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Servitization:
Disentangling the impact of service business model innovation on manufacturing firm performance

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As manufacturing businesses operate in an ever more competitive, global economy where products are easily commoditized, innovating by adding services to the core product offering has become a popular strategy. Contrary to the economic benefits expected, recent findings pinpoint implementation hurdles that lead to a potential performance decline, the so-called 'servitization paradox'. In this paper, we analyze this paradox by disentangling the value creation and value appropriation processes of 44 national subsidiaries of a global manufacturing firm turned product-service provider, in the 2001-07 period. Our findings show that the firm under study is able to successfully transcend the inherent substitution of products by services and to enact complementary sales dynamics between the two activities. Moreover, labor-intensive services such as maintenance, which imply higher levels of customer proximity, further enhance product sales. Empirical results also reveal a positive yet non-linear relationship between the scale of service activities and profitability: while initial levels of servicing result in a steep increase in profitability, a period of relative decline is observed before the positive relationship between the scale of services and profitability re-emerges. These findings suggest the presence of initial short-term gains but also indicate the existence of a 'profitability' hurdle; profitable growth seems feasible only to the extent that investments in service capability are translated into economies of scale. In helping to clarify the performance implications of service innovation, our findings suggest pathways to sustainable growth through servitization for manufacturing firms.

Keywords: Servitization, Open service innovation, Business model, Performance

1. Introduction

Increasingly, durable goods manufacturers choose to innovate their offerings by providing services to accompany their existing products throughout the life cycle. This trend, known as 'servitization', was first coined by Vandermerwe and Rada (1988) to delineate the tendency of manufacturing firms to "offer fuller market packages or bundles of customer-focused combinations of goods, services, support, self-service, and knowledge". Moreover, servitization (Neely, 2008) or open service innovation (Chesbrough, 2011) can be seen as developing an organization's innovation capabilities by effecting a shift from products to product-service systems, thereby better satisfying customer needs and escaping the commoditization trap.

Indeed, recent figures suggest that, globally, over a third of large manufacturing firms offer services, with the proportion increasing to almost 60 percent in Western economies (Neely, 2008). In addition, for an average 'servitizing' manufacturer, the share of service sales has reached 31 percent (Fang et al., 2008). Along with ABB, Caterpillar, GE, IBM, and Xerox (Cohen et al., 2006), Rolls-Royce Aerospace is a well-known representative of this trend. Rolls-Royce has evolved from a pure manufacturer of aero engines into a supplier of spare parts, subsequently developing into a prime provider of maintenance and overhaul services, culminating in the 'power by the hour' Total Care solution package, where customers purchase the capability Rolls-Royce engines deliver whilst the aerospace company retains responsibility for maintenance and risk.

Open questions remain, however, concerning the impact of servitization on the performance of manufacturing firms. While studies (Cohen and Whang, 1997; Guajardo et al., 2011; Kim et al., 2007; Kim et al., 2010) demonstrate the benefits of servicing for the performance of the product itself and for the creation of customer

value, the impact of this innovation on the performance of the product-service provider is less well understood. While anecdotal evidence suggests strategic and economic potential (Agrawal et al., 2012; Chesbrough, 2011; Tuli et al., 2007; Wise and Baumgartner, 1999), empirical studies yield mixed results (Fang et al., 2008; Neely, 2008; Suarez et al., 2011), which may be due to the challenges manufacturers face in formulating and implementing a service-oriented business model (Bowen et al., 1989; Gebauer, 2009; Gebauer et al., 2005; Martinez et al., 2010).

Mixed evidence on the performance implication of servitization underscores the need for a better understanding of its value creation and appropriation processes (Gebauer et al., 2012). Following this literature gap, we studied the processes of value creation and appropriation of a servitizing manufacturer, translated them into a set of hypotheses, and tested them on 44 of its subsidiaries over the 2001-07 period. The firm under study, Atlas Copco Compressor Technique (referred to in the remainder of the text as Atlas Copco), is a global manufacturer of durable industrial equipment with a worldwide network of country sales-and-service subsidiaries. With revenues that exceed $4.4 billion annually, it is the largest business within the Atlas Copco Group. Atlas Copco's compressors are durable industrial products that represent sizeable investments for its customers and offer significant potential for the provision of related services. With more than 130 years of experience in product innovation, Atlas Copco has, in recent decades, extended its innovation trajectory into services. Beginning as a provider of spare parts, it gradually expanded its offering into a service portfolio that encompassed various maintenance services as well as total solution service contracts. Consequently, its innovative thrust in providing a variety of services related to its product offering has led to the development of an integrated product-service business model (Amit and Zott, 2001; Spring and Araujo, 2009).

Our study of Atlas Copco and its subsidiaries reveals the nature of the value creation and value appropriation processes. First, we found that Atlas Copco was able to conceive a business model where products and services act as revenue complements and generate a spiral of revenue growth between them, overcoming the inherent substitution of products by services (services prolong the lifetime of existing products, thereby postponing product replacement). Moreover, the impact of services on product sales is even more pronounced when deploying labor-intensive services, which imply customer proximity. In terms of profitability, our findings underscore an overall positive effect of servitizing while, at the same time, signaling a decrease in profitability for medium-scale levels. More specifically, while low levels of servicing result in a steep increase in profitability, the scaling up of service activities results in a temporary decrease in profitability. Only when a certain critical mass of service activity is built up does a positive relationship with profitability re-emerge. In revealing the nature of value creation and appropriation, our study not only yields one of the first theoretical underpinnings of servitization but also demonstrates how product firms can achieve revenue growth and profitability by engaging in services.

2. Literature review

Service research has been a growing area of operations management research (Chase and Apte, 2007; Heineke and Davis, 2007). Researchers have been particularly interested in the operational phenomena occurring in 'pure' service sectors such as retail and e-retail (Boyer and Hult, 2005; Davis-Sramek et al., 2008; Rabinovich et al., 2008; Rosenzweig et al., 2011), healthcare (Hyer et al., 2009), professional services (Goodale et al., 2008) and hospitality (Kimes and Thompson,

2005), while services in a manufacturing context have been afforded relatively less study.

Not only is evidence on the role of services in a manufacturing context scarce, the handful of studies that examine the impact of services on the performance of manufacturers yield mixed results and pinpoint the difficulty in implementing services in a manufacturing context (Fang et al., 2008; Guajardo et al., 2011; Suarez et al., 2011; Visnjic et al., 2012). Neely (2008) shows that the *decision* to servitize has a positive impact on profitability, while the *extent* of servitization has a negative effect on profitability. Other large-scale studies have identified a U-shape relationship between servitization and performance, where positive results reappear only once a critical mass of services is achieved (Fang et al., 2008; Suarez et al., 2011). However, the performance impact of servitization seems to be highly contingent on the industry, and the nature and size of the service portfolio (Fang et al., 2008).

In line with large-scale quantitative studies, case-based studies show that some companies face implementation issues related to servitization (Kim et al., 2010; Martinez et al., 2010; Oliva and Kallenberg, 2003). In some situations, this may well result in decreased performance – the so-called servitization or service paradox (Gebauer et al., 2005; Gebauer et al., 2012). Implementation obstacles range from lack of attention from top management, deficiencies in organizational design and information technology, the lack of an appropriate culture, to insufficient capabilities for service management (Gebauer et al., 2008; Neu and Brown, 2008; Oliva and Kallenberg, 2003). In particular, the literature points to a cultural and cognitive bias against services and service-specific values such as heterogeneity and flexibility, since these values contradict traditional manufacturing goals and practices such as standardization and efficiency (Bowen et al., 1989). This cognitive bias towards

product-focused practices is present in all levels of the organization but, above all, in the selling process; salesmen who are accustomed to selling tangible and 'pricey' products find it hard to sell intangible services (Gebauer et al., 2005; Mathieu, 2001; Oliva and Kallenberg, 2003). Some manufacturers seek a solution to these challenges by outsourcing services. Yet, this does not come without difficulties – in particular, with regard to maintaining customer relationships. "You're placing one of your most valuable assets – customer relationships – in a stranger's hands," points out Ton Heijmen, senior adviser to The Conference Board (New York City) on offshoring and outsourcing [of services] (Johnson (2007), p.1).

While the evidence regarding a manufacturer's ability to *appropriate* value from servitization is inconclusive, the evidence on the ability of servitization to *create* value on the level of the product and the customer is more positive. A number of contributions have examined effective ways of (commercially) engaging in extended warranty and after-sales service (Balachander, 2001; Balachandran and Radhakrishnan, 2005; Jack and Murthy, 2001, 2007; Patankar and Mitra, 1995). For example, Cohen et al. (2006) developed a product life-cycle model that studies a set of strategic choices manufacturers face as they design their joint product/service bundle – requiring, in all likelihood, after-sales maintenance and repair support. More recent operations literature examined the nature of the relationship between the provider and the customer and, in particular, the characteristics of contracts (Toffel, 2008) and the effectiveness of diverse performance-based contracts for equipment availability and traditional cost-based or fixed-price contracts (Kim et al., 2007). Furthermore, authors investigated the impact of different forms of performance-based servitization contract on product reliability (Guajardo et al., 2011) and the degree of customer involvement (Roels et al., 2010).

Further positive evidence on the value-creating properties of servitization appear in environmental economics literature alongside related phenomena such as leasing (Agrawal et al., 2012). The World Business Council for Sustainable Development identified ‘service extension’ as one of the four important elements in eco-efficiency (Mont, 2004a; WBCSD, 1996). The addition of services such as maintenance, upgrading and remanufacturing prolongs product life and so reduces product turnover (Mont, 2004b). For example, White et al. (1999) cite the case of Electrolux A.B, which conducted a life-cycle analysis of a servitized floor-cleaning machine; they found that life-cycle services (maintenance and optimal utilization) reduced in-use (environmental) impacts as well as material and energy consumption in the product system through life extension, part re-use and recycling. Furthermore, a simulation model developed by Brouillat (2009) demonstrates that services such as maintenance, repair, reconditioning, and technological upgrading result in an extension of the product life cycle and, hence, reduce the overall ecological impact of product use.

So, while studies demonstrate that servitization creates value on the level of the product directly appropriated by the customer, value appropriation by the product-service provider is subject to debate. Moreover, the literature points to worrisome challenges with regard to servitization that may well result in a decline in overall performance, the so-called ‘servitization paradox’. To resolve the paradox, we will clarify the process of value creation and value appropriation, starting from the (better understood) customer’s perspective on value creation and translating these insights into the manufacturer’s perspective.

3. Theoretical development of the research model

From a customer's perspective, servitization represents a 'make or buy' decision, where a customer considers whether to service (e.g. maintain) products in-house, outsource servicing to an independent service provider, or outsource servicing to the original product manufacturer provided he offers services (see Haywood-Farmer et al. (2000) for a case study that illustrates this dilemma). A customer will choose to outsource services to the product-service provider if this product-service bundle is more cost effective compared to the other two options (self-service and outsourcing to an independent service provider). Higher cost effectiveness of the bundle compared to the products and services sold individually results from the demand-side economies of scope (Adner and Zemsky, 2006; Priem, 2007; Ye et al., 2012). For example, customers may experience complementarities in use such as interoperability (Lee et al., 2010; Nambisan, 2002; Tanriverdi and Lee, 2008; Tanriverdi and Venkatraman, 2005) and/or experience reduction in the procurement costs and information asymmetries related to product and service quality (Nayyar, 1993).

The manufacturer's ability to achieve an advantageous proposition will also depend on the presence of economies of scale in services, and economies of scope in products and services (Akan et al., 2011; Chase, 1981; Panzar and Willig, 1981; Teece, 1980, 1982). Economies of scale arise as the manufacturer provides services for its entire installed base, while a single customer would need to invest in service resources and capabilities for a much smaller number of machines. Whereas an independent service provider could benefit from this advantage, economies of scope achieved by leveraging technological and marketing capabilities across products and services (Gebauer et al., 2008) can only be attained by the product-service provider. For example, manufacturing firms can capitalize on the existing CRM information and sales channel infrastructure developed for traditional product activities (Quinn

and Gagnon, 1986) and spread transaction costs over products and services (Williamson, 1975). Combined, arguments for the customer's and the provider's economies of scale and scope strongly suggest that customers will be inclined to purchase related, life-cycle services from the product manufacturer. This logic results in the following hypothesis:

Hypothesis 1a. An increase in product sales will result in an increase in service sales.

While a thriving product business clearly creates opportunities for service business development, the impact of services on the development of the product business is less clear. Environmental economics literature (Brouillat, 2009; Mont, 2004a; WBCSD, 1996; White et al., 1999) suggests that one of the major sources of the value gain from servitization, from the perspective of customers and society at large, comes from prolonging the life of existing products through better care of those products. As the life of an existing product is extended, the replacement – and therefore sale – of a new product is postponed. This means that services may, to a certain extent, substitute products (Siggelkow, 2002).

On the other hand, services can have numerous positive effects on product sales. The regular exchange of disposable parts will prevent breaking and malfunction of the product, leaving the customer with a more positive experience of product quality and brand loyalty. Customers who are satisfied with the services delivered will be more likely to purchase product replacements from the same manufacturer, thereby increasing the product renewal rate (Heskett et al., 2008). Moreover, better understanding of customer needs and product functioning may result in improvements in product design that promote a reduction in the cost of product functioning (e.g. energy costs) and, therefore, promote sales of the new generation of products. By

engaging in service activities, the manufacturer becomes much better informed about the customer's broader needs: this information can be instrumental in enlarging the scope of the product offering to the customer, which may in turn result in sales of related products and add-ons. Additional product sales may accrue from replacing competitors' products with the product-service provider's own products. In particular, if a customer has been buying products from the competitor as well as the focal firm, he may be persuaded to change over time to a single product-service provider in order to increase interoperability and reduce the cost of the entire system. This set of arguments points to high potential for services to act as a complement to products, offsetting the substitution effect; subsequently, higher service revenues will result in higher product revenues.

Hypothesis 1b. An increase in service sales will result in an increase in product sales

Overall, while service sales may have a positive effect on product sales, practice suggests that labor-intensive service activities such as maintenance and repairs imply greater face-to-face customer interaction and, hence, lead to customer intimacy and more detailed knowledge of customer needs. Product-service providers who shift their service mix to services characterized by higher engagement in customer operations and higher responsibility for overall customer performance are likely to learn more about customers (e.g. regular customer encounters) and the product (e.g. harvesting information on product functioning), which may intensify the positive feedback from services to products. Hence, the greater the service contact through labor-intensive services or 'customer proximity', the more knowledge is generated and the greater the opportunities created to strengthen customer relationships. In addition, field service

activities provide valuable information feedback on product development and engineering work. These arguments lead us to the following hypothesis:

Hypothesis 1c. An increase in 'customer proximity', measured by the share of labor-intensive services, results in an increase in product sales.

To summarize, Hypotheses 1a and 1b suggest a reciprocal, positive relationship between products and service activities: an increase in product revenues results in the increase in service revenues and vice versa. In addition, Hypothesis 1c argues that an increase in the share of labor-intensive services of the overall service sales mix will result in additional growth in product sales. Nevertheless, the question remains whether firms can manage to appropriate value in terms of the overall profitability (the overall profit margin) of the product-service business and avoid the servitization paradox (Bowen et al., 1989; Gebauer et al., 2005; Oliva and Kallenberg, 2003).

Given the superior customer utility achieved through the demand-side economies of scope explained earlier, it can be argued that the product-service provider has the ability to increase the price of the entire value system (Cottrell and Nault, 2004; Eisenmann et al., 2011; Priem, 2007) and, thereby, attain higher profits. Furthermore, services may promote economies of scale on the provider side; the accumulation of service activities will lead to economies of scale in services, resulting in a more cost-efficient service delivery. To the extent that service sales lead to an increase in product sales, additional economies of scale on the product side may occur as well. Thus, one can expect profit margins for the product-service business to increase as the economies of scale translate into cost savings on the customer side (Quinn and Gagnon, 1986).

Nevertheless, a manufacturer needs to invest in service-specific resources and capabilities in order to deliver services. The necessary investments range from 'operational' service capabilities and resources such as service delivery, service sales skills (Barney, 1991; Peteraf, 1993), and service information systems and tools (Penttinen and Palmer, 2007), to more dynamic capabilities enabling service deployment (Teece et al., 1997) such as service management and top management capabilities to reorganize a manufacturing firm from pure product provider to product-service provider. Sizeable investments in services could temporarily decrease profit margins (Gebauer et al., 2005; Quinn and Gagnon, 1986).

Interplay between the arguments presented above is likely to result in a curvilinear relationship between service scale and profitability where investments paired with a low scale of services initially result in a decrease in margin but then convert to a positive impact as the investment is internalized and higher scale is reached (Fang et al., 2008; Suarez et al., 2011). Nevertheless, after consultation with top management in the firm under study, we have learned that the period of investment associated with low scale of services may be preceded by a highly lucrative phase where services are demanded by a handful of proactive customers with a readiness to pay. Hence, the manufacturer may start to servitize unintentionally to reach the 'low hanging fruit that can be harvested very early on' and may only begin to consider servitization as a strategy and an investment opportunity after a certain number of services have been sold. Thus, it can be conceived that the profit margin exhibits a steep *increase* at very low levels of service scale, a decrease at the medium-scale level due to investments and, finally, an increase as economies-of-scale effects take off. Thus, our models account for the possibility of a curvilinear relationship between service scale and

profitability characterized by two saddles or a cubic relationship. In line with this reasoning, we advance the following hypothesis:

Hypothesis 2: The relationship between the scale of service activities and the profit margin is curvilinear and characterized by two saddles: while very low levels of service activity exhibit a steep increase in margin, low levels of service scale exhibit a relative decrease in margin, which then reverts to an increase once sufficient economies of scale are achieved.

4. Research methodology

4.1 Research design

To test the hypotheses, we collected data from the national sales-and-service subsidiaries of a large multinational equipment manufacturer, Atlas Copco. The firm under study achieved consolidated annual revenues in excess of €3.2 billion ($4.4 billion), with the service business amounting to approximately 40 percent of revenues in 2007. Its product offering encompasses an assortment of equipment types used for powering a diverse set of factory machines in a variety of industrial applications, such as power machines used to produce plastic bottles, textiles and automobiles. For the majority of customers – mostly industrial manufacturers themselves – these products represent investment goods priced in excess of €50,000 – and even €100,000 in some cases – that will form part of their production infrastructure for years to come. Over time, a given country subsidiary may have sold tens of thousands of equipment units to thousands of clients. Service portfolio opportunities range from spare parts and ad-hoc repairs to maintenance agreements with varying degrees of coverage (e.g. from preventative maintenance to maintenance plans with wide coverage of operational and financial risks). In recent years, Atlas Copco has concentrated on promoting a service

offering that covers related machinery, aiming to improve reliability and reduce energy costs for the entire functional group of products.

Atlas Copco's sales and provision of products and services are accomplished through a network of country subsidiaries. Each subsidiary is charged with establishing and maintaining market presence with a full spectrum of product and service offerings in a given country. Atlas Copco's globally diffused network of highly skilled technicians assures high levels of intimacy with its customer base. Regarding the level of decentralization and subsequent diversity of subsidiaries, subsidiaries offer homogeneity with respect to the product and service portfolio, brands and pricing, on the one hand, while each subsidiary differs significantly in terms of its organizational structure, local practices, management style, and deployment of its business model, on the other. Offering the same product portfolio with a similar transfer price for all country subsidiaries enables Atlas Copco headquarters to maintain fair competition in different markets (an Atlas Copco subsidiary from one country can sell in another subsidiary's country market), while the diversity of managerial practices with respect to service business model implementation makes it possible to adjust to different country markets and achieve a global footprint.

In a research endeavor that took three years to complete, we compiled a dataset on 44 Atlas Copco country subsidiaries over the 2001-07 period, which allowed us to test the outlined hypotheses on the value creation and appropriation processes of servitization. The 44 subsidiaries we studied covered countries from Western Europe and North America to Asia Pacific and Latin America, as well as Africa and the Middle East. Each of the subsidiaries was present in the country for at least 15 years, well beyond our seven-year observation period. In addition to the fine-grained

quantitative data obtained from internal sources, we also benefited from numerous discussions at the level of both headquarters and subsidiary. This helped us interpret and give meaning to the data collected (Jick, 1979). “The ability to get closer to theoretical constructs is particularly important in the context of longitudinal research that tries to unravel the underlying dynamics of phenomena that play out over time” (Siggelkow, 2007).

Opting for a longitudinal econometric study on the level of country subsidiaries did pose challenges, with respect to generalizability in particular. Indeed, this study is based on the variability in managerial practices with respect to service business model implementation and environmental factors while the industry, product portfolio, brand and governance practices of the mother company are shared. At the same time, these disadvantages facilitated testing since they decreased the need for a number of control variables (further discussion follows). Also, a longitudinal econometric approach, unlike a survey study, can generate inferences on over-time causality. Finally, to construct particular servitization variables, we needed to construct measures specific to the product and service portfolio of the given mother company; undertaking the study across different companies would mean substantially compromising the precision of the measures and internal validity.

4.2. Dependent, Independent and Instrumental variables

As per H1a, the installed product base enables the sale of services in the following year, after expiry of the obligatory warranty. In turn, services imply greater interaction with customers, which may result in additional sales of products, almost simultaneously with the provision of services (H1b). This feedback loop will be stronger when the service mix includes more labor-intensive services that involve frequent service visits and foster customer proximity (H1c). Finally, service scale is

likely to have an impact on the profitability of the overall business, characterized by a steep increase, relative decline and then further increase (H2).

The reciprocal relationships between products and services expressed in H1a, H1b and H1c represent a system of equations with simultaneous causality. The presence of *simultaneous* causality is a common cause of violation of the standard regression analysis assumption pertaining to the absence of correlation between the error terms and the independent variables, known as endogeneity (Stock, 2001; Stock and Watson, 2003; Wooldridge, 2002). H2, on the other hand, is prone to another common source of endogeneity – missing variable syndrome (Stock, 2001; Stock and Watson, 2003; Wooldridge, 2002); while service scale is likely to impact the overall profitability of the product-service provider, managerial knowledge about the increase in profitability as a result of an increase in service scale may lead to endogeneity and biased results. Because managerial knowledge is a missing variable, it may be correlated with the error term as well as with the dependent variable (profitability) and the independent variable (service sales), resulting in endogeneity and biased, inefficient parameters.

To avoid biased estimates, econometricians recommend the use of the instrumental variables approach (Sargan, 1958), which consists of a system of equations where the (endogenous) independent variable is first 'regressed' on another variable – called the 'instrument' – which explains the independent variable but is unrelated to the dependent variable (for details see Bascle (2008)). The instrumental variables approach has been used as a popular resolution of the endogeneity problem in operations and strategic management, particularly when coupled with estimators such as GMM and two-stage least square (Guajardo et al., 2011; Novak and Stern, 2009; Suarez et al., 2011). An instrument is said to be 'strong' or 'relevant' when it explains

the independent variable well, and it is said to be 'independent' or 'exogenous' when it is unrelated to the error term and the dependent variable (Staiger and Stock, 1997; Stock et al., 2002; Stock and Yogo, 2004).

The search for a strong instrument represents an important study-specific task because the idiosyncratic nature of independent variables implies the absence of an exhaustive theory on appropriate instruments (Wooldridge, 2006). As product sales and service sales represent endogenous independent variables in the first and second models respectively, they both need instruments that are strong and independent of each other. As Atlas Copco allows cross-border sales of products but not services (e.g. the German subsidiary can sell products in France despite the presence of a French subsidiary), we identified the macroeconomic indicator of country exports as an adequate product sales instrument (H1a). ***Country exports*** indicate the climate in a given country for exports, which will positively influence the subsidiary's product sales *abroad* (strength). As these products will not be serviced by the same subsidiary, the export climate will have no influence on service sales (independence). In addition, ***absolute growth of GNP*** will likely stimulate one-time investment in new products with no visible impact on service activities; hence, we chose this as an additional instrument.

For the same reasons, the macroeconomic indicator of ***country imports*** was identified as an adequate instrument of service sales (H1b/H1c). A subsidiary that is located in a country where there are substantial imports of Atlas Copco products may have the opportunity to service these products and, hence, generate higher service sales (instrument strength) that do not stem from national product sales (using the previous case, the French subsidiary would have greater opportunity to sell services on the products sold by the German subsidiary). In addition, we deployed ***Service***

scope – the ratio of service sales to the installed base of products sold over the past four years as an instrument for service sales; this indicator captures the extent to which different country subsidiaries provide services for a given installed base. Further to that, we used ***Product installed base*** or product volume sold over the past four years as an indicator of the installed base. Finally, as the manufacturing sector clients represent the best 'buyers' of services according to the experience of Atlas Copco management, manufacturing ***capital investments (capex)*** in a given country helped us distinguish between countries that were more focused on manufacturing and vice versa. Finally, we instrumented customer proximity (H1c) on ***customer proximity in t-1***, given that a large proportion of the service contracts are renewed annually. In addition, ***service staff*** was deemed to be a good predictor of customer proximity, especially since customer proximity represents an increase in the labor-intensive services that allow greater contact with the customer.

In H2, we have re-used country exports and absolute growth of GNP to instrument product sales. At the same time, we faced a serious challenge to find sufficient instruments for service sales, service sales^2 and service sales^3. Firstly, we complemented the existing instruments for service sales (***country imports, service coverage, lagged product installed base and manufacturing capex***) with ***country population density,*** given that labor-intensive services thrive in densely populated areas. Secondly, we re-used ***customer proximity*** and ***service staff*** as additional predictors of service sales, particularly labor-intensive services. In the model, we also used ***lagged values of product sales, service sales, service sales^2 and service sales^3***.

4.3 Control variables

Due to the scarcity of data and complex nature of interdependencies between products and services, the choice of control variables represented a particularly

important part of the model design. As all subsidiaries have been operating for 15 years or more prior to the observation period, the subsidiary age was deemed irrelevant. Subsidiaries have also exhibited homogeneity with respect to the product portfolio, brand and high-level pricing strategy (allowing a modest degree of discretion for individual client negotiations). This homogeneity allowed us to perform an analysis controlling ***fixed effects*** for country-specific and time-invariant factors such as culture and the propensity to pay for services, while relying on a limited number of control variables for the time-variant factors. In all models, we control for fine differences in product mix, through an indicator of the ***product portfolio mix*** that represents the share of small versus large products used in different applications. Furthermore, we capture differences in market development by ***GNP per capita*** (e.g. subsidiaries operate in countries ranging from China to Switzerland), while a ***year dummy*** variable is used to capture the expected yearly effects of price increases. In addition, in testing H2, we use the ***increases in service staff*** and ***increases in non-service staff*** to capture the negative effect of labor increases on profit margins, in particular in the case of (labor-intensive) services, as well as product sales, given that the (lack of) economies of scale on the product side can also have an impact on profit margins.

Table 1 contains further information on the variables, while Models M1 (H1a), M2 (H1b & H1c) and M3 (H2) are formally represented below. In all models presented below, v_i and $\varepsilon_{i\,t}$ represent the country dummies and specific residuals, respectively. Further discussion on the use of fixed effects and year-trend variables will be presented in the following sections.

----- INSERT TABLE 1 ABOUT HERE -----

M1. service sales$_{i,t}$ = a1+ b1 x product sales$_{i,t-1}$ +c1 x gnppercapita$_{i,t}$ +d1 x product portfolio$_{i,t}$ + e1 x year dummy$_{i,t}$ +v1$_{i,}$ + ε1$_{i,t}$

a. product sales$_{i,t-1}$= f(exports$_{i,t-1}$, gnppercapita increase$_{i,t-1}$)

M2. product sales$_{i,t}$=a2 +b2 x service sales$_{i,t}$ + c2 x customer proximity$_{i,t}$ + d2 x gnppercapita$_{i,t}$ +e2 x product portfolio$_{i,t}$+ f2 x year dummy$_{i,t}$ + v2$_{i}$ + ε2$_{i,t}$

a. service sales$_{i,t}$= f(imports$_{i,t}$, lagged product installed base$_{i,t}$, service coverage$_{i,t}$, manufacturing capex$_{i,t}$)

b. customer proximity$_{i,t}$ = f(service staff$_{i,t}$, customer proximity$_{t-1}$)

M3. profit margin$_{i,t}$= a3+b3 x service sales$_{i,t}$ + c3 x service sales$^2_{i,t}$ + d3 x service sales$^3_{i,t}$ + e3 x product sales$_{i,t}$ + f3 x gnppercapita$_{i,t}$ + g3 x product portfolio$_{i,t}$ +h3 x service staff increase$_{i,t}$+i3 x non-service staff increase$_{i,t}$ +j3 x year dummy$_{i,t}$ + v3$_{i}$ + ε3$_{i,t}$

a. product sales$_{i,t}$ = f(product sales$_{i,t-1}$, exports$_{i,t}$, gnppercapita increase$_{i,t}$)

b. service_sales$_{i,t}$, service_sales$_{i,t}^2$, service_sales$_{i,t}^3$= f(service sales$_{i,t-1}$, service sales$_{i,t-1}^2$, service sales$_{i,t-1}^3$, imports$_{i,t}$, lagged product installed base$_{i,t}$, service coverage$_{i,t}$, manufacturing capex$_{i,t}$, density$_{i,t}$, service staff$_{i,t}$, customer proximity$_{t}$)

4.4. Estimators, model corrections and diagnostic checks

In all econometric models, we use panel data analysis with fixed effects. The fixed-effects model includes dummy variables for each subsidiary, thereby 'specifying an estimable conditional mean and addressing biased and inconsistent parameter estimates' (Greene (2003), p.285). We introduce fixed effects to control for time-invariant, unobserved heterogeneity among subsidiaries, given our expectation that time-constant differences may determine the effectiveness of the service strategy (Greene, 2003). For example, discussions with the firm's management demonstrated

that multiple country-specific differences, such as cultural acceptance of charging for service provision or size of the country's territory, could have a considerable impact on service-related performance.

In the model specification, we also use 'heteroskedasticity and-autocorrelation-consistent' (HEC) standard errors (Bascle, 2008) to avoid concern over invalid inferences caused by these two violations of standard OLS assumptions (Arellano and Bond, 1991). The expected yearly effect of price increases and growth targets is countered by introducing a year dummy variable in each model. Furthermore, we stationarized all monetary data (e.g. sales, GDP/capita, exports and imports) by transforming the nominal values into real 2000 values, using the World Bank's GDP deflator. While diagnosis of multicollinearity is difficult in the IV models, tests on the models using the OLS estimator show that the variance inflation factor scores (VIFs) are well below 10 for the first two models (average VIF for M1 is 1.84 and M2 is 3.06). In Models 3a, 3b and 3c, all variables have VIFs well below 10, apart from service sales, service sales^2 and service sales^3, which have VIFs exceeding 10, as anticipated.

The dataset was considered fairly balanced: all data was present apart from data on profit margins for three subsidiaries, product-installed base and consequently service coverage for two subsidiaries, manufacturing capex for two subsidiaries, and country density for one. For service staff and consequently non-service staff, data was missing for nine subsidiaries, and on four years in the case of one additional subsidiary. Since IT system issues were responsible for the missing data, we do not expect bias to be introduced. Table 2 below provides descriptive statistics for all the variables.

In all models, we use one of the most common approaches to address endogeneity (Hahn et al., 2004; Murray, 2006) – the instrumental variables approach (Wooldridge,

2002). We started by using two-stage least square generalizations of simple panel-data estimators (Anderson and Hsiao, 1981; Baltagi, 2002), but then we proceeded to check various other IV estimators, including limited information maximum likelihood (LIML), Fuller's modified LIML (FULL) estimation and Generalized Method of Moments (GMM) (see (Bascle, 2008) for an overview). While all estimators produced very similar results, we decided to report the most conservative ones that GMM has yielded. This choice was also in line with Suarez et al.'s (2012) choice of GMM to test the impact of servitization on performance.

Each of the models has relevant instruments, since F-statistics for the first-stage regressions exceed the threshold (see Table 3) (Bascle, 2008; Staiger and Stock, 1997; Stock and Yogo, 2004). In addition, instruments are jointly exogenous for each of the models, given that the P-value of Hansen's J statistic exceeds 10%, thereby rejecting endogeneity in instruments (Hansen, 1982). Various additional robustness checks were performed. First, different instruments to the retained ones were used (lagged products sales as an IV for products sales, lagged service sales and installed-base size as an IV for service sales). Additionally, different controls were used (e.g. service staff and employees in absolute figures, population density instead of service staff).

----- INSERT TABLE 2 ABOUT HERE -----

5. Results

Table 3 below summarizes the results obtained in relation to the testing of the hypotheses. Results displayed in Model 1 confirm the arguments posited in H1a: as customers seem to realize higher economic benefits by outsourcing their servicing to the product-service provider, 1 unit (euro) of increase in product sales in t-1 leads to an increase of 0.86 units (euros) in service sales in t (b1=0.86; p=0.000). Interestingly,

service sales has a greater impact on product sales too. As Model 2, confirming H1b, suggests, a 1-euro increase in service sales results in approximately a 1.53-euro increase in product sales (b2=1.53; p=0.000). Indeed, Atlas Copco is not only able to transcend inherent substitution but it enacts economically and statistically robust complementary effects from services to products. Furthermore, Model 2 reveals that customer proximity leads to an additional increase in product sales (c2=35.65; p=0.046), thereby confirming H1c.

----- INSERT TABLE 3 ABOUT HERE -----

Table 3 shows the empirical results of testing the impact of servitization on profit margins, as advanced in H2. First, Model 3a, which tests the impact of service sales on overall profitability, reveals the absence of a linear relationship ($b3= -0.001 * 10^{-4}$, p=0.565). Model 3b, which stipulates the presence of a quadratic relationship, shows that this relational pattern is not present either (b4=0.002, p=0.533; $c4= -3.12*10^{-5}$, p=0.156). Finally, Model 3c, which assesses the presence of a cubic relationship between service sales and profitability, returns convincing results; suggesting a non-linear relationship with the presence of two inflection points, as stipulated by H2 (b5=0.021, p=0.005; $c3= -4.09*10^{-4}$, p=0.002; $d3=3.03*10^{-6}$, p=0.003) and illustrated in Figure 1.

----- INSERT FIGURE 1 ABOUT HERE -----

Further to the relationships hypothesized, our models demonstrate a strong and significant influence of country development, as measured by the GNP/capita. The product portfolio's significant impact on product sales also confirms the greater contribution that larger equipment makes to revenues, as anticipated. Contrary to what might be expected, a positive impact of product sales on profit margins is absent. In

discussing this finding with Atlas Copco, the management suggested to us that it could be due to the limitation of the research setting – given that the products are designed and manufactured centrally, the observed variation among the subsidiaries is based on the differences in sales and business model activities on the level of the subsidiary rather than the whole product business.

6. Discussion and conclusion

6.1. Study results and the contribution to theory and practice

The results of Model 1 (H1a) and Model 2 (H1b and H1c) indicate that product sales and service sales complement each other and that the customer proximity of service offerings reinforces the positive feedback from services to product sales. While positive effects are anticipated in progressing from products to related service activities, the reverse relationship – whereby service sales positively influence product sales – is far less obvious, since the impact of servicing may be negative when services act as substitutes for products. Atlas Copco overcomes inherent substitution effects by using services to extend the sales potential of products; moreover, increasing levels of labor-intensive service offerings result in higher customer proximity and further enhance the positive effect of service activities on product activities.

The presence of complementary dynamics on the level of product and service sales (M1 and M2) seems highly related to the manufacturer's choice of business model (Casadesus-Masanell and Ricart, 2010; Zott and Amit, 2010). Our findings suggest that an integrated product-service business model – which creates opportunities for growth beyond the installed product base by relying on related services, coupled with managerial practices that reinforce complementarity through customer proximity – is important in this respect. An integrated product-service business model also requires

services to be viewed as a strategic complement to products; if services are approached merely as an add-on, revenue growth will be limited by the installed product base, which may well encourage firms to expand into independent services. However, if services become unrelated to the products, complementary dynamics and economies of scope in products will no longer act as sources of value creation, and specialized service providers (focused on accomplishing service economies of scale and learning effects) may be a more efficient choice for the customer.

These findings contribute to the servitization literature (Fang et al., 2008; Guajardo et al., 2011; Kim et al., 2007; Neely, 2008; Suarez et al., 2011) by illuminating the process of value creation through servitization from the perspective of the manufacturer-turned-service provider, offering insights for product-service providers on how to move beyond the threat of value 'destruction' to value creation. Furthermore, the presence of the reciprocal, positive revenue relationship between products and services may be seen as an indicator of complementarities (Milgrom and Roberts, 1990, 1995; Siggelkow, 2001) on the customer side. It is interesting to note that complementarity will be contingent upon or 'contextual' to (Porter and Siggelkow, 2008) the business model and managerial practices that help enact complementary feedback from services to products (e.g. systems that transform service-field information into product-relevant insights) and override the innate substitutive effect of services on products (Siggelkow, 2002). Contextuality of complementary and substitutive effects is an interesting observation in itself, since extant literature perceives complements and substitutes to be mutually exclusive (Siggelkow, 2002).

Models 3a, 3b and 3c (H2) disprove the linear and quadratic relationship between service sales and overall profitability and, as hypothesized, suggest a cubic

relationship. Model 3c confirms that, when the scale of service activity is low, growth coincides with higher profit margins, suggesting that the product-service provider can indeed harvest the 'low-hanging fruit'. In practice, this phase is marked by a high proportion of spare-parts activity and a handful of service contracts for high-paying customers, where attractive margins can be achieved without substantial investment in staff and organization. A moderate scale of service activity is associated with diminishing profit margins. A manufacturer hosting a moderate level of service activity is faced with the need to invest in a service organization that countenances systematic, large-scale service provision. Finally, a higher scale of service operations again results in a positive relationship between scale and profit margins, suggesting that economies of scale (together with economies of scope in products) eventually compensate for investment costs.

While these findings provide reassurance, they also suggest that manufacturers face a real risk; after going through an initial, lucrative phase, firms that expect the adoption of servitization to equate to harvesting low-hanging fruit may well become frustrated and inclined to discard service activities prematurely. These insights offer advice to product-service providers to estimate the potential of the service business well in advance, thereby ensuring they will be able to overcome the investment hurdles encountered. Besides economies of scale, the preliminary tests we have conducted (available upon request from the authors) suggest that accumulating levels of service over time will result in service learning effects (Heim and Ketzenberg, 2011), which are likely to further improve profit margins. For example, the more a service technician visits her/his customer for machine maintenance, the more s/he learns about the machine itself and customer operations; the adequate application of

information technology over the entire product population enhances the predictability of servicing and decreases the risk of machine failure.

Our study also contributes to the literature on servitization by disentangling the complex relationship between servitization and profitability. Using a lower level of unit of analysis, we attain more granular insights on the interplay between an increase in customer willingness to pay due to demand-side economies of scope and economies of scales on the service provider's side. These more detailed insights – unobtainable from the cross-industry accounting data – help us to shed light on the factors that underpin the 'servitization paradox', an issue that scholars have been debating for over a decade.

In short, our study makes three recommendations for service-oriented manufacturing firms: a) the adoption of an integrated product-service business model as a way of creating reciprocal spillovers between products and services, b) the implementation of practices that generate customer proximity, and c) the consideration of necessary investments as well as the enactment of economies of scale and learning effects in services in order to achieve long-term profitability.

6.2 Limitations and future research

We are fully aware of the limitations of the research reported in this paper. While our study has benefited immensely from the insights from practice as well as from direct access to proprietary company data, sourcing data from a single firm points to limitations in terms of external validity. Firstly, we have focused only on one mother firm with one business model – the integrated product-service business model – whereas servitization can equally imply the deployment of less related service offerings. Consequently, this research should be complemented by similar efforts in different industries to assess the broader validity of the findings obtained. Secondly,

due to the centralized design and production of products, we cannot fully explore the question concerning economies of scope between products and services. Future studies should examine this source of value creation that, according to the anecdotal evidence we have gathered, may exist on the customer interface as well as in the innovation function.

Furthermore, our analysis captures the overall net effect of product-service dynamics rather than focusing on specific service offerings. Hence, it would be interesting to further analyze how specific services such as leasing (which implies retention of ownership on the manufacturer's side) change the value functions of manufacturer and customer. Also, the impact of product monitoring services might be further scrutinized; though it clearly represents one of the more sophisticated service activities, it may reduce intimacy with the client due to remote provision. In general, future research efforts aimed at validating the occurrence of interdependencies on a larger sample of firms are necessary to assess the extent to which our findings are common to different industrial settings and to examine additional contingencies that might affect the value dynamics observed. Between-firm comparisons are also needed to further assess the extent to which integrated business models are indeed superior or sustainable compared to other service strategies, such as unrelated product-service diversification.

Finally, further substantiation of different sources of complementarities, economies of scale, scope and learning effects, as well as the presence of substitution effects, seems highly relevant in increasing our understanding of the effectiveness of product-service business models for manufacturing firms. For example, future studies could significantly improve our results by correcting for third-party competition. While, at this stage, we can only distinguish between the sale of spare parts and the sale of

labor-intensive services such as maintenance, it is to be hoped that future studies will be able to provide more fine-grained insights with respect to the relationships between particular types of product and service.

Furthermore, it should be noted that, while this study focuses on sales complementarities, engaging in servicing can also yield spillovers by generating insights that have a considerable impact on product development activities. On the other hand, product innovations may facilitate service provision by taking into account the requirements of the service environment in product design, or it may reduce the need for servicing and lead to cannibalization of the service business. Assessing the presence of complementarities and substitution effects over longer time periods would add significant value to the results reported in this paper. For example, complementary effects from services to products may strengthen as product-service providers spend more years servicing a customer. Finally, our findings reveal considerable implementation differences between subsidiaries operating within a similar service business model, strongly suggesting the relevance of scrutinizing further organizational antecedents that affect servitization performance. We hope that our findings inspire colleagues to engage in such efforts.

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Table 1.a Overview of the variables and their use

Variable name	Measure	Formula	Definition and Use	Transformation
Total profit margin	%	Subsidiary profits/ Subsidiary sales.	Profit margin of the total product-service business in a subsidiary, before deduction of the headquarters overhead that is proportional in all subsidiaries. Dependent variable for H2 (M3a, M3b, M3c).	None.
Product sales	EUR million	N/A*.	Sales of the full product portfolio in the subsidiary. Independent variable in H1a/M1 and H2/M3a, M3b, M3c; dependent variable in H1b and H1c / M2.	Normalized to year 2000, using World Bank's GDP deflator.
Service sales	EUR million	N/A.	Sales of the full service portfolio in the subsidiary. Independent variable in H1b and H1c / M2 and H2/M3a, M3b, M3c; dependent variable in H1a/M1.	Normalized to year 2000, using World Bank's GDP deflator.
Customer proximity	%	Maintenance sales/ Service sales, where Service sales= Maintenance + Spare parts.	Share of labor-intensive services, identifies the level of relational proximity to customers. E.g. the higher the % of labor-intensive services, such as maintenance, the more often technicians visit a customer. Independent variable for H1c/M2 and instrumental variable in H2/M3.	None**.**
GNP per capita	USD thousand	Gross National Product (GNP)/ Number of people.	A control for the level of development of a subsidiary's country market in all the Models.	Normalized to year 2000, using World Bank's GDP deflator.
Product portfolio	%	Sales of large products/ Sales of small products, *where Total products sales= large +small products.*	Controls for the differences in subsidiaries' product portfolios in all the Models.	None.

* N/A- Not applicable

Table 1.b Overview of the variables and their use

Variable Name	Measure	Formula	Definition and Use	Transformation
Service staff	Integer	N/A.	The number of service employees in a subsidiary. Use 1: Used to control for differences in labor efficiency of service staff in the M3a, M3b and M3c. Use 2: Used as an instrumental variable of service sales in the M3a, M3b and M3c.	Transformation 1: Absolute yearly increase in the number of service staff. Transformation 2: none.
Non-service staff	Integer	Non-service employees= Total employees- Service employees.	The number of non-service employees in a subsidiary. Used to control for differences in labor efficiency for non-service staff in the M3a, M3b and M3c.	Absolute yearly increase in the number of non-service staff.
Year dummy	Integer	A year dummy variable.	Used to control for yearly effects, e.g. price increases.	N/A
Exports	USD billion	N/A.	Value of country exports. Instrument for the product sales in H1a/M1.	Normalized to year 2000, using World Bank's GDP deflator.
Imports	USD billion	N/A.	Value of country imports. Instrument for the service sales in H1b and H1c/M2 and H2/M3a, M3b and M3c.	Normalized to year 2000, using World Bank's GDP deflator.
Density	000 people/km^2	Country population /country surface.	Country population density used as instrument for service sales in H2/M3a, M3b and M3c.	None.
Product installed base (IB)	Integer	Product volume sales in t-1 + t-2 + t-3 + t-4.	Installed base over 4 years used as instrument for service sales in H1a and H1b/M2 and H2/M3a, M3b and M3c.	None.
Service scope	EUR thousand	Service sales/ Product installed base (see above).	Level of service provision for a given installed base of products, instrument for service sales in H1a and H1b/M2 and H2/M3a, M3b and M3c.	None.
Manufacturing capex	USD million	N/A.	Value of country manufacturing capital investments. Indicates the prevalence of the most service-oriented client sectors. Instrument for the service sales in H1b and H1c/M2 and H2/M3a, M3b and M3c.	Normalized to year 2000, using World Bank's GDP deflator.

* N/A- Not applicable

Table 2. Summary statistics and correlation coefficient

No	Variable	Obs	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Total profit margin	287	0.30	0.06	0.14	0.45	1													
2	Product sales	308	17.89	23.40	0.54	141.80	-0.21*	1												
3	Service sales	308	10.56	10.97	0.22	75.88	-0.22*	0.81*	1											
4	Customer proximity	308	0.58	0.23	0.09	0.96	-0.04	-0.07	0.13*	1										
5	GNP/ capita	308	15.44	12.69	0.40	45.85	-0.31*	0.17*	0.47*	0.47*	1									
6	Product portfolio	308	1.09	0.51	0.08	3.00	0.02	0.38*	0.28*	0.02	-0.12*	1								
7	Service staff	241	18.17	15.46	0	93.00	-0.25*	0.60*	0.68*	0.17*	0.16*	0.21*	1							
8	Non-service staff	241	114	105	0	662	-0.28*	0.90*	0.80*	-0.21*	-0.01	0.27*	0.69*	1						
9	Exports	308	219	292	1	1666	-0.23*	0.88*	0.87*	0.03	0.37*	0.38*	0.57*	0.78*	1					
10	Imports	308	221	333	3	2260	-0.24*	0.86*	0.90*	-0.01	0.37*	0.34*	0.55*	0.77*	0.96*	1				
11	Density	301	1.17	1.14	0.02	4.84	-0.05	0.16*	0.17*	-0.03	0.12*	0.31*	-0.03	0.05	0.27*	0.20*	1			
12	Product IB	294	938	1289	25	7397	-0.25*	0.85*	0.71*	-0.13*	0.09	0.22*	0.56*	0.84*	0.74*	0.70*	0.19*	1		
13	Service scope	287	4.48	2.46	0.71	14.57	0.12*	-0.29*	-0.05	0.28*	0.06	0.05	0.02	-0.27*	-0.13*	-0.11	-0.12*	-0.40*	1	
14	Manufact-uring capex	294	23112	41298	402	316255	-0.26*	0.91*	0.67*	-0.22*	0.10	0.43*	0.51*	0.81*	0.82*	0.79*	0.20*	0.80*	-0.28*	1

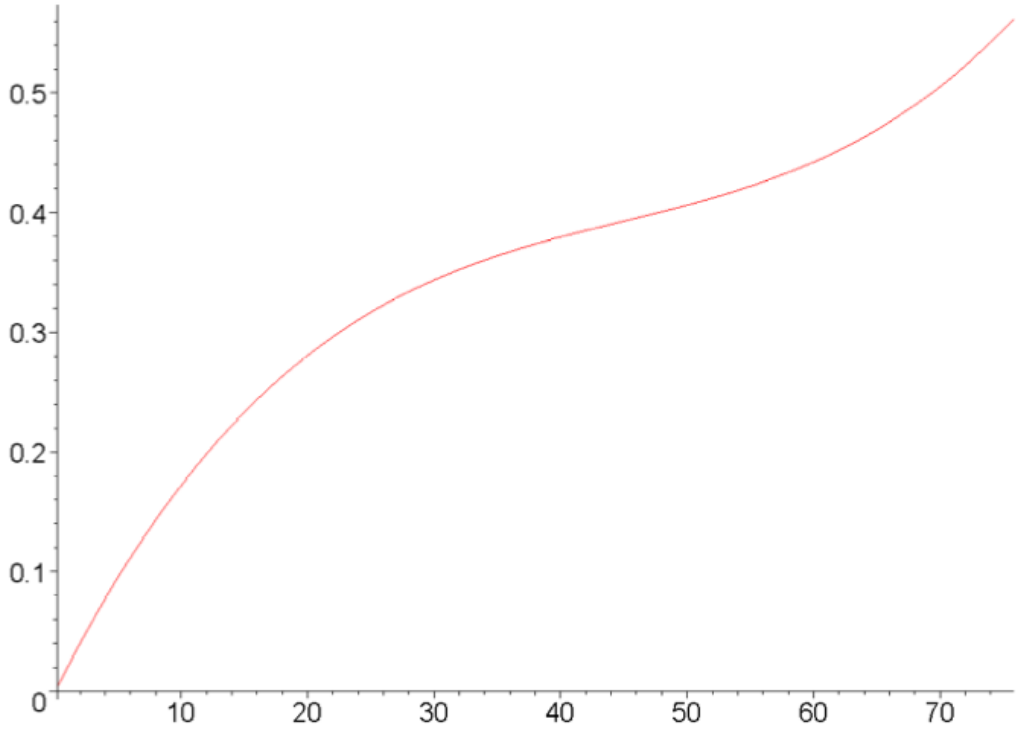
* $p < 0.05$.

Table 3. Results from Hypotheses Testing

Model: Hypotheses	**M1: H1a**	**M2: H1b & H1c**	**M3a: H2**	**M3b: H2**	**M3c: H2**
Dependent variable	**Service sales**	**Product sales**	**Profit margin**	**Profit margin**	**Profit margin**
Variable					
Product sales $_{t-1}$	0.859 (0.000)***	-	-	-	-
Product sales	-	-	$7.60 * 10^{-4}$ (0.627)	$3.76 * 10^{-5}$ (0.983)	- 0.003 (0.140)
Service sales	-	1.53 (0.000)***	$-0.001 * 10^{-4}$ (0.565)	0.002 (0.533)	0.021 (0.005)**
Service sales^2	-	-	-	$- 3.12 * 10^{-5}$ (0.156)	$- 4.09 * 10^{-4}$ (0.002)**
Service sales^3	-	-	-	-	$3.03 * 10^{-6}$ (0.003)**
Customer proximity	-	35.65 (0.046)*	-	-	-
GNP/capita	0.390 (0.006)*	0.65 (0.007)*	0.006 (0.001)**	0.006 (0.002)**	0.007 (0.001)**
Product portfolio	- 0.159 (0.851)	4.02 (0.003)**			
Year dummies	*Eliminated from the data table due to space limitations*				
Service staff increase	-	-	$- 4.19 * 10^{-4}$ (0.210)	$-3.76 * 10^{-4}$ (0.300)	$-3.3 * 10^{-4}$ (0.407)
Non-service staff increase	-	-	$- 1.40 * 10^{-4}$ (0.302)	$-0.66 * 10^{-4}$ (0.714)	$-1.5 * 10^{-4}$ (0.455)
Model statistics					
Number of observations	220	202	165	165	165
F statistics (P-value)	0.000	0.000	0.000	0.000	0.000
R-squared (%)	49.9%	79.2%	23.1%	24.7%	19.7%
First-stage F-statistics*: >10 for one instrumented variable (M1) (Staiger and Stock, 1997); >7.56 for two instrumented variables (M2 & M3a) (Stock and Yogo 2004); >6.61 for three and more (M3b and M3c) (Stock and Yogo, 2004)*					
Product sales t-1	16.40	-	-	-	-
Product sales	-	-	10.14	10.14	10.14
Service sales	-	51.46	174.73	174.73	174.73
Service sales2	-	-	-	146.50	146.50
Service sales3	-	-	-	-	112.97
Customer intimacy	-	8.12	-	-	-
Hansen J P-value > 0.10	0.27	0.11	0.35	0.32	0.84

† p < 0.10. * p < 0.05. ** p < 0.01. *** p < 0.00

Figure 1. Relationship between service scale and subsidiary profit margin*



* Before the deduction of the central headquarters' costs