ROE of Non-servitized companies were forecasted in the same way as the one in the main result. The adjusted result is reported in Panel C. The mean and median q-values of servitized companies are 1.89 and 0.81 respectively, which are slightly larger than those of the main result. Overall, we find the result is not sensitive to the forecast ROE trend.

Lastly, we changed the beta estimation method, and the result is reported in Panel D. Instead of S&P 500 index, we used the CRSP index as the benchmark to estimate beta. The mean q-value for servitized and non-servitized companies in this test are slightly lower than those in the main result. The reason might be that the companies' sizes in S&P 500 are relatively larger than those in CRSP index, which includes all securities issued in US market, and thus resulting in a higher

[6] The estimated ROE value is either based on analyst's company ROE forecast from IBES database or the average ROE from past five years.

and more stable beta than the one based on CRSP index. Generally speaking, changing the beta estimation method did not bring much difference in our result.

Variables such as forecast horizon, ROE forecast, and beta in the CAPM model were verified in the sensitivity analyses because they require assumptions made by researchers and thus are regarded as more subjective. Overall, the result revealed that the main result is stable and not sensitive to subjective assumptions.

4.4 An Examination of the Differences in Implied q-value – Servitization Assets

Based on prior literature, the intellectual capital brought by servitization business model is assumed to be the main driver of the q-value's difference. However, since intellectual capital normally lies outside of accounting framework, "servitization asset" is taken in this case to proxy for intellectual capital. Hence, a further examination was applied to verify if the difference in servitized and non-servitized implied q-value is due to the generation of the "servitization asset". Accordingly, an assumption was made:

The difference in the two implied q-values equals the implied q-value of estimated servitization assets generating from servitization business model

The equation is written as:

$$\bar{q}_{ser} - \bar{q}_{nonser} = q_{imp.ser\ SA}$$

Where $\bar{q}_{ser} =$ Average implied q-value of servitized firms

$\bar{q}_{nonser} =$ Average implied q-value of non-servitized firms

$q_{imp\ SA} =$ Implied q-value of estimated servitization asset brought by servitization

Simply put, the differences between the two implied q-values are assumed to be generated by the implied q-value of servitization assets. Following we computed the measurement bias of

estimated servitization assets in servitized firms and calculated the estimated q-value accordingly to verify this assumption.

4.4.1 Estimated Measurement Bias and q-value of Servitization Assets

Assume that

- The companies in the same industry have the same economic life on servitization asset
- The residual value of servitization asset is equal to zero
- Estimated servitization assets are made at the beginning of each year
- All servitization assets are linearly depreciated

$$MB_{SA} = \sum_{t=1}^{T} [Estimated\ service\ investment_{T-t} * \frac{remaining\ economic\ life}{total\ economic\ life} * \prod_{t=1}^{t} (1 + inflation\ rate_{T-t})] - \mathrm{BV}_{SA}$$

Where $MB_{SA} =$ Measurement bias of estimated servitization asset

$Estimated\ service\ investment = \text{service revenue}_i * (1 - gpm_i)$, where gpm = gross profit margin $= \frac{\text{revenue} - \text{cost of goods sold}}{\text{revenue}}$, i = servitized company i

$BV_{SA} =$ Book value of total servitization asset = Book value of intangible asset

$T =$ Total economic life of estimated servitization asset

Similar to the capitalized marketing expense, the service investments here were based on the service revenue and the gross profit margin of the company, meaning that the service expense is used to proxy for the investment in servitization asset.

The total intangible asset is taken as the book value for this examination for two reasons. On one hand, in order to adopt servitization, some firms might need to acquire other companies to perform service and therefore generates goodwill in their financial reports. On the other hand,

while there is a lot of intellectual capital generated by servitization identified in previous research, only few are recognized in intangible assets such as customer relationship, intellectual property and marketing supply network, and therefore total intangibles are the best implication we can find in the book.

And for the economic life of servitization asset, 3 year is taken based on two reason. Firstly, we went through all selected sample companies' annual reports and found that the average industry asset useful life ranging from 3 to 15 years. For example, the assets in SIC 36[7] have the average economic life of 7 years, while those in SIC 20[8] have the longest average economic life of 15 years. Considering the similarity between capitalized marketing expense and servitization asset, a rather shorter economic life is taken to reflect the uncertainty of this kind of new asset. Secondly, since this is a developing business model, no standard economic life is regulated or generally accepted. Therefore, a shorter economic life is taken in this thesis in response to accounting conservatism. Worth noticing, when we manually went through companies' annual reports, we found that a stronger customer loyalty and trust could lead to a higher economic life in company assets. For example, a longer economic life is found in the food industry compared to electronic products, and this is especially highlighted when the manufacturing firms provide healthy food products or organic food offerings which leads to a stronger customer loyalty.

Moreover, the formula of estimated q-value of servitization assets is presented below:

$$q_{est\ SA} = \frac{MB_{SA}}{BV_{SA}}$$

Where $q_{est\ SA} =$ estimated q-value of servitization asset

In order to avoid extreme values, absolute estimated q-values above 4.53 were adjusted to 4.53. We adjusted the q-value to 4.53 in accordance to the empirical research of Goebel (2015)

[7] Electronic, Elctrcl Eqpmnt & Cmpnts, Excpt Computer Eqpmnt industry
[8] Food and Kindred Products industry

regarding intellectual capital value. The research provides an average market to book ratio (M/B) of intellectual capital (3.42) based on a sample of 1511 firm years of German companies. In order to estimate the maximum reasonable q-value for servitized intangible assets, we calculated the M/B with a 95% confidence level and found a confidence interval between 1.31 and 5.53. Hence, it is logical to suggest that the maximum q-value for intellectual capital in our study should be 4.53 (5.53 - 1).

4.4.2 The Outcome of the Estimated q-value of Servitization Asset

Table 13 Measurement Bias Statistic Result

Panel A: Measurement Bias					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
Estimated Service Investment (MUSD)[a]	3392.8	7607.2	42666.6	898.8	1.1
Accumulated Investment (MUSD)	3437.9	7708.4	43234.1	910.8	1.1
Book Value (MUSD)	6954.1	28212.9	189362.4	850.5	2.5
Measurement Bias	1974.9	7870.7	41490.9	91.3	-14170.3
Panel B: Estimated q-value of Servitization Asset					
	Mean	**Standard Deviation**	**Maximum**	**Median**	**Minimum**
Estimated q-value	0.62	1.65	4.53	0.40	-4.53

[a] Estimated Service Investment = Service revenue * (1 – gross profit margin)

Altogether, the average $q_{est\ SA}$ is 0.62 (see Table 12). This average $q_{est\ SA}$ is intended to reflect the accounting bias caused by servitization assets. For instance, although almost all servitized companies pinpoint customer relationship essential for their business in annual reports, only 41.7%[9] of servitized manufacturing firms have recognized the value of customer relationship in their book. Hence, with great market value and limited booked value for servitization assets, a higher q-value for those servitized companies is found reasonable.

However, as presented in table 12, the minimum $q_{est\ SA}$ is negative, and this is mainly due to goodwill. Since we were not able to find the book value of total servitization asset (intellectual

[9] This number is based on a manual research of servitized companies' annual report

capital) in servitized firms and took the total intangible assets instead, this limitation leads to the emergence of a negative estimate q-value. Yet, with manually went through the acquisition in financial reports, we found most merger and acquisition in servitized companies are related to service. For example, many manufacturing firms expand their business to logistics provider to offer end-to-end solution. Therefore, we found it reasonable that servitized firms with more merger and acquisition could potentially lead to a negative $q_{est\ SA}$.

Overall, the estimated q-value (0.62) for servitization assets is smaller than the difference in the implied q-values (0.96) of different business models. Since the servitization asset here refers to intellectual capital as discussed in prior literature, we conclude that except intellectual capital generated by servitization business model, there could be other factors contributing to the value difference between servitized and non-servitized firms. For example, R&D and Deferred Tax Liabilities can also generate higher measurement bias and thus a higher q-value. However, though the estimated q-value of servitization assets does not explain the higher implied q-value in servitized companies perfectly, we can still reasonably conclude that the main driver of the higher q-value lies in servitization assets, the intellectual capital.

5. Conclusion

In summary, a higher implied q-value in servitized firms was found and discussed in this research. Starting by a fundamental analysis on RIV variables, a lower ROE and a higher bankruptcy rate were found in response to servitization characteristics. Subsequently, the reasons for generating a higher implied q-value for servitized firms were discussed and verified. The reasons mainly lie in the interplay of accounting limitations and servitization characteristics. For instance, the servitization characteristics such as more long-term investments and longer production cycle will all contribute to a higher q-value due to accounting conservatism and revenue recognition delay. Finally, in the last part, we specifically investigated intellectual capital, which is proxied by servitization assets, and discussed its role in the higher q-value.

Simply put, we find it reasonable that intellectual capital explains most of the difference in the q-value since it is the value driver for servitization while it generally lies outside the accounting framework. Altogether, this study does not only prove that the characteristics of the servitization business model are significantly different from those of traditional manufacturing business model but also quantifies the value driver, intellectual capital, in this business model.

With our research question in mind, this study does not only demonstrate that the servitization business model generates a different firm value compared to the traditional manufacturing business model but also support previous research on the existence of intellectual capital.

5.1 Contributions

Our study contributes to accounting research and practice in mainly three ways. First, we provide an empirical research on the financial implications of the servitization business model. Although there is a lot of previous research on servitization, most of them illuminate the firm value change in servitized companies while few measures the difference between servitization business model and traditional manufacturing business model. Therefore, regarding the research on this topic still at an early stage and need more attention, we contribute to shed light on quantifying the firm value difference between these two business models.

Second, instead of taking a marketing or strategic perspective, we analyze the difference in business model from an accounting point of view. To be more specific, the differences between market value and book value is illustrated by the implied q-value in this study. Worth noticing, a higher implied q-value is found for servitized manufacturing firms in this study, indicating a change in business characteristics such as holding more long-term investments and intellectual capitals.

Lastly, in order to explain the implied q-value difference, we analyzed the value driver behind servitization and brought in the concept of intellectual capital. By investigating the q-value of

intellectual capital, we found evidence that most of the implied q-value differences between servitized and non-servitized firms are due to intellectual capital. In other words, we contribute to accounting research that a business model with a range of intellectual capital will increase its implied q-value and thus a higher difference between market value and book value.

5.2 Limitation & Future Research

Our research has several limitations that need to be taken into account when interpreting our results. We are confined by a relatively small data set, and our core value driver, intellectual capital, is derived from the qualitative assessment of previous research rather than from hard, quantitative evidence. Below are the limitations we identified in our research and requiring future research.

First, the sample in this study is rather small containing only 96 companies in total and 48 companies in each group. This is mainly due to a time restriction. Although we based our sample selection on servitization degree and had quickly gone through each company's annual report, there is much other information that could be taken into consideration when selecting samples. For example, most of our data is extracted from the COMPUSTAT database which provides standardized company information, and hence specific company information is found simplified and sometimes removed. As a result, there might be some companies that are highly servitized but not included in our sample. For further research, we suggest researchers look into annual reports and other company disclosures to determine their company samples.

Second, although a strong relation between servitization and intellectual capital is implied by the study, we did not quantify the correlation between implied q-value and intellectual capital due to technical restriction. Currently, there is no generally accepted way to quantify intellectual capital beside qualitative questionnaires and balanced scorecards. Therefore, further research can discuss the correlation coefficients between q-value and servitization value driver.

Third, some data used in this research were based on prior literature which published at the end of 20th or beginning of 21th and may be considered outdated or unrepresentative now. For example, the average bankruptcy rate for industries was based on a research conducted in 2004, fourteen years ago. Hence, it may increase the validity of results if researchers can find more recent data to use for future studies.

Last but not least, this study focuses on the implied q-value for servitized firms in the steady state, which means that we focus only on mature servitized firms. However, we do believe that the implied q-value would vary in different phase. Hence, further research is suggested to consider the changes of q-value during the development of servitization.

6. Appendix

Appendix A Variables in the RIV model

Panel A: Test of validity of RIV

		Variables used in the RIV model					
Authors (Year)	**Sample**	**Dividend policy**	**Prepetuity growth rate**	**t=0**	**T**	**Required rate of return**	**ROE**
Dechow et al (1999)	All US firms from 1976 to 1995, and a total of 50133 observations	Assumed dividends equal to the earning of the last period of explict forecast horizon		End of April	3 years	12% (Approximatly the long-run average realized return on US equities)	
Francis et al (2001)	2907 firm-year observations between 1989 to 1993		Presented both result for growth rate equals to 0% and 4%	End of December	5 years	CAPM	
Jorgensen et al (2011)	24886 observations of 4292 US firms between 1984 and 2005	Estimated the future dividend-payout ratio by dividing actual dividends paid by earning of the most recent years	Assumed a common growth rate for all firms equals to the risk-free rate less 3%	End of April	12 years	CAPM	Assumed the ROE trends linearly from the level implied by analysts' earnings forecasts for the end of the forecast horizon to the industry median in 12 years

Panel B: Estimation of implied cost of capital and ROE

		Variables used in the RIV model					
Authors (Year)	**Sample**	**Dividend policy**	**Prepetuity growth rate**	**t=0**	**T**	**Required rate of return**	**ROE**
Gebhardt et al (2001)	All US firms from 1979 to 1995	Divided actual dividends from the most recent fiscal year by earnings over the same time period	Obtain from IBES	End of June	12 years	Implied cost of capital	The moving median of past ROEs from all firms in the same industry.
Claus & Thomas (2001)	The sample includes firms whose forecast data can be found in the database IBES from 1985 to 1998.	Based on the dividend payout ratio of previous years and found it is around 50%	Assumed the growth rate equals to the growth rate provided in IBES over the first five forecast years	End of April	5 years	Implied cost of capital	
Daske et al (2010)	Contain 8036 US firms from 1970 to 2009		Estimated the growth rate for the first period and then use this forecast iteratively to obtain further forecasts		50 years	Implied cost of capital	Monte Carlo simulations
Skogsvik & Skogsvik (2010)	Manufacturing companies listed on the Stockholm Stock Exchange from 1970 to 2003	Assumed that the market-based expectation of dividend payout ratio equals to the historical average value of dividend payout ratio		End of March	3 years	CAPM	Implied ROE

Appendix B US SIC codes included in the sample selection

20	Food and Kinderd Products
21	Tabacco Products
22	Textile Mill Products
23	Apparel and other Finished Products Made from Fabrics and Similar Materials
24	Lumber and Wood Products, except Furniture
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing, Publishing, and Allied Industries
28	Chemicals and Allied Products
29	Petroleum Refining and Related Industries
30	Rubber and Miscellaneous Plastics Products
31	Leather and Leather Products
32	Stone, Clay, Glass, Concrete Products
33	Primary Metal Industries
34	Fabricated Metal Products, except Machinery and Transportation Equipment
35	Industrial and Commercial Machinery and Computer Equipment
36	Electronic and other Electronic Equipment and Components, except Computer Equipment
37	Transportation Equipment
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks
39	Miscellaneous Manufacturing Industies

Appendix C The partial PMB estimates for each industry as classified by Runsten (1998)

MES (= machinery, equipment and ships)

Table 5.2 Summary of the estimated partial *PMB*s per industry. The industries have been ranked in descending *PMB* order.

Estimated partial *PMB*s due to different measurement problems for different industries	MES	Buildings	Trading property	Land	Investment in shares	R&D expenses	Personnel develop. expenses	Marketing expenses	Deferred taxes	= Total *PMB*
Pharmaceutical	0.06	0.09				1.08			0.51	**1.74**
Capital-intensive service*	0.23	0.15		**	0.06				0.33	**0.76**
Consumer goods	0.15	0.11			0.01			0.25	0.20	**0.72**
Investment companies					0.53				0.16	**0.68**
Pulp and paper*	0.23	0.08		0.07	0.01				0.27	**0.67**
Shipping	0.47	0.02			0.02				0.14	**0.65**
Other service	0.03	0.04			0.02		0.40		0.14	**0.62**
Consultants & computer*	0.03				0.01		0.40		0.15	**0.59**
Real estate		0.31	0.12	0.01	0.01				0.10	**0.56**
Mixed build. and real est.	0.02	0.02	0.35	0.01	0.01				0.12	**0.55**
Trading and retail	0.03	0.21							0.23	**0.47**
Chemical industry*	0.10	0.12			0.01				0.21	**0.44**
Building and construction	0.03	0.03	0.12	0.01	0.02				0.16	**0.38**
Engineering*	0.07	0.10			0.01				0.15	**0.33**
Other production*	0.07	0.10			0.01				0.13	**0.31**
Conglom. & mix. inv. *	0.04	0.08			0.08				0.09	**0.28**

* Industries that contain particular companies with an estimated bias related to R&D.
** Two electrical utility companies have partial *PMB*s amounting to approximately 0.30.

Appendix D Detailed descriptions about how to obtain data in Table 10

We went through the " About US " section of companies' websites and verified whether this part mentions service directly or indirectly. For example, Deluxe, a check producer in the US, describes itself as following:

> *"At Deluxe we strive to be an indispensable partner to the small businesses and financial institutions we serve. Our goal is to provide you with products, services and advice you need to help you achieve success.*
>
> *Small Businesses: From personalized printed products to logo design, web services, and search engine marketing that helps your business get found, we work to deliver the most innovative products and services to help you live your passion…"*
>
> From Deluxe Corporate Website, About Us

On the other hand, below is the website "About Us" of American Biltrite Inc, a traditional non-servitized manufacturer:

> *American Biltrite Inc. has three primary operating divisions; the Tape Products Division (pressure sensitive adhesive tapes and protective films), American Biltrite Canada Ltd. (commercial flooring and performance sheet rubber), and K&M Associates L.P. (fashion jewelry and accessories). With over 100 years of product design and manufacturing excellence, American Biltrite products are recognized internationally for quality, value, and performance.*
>
> From American Biltrite Inc Website, Company Overview

Therefore, although both manufacturing firms provide customer-oriented solutions, Deluxe Corporate clearly states its service business in their company description while American Biltrite Inc emphasizes purely on its products.

Besides, 76% of servitized companies provide service as an independent business segment separated from products on their websites, while normally non-servitized firms only focus on their products. For example, in Deluxe's website offerings for small businesses, it has *Check & Business Supplies* (products focus), *Logo Design & Print Marketing* (service focus), and *Website & Online Marketing* (service focus). In contrast, we can only find products such as *Pressure Sensitive Tapes, Flooring & Industrial Rubber,* and *Fashion Jewelry* on American Biltrite Inc's website.

Moreover, we did a statistical analysis on the frequency of the term "service" used in the annual report of selected manufacturers and found a difference between servitized and non-servitized firms. A frequency of 1.1 "service" per page is found for servitized firms and 0.6 "service" per page for non-servitized firms. The difference could increase much more if we include more terms related to service such as "maintenance", "consultancy", "distribution", and "advertisement". However, we found it too difficult to identify all terms related to service and therefore we only took service in this terminology analysis. Even though the difference is not significant, we found it indicative as it showed that companies applying servitization are intended to deliver this message to stakeholders.

Appendix E Raw data for 48 servitized companies

Ticker symbol	Company name	Stock price	Share outstanding	Stockholders equity (MUSD)	Net income (MUSD)	Dividends (MUSD)
ACRS	ACLARIS THERAPEUTICS INC	23.78	26733000	169.49	-48.079	0
ADM	ARCHER-DANIELS-MIDLAND CO	41.58	568357000	17181	1279	701
AHC	A. H. BELO CORP	5.65	19259000	89.152	-19.31	8.792
ANDV	ANDEAVOR	83.24	117521000	8127	734	249
BG	BUNGE LTD	79.97	140377000	7343	745	262
BRSS	GLOBAL BRASS & COPPER HLDGS	30.3	21885000	95.2	32.2	3.3
CNRD	CONRAD INDUSTRIES INC	17.5	7291000	115.839	-1.694	2.06
COT	COTT CORP QUE	13.19	138938000	873.8	-77.8	31.7
DAR	DARLING INGREDIENTS INC	15.67	164651000	2076.222	102.313	0
DBD	DIEBOLD NIXDORF INC	26.45	75477000	1024.8	-33	64.6
DLX	DELUXE CORP	68.16	48501000	880.97	229.382	58.72
E	ENI SPA	31.86	3634185000	56016.348	-1544.813	3040.031
EBF	ENNIS INC	16.05	25435000	251.355	1.78	57.2
GCI	GANNETT CO INC	7.85	113636000	856.761	52.71	73.994
GIFI	GULF ISLAND FABRICATION INC	9.25	14851000	263.032	3.515	0.588
HCHC	HC2 HOLDINGS INC	5.3	42156000	96.898	-94.549	10.849
HCMC	HEALTHIER CHOICES MNGMT CORP	0.0001	27536252000	2.458	10.684	0
HII	HUNTINGTON INGALLS IND INC	195.81	46020000	1653	573	98
HMHC	HOUGHTON MIFFLIN HARCOURT CO	12.35	123205000	880.04	-284.558	0
IBA	INDUSTRIAS BACHOCO SAB DE CV	55	600000000	1538.351	191.426	37.831
IMAX	IMAX CORP	25.05	66597000	621.574	28.788	0
INGR	INGREDION INC	114.09	71641000	2595	485	138
JW.A	WILEY (JOHN) & SONS -CL A	50.7	48156000	1003.137	113.643	71.545
KEWL	KEWEENAW LAND ASSN LTD	102.5	1293000	20.097	0.699	0
LABL	MULTI-COLOR CORP	85.9	16952000	381.82	60.996	3.383
LKSD	LSC COMMUNICATIONS INC	21.27	33942000	240	106	8
MDR	MCDERMOTT INTL INC	6.21	283862000	1595.468	34.117	0
MHGVY	MARINE HARVEST ASA	17.572	490168000	2183.525	569.386	441.179
MIDD	MIDDLEBY CORP	128.36	57532000	1265.318	284.216	0
NEWM	NEW MEDIA INVESTMENT GROUP	12.93	53614000	754.973	31.641	60.101
NS	NUSTAR ENERGY LP	45.58	93031000	1611.617	150.003	396.812
NYT	NEW YORK TIMES CO -CL A	17.6	160738000	844.244	29.068	25.901
OGZPY	GAZPROM PJSC	4.238	23673513000	189362.435	15749.592	2885.857
PCH	POTLATCHDELTIC CORP	45.75	40609000	156.274	10.938	60.842
PME	PINGTAN MARINE ENTERPRISE	3.04	79055000	139.712	-13.718	3.162
PPC	PILGRIM'S PRIDE CORP	23.27	248753000	896.747	440.532	699.915
PRBZF	PREMIUM BRANDS HLDGS CORP	69.015	29860000	426.4	68.9	44.5
RENX	RELX NV	20.68	1016812000	2909.065	1432.326	842.617
SATS	ECHOSTAR CORP	59.05	47805000	4006.805	179.93	0
SFLY	SHUTTERFLY INC	49.49	33765000	559.161	15.906	0
TGEN	TECOGEN INC	3.38	24706000	14.511	-1.096	0
TRI	THOMSON-REUTERS CORP	43.66	720550000	13256	3098	1017
TRT	TRIO-TECH INTERNATIONAL	5.42	3523000	20.871	0.779	0
VALU	VALUE LINE INC	17.25	9715000	37.854	10.367	6.705
VCYT	VERACYTE INC	8.14	33870000	59.581	-31.358	0
VJET	VOXELJET AG	5.31	3720000	54.381	-11.91	0
VVPR	VIVOPOWER INTERNATIONAL PLC	3.49	13557000	64.606	5.581	0
WY	WEYERHAEUSER CO	32.96	751933000	9180	1027	955

Appendix F Raw data for 48 non-servitized companies

Ticker Symbol	Company name	Stock price	Share outstandin	Stockholders equity (MUSD	Net income (MUSD	Dividends (MUSD)
ABLT	AMERICAN BILTRITE INC	280	34000	33.305	1.265	0
ACCO	ACCO BRANDS CORP	11.35	109551000	708.7	95.5	0
BF.B	BROWN FORMAN CORP	51.95	215717000	1370	669	274
BIBLF	BRICK BREWING CO LTD	3.75	34969000	37.836	3.997	1.822
BREW	CRAFT BREW ALLIANCE INC	16.7	19263000	119.661	-0.32	0
BRFS	BRF SA	13.36	812473000	3756.117	-114.472	30.186
CPB	CAMPBELL SOUP CO	57.65	304379000	1533	563	390
CPS	COOPER-STANDARD HOLDINGS II	108.01	17858000	721.791	138.988	0
CRS	CARPENTER TECHNOLOGY CORP	36.47	46741000	1104.9	11.3	34.8
CVRR	CVR REFINING LP	9.7	147600000	1296.7	15.3	0
CYAN	CYANOTECH CORP	3.8	5669000	16.607	-1.215	0
DCI	DONALDSON CO INC	47.96	132104000	771.4	190.8	91.5
EVA	ENVIVA PARTNERS LP	28.1	14412000	309.517	21.377	138.505
FPNUF	FP NEWSPAPERS INC	0.12	6903000	8.699	-9.491	0
FTPLF	FORTRESS GLOBAL ENTRPRS INC	4.8494	14323000	210.549	6.879	0
GURE	GULF RESOURCES INC	1.77	46794000	349.461	36.226	0
HAIN	HAIN CELESTIAL GROUP INC	34.93	103448000	1664.514	47.429	0
HUSKF	HUSKY ENERGY INC	11.6035	1005452000	17627	922	36
IDWM	IDW MEDIA HOLDINGS INC	45.11	4843000	36.712	3.669	0.844
IFSPF	INTERFOR CORP	17.63	70030000	786.667	65.643	0
ITPOF	INTERTAPE POLYMER GROUP INC	17.48	59125000	242.943	51.12	31.694
JJSF	J & J SNACK FOODS CORP	130.1	18718000	637.974	75.975	29.081
MLFNF	MAPLE LEAF FOODS INC	25.3351	129610000	2088.023	181.702	48.348
MNGA	MAGNEGAS CORP	1.84	6460000	3.829	-17.47	0
NANO	NANOMETRICS INC	27.8	25252000	243.774	44.035	0
ORBT	ORBIT INTERNATIONAL CORP	4.24	4485000	15.194	1.392	0
PEP	PEPSICO INC	116.87	1428501000	11199	6329	4283
PFIE	PROFIRE ENERGY INC	1.45	50221000	41.388	0.078	0
POLA	POLAR POWER INC	5.19	10143000	23.652	4.403	0
PPSI	PIONEER POWER SOLUTIONS INC	7	8713000	26.199	-1.063	0
QUAD	QUAD/GRAPHICS INC	22.27	37787000	441.5	44.9	63.2
QUTIF	QUESTOR TECHNOLOGY INC	0.9345	26457000	14.766	-0.445	0
SCHL	SCHOLASTIC CORP	42.53	33170000	1307.9	52.3	20.9
SIF	SIFCO INDUSTRIES	7.5778	5599000	60.37	-11.335	0
SPPJY	SAPPI LTD	7.327	556303000	1378	319	0
SSD	SIMPSON MANUFACTURING INC	40.18	47654000	865.842	89.734	33.53
TEX	TEREX CORP	32.78	97600000	1521.2	-176.1	30
TIS	ORCHIDS PAPER PRODUCTS	14.29	10303000	133.245	12.811	14.4
TORSF	TORSTAR CORP -CL B	1.1862	70909000	326.17	-74.75	14.514
TREC	TRECORA RESOURCES	10.7	24253000	164.376	19.428	0
TSN	TYSON FOODS INC -CL A	57.34	288192000	9624	1768	233
TWI	TITAN INTERNATIONAL INC	10.37	59657000	289.934	-33.987	1.081
TWNK	HOSTESS BRANDS INC	15.74	99286000	1231.411	52.807	0
UBNT	UBIQUITI NETWORKS INC	47.16	80268000	440.376	213.616	0
UFAB	UNIQUE FABRICATING INC	9.29	9755000	50.059	6.684	5.812
WFSTF	WESTERN FOREST PRODUCTS INC	1.5517	395448000	522.5	94.2	31.6
XOM	EXXON MOBIL CORP	80.5	4237266000	173830	7840	12453
ZCOM	IMPRESO INC	0.71	5279000	14.653	0.116	0

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