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The impact of digitalization and servitization on the financial performance of a firm: an empirical analysis — Source link

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Abstract

Manufacturing firms have vigorously pursued opportunities for profitability and growth through servitization and digitalization processes. However, the current body of research provides contradictory results on the impact of servitization and digitalization on firm financial performance. This paper seeks to address the interdependency between servitization and digitalization and how they enhance operations and the business bottom line, it also addresses how manufacturing companies can turn technology into business process transformation. To address this gap this paper develops and tests a framework for assessing the impact of servitization and digitalization on firm financial performance. This study analyses a survey of 185 U.S. and European manufacturing firms showing empirical evidence that digitalization and servitization had a direct positive effect on a firm's financial performance, in terms of revenue generation, profit and market value. This research gives managers some insights to better understand the digital transformation role in enhancing the servitization process. These results also have significant theoretical implications to the servitization literature, since achieving superior bottom-line results is contingent on the integration of the digital and service-specific capabilities that reinvent the nature of an offering, this enables a manufacturing firm and its customers to operate radically better than before.

Keywords: Servitization, Digitalization, Firm performance, Structural equation modelling.

1. Introduction

In recent years, manufacturing firms have been increasingly looking for opportunities to grow beyond traditional core products by providing services; this is conventionally known as 'servitization,' a term first coined by Vandermerwe & Rada, (1988). This strategy allows an organization to shift from selling a product to selling an integrated product and service offering (Barrett, Davidson, Prabhu, & Vargo, 2015). Pursuing servitization can enhance and transform a manufacturers' competitive landscape by providing a combination of product-service systems rather than standalone products (Baines & Lightfoot, 2014; Neely, 2008).

Prior empirical studies investigated the impact of servitization on a firm's financial performance (e.g. Eggert, Hogreve, Ulaga, & Muenkhoff, 2014; Fang, Palmatier, & Steenkamp, 2008; Kastalli & Van Looy, 2013; Kharlamov and Parry, 2020; Kohtamäki, Partanen, Parida, & Wincent, 2013; Kohtamäki et al., 2020 ; Suarez, Cusumano, & Kahl, 2013; Bigdeli et al., 2018; Wang, lai and Shou, 2018; Zhou et al.,2020), but produced conflicting results and addressed the "servitization paradox" (Gebauer, Fleisch, & Friedli, 2005). This paradox refers to an increase in business investment to enhance service offerings which leads to higher expenditures and lower corresponding returns.

Stanley and Wojcik (2005) found that manufacturing firms who transcended the market offering to include more services often fell short of outperforming the pure product counterparts. The services missed the mark in terms of revenue growth, profit margins and returns on equity. Only 21% of companies succeeded with service-led growth strategies (Baveja, Gilbert, & Ledingham, 2004). Several empirical studies have also confirmed a

positive effect of the services on manufacturers' sales and revenues (e.g. Antioco, Moenaert, Lindgreen, & Wetzels, 2008; Fang et al., 2008; Homburg, Fassnacht, & Guenther, 2003).

In this context, servitization is defined by Baines et al., (2009a) as "the innovation of an organisations' capabilities and processes to better create mutual value through a shift from selling product to selling product service system (PSS)." This definition is from the field of operations management, which has stressed the importance of servitization and service innovation in order to enhance manufacturing productivity and efficiency (Spring & Araujo, 2009; Baines et al., 2009a). Despite many efforts, servitization can still be considered as a theoretically nascent domain (Kowalkowski, Gebauer and Oliva, 2017) that needs further development and more empirical evidence on its impact on firm performance is needed.

In terms of service innovation, digitalisation can be considered one of the major trends of modern manufacturing (Schiavone & Sprenger, 2017; Vendrell-Herrero et al., 2017). Digitalization refers to "the way many domains of social life are restructured around digital communication and media infrastructures" (Brennen and Kreiss, 2016) Often used as a synonym, digitization refers to "the material process of converting analogue streams of information into digital bits" (Brennen and Kreiss, 2016). Sebastian et al., (2017) articulate the operational definition of digitalization on the macro level highlighting the importance of two technology-enabled assets which found fundamental to a successful digital transformation: first the operational backbone which ensures efficiency and reliability of major operations; and a digital service platform supporting and integrating IoT and Cyber-Physical Systems increasing operational agility and sustainable innovation (Ardolino et al., 2018). Furthermore, digital technologies allow product and service companies to choose, design and provide new smart and connected products and services that transform their competitive advantage (Porter and Heppelmann, 2014).

The digitalization of manufacturing processes, especially through using big data and predictive analytics, is now paving the way for companies to enhance demand forecasting, increase asset utilization, and optimize resources in the manufacturing process. The use of sensor data for predictive maintenance is also helping companies to increase up time and achieve smoother operations (Vendrell-Herrerro, Bustinza, Parry and Georgantzis, 2017)

The current digital initiative, in which manufacturing companies can collect, analyse, integrate and interpret high quality, real-time data, is fuelling process automation, predictive analytics, artificial intelligence, and robotics in the manufacturing operation (Vendrell-Herrerro et al., 2017). The use of the new digital technologies, such as block chain, are enhancing collaboration between parties and helping to track the flow of goods and services across borders, which ensures trust between businesses (Golzer and Fritzche,2017). Artificial intelligence is also improving the repetitive processes in the supply chain, such as procurement, invoicing and some aspects of customer service (Golzer and Fritzche,2017)

Westerman, Bonnet, and McAfee (2014) found that 45% of manufacturing firms were still in the very early stages of digital transformation. This clearly indicates that the manufacturing sector is trailing others in embracing digitalization initiatives. However, the empirical findings of Westerman et al. (2014) confirmed that the manufacturing firms that are advanced in combining digital and leadership capabilities significantly outperformed counterparts in revenue generation, profitability and productivity.

In addition to this, Vendrell-Herrerro et al., (2017) confirmed the links between servitization and digitalization exploring the benefits of digital servitization in the supply chain. The process of strategic change to develop a business model to be more customer-centric (with servitization) and data-driven (with digitalization) can become a competitive advantage and may cause superior financial performance, as it increases the firm's strategic fit with ongoing contextual changes (Coreynen, Matthyssens, & Van Bockhaven, 2017; Gebauer, Edvardsson,

Gustafsson, & Witell, 2010). Consequently, this supports the assumption that both servitization and digitalization have a direct effect on a company's financial performance.

Despite the valuable insight gained from the servitization literature so far, a large-scale empirical proof of the relationships between the implementation of services, digital capabilities and firm financial performance remains scant, vague and far from conclusive (Baines, 2015; Benedettini, Neely, & Swink, 2015; Bigdeli et al., 2018; Eggert et al., 2014). After reviewing this growing body of research, the present paper suggests the need to advance knowledge in two directions. First, the servitization field lacks common lexicon and accepted analytical tools to understand servitization (Kowalkowski et al., 2017; Bigdeli et al., 2018). Thus, this study is contributing with a measurement scale for the servitization construct. Second, given the contradictory results of the effect of industrial services on firm performance, a more fine-grained empirical model of the interdependencies among servitization, digitalization and firm financial performance is required (Kohtamäki et al., 2018). Therefore, this study will shed light on this research gap. In order to achieve these objectives, the remainder of this paper is organized as follows. In Sections 2, the existing servitization literature related to its theoretical underpinnings is reviewed and three research hypotheses are suggested. In Section 3, the research methodology and measures are explained. Section 4 and 5 introduce the empirical methods utilized to test the hypotheses and infer causality culminating in presenting the results. Section 6 discusses the findings and the associated managerial implications. Finally, limitations and future avenues for research are presented in Section 7.

2. Research Framework and Hypotheses

The proposed model linking the servitization with financial performance and linking digitalization with both Servitization and financial performance is illustrated in *Fig. 1*. This paper provides definitions of the constructs used in the model in Table 1. The model has been

controlled for the confounding effects of company's size, age, slack resources and industry (see Figure 1).

[INSERT FIGURE 1 HERE]

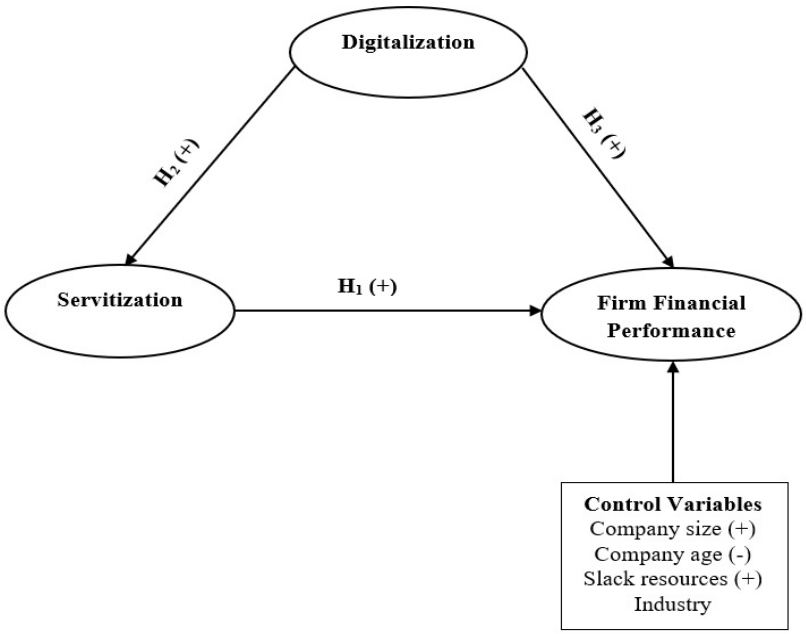

Figure 1 Research framework and hypotheses.

[INSERT TABLE 1 HERE]

Table 1 Definitions of the constructs.

Construct	Definition
Servitization (Baines et al., 2009a)	Servitization is the innovation of an organisation's capabilities and processes so that it can better create mutual value through a shift from selling products to selling Product□ Service Systems.
Digitalization (Matzler et al., 2016 ; Vendrell- Herrero etal., 2017)	Digitalization is defined as the exploitation of digital opportunities. By combining different technologies (e.g. cloud technologies, sensors, big data, 3D printing) that opens possibilities to develop radically new products, providing digital services embedded in a physical product and business models.

Financial performance (Westerman et al., 2014)	Financial performance is defined as the firm's ability to generate revenue, make profit and increase its market value.

2.1 Servitization impact on firm financial performance

A substantial body of servitization research argued that services could represent a more profitable long-term source of revenue than initial product sales (Eggert et al., 2014). However, services are known to be knowledge-intensive, labour-intensive and difficult to standardise, which can increase the transaction cost and hamper profitability (Kohtamäki & Partanen, 2016). Prior research suggested that servitization was a beneficial strategy in which manufacturers could differentiate themselves from competitors (Oliva & Kallenberg, 2003). Additionally, it was shown to lead to higher profitability (Suarez et al., 2013), an increase in market value (Fang et al., 2008) and an increase in customer loyalty (Baines & Lightfoot, 2013).However, these studies offered little robust evidence on the real impact of servitization on firm performance (Crozet & Milet, 2017; Gebauer et al., 2005; Visnjic Kastalli & Van Looy, 2013). Add to that the contradictory results produced by prior empirical studies, and the need to develop a fine-grained empirical model to clarify the true nature of this relationship emerged (Benedettini et al., 2015). The model is required to further explain why the expected benefits of servitization did not materialise in many cases, causing what has been named as the "service paradox" (Gebauer et al., 2005).

Prior empirical research investigated the financial consequences of servitization (e.g. Neely, 2008), and found that servitization of manufacturers generated higher revenues but lower net profits than pure manufacturing firms. This was because servitized firms encountered higher

average labour costs, working capital and net assets. Conversely, other scholars empirically established a positive relationship between service offerings and company outcomes (Antioco et al., 2008; Homburg et al., 2003).

For instance, the study by Homburg et al. (2003) supported (indirect) effects of service orientation on service profitability and overall company profitability. Similarly, Gebauer (2007) found a positive relationship between the customer service support strategy and overall profitability. While Ruiz-Alba et., (2019) B2B empirical servitization study adds more evidence that servitization positively impacts firm performance when a high level of cocreation of service exists, especially if the manufacturing firm is delivering advance services and need more customer integration.

Fang et al. (2008) investigated the effect of service transition on firm value in the U.S. and showed that a nonlinear relationship did exist (in a U-shape). This exhibited an improvement of the market value of the manufacturing firm. For this enhancement to materialise and become noticeable service, sales service intensity had to surpass a critical level of 15%–20% of the total revenue. This non-liner performance effect was later confirmed by Kohtamäki et al. (2013). Zhou et al., (2020) also confirm that servitization has a U-shaped relationship with a manufacturer's financial performance and manufacturers have to leverage their service supplier networks to increase the financial return from their servitization incentives. Suarez et al. (2013) found a convex, non-linear relationship between advanced service implementation and financial performance in the software industry. Firms with a very high level of product sales were most profitable, whilst raising the service provision was linked with declining profitability. Wang, lai and Shou (2018) meta-analysis results, found that the overall servitization-performance relationship is significant and positive as it enhances service revenue, customer loyalty and leads to a stronger buyer-seller relationship. Furthermore, the most recent empirical evidence also confirms the positive impact of servitization and

digitalization combined on profitability (Kharlamov and Parry, 2020).Based on the aforementioned discussion, this research postulated the following hypothesis:

Hypothesis 1 *Servitization strategies have a positive influence on a firm's financial performance.*

2.2 Digitalization impact on Servitization and firm financial performance

According to Kindström and Kowalkowski (2014) advancing digitalization incentives while adopting a service business model can enhance service quality and foster the development of more cost-efficient operations. This challenge can be achieved through a more adequate resource allocation, higher transparency and better information flow within inter-organisational networks (Opresnik, Hirsch, Zanetti, Taisch, & Isaja, 2014). In this context, manufacturing firms are increasingly adopting digital systems to support services (Suarez et al., 2013).

Servitization and the degree of digitalization are intertwined; for instance, the higher the digitalization the better the firm is equipped to introduce a complex service offering (Gebauer, Gustafsson, & Witell, 2011), enhancing the success of servitization and customer experience (Lerch & Gotsch, 2014). Therefore, digital services represent an important component in the service-centric business model, hence, the term 'digital servitization' (Vendrell-Herrero et al., 2016).

In addition, digitalization and technology-based solutions are an enabler of service quality, due to better resource allocation and more accurate information sharing inside and outside the boundaries of a firm. Hence, the provision of digital services has become a sub-stream of service business model creation or servitization (Baird & Raghu, 2015).

Similarly, Opresnik and Taisch (2015) explored the use of big data (which is a form of digital asset in manufacturing) to enhance servitization. The findings from these authors suggested that the use of big data in a servitized offer led to a sustained competitive advantage. Additionally, digitalization can and has been known to enhance the effectiveness of servitized supply chains (Holmström & Partanen, 2014). 'Service-related data processing and interpretation capabilities' are also required to leverage servitized offerings (Ulaga & Reinartz, 2011).

Overall, digital servitization can expand the service portfolio manufacturing firms offer in the market place (Coreynen et al., 2017; Vendrell-Herrero et al., 2016), enhance service quality and cut inter- and intra-operational costs (Kindström & Kowalkowski, 2014). Manufacturers' digitalization capabilities play a critical role in facilitating advanced service offerings by leveraging both customization and efficiency (Silvestro & Lustrato, 2015; Sjödin, Parida, & Kohtamäki, 2016; Tuunanen & Cassab, 2011). Furthermore, Ardolino et al., (2018) found a positive impact of the firm's digital capabilities such as IoT, cloud computing and predective analytics on servitization excelence. Therefore, in order to succeed, servitized offerings must include two components: (1) the digital component, built on top of information modules in the market offer, and (2) the physical component that represents the actual product (Cenamor, Rönnberg Sjödin, & Parida, 2017). Following this rational, the following hypothesis was suggested:

Hypothesis 2 *Digitalization exerts a positive influence on servitization.*

Manufacturing firms increasingly differentiate by adopting new service-oriented revenue models. Rasouli, Kusters, Trienekens, & Grefen, (2018) highlighted the importance of service orientation in manufacturing firms through delivering co-creating mass-customized integrated solutions in which digitalization plays an important role in enabling this kind of business model

(Schroeder & Kotlarsky, 2015). The argument is that servitization and digitalization can be considered, to some extent, to be similar constructs (Vendrell-Herrero et al., 2017). Given this, the interdependencies between these two constructs are deemed to be significant (Lerch & Gotsch, 2015).

Although conflicting definitions between these concepts exist, this study makes a clear distinction between the two. It is possible to shift from a product-centric business model to a more service-oriented business model without introducing a great deal of digital aspects into the market offering (Vendrell-Herrero et al., 2016). To have a clear understanding of the meaning of digitalization, this research refers to it as a two-dimensional construct where the first dimension encapsulates the provision of IT-enabled (i.e. digital) services relying on digital components embedded in physical products (Schroeder & Kotlarsky, 2015). The second dimension consists of those digital capabilities embedded in the operational aspects of the manufacturing processes. These core digital capabilities include the use of data-driven networks, cloud technology, internet of things as related to machine-to-machine (M2M) communications, advanced analytics, touch operation/interface, big data, 3D printing, advanced robotics, mobile apps, additive manufacturing, plant Wi-Fi, 3D visualization/simulation, social technologies, zero personnel operations, augmented reality, radio-frequency identification (RFID), blockchain, facial recognition and fog computing (Conner et al., 2014; Demirkan, Bess, Spohrer, Rayes, & Allen, 2015). These capabilities will be increasingly fundamental to manufacturers' success, enabling product and customer insight, along with value-added offerings to drive uptime, safety, real time analytics and sustainable competitive advantage (Lenka, Parida, & Wincent, 2017). Current literature also highlights that manufacturers introducing digitalization capabilities and technologies to increase the efficiency of service delivery and enhance customer integration could lead to a higher value of

their product-service system offerings and better long-term profitable relationship (Adrodegari et al., 2017 ; Lenka et al., 2017).

Companies that pursue a digitalization strategy are, on average, 26% more profitable and generate 9% more revenue with employee and physical assets than industry competitors (Westerman et al., 2014). Therefore, a firm's ICT and digital capabilities are highly correlated with higher financial performance as proposed by (Westerman et al., 2014; Cardona et al. 2013). Following this rationale, the following hypothesis was proposed:

Hypothesis 3 *Digitalization exerts a positive influence on firm financial performance.*

3. Methodology

3.1. Questionnaire design and data collection

The present research collected data from two different sources, namely perceptual data from a primary firm-level survey and objective data from a secondary source OSIRIS database. A cross-sectional self-administrated survey was employed as a means to collect firm-level data from the target population, the use of such instrument allows the collection of a large amount of data from a sizeable population in a highly economical way and also have the advantage of established validity and reliability (Van de Ven, 2007).

The questionnaire was created in English and then back translated into German and French by two different groups of professional native speakers to ensure similarity of meaning and semantic equivalence across countries (Schaffer & Riordan, 2003). The survey data was collected through the application of a web-based questionnaire by sending the survey link through email to purposely selected potential respondents. A two-step approach in collecting data was adopted to ensure data quality and a high response rate. First, each potential participant was contacted by phone to request his/her participation in this study, with reminder phone calls performed at 15 to 20-day intervals to motivate respondents. Second, questions were presented in the questionnaire to subjectively determine the quality of the information

provided by the respondents, as well as their knowledge about the research topic (Kumar, Stern, & Anderson, 1993).

From September 2016 to May 2017 data was collected from a total of 215 firms out of 1156 (18.6%), from which, 20 responses were excluded for incompletion. Further data screening for outliers and unengaged responses resulted in an exclusion of an additional 10 respondents. All remaining firms had financial data available. Overall, the final data set consisted of 185 fully completed questionnaires yielding an effective response rate of 16% (185/1156). This response rate was considered satisfactory in comparison to similar management studies employing the same data collection instrument (Gebauer, Edvardsson, & Bjurko, 2010; Wagner, Grosse-Ruyken, & Erhun, 2012).

3.2. Sample

Table 2 provides a detailed breakdown of the sample and the respondents. The target was a population of firms with primary Standard Industrial Classification US (SIC) codes in the range of 7–32 in order to comprehensively and effectively include all codes relating to manufacturing firms.

The sample population included 1156 possible manufacturing firms; whose main activities included offering industrial services. Those industrial service manufacturers were distinguished from pure manufacturers through an analysis of the firm description and history fields in the data retrieved from the OSIRIS database following the methodology by Neely (2008). A question was also included in the data collection instrument asking respondents to highlight the percentage of services sold with respect to the total company revenue to ensure that adequate and relevant data was collected.

Key informant targeting techniques were used (see Table 2). The respondents averaged eight years of employment with their firm (std. deviation = 3.43), indicating an adequate amount of experience and knowledge. 84% and 16% of the key informants stated that they had a high

level of knowledge and a moderate level of knowledge, respectively, about the research area (servitization and digitalization).

All respondents indicated that they had been introducing services in their market offering for more than three years and had a standalone service unit. As shown in Table 2, results indicated a strong service orientation in the majority of the sample. Fang et al., (2008) suggested that 20% was the critical mass required to obtain a substantial return from providing a service provision. The sample consisted of well-established manufacturing firms in their industries, averaging 18.3 years of incorporation (SD = 31). The firms' average annual sales were USD 15 billion (SD = USD 25 billion), with an average of 36,187 employees (SD = 57,008) and an average return on equity (ROE) of 11% (SD = 3). The study sample obtained an average of 5% (SD = 16) growth in revenues over the observation time of three years.

[INSERT TABLE 2 HERE]

Table 2. Sample demographics.

Country	**N**	**%**
Germany	50	27
United Kingdom	32	17
USA	30	16
Spain	18	10
France	18	10
Italy	15	8
Sweden	11	6
Switzerland	11	6
Total	**185**	**100**
Respondent job title		
Service manager	89	48
Marketing manager	50	27
Operation manager	46	25
Total	**185**	**100**
Service share of total revenue		
Less than 20%	7	4
Between 20-30%	150	81
More than 30%	28	15
Total	**185**	**100**

3.3. Non-response bias

To account for non-response bias, a multivariate analysis of variance (MANOVA) was performed to compare both respondent and non-respondent firms, ROE, size (by means of number of staff), revenue and assets. The results yielded no significant difference between the groups in question and any financial measures used in the comparison ($p > .05$).

Following the recommendation of Armstrong and Overton (1977), t-tests were then employed on early and late-returned questionnaires. Respondents were grouped into two waves: (1) those who responded within the first eight weeks and (2) those who responded in the ninth week or later. These t-tests did not indicate any statistically significant differences in the means between early and late respondents ($p < .05$). Overall, these aforementioned difference tests indicated that it was safe to assume no evidence of response bias in the sample.

3.4. Measures

3.4.1 The C-OAR-SE method for servitization scale development

The construct of servitization was developed using the C-OAR-SE method (Rossiter, 2002), which stands for construct definition, object classification, attribute classification, rater identification, scale formation and enumeration. Following this method, the servitization construct operationalization takes into consideration both the study's research design and the empirical context requirements. First, servitization is defined and conceptualized in line with previous work (e.g. Antioco et al., 2008; Baines, Lightfoot, & Smart, 2011; Bigdeli et al., 2018; Brax & Visintin, 2017; Calabrese et al., 2019; Gebauer, Edvardsson, & Bjurko, 2010; Kowalkowski et al., 2017) to include any possible constituents or components for the servitization construct. Second, the rater entities were selected, which included academics familiar with the concept as well as an expert panel with practical knowledge about the phenomenon.

In this context, servitization was defined as a strategy in which manufacturing firms constantly and continually adapt business models in order to sell capabilities. This requires top

management service orientation, proper investment and mobilization of the organizational resources in order to leverage the service-centric business model approach.

After the scale development, 15 experts in industrial services and three academic experts were interviewed, during which the content validity index (average I-CVI) was conducted. This resulted in all servitization dimensions exceeding the cut-off value of 0.8 (Polit-O'Hara & Beck, 2006).

As advised by the C-OAR-SE method when testing construct reliability, a proportional reduction in loss (PRL) was applied to inter-judge agreements (Rust & Cooil, 1994). The PRL accounts for the loss in confidence attributed to poor decisions by the judges. The proportion of inter-judge agreement in this study's panel was 0.85 between 15 judges, which resulted in a PRL of one. Thus, the PRL was substantially high, ensuring servitization construct reliability (Rust & Cooil, 1994).

After the data collection phase, an exploratory factor analysis (EFA) was conducted to test the proposed three dimensions of the servitization construct, as well as the other study constructs. This study used principal axis factoring to conduct the EFA. The oblique rotation method with an eigenvalue greater than one and a Promax oblique rotation solution for correlated variables were used (Kline, 2014). The EFA input was 12 items for the servitization construct and resulted in nine items with loading well above .40 on the respective main factor without significant side loading (i.e. < .04). These results were deemed satisfactory (cut-off point at 0.40) with an internal consistency/reliability alpha higher than 0.70, which indicates a practical significance (Hair, 2010). Three items had poor loading (i.e. < .40), which indicated that these items were irrelevant and have thus been excluded from the final measurement model analysis. The final three dimensions of the servitization construct were top management service orientation, resource mobilization and the market offering see (Appendix A). The construct

was anchored on a seven-point Likert-scale ranging from one (extremely disagree) to seven (extremely agree) (Churchill, 1979).

3.4.2 Operationalization of digitalization

In this study, the digitalization construct was measured with a nine-item instrument adopted from Westerman et al. (2014). This construct encapsulated two dimensions: (1) digital components embedded in physical products (Schroeder & Kotlarsky, 2015) and digital capabilities embedded in the operational processes, which improve the manufacturer's supply chain and operational performance (Hennelly et al., 2019). The two-dimensional construct of digitalization was measured by Likert-scale items ranging between (one = "extremely disagree", seven = "extremely agree"). After data collection, the EFA was conducted for the digitalization construct with principal axis factoring and the oblique rotation method to validate the two-dimensional structure. All items were loaded well above .40 preserving the dimensionality of the constructs and no major cross loadings were reported, supporting the multidimensionality of the digitalization construct (Hair, 2010).

3.4.3 Financial performance of the firm

Drawing from the previous literature related to firm financial performance (Coltman, Devinney, & Midgley, 2011; Gunday, Ulusoy, Kilic, & Alpkan, 2011; Westerman et al., 2014;), a self-evaluation of companies' financial performance was used. Respondents indicated on a seven-point scale (one = "poor" and seven = "excellent") revenue generation, profit and the market value of the company in the respective year compared to the previous years. This was conducted following various recommendations (Dess, 1987; Eggert, Hogreve, Ulaga, & Muenkhoff, 2011; Gebauer, Edvardsson, & Bjurko, 2010; Powell, 1995), in which this construct was measured subjectively. This is common practice in the research of companies and business units and is widely accepted in organizational research (Powell, 1995). In

particular, overall financial performance was measured subjectively, using the six items shown in appendix A, addressing the three dimensions of revenue generation, profitability and market value.

The first dimension evaluated the firm's ability to generate revenue by measuring two items:

1. Revenue / number of employees
2. Fixed assets turnover (revenue / property, plant, equipment)

The second dimension evaluated the firm's profitability measured by the following three items:

1. Return on sales (profit/total sales), measuring the profitability of a firm relative to its total assets
2. Return on investment (after tax), measuring the success of the firm at generating revenue from new products and services
3. General profitability of the firm

The third dimension evaluated the firm's market valuation using one item:

1. Market capitalization

3.4.4 Control variables

To reduce undesirable sources of variance in the study's model, the control variables, which may influence and confound the relationships between the study's dependent variables were included. First, this study eliminated the effect of *company age*. Older companies may have issues, such as inertia and sunk costs in ongoing operations that may hamper the ability to explore innovative strategies that could affect performance. This study followed the recommendation to control for firm age (Park & Ro, 2011; Terjesen, Patel, & Covin, 2011) and calculated the natural logarithm of the number of years between the observation financial year and the incorporation year as the proxy for company age.

Second, *company size* could also be related to firm financial performance. Larger companies typically have the slack resources to entertain and accommodate servitization and digitalization strategies. Furthermore, larger firms tend to exhibit more market power to eliminate competition and build barriers for entry, which reflects higher financial performance,

competitive advantage and scale efficiencies. Given these justifications, and following the recommendation to control for firm size (Park & Ro, 2011; Terjesen et al., 2011), the effect of company size was controlled for by using the natural logarithm of the number of employees as the proxy for firm size.

Third, this study controlled for *slack resources* by including the firm's current ratio (Fang et al., 2008; Kohtamäki et al., 2013), measured by its current assets to current liabilities. Higher slack resources support higher financial performance (Tan & Peng, 2003).

Fourth, to eliminate any industry effects, *industry* was controlled, following recommendations from previous studies (Huang, Kristal, & Schroeder, 2008). The industry effect was operationalized using a series of dummy variables at the two-digit SIC level, with the manufacture of machinery and equipment industry used as the reference group. For the US SIC code see (Appendix B).

4. Reliability and validity

4.1 Measurement model

The model depicted in Figure 2 was tested using the AMOS 21 program and all descriptive analyses are conducted using SPSS (24). The study followed recommendation by Anderson and Gerbing (1988) for a two-stage approach. In the first step, the validity of the measurement model was tested by performing confirmatory factor analysis (CFA). The second step involved testing the hypothesised structural model that prescribed the relationships among the latent variables (see section 5).

For measurement model validation, the CFA resulted in a good model fit with chi square / DoF [$\chi 2/df$] =1.694 ($p<0.001$), Tucker–Lewis-index [TLI] = 0.941, normed fit index [NFI] = 0.903, comparative fit index [CFI] = 0.957, incremental fit index [IFI] = 0.958 and root mean squared error of approximation [RMSEA] = 0.040 (Hair, 2010; Steiger, 2007).

With regards to construct and scale reliability in this study, Table 3 shows the coefficient alpha that ranges from 0.891 to 0.923, well above the threshold of 0.7. The construct composite reliability (CR) ranged between 0.916 and 0.936, well above 0.7 (Hair, 2010; Nunnally & Bernstein, 1994) and the average variance extracted (AVE) ranged between 0.582 and 0.646, which was above the cut-off value of 0.5 (Fornell & Larcker, 1981). All loadings for first and second order factors were > 0.40 (see appendix A).

Discriminant validity was tested using the Fornell–Larcker criterion, showing that the square root of the average variance extracted for each reflective construct was greater than all corresponding correlation involving the constructs (Fornell & Larcker, 1981). For this reason, the discriminant validity result can be considered satisfactory and showed that each construct shared more variances with its items than with any other construct.

Multicollinearity was also investigated by testing the variance inflation factor (VIF) with a threshold of five (Cohen, Cohen, West, & Aiken, 2013). Results showed a maximum VIF of (4.7), which implies that multicollinearity did not pose a serious problem to the structural equation modelling SEM analysis.

Despite using subjective financial performance measures, which are generally reliable (Dess & Robinson, 1984), the reliability of the self-reported performance data was also examined to account for any potential reporting biases. Data on common accounting-based measures to objectively assess performance were collected from the commercially available OSIRIS database. The collected data were from the financial years of 2013, 2014 and 2015. The industry average (based on a firm's four-digit SIC code) was subtracted from each firm's measurements to control for the influence of the industry (Agle, Mitchell, & Sonnenfeld, 1999). Three years of performance data were then averaged to create composite firm-specific measures. The correlation between 'overall performance' and the objective 'profit/revenue ratio' was 0.43 (p<0.05). Significant correlations were also found between the study's

subjective 'market value' and objective 'book/price ratio,' which was statistically significant at the 0.05 level. The positive and significant correlation observed between subjective and objective financial performance measures indicated that the archival data encapsulated a key element of the respondents' subjective evaluation (Powell, 1995). This provided additional confidence in the validation of the survey measure of performance.

4.2 Common method variance tests

To statistically test for common method bias (CMV), a marker variable was used (Lindell & Whitney, 2001). This marker variable was not theoretically related to any of the study latent variables. The maximum correlation between the study latent variables and the marker variable was $r = 0.09$ with $p > 0.1$. By squaring this correlation, the result indicated that the maximum variance shared with the study variables was less than 1%. Thus, the test results suggested that the data was not contaminated with method variance.

Table 3 summarizes the descriptive statistics and the intercorrelation among the study variables. As illustrated, the CFA results validated the assumption that this study measures psychometric properties, which are acceptable for hypothesis testing (Bagozzi & Yi, 1988).

[INSERT TABLE 3 HERE]

Table 3. Means, standard deviations and intercorrelations among the study's variables (N=185)

	Mean	SD	CR	AVE	1	2	3	4	5	6	7
1. Servitization	4.02	0.77	0.94	0.62	(0.92)						
2. Firm financial performance	3.82	0.90	0.92	0.65	0.66***	(0.89)					
3. Digitalization	4.35	0.78	0.93	0.58	0.60***	0.64***	(0.91)				
4. Company size (LN employees) *	10	11	–	–	-0.11	0.27**	-0.04	(n/a)			
5. Slack resources	2	1	–	–	-0.12	0.32**	0.07	0.20**	(n/a)		
6. Industry type	0.08	0.09	–	–	-0.02	-0.05	-0.06	0.11	-0.02	(n/a)	
7. Company age (LN)*	2.9	3.4	–	–	0.13	-0.01	-0.02	0.01	0.04	0.01	(n/a)

Coefficient alpha (α) presented along diagonals.
AVE = average variance extracted, CR= composite reliability.
* Log transformed to reduce skewness.
**$p < 0.05$ (two-tailed).
***$p < 0.01$ (two-tailed).

5. Results and Discussion

The existing industrial service and operation management research provided a small amount of empirical evidence on the interdependencies between servitization, digitalization and firm performance (Myrthianos, Vendrell-Herrero, Parry, & Bustinza, 2014). This study contributes to the servitization practices and capabilities literature, arguing that digitalization plays a pivotal role in enabling servitization, and in return, servitization augments the impact of digitalization on bottom line results. Aligned with the outlined review of the literature (Kharlamov and Parry, 2020; Ziaee Bigdeli et al., 2018) the results of the path analysis showed that the relationships between digitalization, servitization and firm performance were significant. This study also advanced this research stream by novel operationalization of servitization construct and measurement scale following recommendation from (Dmitrijeva et al., 2019; Wang, lai and Shou 2018).

The study used SEM to test the research hypotheses. The resulting structural model provided a good fit to the data, as follows: X^2/df **=1.373, p< 0.001, CFI=0.971, NFI=0.903, IFI=0.972, TLI=0.960, RMSEA=0.045** (see Figure 2). The goodness-of-fit indices of the structural model were satisfactory according to the relevant literature (Bagozzi & Yi, 1988). As illustrated in Figure 2, the results support all three hypotheses regarding the relationship between digitization, servitization and firm financial performance.

[INSERT FIGURE 2 HERE]

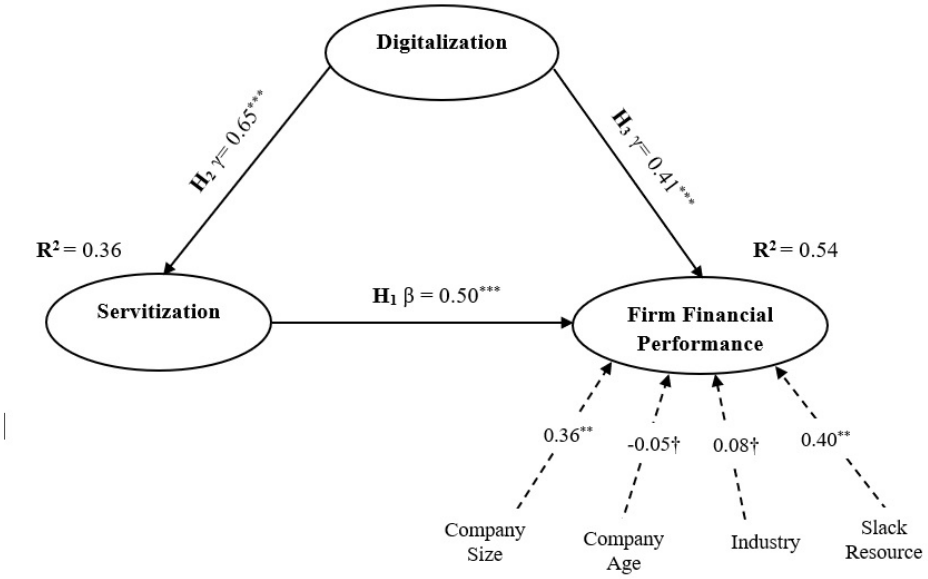

Figure 2: The results of the basic model.

† Path is not significant.
**$p < 0.05$
***$p < 0.001$
γ denotes the relationships between the exogenous and endogenous variables.
β denotes the relationships between endogenous variables.
R^2 denotes the coefficient of determination.
The dotted line represents the effects of control variables on financial performance (-------).

As shown in Table 4 this study confirmed the direct causal relationship between servitization and firm financial performance (**H1**), which was also supported by the literature (Fang et al., 2008; Suarez et al., 2013; Visnjic, Wiengarten, & Neely, 2016). The results showed that servitization significantly increased firm financial performance (β = 0.50, t = 5.84, p<0.001). A higher service offering led to higher profitability and market value for the manufacturing firms, this finding also in line with Kohtamaki at el., (2015) empirical study of manufacturing firms offering services, they concluded that offering services impact the company's top line in terms of sales level and sales growth and the bottom line in terms net profit and return on investment (ROI). This relationship also supported by Song et al., (2015) who found positive relationship between Servitization and financial performance measured by growth in revenue and profit. Same conclusion also supported by Wang, lai and Shou (2018).

Digitalization also had a direct causal effect on servitization (**H2**). Results showed that digitalization had a significant and positive effect on firm financial performance ($\gamma = 0.41$, t = 4.61, $p < 0.001$), confirming H2. This relationship can be explained by the fact that digitalization can enable servitization in the ecosystem. This could be achieved by the implementation of the digital technologies that bring both the buyers and suppliers closer together, and enhance customer integration in the service design process (Boehmer et al., 2019). The current literature also highlighted that manufacturers increasingly adopt their business model to incorporate more digital incentives that reshape customer preferences for instance offering more diagnostic, predictive and remote maintenance which helped in creating new business models and value propositions that enhance the firm financial performance (Dellarocas, 2003; Ng & Wakenshaw 2017) .

This finding also in line with Dmitrijeva etal., (2019) study where they found that digitalization and technological transformation impact servitization and enhance the oprational exellance of a manufacturing firm. This relationship also confirmed by Boehmer et al., (2019) where they found that digitalization and the internet of things (IoT) is an enabler of servitization that enhances the implementation for the service transformation of manufacturers, which ultimately enhance the overall value-creation process.

As shown in Table 3, the path between digitalization and servitization was significant and positive ($\gamma = 0.65$, t = 12.44, $p<0.001$). Digitalization in manufacturing firms enhanced financial performance, therefore **H3** is confirmed and in line with prior findings (Westerman et al. 2014; Porter and Heppelmann, 2014). This conclusion is also consistent with those reported in Martín-Peña, Sánchez-López and Díaz-Garrido, (2019) empirical study, where they found that in this context manufacturing firms try to monetize their digitalization initiatives by selling data analytics solution to customers which enables more cost-efficient operations and better resource allocation which positively impact firm performance (Kindström and

Kowalkowski, 2014). This finding also supports the argument that digital capabilities would enhance the servitized firm value propositions (Lusch, Vargo, & Tanniru, 2010), and more importantly operational agility and efficiency will increase (BarNir, Gallaugher, & Auger, 2003), which the manufacturer can capitalize on (Gebauer, Edvardsson, Gustafsson, et al., 2010).

[INSERT TABLE 4 HERE]

Table 4. Structural model path coefficients.

Hypothesis	Path	Standardized path estimate	t-value	Result
H1	Servitization >>>> Financial performance	0.50***	5.9	
H2	Digitalization>>>> Servitization	0.65***	12.4	
H3	Digitalization>>>> Financial performance	0.41***	4.7	

Black circle Indicates full degree of confirmation.
*** Significant at the 0.001 level.

Furthermore, as shown in Table 5 this study used bootstrapped SEM (n=5000 bootstrap resamples) (Zhao, Lynch Jr, & Chen, 2010) to establish the statistical significance of the indirect effect and measure its magnitude (Hayes, 2009). The results provided support for one indirect effect unexpectedly found during the analysis phase; specifically, the paths from the two predictor variables, digitalization and servitization, to firm financial performance. Therefore, the SEM model revealed that servitization partially mediated digitalization and firm financial performance, with digitalization having an indirect effect on firm financial performance of $\beta = 0.30$, $t = 5.20$, $p < 0.001$ and a total effect equal of 0.77, $p < 0.001$; see Table 4. This result contradicts Martín-Peña, Sánchez-López and Díaz-Garrido, (2019) study results where they found that digitalization mediates the relationship between servitization and firm performance. In addition, the findings regarding control variables indicated better

financial performance for those servitized and digitalized manufactures that exhibited a larger size and higher slack resources, with β = 0.36 and 0.04 at $p < 0.05$, respectively.

[INSERT TABLE 5 HERE]

Table 5. Bootstrapped SEM indirect effect estimates.

Indirect effect relationships	Indirect effect	Total effect
Digitalization>>>> Servitization >>>> Financial performance	0.30***	0.77***

Indirect effect is reported in standardized form.

*** Significant at the 0.001 level.

6. Managerial implications

This paper empirical findings suggest that servitization can serve as enhancer to financial performance for manufacturing firms looking for service growth, the digitalization and data driven based solutions can also foster both financial performance and servitization and help in building more efficient market offering. The value proposition developed by companies can be more customer driven relating on real time accurate data can also enhance both service provider and customers profitability and satisfaction. This paper adds to the discussion of the impact of digitalization on servitization (Rymaszwska, Helo, & Gunasekaran, 2017). This paper can serve as a reference for those managers who are confronted with the question of how to pursue servitization strategies to avoid the 'commoditization trap,' to achieve higher performance, to enhance customer experience and to spur and sustain competitive advantages.

As confirmed in this study, enhancing the servitization process can be augmented by pursuing a structural digitalization initiative based on IoT based solutions which play a pivotal role in enabling servitization. This shift to a more digitalized service business model can be enhanced by better management orientation in identifying the digitalization challenge facing the industry and how this can affect the servitized market offering while delivering a unique value propositions and cutting down on cost and time-to-market.

The findings also highlighted the importance of capitalizing on the firm's capabilities to enhance the synergy between digitalization and servitization initiatives in order to achieve better financial performance. Prior astute digital investment in organizational resources, supply chain capabilities, skills and IoT capabilities was one of the most important aspects agreed upon between the study's participants. This strategic resource allocation and Omni-channel strategy make or break the company's servitization and digitalization process (Seyedghorban et al., 2019). More importantly, managers must actively compare the actual progress in digitalization and servitization strategies against pre-developed key performance indicators KPI's. Digitalization initiatives informing servitization design and implementation is a sequential process. A clear digitalization and servitization strategy to achieve the desired performance outcomes is a prerequisite for ensuring financial soundness and achieving a significant potential for value creation.

This study also has implications for supply chain managers, who must profoundly change their perspectives and management skills from managing people doing repetitive and transactional tasks to managing information and analytics tools which integrate both sides of the experience centric network in a more collaborative manner (Romero & Molina , 2011), these managers also have to be able to address the intersection of operations and technology to be able to design a more responsive and technology-driven supply chains that use digital technologies (Zangiacomi et al., 2019).

The shift to data-driven service business models that consider service infusion and innovation as core capabilities, better management orientation is required. Managers must identify the digitalization challenge facing their industry and how it can affect the servitized market offering especially in terms digitalized PSS and digital services (Moro, Cauchick-Migue and Mendes, 2020). The findings also highlighted the importance of the firm service capabilities to

enhance the synergy between digitalization and servitization initiatives, in order to achieve better financial performance.

A profound insight to managers can also be derived from the finding that although digitalization enhances the firm's financial performance, incorporating service provision in the offering can lead to even better financial performance. This study showed that servitization mediates digitalization and firm performance. Digitalization was the most important aspect that held the value chain together from research and development to after sales. It also highlighted the role advanced manufacturing technologies play in fostering network collaboration and more localized and agile supply chain (Tziantopoulos et al., 2019).

Managers ought to understand that digitalization initiatives inform servitization design and implementation. Furthermore, a clear digitalization and servitization strategy to achieve the desired performance outcomes is a prerequisite for ensuring financial soundness as well as significant potential for value creation. Furthermore, digitalization needs a new set of technological and analytical capabilities to enable the servitized business model and value creation (Iansiti and Lakhani, 2014).

The findings also showed that to be financially successful, the implementation of service technologies must be treated as a business initiative (Smith & Milligan, 2002) that requires support by management and a vision to servitization and digitalization (Antioco et al., 2008). Servitization and digitalization strategies must be linked to proper reward and incentive systems in manufacturing firms. Most manufacturing incentive systems remain linked to R&D and operations, and revolve around a core product offering.

Finally, the introduction to the servitization measurement scale can serve as a step towards the development of a prescriptive management tool to assess service capabilities and infusion inside the firm.

7. Research limitations and future directions

The choice of an empirical setting raises theoretical and methodological issues, but also points towards important avenues for future research. First, future research should consider enhancing the operationalization of the servitization construct by including other items that might prove relevant in establishing robustness. Second, this research is building on self-reported data that may imply some method bias (Podsakoff & Organ, 1986). Therefore, further data triangulation would be useful to support the results.

Third, the stability of the relationships between servitization, digitization and firm financial performance over time remains untested. This can be investigated in future studies by using longitudinal data to further support the causality claims. Fourth, for cross-cultural/cross-national research, (measurement equivalence) is an important methodological issue (Malhotra & Sharma, 2008). The Sweden and Switzerland samples were too small, therefore a measurement equivalence assessment was not completed using a multi-country CFA or the generalizability theory approach (Webb & Shavelson, 1991). Hence, this shortcoming will be addressed in further research. Finally, the issues of cybersecurity and governance also deserve attention in future research (Huxtable & Schaefer, 2016).

Fourth the mediation effect of servitization found in this study proposed model need to be further tested to address this specific finding and the contradictory results found within the literature.

8. Concluding remarks

This study advanced the conversation of the impact of digitalization on firm performance and servitization, confirming a significant positive relationship. Indeed, this study's results yielded novel insights on this relationship in the context of servitized manufacturers. Servitization and digitalization played a significant role on enhancing firm financial performance. This can be

explained by understanding the effect of embedding digital technologies in the service offering, which enhances the customer experience, reduces time and cuts cost for the manufacturers (Rymaszewska, Helo and Gunasekaran, 2017).

This study examined the impact of digitalization and servitization on firm financial performance. The results of this study indicated that the two constructs were valid predictors of firm financial performance. Therefore, this study paves the way for better insight into manufacturing firms transitioning into a more data-driven customer-centric business model. As digitalization and servitization converge to ramp up manufacturers' transition toward a service provision, those companies who are able to excel in this transformation must integrate the physical and the digital aspect of the market offering. Bearing this in mind in order to unlock the full potential of the service model, the service and digital journeys must converge.

Disclosure Statement
The authors report no potential conflict of interest.

Appendix A
[INSERT TABLE 6 HERE]

Table 6 Constructs and measurement items (Constructs and Items All measured on 7-point Likert scales).

Q#	Variables	Factor loading
Digitalization		
For each statement, show the extent of your agreement by selecting the box that reflects your current view of your expectation as a whole.		
1	We are using digital technologies (such as analytics, social media, mobile, and embedded devices) to understand our customers better.	**0.77*****
2	We market and sell our products and services through digital channels.	**0.73*****
3	We use digital channels to provide customer service.	**0.66*****
4	Technology is allowing us to link customer-facing and operational process in new ways.	**0.67*****
5	Our core processes are automated.	**0.72*****
6	We have an integrated view of key operational and customer information.	**0.72*****
7	We use analytics to make better operational decisions.	**0.74*****
8	We use digital technologies to increase the performance or added-value of our existing products and services.	**0.75*****
9	We have lunched new business model based on digital technologies.	**0.65*****
Servitization		
For each statement, show the extent of your agreement by selecting the box that reflects your current view of your expectation as a whole.		
	Top Management service orientation	
1	Our senior leaders are aligned around the strategic importance of servitization transformation.	**0.66*****
2	Our senior leaders are actively promoting a vision of the future that involves servitized offerings.	**0.77*****
3	We regularly review with the top team our progress on servitization transformation.	**0.81*****
	Mobilization of resources	
1	Our employees understand the benefits of servitization change.	**0.70*****
2	The organization is investing in the necessary skills and capabilities to provide servitized offerings.	**0.67*****
3	Our business cases and key performance indicators are linked to our roadmap.	**0.74*****
	Market offering	
1	Our firm has taken over some of our customers' business processes.	**0.81*****
2	Our firm has taken over the operational functions of our products in customers' businesses.	**0.84*****
3	Our service contracts related to our products is designed to share 'risk and reward' with our customers, so our customers pay for the product capabilities outcomes and results.	**0.74*****

Financial performance

How would you rate the level of achievement of the following financial performance items in your organization in the last three years compared to the previous years? (seven-point scales ranging from (1= "poor", and 7= "excellent")

	Revenue Generation	
1	Revenue per Employee	**0.75*****
2	Fixed Assets Turnover (Revenue / Property, Plant & Equipment)	**0.77*****
	Profitability	
1	Return on sales (ROS)	**0.79*****
2	Return on investment (ROI)	**0.70*****
3	General profitability	**0.73*****
	Market Valuation	
1	Market capitalization	**0.76*****
	Control variables (objective measures)	
	1. Company size (LN employee)	**-**
	2. Company age (Since incorporation)	**-**
	3. Industry classification (2 digits US-SIC code)	**-**
	4. Slack resources (Current ratio)	**-**

(***$p < 0.001$).

Appendix B
[INSERT TABLE 7 HERE]

Table 7 Sample industry US SIC Code distribution.

US SIC	**Industry**	**N**	**%**
7.	Mining of metal ores	4	2
10.	Manufacture of food products	5	3
18.	Printing and reproduction of recorded media	5	3
19.	Manufacture of coke and refined petroleum products	4	2
20.	Manufacture of chemicals and chemical products	11	6
21.	Manufacture of basic pharmaceutical products and pharmaceutical preparations	14	8
22.	Manufacture of rubber and plastic products	6	3
23.	Manufacture of other non-metallic mineral products	2	1
24.	Manufacture of basic metals	5	3
25.	Manufacture of fabricated metal products, except machinery and equipment	12	6
26.	Manufacture of computer, electronic and optical products	29	16
27.	Manufacture of electrical equipment	25	13
28.	Manufacture of machinery and equipment	36	19
29.	Manufacture of motor vehicles, trailers and semi-trailers	4	2
30.	Manufacture of other transport equipment	15	8
32.	Other manufacturing	8	4
	Total	**185**	**100**

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