The role of Collaborative Networks in Product-Service System Business Models for an Advanced Manufacturing Technology SME

João Rodrigues Simões[1], J. M. Vilas-Boas da Silva[2,3], Isabel Duarte de Almeida[2,4]

[1]*ROFF Consulting,*
Torre de Monsanto, Rua Afonso Praça, 30, 13º, 1495-061 Algés, Portugal
E-mail: joao.rodrigues.simoes@roff.pt

[2]*Instituto Universitário de Lisboa (ISCTE-IUL),* [3]*Business Research Unit (BRU-IUL),*
Avª das Forças Armadas, 1649-026 Lisboa, Portugal
Fax: +351 217 964 710; E-mails: jmvbs@iscte-iul.pt; icspd@iscte-iul.pt

[4]*Universidade Lusíada, (CLISSIS-UL),*
Rua da Junqueira 188-198 1349-001 Lisboa, Portugal
Fax: +351 213 638 307; E-mail: isabel.dalmeida@edu.ulusiada.pt

Abstract
This research appreciates the relevance of servitization business models for an Advanced Manufacturing Technology (AMT) SME in the Ornamental Stones (OS) cluster. A holistic conceptual model was designed and tested addressing strategy, organizational structure and technological infrastructure. Primary data gathered by semi-structured interviews were completed by unstructured observation and documentation studying. The model usefulness/usability was qualitatively confirmed by the outcomes relevance. As regards results, primary stages of servitization are already occurring in the case. They might progress towards advanced servitization, if both digital business platforms and Industry4.0 and collaborative networks are deployed. Moreover, the lack of open innovation in the OS SME generates strong feelings of ownership towards resources, which constrains servitization progress and provides a threat to cluster survival. However, a mandatory progress towards Building Information Modelling is expected, which is going to demand virtual breeding environments and virtual organizations that will leverage competitive advantage and enable servitization progress.

Keywords: Collaborative Networks (CN), Industry 4.0 (I4.0), Servitization, Product-Service System (PSS).

1. Introduction

Nowadays, manufacturers cannot survive in developed economies if they stick to pure manufacturing. Neely (2007) considers that they should move ahead and offer services and solutions, delivered through their products. Therefore, servitization is one of the key strategic choices to create differentiation from competitors by offering value-added services (Ahamed et al., 2013) and so, by shifting from the products sale to a Product-Service System (PSS) (Baines et al., 2009).

This paper reports the development and preliminary test of a new conceptual business model for a small machine tool manufacturer (designated by AMT SME) based on a servitization strategy, organizationally supported by both a Collaborative Network (CN)

and a Digital Business Platform (DBP). Servitization has been adopted mostly by large manufacturers like Rolls-Royce with "power-by-the-hour" (Davies, 2004), but SME are ≈95% of existing businesses, employing ≈60% of private-sector workers (Gasiorowski-Denis, 2015). However, the ability of SME to address such a solution will increase, if they work with partners, in a win-win CN relationship, since they are not prepared to deal with the consequent emerging managerial and technological challenges.

In fact, the move to servitization and, the PSS offer, generate huge managerial challenges requiring different business models that many companies are not yet prepared to deal with (Oliva and Kallenberg, 2003). In addition, Romero et al. (2009) have been arguing for Collaborative Networked Organizations as a growing trend in a highly competitive, globalized economy, where collaboration is essential for business success. Collaborative Organizations might share core competencies and resources, for a better and quicker response to business opportunities (Camarinha-Matos and Afsarmanesh, 2003). Camarinha-Matos (2009) also suggests that collaboration supported by Information and Communication Technology (ICT) enables SME to overcome geographic limitations and dispersion, generating economies of scope and scale. Four research questions arise, as a consequence of this reasoning, as follows:

- RQ1- Are PSS feasible for SME, its Customers and Service Providers alike? Is there a convergence of interest?
- RQ2- How may a CN fit the challenges imposed by servitization for SME?
- RQ3- What is the role of ICT in the adoption of servitization, and in the creation and maintenance of a CN?
- RQ4- Are technological factors relevant influences for the creation a CN?

The research sponsor is a SME that develops Advanced Manufacturing Technology (AMT) for other SME from the cluster of Ornamental Stones (OS). The decorative role of OS in the Architecture, Engineering and Construction Industry (AEC) places new demands on the transformation of the stones, asking for a consumer attractive product. The sector leaders are Italian firms that compete on lower costs coming from higher volumes, high product quality and, also, from their long-term reputation.

Therefore, a business model that enables customers to focus in their core business and cutting on capital investment by transferring equipment maintenance and machine update risks to the supplier might be very attractive for many small players of the cluster. This deal might become more appealing to SME, if one adds up technology customization and elimination of down times, as well as their related maintenance costs, all included in a long-term pack of advanced services (Baines and Shi, 2015) to be paid as a rent. Thus, to implement a PSS the sponsor needs to develop its machines by considering the information requirements to monitor the working condition of the equipment, in real-time and, by introducing sensors enabling the collection of huge amounts of data. In addition, adequate software tools explore the relationship between prognostics & health management technologies and, servitization (Greenough and Grubic, 2011). The results will support the planning of the interventions of a CN of maintenance experts.

A conceptual model was designed and tested. It proposes a holistic context that is cross sectional to SME operations by addressing the strategy, organizational structure and technological infrastructure. An organized and systematic process of inquiry to approach the state-of-the-art of servitization in the investigated case study is generated from this

model. Primary data were gathered by semi-structured interviews and, completed by in loco observation and secondary data. The model usefulness and usability to discuss and appreciate the adoption of innovative business models in a SME was qualitatively confirmed by the outcomes relevance.

This research has identified primary stages of servitization taking place into the AMT SME. They might progress towards advanced servitization, if both DBP associated with Industry4.0 and collaborative networks are deployed as the standard for organizational arrangements. Moreover, the lack of open innovation in the OS SME generates strong feelings of ownership towards physical resources, capital, information and data that constrains the progress of servitization and provides a threat to the cluster survival. However, a mandatory progress towards Building Information Modeling in OS SME is expected, which is going to generate strong requirements for virtual breeding environments and virtual organizations that will leverage competitive advantage and enable the servitization progress in the AMT supplier.

2. Literature review

In this section, four propositions are introduced. They are supported on a literature review guided by the research questions previously formulated. The main outcome is a conceptual model.

Propositions

Proposition 1 – PSS are feasible and desirable for SME, its Customers and Service Providers alike because there is a convergence of interest.

Servitization stresses long term customer relationships (Tuli et al., 2007) and promotes innovation co-creation (Vargo and Luch, 2004). In *use-oriented and result-oriented services* the supplier owns the equipment, while the customer pays a long-term rent, getting rid of equipment responsibilities (Baines and Shi, 2015). This enables the customer differentiation (Brax, 2005; Malleret, 2006; Gebauer and Friedli, 2005; Ostrom et al., 2015), supporting a sustainable competitive advantage (Davies, 2004; Greenough and Grubic, 2011; Martinez et al., 2010), based on a different way to deliver product functionality (Slack, 2005). Moreover, setting strategic alliances is a relevant way to overcome SME resources constraints (Camarinha-Matos, 2009; Lee et al., 2010), being a growing phenomenon in servitization (Baines, 2013; Gulati, 2007). In fact, collaboration and co-innovation in services open generate new paths to value creation (Camarinha-Matos et al., 2013).

Proposition 2 – Collaborative Networks fit the challenges imposed by servitization for SME

Business strategy and organizational structure are mutually dependent (Silva, 2009). So, the increase in SME organization complexity introduced by servitization generates new needs for the structure (Oliva and Kallenberg, 2003; Gebauer and Friedli, 2005; Vandermerwe and Rada, 1988; Mont, 2002), a requirement for organizational change (Bustinza et al., 2015) and different relationships with the stakeholders (Oliva and Kallenberg, 2003; Gebauer and Friedli, 2005; Mont, 2002), as well as the adoption of new technologies (Baines, 2015). Virtual Organization (VO) implementation leverages competencies, services and resources, in order to overcome limits to growth imposed by

rules and hierarchies (Silva and Almeida, 2017) that are required to capture value. VO are based on networks that describe different relationships with external stakeholders (Reim et al., 2015). In VO, the important process of partner selection (Mont, 2002) might be conducted from the full population of organizations, which is not advisable, or from potential partners previously identified and prepared to collaborate that are grouped into a Virtual Breeding Environment (VBE) (Afsarmanesh and Camarinha-Matos, 2005; Camarinha-Matos and Afsarmanesh, 2007). This is a long term association that includes an interoperable ICT, working rules and cooperation agreements, which assure the basic functioning of a collaborative network (Afsarmanesh and Camarinha-Matos, 2005).

Proposition 3 – ICT has a two fold role: as a central topic in the creation and maintenance of a CN and, as a cornerstone for the adoption of advanced services in servitization

Technology is continuously changing the nature of products, processes, strategies, business models and competition (Porter and Heppelmann, 2014), which might support the adoption of a PSS strategy (Reinartz and Ulaga, 2008) through an interoperable collaborative network. On the other hand, the new IT requirements for the implementation of advanced services in servitization are illustrated by the four main topics, as follows: new ERP needs, Remote Repair Diagnostics and Maintenance Technology (RRDMT), Digital Business Platform (DBP) and Industry 4.0. For instance, in servitization there is a requirement for continuous data collection, treatment and processing (Neely, 2007) on a relational base that is out of the ERP scope. In fact, RRDMT enable the identification and improvement of behaviour patterns (Lee and Lee, 2015) that are critical to servitization (Neu and Brown, 2005), equipment remote control and repair (Biehl et al., 2004), customers needs (Baines and Lightfoot, 2013) and suppliers relationships (Saccani et al., 2014). In addition, a DBP is a common platform including several technologies targeting mutual development based on new digital business models (Gartner, 2017b) that might enable SME to compete with big size companies (Manyika et al., 2017). As regards outputs (Jost, 2017), the DBP would share information concerning the PSS such as the equipment performance (e.g. availability, reliability), as well as service cost (Lightfoot et al., 2011), linking the physical and virtual worlds. Furthermore, the Enterprise Architecture (EA) (FEAPO, 2013) is an emerging concept to deal with ineffective strategy implementation (Porter, 2008) by orienting the planning and design of IS/IT resources to match institutional objectives (Lapalme, 2012; Burton, 2017) and so, close the strategic gap (Gartner, 2017a). In the EA context, the business architecture (BA) – e.g. servitization – is the strategic path used to orient the design of competitive business processes strategically aligned – e.g. VO/VBE – according to Gartner (2017a). Gartner (2017a) anticipates that 50% of BA will focus on DBP, until 2018. Finally, I4.0 supports the digitalization of Industry by innovative interfaces and services based on transparent data ecosystems putting together customers, suppliers and other partners (Vermeire et al., 2017). Therefore, sensors, WiFi networks, intelligent machines, computer downsizing at low cost and big data processing support this concept that integrates buzzwords such as *Internet of Things & Services*, *Cyber-Physical Systems*, *Smart Products*, *Big Data*, *Cloud Computing*, *Cyber Security* and *Autonomy* (Huxtable and Schaefer, 2016).

Proposition 4 – Technological factors appear to be critical drivers of Collaborative Networks

As highlighted in proposition 3 technology is essential to the servitization business model, namely by pushing and enabling the ability of two or more systems to exchange and use information among them (bottom up effect) (Geraci, 1991). This interoperability requirements are placed at organizational level (business objectives and processes), semantic level (digital meaning of exchanged resource) and, at technical level (technology heterogeneity) (Pagano et al., 2013). Moreover, it is difficult to find out relevant data, to convince data owners to share them and to convince data consumers to trust them (Batini and Scannapieco, 2006), which are core issues to assure a good DBP performance. On the other hand, focusing on collaborative networks might help SME to overcome both their organizational (structural, human and technical) and financial weaknesses that are holding the development of the core essential I4.0 competencies (top down effect) (Faller and Feldmuller, 2015). To sum up, technology appears to be involved in a circular relationship both as a core requirement of PSS and as an enabler of CN.

Conceptual Model

Competitive challenges to an Advanced Manufacturing Technology (AMT) SME in the domain of the Ornamental Stones might be addressed by a servitization business model. This does have a top down effect on the AMT SME organizational structure by requiring the creation of a collaborative network, in order to form a VBE and virtual organizations. However, the resulting structure does also impact the PSS through a significant emerging strategy. In addition, the strategic requirements for smart products place a different type of demand on IS/IT, of which availability also actively contributes to the business value proposal, by leveraging and magnifying it. In summary, one might put together the conceptual model depicted in Figure 1. This is an iterative model where business strategy influences and is influenced by the organizational structure. Moreover, the relevance of the special role of technology deserves to be explicitly addressed, despite these decisions are part of the organizational structure. The conceptual model is completed by the propositions that were previously introduced.

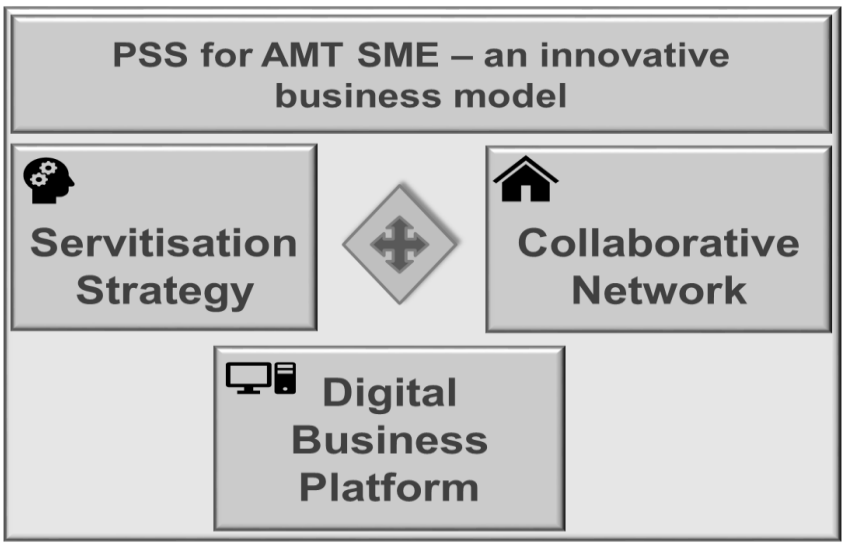

Figure 1. Proposed conceptual business model for an AMT SME.

3. Methodology

This research aims at exploring the degree of fitness, adequateness and usefulness among PSS, CN and DBP, as integrated in Figure 1, both theoretically and empirically. A hypothetical-deductive approach was pursued by deducting a conceptual model from a literature review ahead of the field work. Therefore, four propositions aiming at empirical cross-sectional discussion were developed. Therefore, an organized and systematic process of inquiry to approach the state-of-the-art of servitization in the investigated case study was generated from this model (Simões, 2017). Primary data were gathered by semi-structured interviews and, completed by in loco observation and secondary data. Company directors were interviewed from an innovative firm with close academic relationships. An interview guide was designed based on the conceptual model (Simões, 2017), according to Patton (2009) and Saunders et al. (2009) advices. However, some open questions were considered, in order to enable some exploration of relevant topics not included in the guide (Saunders et al., 2009, Yin, 2009). A company visit was run to better understand the business context, as well as to collect some data both secondary from documentation analysis and primary from unstructured observations. Then, source triangulation was, not only possible, but pursued (Saunders et al., 2009). Finally, construct validity and reliability were assured by sending to the interviewees copies of the notes, asking for their feedback and further correcting them. Since that the case study choice was purposeful, then the external validity of the results only concerns the chosen case, which is part of the Portuguese OS cluster. Some analytical generalization (Yin, 2009) might be possible.

4. Empirical Findings from the Case Study

Findings will be organized according to the developed propositions, as follows.

Proposition 1 – PSS are feasible and desirable for SME, its Customers and Service Providers alike because there is a convergence of interest.

The case study firm develops horizontal technologies. It has already promoted innovation through cross-fertilization with the shoes industry, concerning the water jet cutting machines. Its main business model is oriented to product, despite a certain level of servitization having been offered as services associated to the products, as follows: 1) in sales - machine transportation, deployment on customer, customization, training and machine revision; 2) in maintenance – remote during lifecycle at no cost, corrective (free during 2 years, for manufacturing defects) and corrective to fix breakdowns (paid). Despite this PSS stage being possible among SME customers, the risk is higher, because these companies, i. e. SME, are more fragile. However, one might still expect the AMT SME requirement for PSS to increase, depending on: the evaluation of business risk, specific marketplace demand, customer attitude towards machine use, relationships closeness, contractual conditions, customer assessment (education, training, use adequateness, maintenance concerns, etc.), geographic location, local partners typologies, etc. On the other hand, the requirements for BIM procurement are also expected to facilitate the introduction of PSS supported by I4.0 initiatives, on both the manufacturers

(OS SME) and OS customers sides, by bringing together partners to build up collaborative partnerships to address that threat. In fact, there appears to be a convergence of interest on collaborative networks that might serve a threefold purpose, i.e. the new business models concerning the servitization of technology (AMT SME), the focus on the core business processes leaving out complex technologies for the experts (OS SME) and the partnerships to address BIM procurement (OS SME and OS customers).

Proposition 2 – Collaborative Networks fit the challenges imposed by servitization for SME

The decreasing of times-to-market of technological solutions introduced at higher rates, the increasing investment costs and, the increasing complexity of both solutions and technology are reasons why the case company has been involved with other partners, such as: AMT suppliers, Universities, Sectorial Technological Centers, Sectorial Associations and Customers into consortiums put together to address mobilizing R&D projects, or other types of collaborative initiatives, e.g. innovative co-creation of technologies (AMT). This is the tested routing that will be used (Silva et al., 2017), once again, to implement I4.0 within the context of a DBP that aims at supporting a collaborative network to enable a PSS business model, despite requirements for this purpose being different (in both scope and scale) from the ones for the focused development of AMT in equipment. In fact, the task is so huge that it is impossible to address it as an independent firm. So, the new business model itself (servitization) will be dependent on a VBE from where VO will be formed to address the needs of a Product-Service System configuration. To sum up, CN not only fit the challenges of servitization in the AMT SME, but they can simultaneously serve other purposes, e.g. development of broader technological solutions by generating different VO from the same VBE.

Proposition 3 – ICT has a two fold role: as a central topic in the creation and maintenance of a CN and, as a cornerstone for the adoption of advanced services in servitization

The case study firm specially highlighted the role of ICT in the adoption of advanced services in servitization in several ways, as follows: i) production - sensors, cameras and advanced proprietary software enabling digitalization and optimization of the cut profile to avoid defects and, also, to enable pattern matching; gathering production data to enable reliable production management, e.g. actual schedule, used materials, quality control, machine and operator times, set up times, down times, idle times, etc. ii) maintenance – gathering, treating and processing massive amounts of data about equipment condition (e.g. energy consumption, oil leakages, equipment performance) through sensors, augmented reality and proprietary software enable remote maintenance. This means on time, cheaper and effective service, saving on travelling expenses. The drawback concerns the “secrecy of clients' information” causing equipment to be off-line most of the time. On the other hand, data interoperability was mentioned in relationship with the future requirements for BIM standards in procurement, despite many concerns of I4.0 already being addressed do have this concern. In addition, it looks that the involvement with the ICT support to CN (mezzo level) is not yet a priority concern, perhaps because the company has mainly been focused in the development of advanced CNC machinery (micro level). It appears to be an interesting idea to look for partners (Silva et al., 2017) to help to develop this path already recognized but not yet explicitly addressed.

Proposition 4 – Technological factors appear to be critical drivers of Collaborative Networks

Many of the current equipment features at the micro level are already critical drivers of CN (mezzo level), e.g. data interoperability, big data and related patterns, remote control, remote maintenance, specific proprietary software, standard CAD/CAM data formats, data security, real time operation, etc. So, the use of these equipments is a *sine qua non* condition for the deployment of CN. Moreover, there appears to be an ongoing Digital Business Platform (DBP) under development, of which value/interest is–adequate for "different" CN, as far as their operating purposes require advanced manufacturing equipment; so, the same DBP is equally relevant to support; i) either a new PSS business model for the AMT SME; ii) or a servitization situation that enables OS manufactures to focus on their core business (OS SME); iii) or, even, a new BIM business procurement model for OS SME and OS customers. These means that the scope of the collaboration relationship enabled by these equipment features being introduced by AMT SME appear to reach applications and uses far beyond their strictest interest on a different business model (servitization) for AMT SME. Therefore, despite a VO aiming at this purpose might be formed from the emerging VBE, other VO with different purposes might also be formed (Figure 2). To sum up, huge synergies might be gathered without a sharp increase in complexity, since different VO will address different purposes, despite being formed from a common VBE. It appears that there is a requirement for an analysis at a macro level that sets the scene for a VBE in the Ornamental Stones Cluster aiming at a broader purpose.

5. Discussion and Conclusions

The case study AMT SME belongs to the OS cluster, i.e. a set of organizations within the same specialization scope (OS), closely located, collaborating and achieving better results than isolated firms working on their own (Porter, 2008). This is a different situation from belonging to a sector that is a grouping of companies put together for administrative or statistical purposes. The cluster behaves as a collaborative network constrained by a geographic area accomplishing the pre-requisites of PSS (Gulati, 2007; Williams, 2007), since the delivery and contracting of services depend on the geographical relationship between customer and supplier (Baines, 2013; Kumar and Kumar, 2004). On the other hand, Camarinha-Matos et al. (2005) argue that that the participation in a cluster in not enough for an advanced servitization strategy. In addition, Camarinha-Matos (2009) refer to a VBE as a more feasible environment for service providing by acting as a kind of a "permanent internal network" as one interviewee called it.

A record of Past collaboration and good institutional relationships were found as significant enablers of a VBE where VO dedicated to repairing services might be bred. Moreover, other different VO might come out of the very same VBE to address different needs. The VBE might also be supported by a DBP, which is essential for deploying PSS as well as for developing an e-procurement strategy to implement a Building Information Modeling (BIM) approach in the AEC sector. Consequently, emerging VO might result from the implementation of Cyber-Physical Systems (CPS) integrating cloud data, knowledge, systems and resources from several physical organizations (Figure 2).

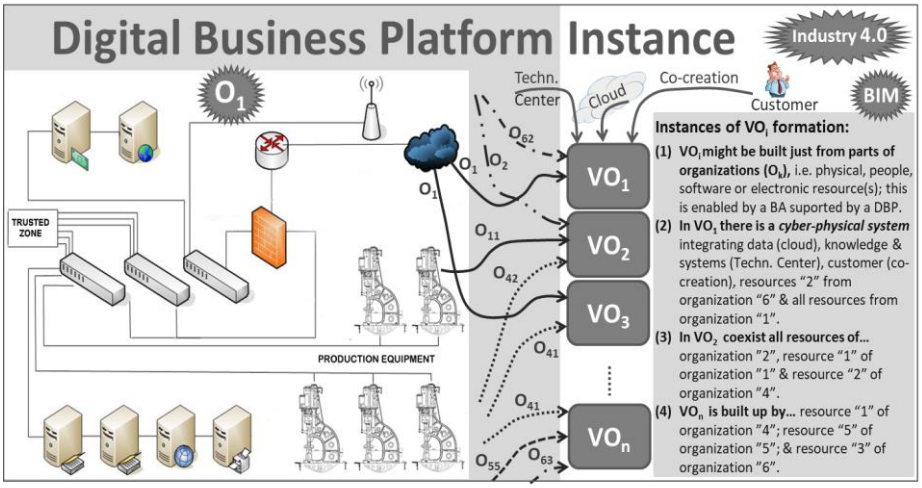

Figure 2. Instance of a DBP supporting the formation of Virtual Organizations (Silva et al., 2017).

Therefore, there is a requirement for AMT SME to adopt I4.0 technologies, i.e. IoT, Big Data, Cloud Computing, etc., which demand data interoperability among partners. For instance, this could result into a cloud resident CPS (receiving information from an equipment concerning a problem) being able to automatically search the VBE for resources, put them together and suggest a VO aiming at solving the problem (Figure 2). In this sense, CN might very well be considered as major enablers of the deployment of I4.0 solutions (Camarinha-Matos et al., 2017). In summary, the major contribution of this research is the recognition of the emergence of VBE supported by DBP as major forms to deploy collaborative networks as organic and flexible organizational structures that enable the development of innovative business models for SME.

Finally, two significant limitations to servitization are going to be addressed. First of all, in some markets, for some customers it might be difficult or unattractive to build up a VBE, which affects the availability of some advanced services of PSS (Kumar and Kumar, 2004). Secondly, the lack of open innovation in the OS SME generates strong feelings of ownership towards physical resources, capital, information and data that constrains the progress of servitization and might even provide a threat to the cluster survival. Therefore, hybrid business models are advisable for AMT SME looking for situational adaptation to different business contexts. Nevertheless, it should be added that "mandatory" progress towards Building Information Modeling in OS SME is expected, due to the current trends in the AEC sector. This is going to generate strong requirements for VBE and VO, which will leverage competitive advantage and enable the servitization progress in the AMT suppliers.

References

Afsarmanesh, H., Camarinha-Matos, L., 2005. A Framework for management of virtual organization breeding environments. In: Camarinha-Matos, L., Afsarmanesh, H., Ortiz, A (eds.). Collaborative networks and their breeding environments, pp. 35–48. Springer, Boston.

Ahamed, Z., Kamoshida, A., Inohara, T., 2013. Organizational factors to the effectiveness of implementing servitization strategy. *J. Service Science & Management,* 6(2), pp.177–185.

Baines, T., Lightfoot, H., Benedettini, O., Kay, J., 2009. The servitization of manufacturing: A review of literature and reflection on future challenges. *J. Manufacturing Technology Management,* 20(5), pp.547–567.

Baines, T., 2013. Servitization impact study: How UK based manufacturing organisations are transforming themselves to compete through advanced services. Aston Business School, Birmingham.
Baines, T., Lightfoot, H., 2013. Servitization of the manufacturing firm: Exploring the operations practices and technologies that deliver advanced services. *Int. J. Operations & Production Management*, 34(1), pp.2–35.
Baines, T., 2015. Exploring service innovation and the servitization of the manufacturing firm. *Research Technology Management*, Sept-Oct, pp.9–12.
Baines, T., Shi, V., 2015. A Delphi study to explore the adoption of servitization in UK companies. *Production Planning & Control*, 26 (14-15), pp.1171–1187.
Batini, C., Scannapieco, M., 2006. Data quality: Concepts, methodologies and techniques. Springer, Berlim.
Biehl, M., Prater, E., McIntyre, J., 2004. Remote repair, diagnostics, and maintenance. *Communications of the ACM*, 47(11), pp.100-106.
Brax, S., 2005. A manufacturer becoming service provider - challenges and a paradox. *Managing Service Quality: An Int. J.*, 15(2), pp.142–155.
Burton, B., 2017. Digital business architecture - From strategy to guiding execution. Gartner, https://www.gartner.com/webinar/3251017. Accessed 9 May 2017.
Bustinza, O., Bigdeli, A., Baines, T., Elliot, C., 2015. Servitization and competitive advantage: the importance of organizational structure and value chain position. *Research-Technology Management*, 58(5), pp.53–60.
Camarinha-Matos, L., Afsarmanesh, H., 2003. Elements of a base VE infrastructure. *J. Computers in Industry*, 51(2), pp.139–163.
Camarinha-Matos, L., Afsarmanesh, H., Ollus, M., 2005. "ECOLEAD: A holistic approach to creation and management of dynamic virtual organizations", In: Camarinha-Matos, L., Afsarmanesh, H., Ortiz, A (eds.). Collaborative networks and their breeding environments, pp.35–48. Springer, Boston.
Camarinha-Matos, L., Afsarmanesh, H., 2007. A framework for virtual organization creation in a breeding environment. *Annual reviews in control*, 31(1), pp.119–135.
Camarinha-Matos, L., 2009. Collaborative networked organizations: Status and trends in manufacturing. *Annual Reviews in Control journal*, 33(2), pp.199–208.
Camarinha-Matos, L.M., Ferrada, F., Oliveira, A.I., Afsarmanesh, H., 2013. "Supporting product-servicing networks", In: Proceedings of 2013 International Conference on Industrial Engineering and Systems Management (IESM), Rabat, pp.1–7.
Camarinha-Matos, L., Fornasiero, R., Afsarmanesh, H., 2017. "Collaborative Networks as a Core Enabler of Industry 4.0". In: Camarinha-Matos L., Afsarmanesh H., Fornasiero R. (eds) Collaboration in a Data-Rich World. PRO-VE 2017. IFIP Advances in Information and Communication Technology, vol. 506. Springer, Cham.
Davies, A., 2004. Moving base into high-value integrated solutions: A value stream approach. *Industrial and Corporate Change*, 13(5), pp.727–756.
Faller, C., Feldmüller, D., 2015. Industry 4.0 learning factory for regional SMEs. *Procedia CIRP, 32*, pp.88–91.
FEAPO, 2013. Common perspectives on enterprise architecture. Federation of EA Professional Organizations. *Architecture and Governance Magazine*, *November*, pp.1–12.
Gartner., 2017a. Gartner Says That by 2018, Half of EA Business Architecture Initiatives Will Focus on Defining and Enabling Digital Business Platform Strategies. Gartner Press Release, http://www.gartner.com/newsroom/id/3660017. Accessed 7 April 2017.
Gartner, 2017b. Digital Business. http://www.gartner.com/it-glossary/digital-business/. Accessed 9 May 2017.
Gasiorowski-Denis, E., 2015. The big business of small companies, International Organization for Standardization, http://www.iso.org/iso/news.htm?refid=Ref1937. Accessed 7 April 2017.
Gebauer, H., Friedli, T., 2015. Behavioral implications of the transition process from products to services. *Journal of Business & Ind. Marketing*, 20(2), pp.70–78.
Geraci, A., 1991. IEEE standard computer dictionary: Compilation of IEEE standard computer glossaries. IEEE Press.
Greenough, R., Grubic, T., 2011. Modelling condition-based maintenance to deliver a service to machine tool users. *Int. J. Advanced Manufacturing Technology*, 52(9), pp.1117–1132.
Gulati, R., 2007. Silo busting - how to execute on the promise of customer focus. *Harvard Business Review*, *May*, pp.98–108.
Huxtable, J., Schaefer, D., 2016. On servitization of the manufacturing industry in the RU. *Procedia CIRP*, 52, pp.46–51.

Jost, W., 2017. Digital Business Platform 2.0. AG Software, https://info.softwareag.com/dbp-digital-business-platform-thank-you.html?aliId=109895149. Accessed 11 May 2017.
Kumar, R., Kumar, U., 2004. A conceptual framework for the development of a service delivery strategy for industrial systems and products. *J. Business & Industrial Marketing*, 19(5), pp.310–319.
Lapalme, J., 2012. 3 Schools of Enterprise Architecture. *IT Professional*, 14 (6), pp.37–43.
Lee, S., Park, G., Yoon, B., Park, J., 2010. Open innovation in SMEs - an intermediated network model. *Research Policy*, 39(2), pp.290–300.
Lee, I., Lee, K., 2015. The internet of things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons*, 58(4), pp.431–440.
Lightfoot, H., Baines, T., Smart, P., 2011. Examining the information and communication technologies enabling servitized manufacture. Proceedings of the Institution of Mechanical Engineers, Part B, *J. Engineering Manufacture*, 225(10), pp.1964–1968.
Malleret, V., 2006. Value creation through service offers. *European Management J.*, 24(1), pp.106–116.
Manyika, J., Chui, M., Lund, S., Ramaswamy, S., 2017. What's now and next in analytics, AI, and automation. McKinsey Global Institute, http://www.mckinsey.com/global-themes/digital-disruption/whats-now-and-next-in-analytics-ai-and-automation?cid=other-eml-alt-mgi-mgi-oth-1705&hlkid=9a6016170fcb420f8a121a17c5a33c63&hctky=2399862_&hdpid=8ce712f8-63e5-406f-bcdf-1cbc2c3f7d05#Table. Accessed 22 May 2017.
Martinez, V., Bastl, M., Kingston, J., Evans, S., 2010. Challenges in transforming manufacturing organizations into product-service providers. *J. Manufacturing Technology Management*, 21(4), pp.449–469.
Mont, O., 2002. Clarifying the concept of product–service system. *J. Cleaner Production*, 10(3), pp.237–245.
Neely, A., 2007. "The servitization of manufacturing: an analysis of global trends", In: Proceedings of 14th EurOMA - Managing Operations in an Expanding Europe, pp. 1–10. University of Ankara, Ankara, Turkey.
Neu, W., Brown, S., 2005. Forming successful business-to-business services in goods-dominant firm. *J. Service Research*, 8(1), pp.3–17.
Oliva, R., Kallenberg, R., 2003. Managing the transition from products to services. *Int. J. Service Industry Management*, 14(2), pp.160–172.
Ostrom, A., Parasuraman, A., Bowen, D., Patricio, L., Voss, C., 2015. Service research priorities in a rapidly changing context. *J. Service Research*, 18(2), pp.127–159.
Pagano, P., Candela, L., Castelli, D., 2013. Data Interoperability. *Data Science J.*, 12, pp.19–25.
Patton, M., 1987. How to use qualitative methods in evaluation. Sage Publications, EUA.
Porter, M., 2008. The five competitive forces that shape strategy. *Harvard Business Review, January*, pp.79–93.
Porter, M., Heppelmann, J., 2014. How smart, connected products are transforming competition. *Harvard Business Review*, 92(11), pp.1–23.
Reim, W., Parida, V., Ortqvist, D., 2015. Product service systems (PSS) business models and tactics e a systematic literature review. *J. Cleaner Production*, 97, pp.61–75.
Reinartz, W., Ulaga, W., 2008. How to sell service more profitable. *Harvard Business Review*, 86(5), pp.90–96.
Romero, D., Galeano, N., Molina, A., 2009. Mechanisms for assessing and enhancing organisations' readiness for collaboration in collaborative networks. *Int. J. Production Research*, 17(1), pp.4691–4710.
Saccani, N., Visintin, F., Rapaccini, M., 2014. Investigating the linkages between service types and supplier relationships in servitized environments. *Int. J. Production Economics*, 149, pp.226–238.
Saunders, M., Lewis, P., Thornhill, A., 2009. Research methods for business students 5ª eds. Pearson, Harlow.
Silva, J., 2009. "Restating a research definition in conformance to soft systems semantics", In: Proceedings of 16th EurOMA Conference, Implementation – Realizing Operations Management Knowledge, Sweden, 14–17 of June.
Silva, J., Almeida, I., 2017. Collaborative networks as incubators of dynamic virtual organizations: a case study of the emerging MAP sector. *Int. J. Manufacturing Technology and Management*, 31(1-2-3), 192–216.
Silva, A., Vilas-Boas, J., Simões, J., 2017. Definition of the mobiliser project INOVSTONE 4.0 (Definição do projeto mobilizador INOVSTONE 4.0). Unpublished internal report Draft. Gestor do INOVSTONE 4.0.
Simões, J., 2017. Evaluation of innovative business models for SME: the servitization of the suppliers of advanced manufacturing tecnhologies for the ornamental stones cluster (Avaliação de modelos de

negócio inovadores em PME: a servitização dos fabricantes de tecnologia de produção avançada para as rochas ornamentais). MSc Thesis, Supervisor – Prof. João Vilas-Boas, IBS, ISCTE-IUL, Portugal.
Slack, N., 2005. Operations strategy: will it ever realize its potential? *Gestão & Produção*, 12(3), pp.323–332.
Tuli, K., Kohli, A., Bharadwaj, S., 2007. Rethinking customer solutions: From product bundles to relational processes. *J. Marketing*, 71(3), pp.1–17.
Vandermerwe, S., Rada, J., 1988. Servitization of business: adding value by adding services. *European Management J.*, 6(4), pp.314–324.
Vargo, S., Luch, R., 2004. Evolving to a new dominant logic for marketing. *J. Marketing*, *68*(1), pp.1–17.
Vermeire, P., Torfs, D., Van der Straeten, J., Vanderlinden, S., Van den Kerkhof, G., 2017. Industry 4.0: hype or reality?. PWC, https://www.pwc.be/en/news-publications/publications/2017/industry-hype-or-reality.html. Accessed 2 June 2017.
Williams, A., 2007. Product service systems in the automobile industry: contribution to system innovation?. *J. Cleaner Production*, 15(11-12), pp.1093–1103.
Yin, R., 2009. Case study research: Design and methods 4ª eds. Sage Pub., Thousand Oaks.