Service providers and firm performance: investigating the non-linear effect of dependence

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Abstract

Purpose – Servitized manufacturers can leverage close relationships with external providers of product-related services to mobilize value creation and improve the responsiveness of their offerings to customer needs. This paper investigates the economic link between the relational embeddedness of external service providers, as arising from the key dimension of dependence, and firm performance.

Design/methodology/approach – The study evaluates financial statement data pertaining to 190 dyadic relationships of servitized manufacturers with service providers operating in downstream channels and accounting for more than 10 per cent of their revenue.

Findings – The results indicate that service providers’ dependence has an inverted U-shaped relationship with manufacturers’ return-on-assets (ROA), via non-linear effects on return-on-sales (ROS) and asset turnover (ATO). The results therefore suggest that the observed U-shaped relationship for ROA is driven by diminishing returns of dependence in terms of both differentiation ability and operational efficiency.

Research limitations/implications – Future research could examine other dimensions of embeddedness, as well as contingency factors that may influence the embeddedness-performance relationship.

Practical implications – The study conclusions suggest that managers of servitized firms should foster the embeddedness of external service providers, but they should also be careful to maintain an adequate level of dependence to maximize benefits and minimize liabilities.

Originality/value – The study adds to the limited research delving into inter-firm relationships between servitized manufacturers and external service providers. It empirically demonstrates the economic effects of service providers’ dependence-based embeddedness, challenging the general assumption about a monotonic positive effect of relational embeddedness.

Keywords Servitization, Relational embeddedness, Dependence, Service providers, Financial performance

Paper type Research paper
1. Introduction

There is little dispute that the increasing addition of services to market offerings has been a main trend among product manufacturing firms for the past two decades. However, limited financial resources to invest in the service infrastructure (Bikfalvi et al., 2013; Kowalkowski et al., 2013; Story et al., 2017), a poor fit between existing competencies and service content (Gebauer et al., 2013; Paiola et al., 2013), the risks of channel conflict with professional service firms (Antioco et al., 2008; Kowalkowski et al., 2011) and the geographical distance of customers (Bikfalvi et al., 2013) often mean that it is not viable for a manufacturing firm to perform internally all the relevant service activities related to its products. Therefore, a common occurrence in many industries is that, despite pursuing servitization (Vandermerwe and Rada, 1988), manufacturers let external service providers build service practices around their products and, more or less independently, provide product-related service components (Cohen et al., 2006; Kowalkowski et al., 2011). Manufacturers of capital equipment, for example, tend to sell and deliver product-related services to certain customers/markets themselves, through their own dealerships and service departments. Additionally, they work with independent distributors and other intermediaries, which are also enabled to sell the manufactured equipment and offer services such as delivery, set-up, installation, integration, modification, maintenance, repair, training, technical support, operation optimization, leasing and renting (Hakanen et al., 2017; Hullova et al., 2019).

In this respect, some studies hint that manufacturers adopting a servitization strategy can leverage strong relationships with external service providers to mobilize value creation and improve the responsiveness of their offerings to end-customer needs (e.g. Windahl and Lakemond, 2006; Gebauer et al., 2013; Jaakkola and Hakanen, 2013; de Vries et al., 2014; Zarpelon Neto et al., 2015; Weigel and Hadwich, 2018; Reim et al., 2019). Researchers such as Bastl et al. (2012) affirm that the commitment of third-party providers of product-related
services to the business relationship with the product manufacturer fosters cooperative interactions that directly influence the manufacturer’s financial performance. However, evaluations of service providers’ relational engagement and its managerial outcomes are virtually absent from the extant literature on servitization. Although a relational perspective is slowly permeating servitization research (Eloranta and Turunen, 2015; Forkmann et al., 2017), the predominant focus has been on offering guidance regarding the strategic choice between producing and delivering services through internal resources or through resorting to external service providers (e.g. Kowalkowski et al., 2011; Paiola et al., 2013; Bustinza et al., 2019a; Bustinza et al., 2019b). Inter-firm relations with third-party service providers have not been examined specifically, but they are most often collapsed into a single construct that also includes relations with part suppliers, end-customers or other exchange partners in the firm’s network (e.g. Windahl and Lakemond, 2006; Hakanen and Jakkola, 2012; Kohtamäki et al., 2013; Zhang et al., 2017). Furthermore, to date, the emphasis has largely been on value creation for customers; in other words, the capture of value by servitized manufacturers that collaborate with external service providers remains underexplored.

This study, therefore, addresses the following research question: How does the level of engagement of external service providers with the business relationship with a servitized manufacturer affect the manufacturer’s financial performance? To address this question, the study draws upon research on inter-organizational relationships and the theoretical lens of *embeddedness*, (Uzzi, 1997; Choi and Kim, 2008). The study focuses on relational embeddedness, which is principally concerned with the relational quality of exchange ties among firms (Nahapiet and Ghoshal, 1998; Bernardes, 2010). In particular, it analyses the performance consequences that accrue to servitized manufacturing firms from one key dimension of relational embeddedness: the degree of *dependence* of external service providers.
The embeddedness argument suggests that higher levels of dependence promote exchange partners’ cooperative behaviour that, by increasing the efficiency and scope of their actions, provides a “bright side” to the focal firm (Gulati and Sytch, 2007). Nonetheless, some studies in the supply chain management literature have also considered a potential “dark side” of highly dependent relationships that may lead to ineffective decision-making and a waste of resources in dyadic interactions with exchange partners (Villena et al., 2011). This study is aligned with this notion and considers both sides of external service providers’ dependence in a single model.

A unique database of servitized manufacturer–service provider relationships is compiled using Statement of Financial Accounting Standards (SFAS) No. 131’s major customer disclosures. As will be illustrated in later sections, using this data source means that the analysis concentrates on service providers operating in downstream channels (e.g. dealers, distributors, systems integrators) and neglects upstream suppliers to whom the core manufacturer might have outsourced some service activities (e.g. logistic providers, other maintenance specialists).

The study makes several contributions. First, it responds to the limited attention given to inter-firm relationships in the servitization literature (Raddats et al., 2019). To these authors’ knowledge, this study is the first to focus specifically on the relationships of servitized manufacturers with external providers of product-related services, and it is the first to empirically demonstrate their economic link to manufacturers’ performance. Second, the study adds theoretical precision to the servitization literature by also considering the dark side of close manufacturer–service provider relationships. In doing so, the study responds to calls for research that builds and tests theory pertaining to external actors supporting servitization strategies (Gebauer et al., 2013: page 45; Fliess and Lexutt, 2017: page 12). Third, for managers of servitized firms, the study highlights the importance of being aware of
the level of dependence of external providers of product-related services. The results indicate that service providers’ dependence yields diminishing returns for the manufacturing firm; beyond a certain point, greater dependence has the effect of reducing the manufacturer’s economic performance. Thus, managers should be careful to establish and maintain an adequate level of dependence to reap greater benefits from close relationships with external service providers.

2. Background and research hypotheses

2.1 External service providers and servitization

Despite the proliferation of studies on servitization in both operations management and industrial marketing, scholarly research investigating the role of third-party service providers in manufacturers’ service strategies is still at an early stage (Eloranta and Turunen, 2015). The possibility of developing and delivering services by collaborating with external partners, including suppliers, channel members, clients and traditional competitors, has been acknowledged in some seminal works (e.g. Wise and Baumgartner, 1999; Mathieu, 2001). However, these studies were mainly concerned with advocating the increasingly important role of services as a platform for company competitiveness and growth, and they only hinted that manufacturing firms can form collaborative relationships with external actors to harness service opportunities. It is only in the more recent literature on integrated solutions that the idea of networks of business actors that jointly provide service-oriented value propositions to customers has begun to be more fully considered. Davies et al. (2007), for example, usefully exemplify the provision of solutions from a network coordinated by a focal manufacturer. Matthyssens and Vanderbempt (2008) argue that the provision of customized combinations of product and service components as turnkey integrated solutions necessarily requires cooperation with other actors in the business network and, hence, the adoption of a “value

Recognizing that it may not be viable (or simply not rewarding) for manufacturing firms moving towards services to provide all the services relevant to their products internally, a number of studies have focused on the question of when service provision should be organized through internal resources, or entrusted to external service firms. These studies draw on established notions from contingency theory and suggest that one organizational arrangement may be preferable to the other, depending on firm-specific, offering-specific and market-specific factors (Kowalkowski et al., 2011), such as the firm’s financial resources (Kowalkowski et al., 2013), the types of service offered (Bikfalvi et al., 2013; Paiola et al., 2013), the relevant service capabilities (Windahl and Lakemond, 2006; Finne and Holmström, 2013) and the local characteristics of markets where the services should be provided (Zarpelon Neto et al., 2015; Hakanen et al., 2017). Relatedly, another strand of literature has examined the different forms that business arrangements, resource bonds and activity links may take between servitized manufacturing firms and external service providers, in order to understand, for example, the types of service network (Gebauer et al., 2013), the cooperation and information-sharing (Saccani et al., 2014) and the capability requirements (Gebauer et al., 2013; Spring and Araujo, 2013) that may be involved.

In these various ways, the servitization literature has unveiled the importance of the relational engagement of external service providers to enhance the performance of manufacturers’ service “manoeuvres”. However, the existing research does not offer detailed insights into the characteristics of inter-firm relations with external service providers and their outcomes for the focal manufacturer. One reason for this is that contributions that have hitherto incorporated a multi-actor perspective of service provision predominantly collapse
inter-firm relations between manufacturers and any actors in their business network into a single construct. In other words, external actors are treated as a homogeneous entity representing third-party service providers, as well as upstream part suppliers, manufacturers of complementary products, firms in downstream channels and even customers (e.g. Windahl and Lakemond, 2006; Hakanen and Jakkola, 2012; Kohtamäki et al., 2013; Zhang et al., 2017). The implicit assumption is that managing the exchange relations with different network actors requires similar abilities and poses similar challenges to the focal manufacturer. Yet, it can be argued that this underlying assumption of unequivocal demands with respect to relationship management across network roles is not sufficiently supported by empirical investigations or conceptual elaborations in the context of product–service networks. Furthermore, there is a lack of research that assesses whether, and how, service providers’ relational engagement yields economic benefits for a servitized manufacturer. Previous studies emphasize that strong exchange ties with external service firms can help product manufacturers develop and deliver value-creating services. However, it can be argued that, from this monadic value-creation perspective, value-capture considerations have been neglected. While servitized manufacturers are generally able to adopt organizational arrangements that may favour relational exchanges with external service providers, they need to have concrete evidence that they could profit from such efforts. This points to the importance of research that empirically assesses how the level of engagement of external service providers with the business relationship with a servitized manufacturer affects the manufacturer’s financial performance.

2.2 Embeddedness theory

Embeddedness (or social capital) theory provides the theoretical foundation for the research model proposed in this study. Choi and Kim (2008: page 8) explain that “the concept of
embeddedness refers to the contextualization of economic activity in ongoing patterns of social relations and captures the contingent nature of an economic actor's activity by virtue of being embedded in a larger social structure”. In the field of supply chain management, the notion of embeddedness has become an important perspective for analysing the nature of connection and cooperation in dyadic supplier–buyer relationships (Krause et al., 2007; Lawson et al., 2008; Carey et al., 2011; Preston et al., 2017).

This study considers particular supplier–buyer relationships, where the supplier is a manufacturing firm that has adopted a servitization strategy and the buyer is an independent service firm that provides one or more services related to the manufacturing firm's product(s) (Figure I). As such, the study concentrates on service providers that operate in downstream channels and actually buy the product(s) from the manufacturer (e.g. distributors, dealers, systems integrators), while it neglects upstream service suppliers to whom servitized manufacturers may outsource customer-facing service activities (e.g. logistic providers, other maintenance specialists) (Eggert et al., 2017).

Nahapiet and Ghoshal (1998) set forth the distinction between three forms of embeddedness: cognitive, structural and relational. While cognitive embeddedness captures the commitment to align culture and values within relational ties, structural embeddedness refers to the presence or absence of relational ties. Finally, relational embeddedness reflects the strength, or social quality, of those ties (Krause et al., 2007; Lawson et al., 2008). This study focuses on

1 Take the example of Caterpillar, the manufacturer of mining equipment. The company provides product-financing and related services to users of its products, and it owns and directly operates a number of dealerships. However, Caterpillar products are also largely distributed through independent dealers that enter into formal agreements to sell Caterpillar products and service the products in a specific service territory. The relationship between Caterpillar and one of its dealers typifies the supplier–buyer relationships investigated in the study.
this latter form of embeddedness, like most of the previous research that has examined the performance effects of supplier–buyer relationships (Lawson et al., 2008: page 448). Indeed, relational embeddedness is positioned as a proximal antecedent to managerial action and performance in recent research frameworks, whereas cognitive and structural embeddedness influence economic behaviour indirectly through relational embeddedness (e.g. Inkpen and Tsang, 2005; Cousins et al., 2006; Carey et al., 2011; Preston et al., 2017).

Relational embeddedness has been portrayed as a stronger orientation towards trust, fine-grained information-sharing and joint problem-solving (Gulati and Sytch, 2007; Krause et al., 2007; Lawson et al., 2008; Carey et al., 2011; Kim and Henderson, 2015). Trust stems from reciprocity norms of embedded relationships that reduce the likelihood of opportunistic behaviours, and it is reflected in voluntary, non-obligating exchanges of know-how and information (Tsai and Ghoshal, 1998). As trust is built, firms also exhibit greater behavioural transparency, communication openness, and willingness to engage in more risky business interactions (Villena et al., 2011). Fine-grained information-sharing is encouraged in embedded relationships because firms are more concerned about the quality and accuracy of information exchanges (Gulati and Sytch, 2007), while social ties make the information credible and interpretable (Uzzi, 1997). Fine-grained information may be exchanged regarding operations and resources, the business environment and customer requirements, as well as proprietary and tacit know-how (Gulati, 1998; Bernardes, 2010). Finally, joint problem-solving involves developing bilateral solutions to problems, such as operational issues, cost control and poor quality. In the development of relational embeddedness, firms are likely to develop routines of negotiation and mutual adjustment (Uzzi, 1996), which in turn will lead to fewer conflicts, common operational frameworks (Villena et al., 2011) and a better attitude towards collaboration through joint action (Gulati and Sytch, 2007).
This study examines one key aspect of the relational embeddedness of external service providers: their dependence on a servitized manufacturer (Krause et al., 2007; Gulati and Sytch, 2007; Kim and Henderson, 2015). It has been demonstrated that higher levels of dependence motivate organizational commitment and relationship-specific investments, thereby leading to the development of a stronger “relational” attitude towards trust, information-sharing and joint problem-solving (Uzzi, 1996; Narayandas and Rangan, 2004; Gulati and Sytch, 2007; Petersen et al., 2008; Kim and Wemmerlöv, 2015). In line with this property, the higher the level of dependence of the service provider on the manufacturer, the more its economic action will be governed by the logic of embeddedness.

2.3 Research hypotheses

Much of the extant literature on supply chain management describes relational embeddedness² as a valuable asset in supplier–buyer relationships and holds that relational embeddedness is positively related to enhancements in strategic and operational performance (Autry and Golicic, 2010; Bernardes, 2010; Kim and Henderson, 2015). In essence, the performance benefits accrue from cooperative behaviour that aids creativity and increases the efficiency of action (Villena et al., 2011; Kim and Henderson, 2015; Preston et al., 2017). The first theme centres on the achievement of differentiation advantages through product innovation, market creation and technological development. The second theme reflects the accomplishment of improvements to existing processes in terms of cost, productivity, flexibility, service, and so on. For instance, Bernardes (2010) and Villena et al. (2011) develop the argument that relational embeddedness promotes organizational

² The terms “relational embeddedness” and “dependence” are to be seen as interchangeable in the rest of the paper. The term dependence is generally preferred, except in some theoretical discussions where relational embeddedness is used to better resonate with terminology in the broader supply chain literature.
learning, thereby making firms better able to provide fast and innovative responses to emerging customer needs. Others emphasize the transaction cost reductions that arise from commitment, trustfulness and cooperation in embedded relationships (Gulati and Sytch, 2007; Lanier Jr. et al., 2010; Kim and Wemmerlöv, 2015; Kim, 2017). Uzzi (1996) depicts embedded relationships as enabling firms to tackle new external contingencies in ways that are difficult to emulate in arms-length ties.

Together, these arguments suggest that higher levels of dependence of an external service provider may contribute to improving the innovation and cost performance of a servitized manufacturer. Indeed, because of its bridge position between the manufacturer and the customers (Bastl et al., 2012; Finne and Holmström, 2013), the service provider acts as a supplier of customer know-how regarding product improvement possibilities, new functional requirements and market trends (Windahl and Lakemond, 2006; Carey et al., 2011; de Vries et al., 2014; Preston et al., 2017). A service provider that is more dependent on a manufacturer (i.e. which focuses its activities mainly on the manufacturer’s product(s)) will be more willing to help the manufacturer sell more products (Petersen et al., 2008). Accordingly, such a service provider will be more active in providing valuable customer information that increases the manufacturer's ability to understand how to best improve the value of its product(s) and ancillary services (Zhou et al., 2014). In addition to such informational benefits, dependence can increase a service provider’s willingness to collaborate with the manufacturer in risk-taking (Matthyssens and Vandenbempt, 2008) and to invest resources in the joint development of new services (Lawson et al., 2008; Bastl et al., 2012; Kowalkowski et al., 2013). In general terms, dependent service providers are more likely to develop a focus on joint success and to embrace a long-term horizon for the relationship with the manufacturer (Gulati and Sytch, 2007; Kim, 2017). As such, they are also more likely to accept short-term disadvantages, to provide flexible responses to requests and
emergencies, to undertake shared service development/planning activities, and to make adaptations to changing business conditions and new external contingencies (Johnston et al., 2004; Kowalkowski et al., 2013). These mechanisms allow the servitized manufacturer to access previously unavailable resources (Bastl et al., 2012) that can be directed towards responding to the operational and business needs of the customers, improving problem-solving capabilities, competitive advantage and profitability (Bernardes, 2010). Furthermore, dependence is likely to lead a service provider to develop improved insights into role requirements (Petersen et al., 2008). The argument can be extended to suggest that higher levels of dependence instil the expectation of trustworthiness of the service provider for economic, situational and psychological reasons (Krause et al., 2007). As the risk that the service provider will shrink its responsibilities or act opportunistically is reduced, the manufacturer can achieve lower contracting, monitoring and enforcement costs (Lanier Jr. et al., 2010; Villena et al., 2011). By a similar logic, dependence can generate structural convergence between the manufacturer and the service provider (Gulati and Sytch, 2007), thereby reducing operational friction and facilitating the adoption of a common set of conventions, routines and efficiency-enhancing norms (Lanier Jr. et al., 2010). In such a setting, the manufacturer incurs lower transaction costs. Based on the foregoing arguments, the following hypothesis is introduced:

**H1. A manufacturer that has adopted a servitization strategy will benefit financially from the dependence of an external provider of services related to its product(s).**

Some strategy scholars have further identified a “dark side” (Anderson and Jap, 2005; Villena et al., 2011) or “paradox” (Uzzi, 1997; Kim and Henderson, 2015) of embeddedness, which suggests that relational embeddedness entails not only benefits but also potential harmful consequences. Strong relational bonds between parties may become a liability that hinders,
rather than helps, innovation capacity and operational performance (Gargiulo and Benassi, 2000; Zhou et al., 2014).

Situations of over-embeddedness may also arise within the manufacturer–service provider relationships examined in this study. Specifically, prior research provides a basis for the contention that increasing levels of dependence of an external provider of product-related services may also bring about drawbacks for the product manufacturer. In fact, high levels of dependence on a single manufacturer mean that a service provider has few or no links to other manufacturers, their exchange partners and clients. In these conditions, the service provider is a less effective conduit of information about external developments, including innovative ideas (Kim and Henderson, 2015), better ways to do things (Anderson and Jap, 2005) or changes in the business environment (Uzzi, 1997), for the manufacturer. This, in turn, may impair the manufacturer’s ability to innovate its market offering and respond to competitive pressures. Additionally, excessive levels of dependence can lead to “isomorphism” (Uzzi, 1997; Villena et al., 2011) and loss of independent thinking of the service provider (Zhou et al., 2014; Preston et al., 2017). This may have negative consequences for the manufacturer, as it would override the motivation to countenance alternative perspectives and explore creative solutions to problems. Moreover, high levels of dependence may restrict the manufacturer from receiving open and truthful feedback, since the service provider will tend to avoid conflicts in order to maintain harmony in the relationship (Gulati and Sytch, 2007; Villena et al., 2011). This curtails inter-firm learning and thus jeopardizes the manufacturer’s performance. Nevertheless, as dependence rises to high levels, the information exchanged begins to be less valuable. The risk is that too much information that is not critical is transferred from the service provider to the manufacturer, creating confusion, slowing down problem resolution and lowering operational performance (Villena et al., 2011).
While the performance impact of these drawbacks for the manufacturer is relatively small and increases very gradually at low levels of dependence, it becomes significant and escalates rapidly as dependence becomes higher, resulting in an exponential function. This negative trend will additively combine with the linearly increasing benefits of dependence that underlie hypothesis H1. For these reasons, the paper postulates that the service provider's dependence initially improves the manufacturer's financial performance. However, as the dependence of the service provider increases, the rate of benefits for the manufacturer slows down because the drawbacks described above progressively set in. It is likely that there is a threshold at which these drawbacks offset the benefits, and beyond which the performance of the manufacturer begins to decline (Figure II). Service providers often seek to concentrate their attention, energy and efforts on a limited number of products in order to achieve competitive service performance. Moreover, for each manufacturer they work with, they need to sustain a pattern of interaction over time, building up a shared understanding and agreeing ways to work together. For these reasons, some service providers would only work with a very small number of manufacturers (or even with a single manufacturer), reaching high levels of dependence in their business relationships and overshooting the threshold. The paper thus suggests that the service provider's dependence follows an inverted curvilinear relationship with the manufacturer's financial performance, as follows:

H2. A manufacturer that has adopted a servitization strategy will experience diminishing financial benefits from the dependence of an external provider of services related to its product(s); as the service provider's dependence increases beyond a certain level, the manufacturer's financial performance actually starts to decline.
3. Method

3.1 Sample selection

The unit of analysis for the study is the dyadic relationship between a manufacturer implementing a servitization strategy and a third-party service provider offering one or more services related to the manufacturer’s product(s). As previously stated, the focus is restricted to manufacturer-service provider dyads, where the service provider is also a buyer of the product(s) supplied by the manufacturer (e.g. the service provider is a dealer, a distributor or a systems integrator).

The sampling frame consisted of US public companies that reported at least one “major” customer in their 2015 annual financial statements (because the data was collected in late 2016), thus providing a starting point to find matched supplier-buyer dyads. The 2015 Compustat Customer Segment Files were first used to identify supplier-customer (i.e. supplier-buyer) dyads involving a manufacturing supplier (primary SIC code of 20 to 39). Suppliers that reported multiple major customers appeared in more than one dyad. The Compustat Customer Segment Files provide the dollar amount of revenue generated from each major customer, along with the types and names of major customers. This information was scrutinized and only corporate customers with sales data were retained in the sample. The details of this initial screening procedure are provided in Table I.

< Please insert Table I about here >

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3 Major customer disclosures mandatorily include any customer that represents 10 per cent or more of a company's consolidated revenue (Statement of Financial Accounting Standards (SFAS) No. 131). In addition, many companies voluntarily report (in annual 10-K filings or through other means, such as press releases and 8-K forms) information about customers that, though accounting for less than 10 per cent of total revenue, are important to their business. Presumably, a supplier will be significantly committed to the relationship with a major customer.
Every supplier–buyer dyad was inspected by hand-collecting information from the Standard & Poor’s Capital IQ database. Manufacturing suppliers were classified as servitized if their business description in Capital IQ provided explicit evidence that they offered one or more of the service categories identified in either Rabetino et al. (2015: page 61) or Benedettini et al. (2017: page 124) to end-customers. Such an approach is common to prior research (e.g. Benedettini et al., 2015; Visnjic et al., 2016; Benedettini et al., 2017) and is grounded on the principle that, though most manufacturers offer at least some type of service, the fact that a firm’s business description makes explicit reference to a service offering strongly suggests that service activities have strategic importance for the firm. Non-servitized manufacturing suppliers were excluded from the study sample.

The next step was to scrutinize the Capital IQ business description of the buyer for each supplier–buyer dyad still in the sample. As previously described, the initial screening procedure (Table I) ensured that only corporate buyers were retained in the sample. Capital IQ business descriptions were used to check that the buyers were actually providing the manufacturing suppliers’ products to end-customers. Each buyer was further required to appear, according to its Capital IQ business description: (i) to be a service firm, again offering one or more of the service categories identified in Rabetino et al. (2015) or Benedettini et al. (2017) to end-customers; and (ii) to be likely to offer such services for the product(s) of the manufacturing supplier. Therefore, the manufacturing firms, for instance, those that may use the supplier’s product(s) as component(s) of their own product(s) or to produce their own product(s) (e.g. when the supplier provided machine equipment), were removed from the buyer’s sample. Utility providers and other service companies, who used the supplier’s product(s) to produce/deliver their services, were also excluded. On the contrary, systems

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4 Each supplier and buyer name was matched to the registered name of one of the companies listed in the Capital IQ database. Given that the Compustat database records customer names, as disclosed by suppliers, often using abbreviations and different naming conventions, every supplier–buyer dyad was examined manually to correct cases of inaccurate customer identification. In very few cases, where a match could not be found in Capital IQ, the supplier–buyer dyad was removed from the sample.
integrators, who develop unique systems for their clients by aggregating multiple vendors’ products, were included. As well as manufacturers, service providers were allowed to appear in more than one dyad. After removing unsuitable supplier–buyer dyads, the final sample consisted of 261 unique servitized manufacturer–service provider dyads. Examples of manufacturer–service provider dyads included in, and excluded from, the sample are reported in the Appendix.

3.2 Variable definitions

Table II presents the variables used in the study.

< Please insert Table II about here >

3.2.1 Dependent variables

The financial performance achieved by each manufacturing firm was measured at aggregate level by its return-on-assets (ROA) (ROA = net income / total assets). Following Lanier Jr. et al. (2010), Patatoukas (2012) and Kim and Henderson (2015), among others, ROA was also decomposed into two multiplicative components: return-on-sales (ROS) (ROS = net income / sales, i.e. profit margin achieved on sales) and asset turnover (ATO) (ATO = sales / total assets, i.e. asset efficiency in generating sales). This decomposition, known as Du-Pont analysis, is considered to provide useful information regarding the reasons behind a company’s financial performance (Soliman, 2008; Patatoukas, 2012). Furthermore, in the context of the present study, ROS and ATO catch the two main performance areas that may potentially be affected by a manufacturer’s relational embeddedness with an external service provider: differentiation and operational efficiency (cf. Section 2.3). In fact, while ROS is often derived from pricing power, product innovation, first-mover advantage, and so on, ATO generally comes from the lean and efficient use of resource assets (Soliman, 2008: page 824).
3.2.2 Independent variables

The concept of dependence is potentially multifaceted (Kim and Wemmerlöv, 2015). However, researchers that have used the level of dependence as a proxy for embeddedness in supplier–buyer relationships have extensively measured the dependence of a buyer on a supplier by the magnitude of the buyer’s purchases from the supplier (Gundlach and Cadotte, 1994; Lanier Jr. et al., 2010; Kim and Wemmerlöv, 2015). Within each servitized manufacturer–service provider dyad, the dependence of the service provider (buyer) on the manufacturer (supplier) (SP_DEP) was hence measured as the ratio of its purchases from the manufacturer over its total annual cost of goods sold (Casciaro and Piskorski, 2005; Krause et al., 2007; Kim and Henderson, 2015; Kim, 2017). In particular, a service provider’s purchases from the manufacturer in the dyad represent the manufacturer’s revenue generated by the service provider, as given by the Compustat Customer Segment Files. This operationalization captures a large portion of the criticality dimension of embeddedness (Gundlach and Cadotte, 1994; Casciaro and Piskorski, 2005) because it is clearly tied to the extent to which a manufacturer contributes to the economic activity of a service provider; in other words, it (in some way) indicates how much the service provider would be affected if its business related to the manufacturer’s product(s) were ceased (Krause et al., 2007).

3.2.3 Control variables

To ensure the robustness of results, extraneous effects were controlled with several variables related to industry and firm. Indicator variables representing the two-digit SIC codes of manufacturing suppliers were included to control for industry-specific effects (Patatoukas, 2012) and to reduce the possible correlation of performance indicators within a specific industry (Kim and Henderson, 2015; Kim, 2017). Firm-level controls included the following
variables for the manufacturing firms (Villena et al., 2011; Kim and Henderson, 2015; Kim, 2017): (i) firm size (SIZE), measured as the natural log of total assets; (ii) market share (SHARE), defined as the ratio of each firm's sales to total sales of their respective industries (as identified by the two-digit SIC code); (iii) firm’s sales growth (SG), measured as the annual growth of sales; and (iv) financial leverage (LEV), calculated as the ratio of last year's total assets to last year's total equity.

Finally, two firm-level control variables were introduced to proxy for the market power of service providers (Kim and Henderson, 2015): (i) the service provider's size (SP_SIZE); and (ii) the service provider’s market share (SP_SHARE). Both variables were measured analogously to manufacturers’ SIZE and SHARE, respectively.

3.2.4 Data collection

As mentioned previously, the Compustat Customer Segment Files provided the 2015 service providers’ purchases from the manufacturers to estimate SP_DEP values. The remaining data was collected from the Compustat Annual Files. This involved matching each service provider’s name to the unique identifier (i.e. gvkey) of a company listed in Compustat. Information was hand-collected from Capital IQ (accounting data) and Mergent Online (SIC codes) for the service providers that were not listed in Compustat. All the data was collected for the fiscal year 2015. After eliminating 68 observations with missing financial data for service providers, the final sample consisted of 193 unique servitized manufacturer–service provider relationships.

3.3 Analysis

Because the data was nested, with manufacturing firms grouped into specific industries, the appropriateness of a multi-level modelling approach was tested. Likelihood-ratio tests
comparing the multi-level model (with manufacturer–service provider dyads nested within manufacturers’ two-digit SIC codes) with a single-level model (i.e. linear regression) with no industry effects indicated that the single-level approach should be favoured over the multi-level approach (p-value > 0.05 for each of ROA, ROS and ATO – results not reported) (Garson, 2014). Accordingly, the linear regression approach was chosen and industry dummies were used to control for industry-specific effects.

Prior to the regression analysis, the data was examined for influential outliers using the Cook’s distance procedure (Cohen et al., 2003). It was found that three observations (manufacturer–service provider dyads) were “influential” on the results of the regression equations (Cook’s distance greater than one; Cook and Weisberg, 1982; Cohen et al., 2003). These were removed from the data set (Haans et al., 2016). In addition, robust standard errors were adopted in the regression estimation to allow for heteroskedasticity and modest departures from other linear regression assumptions (Stock and Watson, 2003).

4. Results

Three separate models were estimated for each performance metric. Model 1, Model 4 and Model 7 regress only the control variables on ROA, ROS and ATO, respectively. Model 2, Model 5 and Model 8 add the key explanatory variable, namely, the service provider’s dependence (SP_DEP), to test its linear effects. Finally, Model 3, Model 6 and Model 9 also include the squared term of the service provider’s dependence (SP_DEP2) to assess its incremental effects and relationship to each financial performance variable. Table III presents the results of the regression analysis, along with statistics for the explanatory power of the models. Significant F-statistics (p < 0.05 in Models 1 to 3; p < 0.01 in Models 5 to 9) and reasonable amounts of variance explained (R² values ranging from 18.43% to 54.77%) (see Autry and Golicic, 2010:...
page 98) indicate a strong relationship between regressors and dependent variables, lending support to the proposed model specifications.

< Please insert Table III about here >

Regarding hypothesis testing, the results of the linear models (Model 2, Model 5 and Model 7) provide weak support for H1. In fact, the coefficient of the linear dependence variable (SP_DEP) is positive, as expected, but only marginally significant in Model 2 (b = 0.685, p < 0.1) and in Model 8 (b = 1.344, p < 0.1), while not statistically significant in Model 5 (b = 0.531, p > 0.1). The full models (Model 3, Model 6 and Model 9) instead show significant, positive associations of the linear term of the service provider’s dependence (SP_DEP) with the manufacturer’s ROA (b = 2.053, p < 0.05), ROS (b = 2.442, p < 0.01) and ATO (b = 5.501, p < 0.01). The quadratic term of the service provider’s dependence (SP_DEP2) has significant, negative relationships to ROA (b = -4.510, p < 0.05), ROS (b = -6.299, p < 0.01) and ATO (b = -13.706, p < 0.01). Such changes to the previous positive associations indicate a pattern of diminishing returns of the service provider’s dependence, up to a point at which further increases in the service provider’s dependence begin to negatively affect the manufacturer’s performance outcomes. Hence, H2, which describes an inverted U-shaped relationship between the service provider’s dependence and the manufacturer’s financial performance, is supported. Notably, these findings substantiate the hypothesized non-linear relationship for firm performance at aggregate level (ROA), as well as for strategic performance (ROS) and operational performance (ATO), separately.

4.1 Robustness tests

To ensure the correct interpretation of the results, the testing strategy of Lind and Mehlum (2010) was implemented to assess the significance of the detected non-linear relationship
(Haans et al., 2016). The requirement for an inversely U-shaped curve is that the relationship is increasing at the low end of the data range and decreasing at the high end. Table IV shows that the slope of ROA at the low end of the service provider’s dependence (SP_DEP_L) range is positive (2.053), while the slope at the high end (SP_DEP_H) is negative (-1.354). Both slopes are significant or marginally significant (p < 0.05 and p < 0.10, respectively), confirming the existence of a significant inverted U-shaped relationship for ROA. The Sasabuchi-Lind-Mehlum U-test (Lind and Mehlum, 2010) offers a test of the composite null hypothesis that the relationship does not increase at the low end of the observed data range and/or does not decrease at the high end. The test rejected the combined null hypothesis (t = 1.79; p = 0.038) (Table IV), again in favour of an inverted U-shaped association between the service provider's dependence and ROA over the relevant data values. Replicating this analysis for ROS and ATO (results in Table IV) also confirmed the reported result of inverted U-shaped effects of the service provider’s dependence. Lind and Mehlum (2010) further recommend calculating the turning point of the U-shaped relationship and its confidence limits. As shown in Table IV, the derived 95 per cent Fieller confidence interval is within the data range for ROS and ATO (Table III), which provides additional evidence to support the inverted U-shaped effect. The calculated upper bound of the 95 per cent confidence interval of ROA based on the Fieller standard error method is outside the observed data range (Table III) for the service provider’s dependence. However, the 90 per cent Fieller interval (lower bound 0.189, upper bound 0.327) is within the limits of the data (Lind and Mehlum, 2010), as well as the 95 per cent confidence interval for the classical Delta method (Table IV). The turning points of ROA, ROS and ATO are at 0.227, 0.193 and 0.200, respectively. As can be seen in Figure III, they all lie well within the data range.

< Please insert Table IV about here >
Table III further reports the change in R², and F-statistics, associated with the linear and quadratic terms of the service provider’s dependence. Significant R² increases (p < 0.05 for Models 6 and 9 vs Model 4 and Model 7, respectively; p < 0.10 for Model 3 vs Model 1) suggest that the non-linear dependence effects specified in the full models (Model 3, Model 6 and Model 9) significantly improve the prediction of all three performance measures. In addition, a cubic term was added to Models 3, 6 and 9 to test whether the observed relationship was perhaps S-shaped rather than U-shaped (Haans et al., 2016). The cubic term did not improve the fit of any of the three models, confirming that the relationship was indeed quadratic.

In line with Lenox et al. (2010), to further test for an inverted U-shaped relationship, Models 3, 6 and 9 were fit as spline functions, allowing the regression to change coefficients of the service provider’s dependence variable at specified points (Greene, 2002). The data range of the service provider’s dependence was divided into three intervals: below 0.15, from 0.15 to 0.25, and above 0.25. This decomposition isolated low levels of the service provider’s dependence (below the turning point) from high levels (above the turning point). For all of ROA, ROS and ATO, the lowest interval had a positive slope and the highest had a negative slope. Although only the slope for the lowest interval reached statistical significance (p < 0.05 in all the models for ROA, ROS and ATO), this additional analysis suggests an increase in the manufacturer’s performance at low levels of dependence and a decrease at high levels, which is consistent with the existence of an inverted U-shaped relationship.

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5 As a result of the relatively small sample size, 10 per cent statistical significance can be applied.
6 Similarly, exponential and logarithmic transformations yielded worse model fit, except for the logarithmic specification for the ATO model. According to this test, the actual relationship between the service provider’s dependence and ATO might be positive but at a declining rate (coefficient of the logarithmic term positive and significant).
In another robustness test, potential reverse causality was considered. The results in Table III were interpreted as indicating that the service provider’s dependence influences the manufacturer’s financial performance, but the empirical method does not rule out the possibility that stronger financial performance makes manufacturers more able to attain the optimal level of dependence from providers of product-related services. Models 3, 6 and 9 were re-estimated measuring ROA, ROS and ATO by cumulative outcomes over two years (fiscal 2015 and fiscal 2016) (Kim and Henderson, 2015). The results remained statistically unchanged, confirming that the direction of causality was from the service provider’s dependence to the manufacturer’s performance, and not vice versa (Zaefarian et al., 2017). Notably, the turning point estimates also remained almost identical to the values reported in Table IV.

Next, potential multicollinearity problems were examined by calculating the variance inflation factor (VIF) for the independent variables in the models. The largest VIF was 5.37, which is well below the typical cut-off of 10. Therefore, it appears unlikely that multicollinearity among independent variables could distort model results (Tabachnick and Fidell, 2007). To further ensure the robustness of results, Models 1 to 9 were re-run using an alternative operationalization of the service provider’s dependence. Following Lanier Jr. et al. (2010), the service provider’s dependence was measured as the ratio of the service provider’s purchases from the manufacturer over its total annual operating input (sales – operating income). The results of this alternative regression analysis were consistent with the original results. Finally, the analysis was repeated using five randomly selected sub-samples (90% of the overall sample). For all five sub-samples, the results were the same as when using the full sample.

5. Discussion
This paper examines the financial consequences of relational embeddedness arising from the dependence of external service providers in dyadic manufacturer–service provider relationships where the manufacturers have embraced a servitization strategy. The literature on servitization has concentrated on internalized service provision (Kowalkowski et al., 2011; Gebauer et al., 2013) and has not dwelled sufficiently upon inter-firm relations with external service providers (Raddats et al., 2019). However, close relationships with providers of product-related services and other exchange partners in a manufacturer’s business network are claimed to be a powerful resource to mobilize value creation and adapt product–service offers to customer needs (Windahl and Lakemond, 2006; Bastl et al., 2012; Gebauer et al., 2013; Jaakkola and Hakanen, 2013; de Vries et al., 2014; Zarpelon Neto et al., 2015). The results of this study provide weak support for the suggestion that a simple positive linear relationship exists between the service provider’s dependence and the financial performance of servitized manufacturing firms (H1), as previous literature focusing on the “bright side” of relational embeddedness seems to indicate (e.g. Cousins et al., 2006; Krause et al., 2007; Lawson et al., 2008). Instead, the results show an inverted U-shaped relationship between the service provider’s dependence and the manufacturer’s financial performance, providing support for H2. This curvilinear relationship offers evidence for the presence of a “dark side” phenomenon in the economic effects of dependence (Uzzi, 1997; Anderson and Jap, 2005; Villena et al., 2011), wherein the relational embeddedness of an external service provider may become a liability for the manufacturer. Interestingly, the inverted U-shaped relationship with the service provider’s dependence concerns the manufacturer’s ROA and both of its components – ROS and ATO. Hence, it appears that the observed curvilinear relationship is driven by diminishing returns of the service provider’s dependence in terms of both differentiation ability and operational efficiency. It may be that initially higher levels of dependence incentivize an external service provider, not only to share information that
enhances the depth of external knowledge available to the manufacturer (e.g. Petersen et al., 2008; Zhou et al., 2014), but also to contribute directly to the manufacturer’s innovation processes, thereby fostering the exploration of creative, future-focused product/service developments (Gulati and Sytch, 2007; Kim, 2017) that create opportunities for differentiation (Lawson et al., 2008; Bastl et al., 2012; Kowalkowski et al., 2013). Yet, when the service provider’s dependence increases beyond a certain level, its marginal benefits may become negligible and, eventually, end up being detrimental to the manufacturer’s innovation performance, possibly as a result of obstacles to creativity and knowledge enrichment caused by isomorphism (Uzzi, 1997; Villena et al., 20122; Zhou et al., 2014; Preston et al., 2017) and isolation from changes in the business environment (Anderson and Jap, 2005; Kim and Henderson, 2015). Likewise, the manufacturer’s operational performance initially improves as the service provider’s dependence increases. A potential explanation is that dependence enhances the service provider’s cooperative behaviour, flexibility and willingness to share risks and specialized service investments with the manufacturer (MatthysSENS and Vandenbempt, 2008; Bastl et al., 2012; Kowalkowski et al., 2013). This positive effect may also be reinforced by reduced operational friction and lower monitoring costs, due to greater alignment of interests (Krause et al., 2007; Lanier Jr. et al., 2010; Villena et al., 2011). However, there is a threshold at which positive effects are offset by the downsides, which may include greater difficulty in timely decision-making derived from overloading of information, the cost and complexity of dealing with high levels of information, and the expenditure of resources to maintain multiple, frequent interactions (Villena et al., 2011).

Notably, these results appear consistent with some prior studies that more broadly investigated the economic consequences of dependence among supply chain members and also did not find a linear relationship between the buyer’s dependence and the supplier's financial performance (e.g. Kim and Henderson, 2015).
5.1 Contribution to theory

The study extends the extant literature on servitization in several ways. First, it contributes to an emerging understanding of how relationships and interactions with other network actors may affect the results of manufacturing firms seeking service-led growth. This study adopts a specific focus on inter-firm relationships with external service providers and empirically demonstrates an economic link between the quality or embeddedness of such relationships (as determined by the service provider’s dependence) and the manufacturer’s performance. To the best of these authors’ knowledge, no prior research has addressed this link, largely because studies of service “manoeuvres” tend to assume that the success of exchanges with third-party service providers depends exclusively on the structure of activity links and resource ties that is adopted (e.g. Gebauer et al., 2013; Spring and Araujo, 2013; Saccani et al., 2014). Second, the study refines the servitization literature by also theoretically and empirically considering a “dark side” of the embeddedness of external service providers in the relationship with a servitized manufacturer (Gargiulo and Benassi, 2000; Zhou et al., 2014). The evidence of diminishing returns of a service provider’s dependence challenges the general presumption of a monotonic economic effect of increased relational embeddedness (e.g. Matthyssens and Vandenbempt, 2008; Bastl et al., 2012; Kowalkowski et al., 2013). In this way, the study heeds calls for additional research to build and test the theory pertaining to how external actors impact servitization strategies (Gebauer et al., 2013: page 45; Fliess and Lexutt, 2017: page 12) and for more research in the field that extends the unit of analysis beyond the individual firm (e.g. Kohtamäki et al., 2013; Fliess and Lexutt, 2017). In particular, it complements the recent review by Raddats et al. (2019), which highlights multi-actor relationships, communication and exchange as fundamental aspects of servitization in need of further research. Third, by linking to the paradox of embeddedness, the study underscores
that supply chain management research may provide interesting theoretical notions to investigate how manufacturers moving towards services can best manage inter-firm relationships with network actors to support economic performance and growth.

5.2 Contribution to practice

The results of this study are also potentially relevant to managerial practice because they provide empirical evidence reinforcing the idea that stronger links with external providers of product-related services can lead to tangible benefits for product firms that have moved towards services. At the same time, however, the study’s conclusions may serve as a cautionary note for manufacturing managers blindly striving to build business relationships with highly dependent external service providers. Although each manufacturer–service provider relationship may be unique, this study suggests that working with highly dependent external service providers is often not the best choice for a manufacturing firm pursuing service-led growth. In other words, servitized manufacturing firms are likely to achieve sub-optimal results if the potential negative consequences of excessive levels of the service provider’s dependence are neglected.

In short, while the managers of servitized firms should understand the importance of close relationships with external service providers, they should also be careful to maintain an adequate level of dependence with them to maximize the benefits and minimize the liabilities. Likewise, they need to find ways to act on the negative effects of dependence when they find they have moved beyond the threshold point.

5.3 Limitations

This research is not without its limitations. First, the sample selection was based on major customer disclosures. While, in the context of this study, one such customer is likely to
perform an important function in terms of providing information regarding external developments to stimulate product/service innovation, the exclusivity (irreplaceability) with which a major customer performs that function depends on the concentration of the focal manufacturing firm’s customer base. Because of its reliance on Compustat data, the study could not capture this aspect, despite its theoretical relevance. Thus, future research that (perhaps using primary data) may include measuring the irreplaceability of service provider-supplied information would be useful. Second, this study follows some important previous works that have used dependence as a proxy for relational embeddedness among exchange partners in supply chains (e.g. Krause et al., 2007; Gulati and Sytch, 2007; Kim and Henderson, 2015). However, examining other dimensions of relational embeddedness would complement the findings. Third, in order to establish the generalizability of the proposed curvilinear relationship, the study uses a multi-industry sample frame (Jacobs and Swink, 2011). Replications of the model should be carried out in single industry settings in order to identify the inflection point of the dependence–performance relationship with greater precision and practical relevance. Similarly, the study is based on cross-sectional data. Examining the research hypotheses using longitudinal data would enhance the robustness of the findings. Fourth, the study treats the services that can be offered by third-party service providers as a homogeneous entity. However, product-related services can differ substantially with respect to the level of customer interaction, competence requirements, complexity of delivery processes and “productive opportunities” (Preston et al., 2017) that they create (e.g. Eggert et al, 2011). Hence, subsequent research efforts may more thoroughly examine the influence of the implementation of specific service types on the performance effects of the service provider’s relational embeddedness. Finally, it would be interesting to see studies that re-explore the embeddedness–performance relationship focusing on upstream service providers to whom servitized manufacturing firms may outsource customer-facing services (e.g. Eggert
et al., 2017). While there is little a priori reason to suspect that embeddedness would lead upstream and downstream service providers to different economic behaviours, empirically investigating the economic outcomes of embedded relationships with upstream service providers would certainly enrich the findings.

Acknowledgements

The authors would like to thank the two anonymous reviewers for numerous valuable comments and suggestions that have substantially improved this paper.

References


Figure I – Business activities of manufacturers and service providers
Figure II – Rationale for a curvilinear relationship between service provider’s dependence (X-axis) and firm performance.
The initial sample consisted of supplier–buyer dyads that were reported in the 2015 Compustat Segment Files and which involved a manufacturing supplier. Dyads that had one of the following characteristics were removed: buyers with Compustat customer type “MARKET” or “GEOREG”, because these codes identify the whole set of customers in a specific market or geographical region, respectively; (ii) governmental buyers (Compustat customer types “GOVDOM”, “GOVFRN”, “GOVLOC” and “GOVSTATE”), because of the different nature of their activities; (iii) buyers whose identity was not disclosed (SFAS requirements cover the existence but not the identity of major customers). Moreover, since sales information was going to be used to measure the service provider’s dependence, dyads with no sales data were further eliminated (companies that voluntarily disclose major customers may not report corresponding sales).

Table I – Initial sample screening
<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition/Measure</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROA</td>
<td>Return-on-assets of the manufacturer</td>
<td>Compustat Annual Files</td>
</tr>
<tr>
<td>ROS</td>
<td>Return-on-sales of the manufacturer</td>
<td></td>
</tr>
<tr>
<td>ATO</td>
<td>Asset turnover of the manufacturer</td>
<td></td>
</tr>
<tr>
<td><strong>Explanatory Variable(s)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP_DEP</td>
<td>Dependence of the service provider on the manufacturer, measured as the ratio of</td>
<td>Compustat Customer Segment Files,</td>
</tr>
<tr>
<td></td>
<td>the service provider’s purchases from the manufacturer over the service provider’s</td>
<td>Compustat Annual Files</td>
</tr>
<tr>
<td></td>
<td>total cost of goods sold</td>
<td></td>
</tr>
<tr>
<td><strong>Firm-level Controls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>Size of the manufacturer, measured as the natural logarithm of its total assets</td>
<td>Compustat Annual Files</td>
</tr>
<tr>
<td>SHARE</td>
<td>Market share of the manufacturer, measured as the ratio of its sales to the total</td>
<td>Compustat Annual Files</td>
</tr>
<tr>
<td></td>
<td>sales of firms operating in the same industry (two-digit SIC code)</td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>Sales growth of the manufacturer, measured as the rate of growth of its sales with</td>
<td>Compustat Annual Files</td>
</tr>
<tr>
<td></td>
<td>respect to the previous year</td>
<td></td>
</tr>
<tr>
<td>LEV</td>
<td>Financial leverage of the manufacturer, measured as the ratio of its total assets</td>
<td>Compustat Annual Files</td>
</tr>
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<td></td>
<td>in the previous year to its total equity in the previous year</td>
<td></td>
</tr>
<tr>
<td>SP_SIZE</td>
<td>Size of the service provider, measured as the natural logarithm of its total assets</td>
<td>Compustat Annual Files, Capital IQ</td>
</tr>
<tr>
<td>SP_SHARE</td>
<td>Market share of the service provider, measured as the ratio of its sales to the</td>
<td>Compustat Annual Files, Capital IQ</td>
</tr>
<tr>
<td></td>
<td>total sales of firms operating in the same industry (two-digit SIC code)</td>
<td>Mergent Online</td>
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<td><strong>Industry-level Controls</strong></td>
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<tr>
<td>Two-digit industry</td>
<td>Set of dummy variables representing the manufacturing firm’s primary two-digit SIC</td>
<td>Compustat Annual Files</td>
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<td></td>
<td>code industry</td>
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Table II – Variable definitions and data sources
<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>ROA (return-on-assets)</th>
<th>ROS (return-on-sales)</th>
<th>ATO (asset turnover)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 3</td>
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<td><strong>Firm-level Controls</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>1.70</td>
<td>12.02</td>
<td>0.018**</td>
<td>0.014*</td>
<td>0.010</td>
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<tr>
<td>SHARE</td>
<td>6e^-6</td>
<td>0.32</td>
<td>0.654</td>
<td>0.652</td>
<td>0.624</td>
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<td>SG</td>
<td>-0.32</td>
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<td>0.012</td>
<td>0.013</td>
<td>0.014</td>
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<td>LEV</td>
<td>-8.52</td>
<td>21.29</td>
<td>0.005</td>
<td>0.006</td>
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<td>SP_SIZE</td>
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<td>0.027</td>
<td>0.036</td>
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<td>0.55</td>
<td>-0.033</td>
<td>-0.076</td>
<td>-0.093</td>
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<tr>
<td><strong>Industry-level Controls</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Explanatory Variable(s)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP_DEP</td>
<td>6e^-6</td>
<td>0.377</td>
<td>0.685*</td>
<td>2.053**</td>
<td>0.531</td>
</tr>
<tr>
<td>SP_DEP squared</td>
<td>3e^-11</td>
<td>0.142</td>
<td>-4.510**</td>
<td>-6.299***</td>
<td>2.520</td>
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<tr>
<td>Intercept</td>
<td>-0.271</td>
<td>-0.387</td>
<td>-0.457</td>
<td>-0.066</td>
<td>-0.156</td>
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<tr>
<td>R²</td>
<td>25.47%</td>
<td>26.70%</td>
<td>27.59%</td>
<td>18.43%</td>
<td>19.06%</td>
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<tr>
<td>Adjusted R²</td>
<td>17.62%</td>
<td>18.50%</td>
<td>19.02%</td>
<td>9.83%</td>
<td>10.01%</td>
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<tr>
<td>F-statistic</td>
<td>1.77**</td>
<td>1.75**</td>
<td>1.91**</td>
<td>2.19**</td>
<td>2.29**</td>
</tr>
<tr>
<td>Change in R² relative to controls</td>
<td>12.3%</td>
<td>21.2%</td>
<td>6.3%</td>
<td>2.15%</td>
<td>0.63%</td>
</tr>
<tr>
<td>F-statistic for change</td>
<td>3.01*</td>
<td>2.40*</td>
<td>2.25</td>
<td>3.66**</td>
<td>2.94*</td>
</tr>
<tr>
<td>Observations</td>
<td>190</td>
<td>190</td>
<td>190</td>
<td>190</td>
<td>190</td>
</tr>
</tbody>
</table>

**SIZE** = manufacturer’s size; **SHARE** = manufacturer’s market share; **SG** = manufacturer’s sales growth; **LEV** = manufacturer’s financial leverage; **SP_SIZE** = service provider’s size; **SP_SHARE** = service provider’s market share; **SP_DEP** = service provider’s dependence

* p < 0.1; ** p < 0.05; *** p < 0.01 (two-tailed tests)

See Table II for variable definitions

Table III – Regression results
<table>
<thead>
<tr>
<th></th>
<th>ROA</th>
<th>ROS</th>
<th>ATO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope at SP_DEP_L</td>
<td>2.053**</td>
<td>2.442***</td>
<td>5.501***</td>
</tr>
<tr>
<td>Slope at SP_DEP_H</td>
<td>-1.354*</td>
<td>-2.317**</td>
<td>-4.853**</td>
</tr>
<tr>
<td>SLM Test for inverse U-shape</td>
<td>1.79 (p value 0.038)</td>
<td>2.57 (p value 0.005)</td>
<td>2.58 (p value 0.005)</td>
</tr>
<tr>
<td>Turning Point</td>
<td>0.227</td>
<td>0.193</td>
<td>0.200</td>
</tr>
<tr>
<td>95% Confidence Interval, Fieller Method</td>
<td>[0.172, 0.766]</td>
<td>[0.145, 0.248]</td>
<td>[0.158, 0.261]</td>
</tr>
<tr>
<td>95% Confidence Interval, Delta Method</td>
<td>[0.184, 0.270]</td>
<td>[0.158, 0.228]</td>
<td>[0.164, 0.236]</td>
</tr>
</tbody>
</table>

* p < 0.10; ** p < 0.05; *** p < 0.01

Table IV – Robustness tests of regression results
Figure III - Service provider’s dependence and firm performance
<table>
<thead>
<tr>
<th>Manufacturer (Supplier)</th>
<th>Service Provider (Buyer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIONS SEMICONDUCTOR Co.</td>
<td>RICHPOWER ELECTRONIC DEVICES Co.</td>
</tr>
<tr>
<td>Actions Semiconductor Co. Ltd., a semiconductor company, designs, develops and markets system-on-a-chip (SoC) products and solutions worldwide. The company offers integrated platform solutions, including SoCs, firmware, software development tools and reference designs for manufacturers of portable media players and smart handheld devices, such as Bluetooth audio and music devices, tablets and OTT boxes. In addition, it offers semiconductor product testing services, as well as trading in SoC products.</td>
<td>RichPower Electronic Devices Co. Ltd. engages in the distribution of semiconductor and electronic components. The company specializes in PC, networking, communications, multimedia, automotive and consumer electronics applications. The company also provides product development, technical support and system-level hardware and software integration services.</td>
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<td>FORTINET Inc.</td>
<td>EXCLUSIVE NETWORKS Ltd.</td>
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<td>Fortinet Inc. provides cybersecurity solutions for enterprises, service providers and government organizations worldwide. The company offers FortiGate physical and software licenses that provide various security and networking functions, including firewall, intrusion prevention, anti-malware, virtual private network, application control, Web filtering, anti-spam and wide area network acceleration; FortiManager product family. Furthermore, it offers security subscription, technical support, training and professional services.</td>
<td>Exclusive Networks Ltd. distributes cyber security, networking and infrastructure solutions. It offers Cyber Attack Remediation and Mitigation, an integrated solution platform that brings together vendor technologies in an end-to-end solution so that re-seller partners can enable their enterprise customers to identify, contain, respond, remediate and mitigate the impact of security breaches; and Disruptive Enterprise Mobility, a solution framework that blends the best-of-breed capabilities of the mobility and cyber security technologies. The company also provides professional and support, global logistics and field, financing and leasing services.</td>
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<td>APPLIED MATERIALS Inc.</td>
<td>TAIWAN SEMICONDUCTOR MANUFACTURING Co.</td>
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<td>Applied Materials Inc. provides manufacturing equipment, services and software to the semiconductor, display and related industries worldwide. The Semiconductor Systems segment develops, manufactures and sells a range of manufacturing equipment used to fabricate semiconductor chips or integrated circuits. The Applied Global Services segment provides integrated solutions to optimize equipment and fab performance and productivity, including spares, upgrades, services, remanufactured earlier generation equipment and factory automation software for semiconductor, display and other products.</td>
<td>Taiwan Semiconductor Manufacturing Company Limited, together with its subsidiaries, engages in the computer-aided design, manufacture, packaging, testing, sale and marketing of integrated circuits, colour filters and other semiconductor devices, primarily in Taiwan. It manufactures masks and electronic parts; sells solar-related products; wholesales and retails electronic materials; and researches, develops and tests RFID systems. The company is also involved in customer service and technical supporting, marketing and engineering supporting, and investment activities.</td>
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<td>SUNPOWER Corp.</td>
<td>MIDAMERICAN ENERGY HOLDINGS Co.</td>
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<td>SunPower Corporation researches, develops, manufactures and delivers solar solutions worldwide. The company provides solar power components, including panels and other system components. It also offers commercial rooftop and ground-mounted solar power systems, residential mounting systems and power plant systems, as well as utility-scale photovoltaic power plants. In addition, the company offers operations and maintenance services, including remote monitoring, and preventative and corrective maintenance services, as well as rapid-response outage restoration services. Furthermore, it leases solar power systems to residential customers.</td>
<td>Berkshire Hathaway Energy Company, through its subsidiaries, generates, transmits, stores, distributes and supplies energy. The company generates energy from coal, natural gas, hydroelectric, wind, solar, geothermal and nuclear resources. The company also offers residential real estate brokerage services; integrated real estate services, including mortgage originations and mortgage banking; title and closing services; property and casualty insurance; home warranties; relocation services; and other home-related services.</td>
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Appendix – Examples of manufacturer–service provider dyads included in, and excluded from, the sample