A Conceptual Framework for Servitization in Industry 4.0: Distilling Directions for Future Research

Ennis, C., Barnett, N., De Cesare, S., Lander, R. and Pilkington, A.

This is an electronic version of a paper presented at *The Advance Services Group Spring Servitization Conference 2018,* Copenhagen Business School, 14 to 16 May 2018, Aston University and Higher Education Academy.

A CONCEPTUAL FRAMEWORK FOR SERVITIZATION IN INDUSTRY 4.0: DISTILLING DIRECTIONS FOR FUTURE RESEARCH

Caroline Ennis, Nicholas Barnett, Sergio de Cesare, Rachel Lander, and Alan Pilkington

ABSTRACT

Purpose: This paper focusses on developing further the recent conceptual frameworks of competitive dynamics and business-to-business value ecosystems considering the changing environment of Industry 4.0 and the particular perspective of servitization.

Design/Methodology/Approach: This a conceptual paper that reviews and syntheses business model concepts in relation to competitive dynamics, collaborative business ecosystems and supply chain as evolving and reshaping manufacturing and services within Industry 4.0.

Findings: The transformation of organizations in light of Industry 4.0 has led to a reframing of business models and practices, such as stakeholder value and supply chain relationships cooperating within a highly dynamic environment. In an attempt to consider the implications that Industry 4.0 has, particularly from the service perspective, this work attempts to distil directions for future research.

Originality/Value: Previous studies on Industry 4.0 have articulated the reasoning about the benefits of Industry 4.0, with its paradigm shift to cyber-physical systems and revised business models. The intention of this paper, is to be able to further define collaboration and value ecosystems in order to show the interdependence and integration between organisations as applied to servitization within Industry 4.0. Moreover, this paper seeks to begin to articulate how research can be conducted to determine the degree to which the change and paradigm shift has become a reality.

KEYWORDS: Industry 4.0, Servitization, strategic competitive dynamics, value ecosystems, supply network.

1. INTRODUCTION

Technological advances have always impacted manufacturing. Initially it was steam which enabled mechanisation. This was then followed by the intensive use of electrical energy enabling mass production, and more recently by widespread digitalisation which allowed for the automation of production processes. Lasi and Kemper (2014) define the term Industry 4.0 as having two development directions; one, as the application pull (related to the change in the operating framework) and the other, as the technology push, wherein industrial practice and use of mechanisation and automation will further increase. They describe how these are characterised by cyber-physical production systems and networks. The enabler of such a transformation will be the integrated use and coordination of multiple advanced information technologies (e.g. Internet of Things, cloud computing, data analytics, smart objects, etc.) which promises to change the landscape of manufacturing. For example, it is now possible to equip production plants (its machines, components, etc.) with sensory abilities and connection to an Internet-enabled platform enabling an increased level of monitoring and control. A further consequence, is the accumulation of enormous amounts of data (Big Data), which can, if organised and processed effectively and efficiently, provide benefits for the enterprise, its business partners (e.g., supply chain or business ecosystem) and its customers (e.g., mass-customisation). Moreover, Berman (2012), in the context of digital transformation defines the essential business capabilities, which require a consideration of transforming the operating model and to be able to design new business models. In terms of the supply chain perspective, Berman talks of going beyond traditional partnerships with developers and suppliers and to consider that in the new business model, organisations should explore how to collaborate with their competitors.

The increased level of data sharing and cyber-physical integration among network partners can lead to a shift in the way organisations compete/collaborate (Chen and Miller, 2015) and in the way that value is created and captured in a business ecosystem (Urmetzer, et al., 2016). Industry is traditionally recognised for the manufacturing of physical goods.

However, in order to more adequately satisfy customer expectations and compete effectively on the market, industrial firms have increasingly offered services that either complement or integrate the manufactured product. Therefore, relationships between network partners are increasingly becoming service-based relationships and the networks in which they operate are enabling competitive performance as a result of cooperation and collaboration (Prajogo, et al., 2016). It can be expected that the increased flexibility, adaptation and customisation that Industry 4.0 brings to the operating models and production will further reinforce this phenomenon, which is known as Servitization.

2. RESEARCH METHOD

The process considered the literature in order to clarify the understanding of servitization and Industry 4.0. Both servitization and Industry 4.0 naturally lead to an increased cooperation among firms hence the creation of business ecosystems. Therefore, we chose competitive dynamics and the value ecosystem framework as the theoretical backdrop to this analysis. The former highlights, especially in more recent times, the increasingly cooperative relationships even among competitors and the latter focusses on the notions of value creation and value capture among business partners; (2) The authors critically analysed the papers against this theoretical backdrop; (3) The selection of the papers reflected the following approach: (a) recent articles published on Industry 4.0 defining the characteristics of this paradigm shift – this allowed us the frame this new manufacturing paradigm; (b) analyse the seminal papers on servitization followed by a selection of papers which highlight the cooperative nature of servitized firms and their partners, integration of their processes and the 'push' effect of technological advances. This aligns with Rowe's (2014) suggestion on how the aim of understanding a new phenomenon or problem should proceed by analysing related concepts that have been proposed in former research. We have done so by overlapping concepts drawn from the existing research on Industry 4.0 and servitization and interpreting such concepts and their possible relationship in light of Competitive Dynamics and the value ecosystem framework.

Notably, developments in the discipline area of operations management and digital business have led to a major transformation of the way organisations operate and how they capture and benefit from value within the supply chain. This provides academic substantiation from which to build a broad and credible knowledge base. In addition to this our study considers the consultancy reports that provide direction for business strategy development and transformation towards enhanced digital capability. It was important to understand from an academic perspective the types of current business strategy and to explore and determine what was taking place in terms of the B2B supply chain.

3. THEORETICAL BACKGROUND: CONCEPTUALISING INDUSTRY 4.0 AND THE EVOLVING FRAMEWORKS

Industry 4.0 was originally developed in 2011 as a way of focusing attention on the impact of technology in future manufacturing systems and as a blueprint for the development of German industrial competitiveness in the 4th phase of economic transformation (Rüβmann, et al. 2015). Outside Germany however, the term has only recently become widespread and its understanding is still not well articulated. Notably, Industry 4.0 is not just about factories anymore, rather it is the application of the many advances which can be seen currently. Rüβmann, et al., (2015) list nine foundational technologies: big data and analytics; autonomous robots; simulation; horizontal and vertical system integration; the internet of things; cybersecurity; the cloud; additive manufacturing; and augmented reality; whilst others add automation, data exchanges, cyber-physical systems, artificial intelligence, to realise smart industry. As such it is about the digitisation of all the processes involved in industry and it is typified by a constant communication between not only humans but also devices (Dominici et al. 2016). The speed of their integration means that Industry 4.0 seems to be coming to fruition (Strange & Zucchella, 2017 and Almada-Lobo, 2015).

The reshaping of production has been articulated by Brunelli et al. (2017) providing an indication of the types of technology and the way in which these are deployed in relation to

Industry 4.0 (as shown in table 1). They point out that " beyond improving internal processes, a company should explore opportunities to use 4.0 to better integrate its operations with those of customers and suppliers" (ibid: 12). Rehse et al. (2016) have considered how businesses can tap into the power of Service 4.0 describing the range of practices that take place through the deployment of technologies. Table 2 below shows how the service perspetive might correspond to the production perspective. These production and service perspectives seem to provide a framework of practice for businesses in the 4.0 industrial era. A more refined consideration for research would need to seek to relate aspects of these practices to organisational strategy such as collaboration between suppliers and the operational strategy of businesses. It could seek to understand more deeply the value that they bring when cooperating within the business ecosystem and how these apply in relation to product-service-systems in a servitization era.

Table 1 Nine Technologies Are Reshaping Production

Type of technology in use	Relevance to production
Advanced robots	Autonomous, cooperating industrial robots, with integrated sensors and standardized interfaces
Additive manufacturing	3D printers, used predominantly to make spare parts and prototypes Decentralized 3D printing facilities, which reduce transport distances and inventory
Augmented reality	Digital enhancement, which facilitates maintenance, logistics, and SOPs Display devices, such as glasses
Simulation	Network simulation and optimization, which use real-time data from intelligent systems
Horizontal and vertical system integration	Data integration within and across companies using a standard data transfer protocol A fully integrated value chain (from supplier to customer) and organization structure (from management to shop floor)
The industrial internet of things	A network of machines and products Multidirectional communications among networked objects
Cloud computing	The management of huge volumes of data in open systems Real-time communication for production systems
Cybersecurity	The management of heightened security risks due to a high level of networking among intelligent machines, products, and systems
Big data and analytics	The comprehensive evaluation of available data (from CRM, ERP, and SCM systems, for example, as well as from an MES and machines Support for optimized real-time decision making

Note: SOP = standard operating procedure. CRM = customer relationship management. ERP = enterprise resource planning. SCM = supply chain management. MES = manufacturing execution system.

Source: Boston Consulting Group analysis (Brunelli, et al 2017)

Table 2 Nine Technologies Developments Enable Service 4.0

Production Technologies	Nine Technology Developments Enable Service 4.0	Applied to service
Advanced robots	Robotic process automation	Replace humans in work processes that are entirely rule based
Augmented reality	Augmented reality	Provide the necessary information when needed in areas as varied as manuals, pricing, and alerts
Simulation	Cognitive computing	Simulate human thought processes and provide intelligent, virtual assistance
Production Technologies	**Nine Technology Developments Enable Service 4.0**	**Applied to service**

Horizontal and vertical integration	Bionic computing	Interact naturally with virtual agents, digital devices, and services
The industrial internet of things	Ubiquitous connectivity and the internet of things	Create an ongoing connection in areas as varied as on-the-spot service provision and remote monitoring
Cloud computing	Cloud computing	Manage huge data volume in open systems and provide services on demand
Big data and analytics	Big data and analytics	Develop deeper insight into customer behaviour, preferences, and pathways
	Smart devices	Develop an ecosystem of apps and cloud services that utilize high-performance devices
	Virtualization	Free services from reliance on specific software and hardware and ensure flexibility, adaptability, and robustness

Source: Boston Consulting Group analysis (Rehse, et al 2016)

4. SERVITIZATION

In the move from manufacturing towards offering goods associated with services there is a refocussing of the firm's activity towards value. Vandermerwe and Rada (1988) considered servitization as a way of creating new revenue streams. Servitization is defined by Baines et al. (2007) as "the innovation of an organisation's capabilities and processes to better create mutual value through a shift from selling products to selling Product-Service Systems" (PSS). Examples of services offered and bundled with the product are warranties, maintenance and revenue-through-use contracts. Based on a classification developed by Baines and Lightfoot (2013), the former two represent base and intermediate services respectively, while the latter is an example of an advanced service. With the proliferation of advanced services, the service component of PSS tends to dominate, as contracts underpinning such agreements typically focus on the use of the product without transferring ownership which pertinently remains with the manufacturer. The sensory technology underpinning Industry 4.0 can, for example, lead to service level agreements based on more accurate and intelligent monitoring of product use and maintenance. Barnett et al. (2013) considered that servitization brings about a paradigm shift and that the strategic direction being taken by organisations is to move towards supplying goods associated to services. They concluded that in shifting towards servitization, that incremental changes in management and operations are required stating that "the proposal [the paradigm shift], highlights that any future arrangement should consider establishing a single dynamic enterprise that has the prime shared objective of providing the required service" (ibid,:153).

Pertinently, Barnett et al. (2013) summarise that the literature related to servitization is relatively new and developing quickly. Furthermore, Rabetino et al's. (2017) comprehensive literature review characterizes the domain of servitization research as a 'fragmented adhocracy', evidenced by the lack of inter-disciplinary approaches to research. The authors identify three key communities: 1) Product Service Systems (PSS) Community, where new research is currently focusing on sustainability; 2) the Solution Business Community, which encompasses different streams, for example, operations management and industrial marketing; and 3) the Service Science Community, with substantial roots in Information Systems. Bigdeli et al., (2017:13) state that "the topic of servitization also demands consideration of both business model and organisational change" which they determine requires a holistic approach as servitization covers a range of organisational levels and environmental contexts**.**

5. COMPETITIVE DYNAMICS

Chen and Miller (2015) reconsider the Competitive Dynamics (CD) model and in analysing the competitive environment of today and the near future state that there is not a complete conceptual framework. Their view is that CD needs to reflect increasing stakeholder power, the impact of globalisation, economic forces and sustainable business practices. Their

framework has five dimensions: aims of competition; mode of competing; roster of actors; action toolkit, and time horizon of interaction. Their approach calls this relational competition. A key question about the dimensions raised by Chen and Miller [ibid, 2015] is the interdependence of the dimensions with further alignment being possible once adoption has started.

According to Chen and Miller (2015) this lack of a basic structure means that a gap has been created between today's challenges and the central theme to the existing competitive dynamics model. This failure has led to an inability to contextualise and see different variations of the model. Their view is that by identifying, defining and portraying the central idea to CD more openly, a powerful theory of CD may be developed. This starts by defining CD's core tenets, then widening the scope to include competition between organisations and value creation for the community as a whole. An emerging view is more relational in its perspective, in that it fosters and promotes cooperation and sharing from the interactions and network partnerships within upstream and downstream supply chain relationships. They state that rivalry between organisations is about economic and market competition. In developing the argument, they then consider the existing Awareness-Motivation-Capability (AMC) model, when seen through the lens of relational competition, which offers a number of performance consequences in comparison to the CD model where engagement between firms is core to competition. The AMC model suggests that a competitor needs not only knowledge of an action from a competitor, but also the capability and motivation to react. The moving sands of the environment in both the physical and business position has led to more intersections within, between and among different organisations. More attention is paid to all stakeholders as the need to garner support in any given situation becomes more of an imperative and the changing nature of competition drives awareness of the social and business need for closer relationships. For example, technology companies agreeing to one type of micro USB plugs, rather than the nineteen different versions that had existed is a benefit to all, through customer satisfaction at the usability level thanks to the standardisation of technologies. In summary they state that relational competition is more lasting due to the nature of the developed and developing relationships that are formed due to the alignment of incentives and need. The traditional view of rivalry is short term.

There are a range of propositions given by Chen and Miller (2015) however two of them stand out as being the means by which operational change can be considered and analysed. These are:

- Proposition 1c: Firms investing most heavily in physical and human resources to develop core capabilities will be more likely to have the capacity to engage in relational as opposed to rivalrous competition and
- Proposition 4b: Compared with firms engaging in rivalrous competition, firms engaging in relational competition will show performance improvements only when they implement their practices consistently over time and across interactions, relationships, and stakeholders.

Overall, they see the AMC framework of awareness, motivation and capability useful for identifying competitors and co-operators

Paradoxically, in thinking about servitization and territorial competitiveness Vendrell-Herrero and Wilson (2017) state that western manufacturing sectors will become more innovation-intensive and will develop difficult to-imitate business models based on services. This is in the hope that they will sustain their competitiveness in the medium and long term.

5. SUPPLY CHAIN B2B ECOSYSTEM

In considering businesses being organised into networks and the difficulty in handling and interpreting value creation and capture Letaifa (2014) provides an outline of the theoretical developments of business ecosystems which refers to the work of Moore (1993) who in his seminal article "Predators and Prey: The New Ecology of Competition", puts forward the concept of business ecosystem for the first time. Letaifa (2014) talks of a system that includes resources of all sorts, drawing in capital, partners, suppliers, and customers to create cooperative networks determining the transition from supply chains to ecosystems. It provides

a good scope of applied cases including radio stations and universities and it shows how the ecosystem unfolds over time and in concluding it mentions that the ecosystem requires a balance between value-co-creation and value-capture objectives to be able to innovate and survive. Urmetzer et al., (2016) then develop this further to focus on building a framework to help solve the problem of a lack of ability to understand the complete value exchange between partners in business ecosystems (focusing on the direct and indirect value capture and creation between key stakeholders). And in drawing on literature at the intersection of servitization, digital business models and supply chain, Vendrell-Herrero et al. (2017) empirically explore how digital disruption has affected business-to-business (B2B) interdependencies. They mention how dematerialisation of physical products is transforming the way firms are positioned in the supply chain. Specifically, they propose that these new market conditions can empower downstream firms, but that upstream firms can still capture additional value through digital services if their servitized offer includes difficult to imitate elements.

6. CONCLUSIONS AND FUTURE RESEARCH

The aim of this paper was to be able to further define collaborative competitive dynamics and value ecosystems in order to show the interdependence and integration between organisations as applied to servitization within Industry 4.0. In doing so the paper has described the change and move towards increased and enhanced technology use. Moreover, it determines that there is a need to understand more deeply the value that these bring when cooperating within the business ecosystem. The challenges presented by servitization for industry have been documented primarily in case study research, for example Huikkola et al. (2016) focus on resource base change and capability building, Barnett et al., (2013) identify multiple challenges in business organisation and strategy, enterprise management, operations management, including contract and risk management and organisation culture. Practitioners such as Hinchcliffe (2016), have published guidance on frameworks that agrees with the challenges identified in research, highlighting that strategy and culture change should coincide with process and system changes. The perspective on ecosystems includes the rise of intermediaries following a period of extensive disintegration of supply networks. An example of this can be seen in auto-services on insurance and other services as the value chain can be broken down and reassembled with new entrants with negligible or low entry costs.

Servitization research provides several frameworks and the task here is to attempt to categorise these and to see to revisit the research priorities (Baines et al. 2017). For example, Baines and Lightfoot (2013) focus on the delivery system for services with an ambition to develop generic operational strategy for servitization whereas Cusumano et al., (2015) propose a taxonomy of services to assist management decision making in investment. With the range of conceptual frameworks that apply to manufacturing and services for Industry 4.0 we can attempt to analyze the impact that this has on competitive and collaborative dynamics (Chen and Miller, 2015) and how this relates to value within the business ecosystem (Urmetzer et al. 2016). Adopting revised business models and frameworks of practice “requires firstly to deconstruct the model to determine the elements and characteristics in order to reveal if an organisation is creating value in house or using partners for this task” (Remane et al., 2017:45). Moreover, with the transformation to digital operations in a servitization era we should explore how organisations are integrating their operations within the supply network. It is also pertinent to seek to understand how the holistic perspective of the service-dominant ecosystem (Luftenegger et al, 2013) enables collaboration and value and what this business model looks like in a range of product-service system contexts. In doing so prescriptive research “principally concerned with with questions on how the reality should be” (Bigdeli et al. 2017:15) could look at the role of of business partners and technology providers in order to identify the value being created. It could seek to understand more deeply the value that they bring when cooperating within the business ecosystem and how these apply in relation to product-service-systems in a servitization era.

REFERENCES

Almada-Lobo, F. (2015). The Industry 4.0 revolution and the future of Manufacturing Execution Systems (MES). *Journal of Innovation Management, 3*(4), 16-21.

Ang, G. C., Baines, T., & Lightfoot, H. (2010). A Methodology for Adopting Product Service Systems as a Competitive Strategy for Manufacturer. *Proceedings of the 2nd CIRP IPS2 Conference 2010*, (pp. 489-496). Retrieved from http://www.ep.liu.se/ecp/077/ecp10077.pdf

Baines, T. S., Lightfoot, H., Steve, E., Neely, A., Greenough, R., Peppard, J., . . . Wilson, H. (2007). State-of-the-art in product service-systems. *Proceedings of the Institute of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 221*(10), 1543-1552. doi:https://doi.org/10.1243/09544054JEM858

Baines, T., & Lightfoot, H. W. (2013). Servitization of the manufacturing firm: Exploring the operations practices and technologies that deliver advanced services. *International Journal of Operations & Production Management, 34*(1), 2-35.

Baines, T., Bigdeli, A. Z., Bustinza, O. F., Shi, V. G., Baldwin, J., & Ridgway, K. (2017). Servitization: revisiting the state-of-the-art and research priorities. *International Journal of Operations and Production Management, 37*(2), 256-278.

Barnett, N. J., Parry, G., Saad, M., Newnes, L. B., & Goh, Y. M. (2013). Servitization: Is a Paradigm Shift in the Business Model and Service Enterprise Required? *Strategic Change*, 145-156.

Berman, S. J. (2012). Digital transformation: opportunities to create new business models. *Strategy and Leadership, 40*(2), 16-24.

Bigdeli, A. Z., Baines, T., Bustinza, O. F., & Shi, V. G. (2017). Organisational change towards servitization: a theoretical framework. *Competitiveness Review: An International Business Journal*, 12-39.

Brunelli, J., Lukic, V., Milon, T., & Tantardini, M. (2017). *Five Lessons from the Frontlines of Industry 4.0.* BCG Boston Consulting Group.

Chen, M., & Miller, D. (2015). Reconceptualizing competitive dynamics: A multidimensional framework. *Strategic Management Journal, 36*, 758-775.

Cusumano, M. A., Kahl, S. J., & Suarez, F. F. (2015). Services, industry evolution, and the competitive strategies of product firms. *Strategic Management Journal, 36*, 559-575.

Dominici, G., Roblek, V., Abbate, T., & Tani, M. (2016). Click and drive Consumer attitude to product development: Towards future transformations of the driving experience. *Business Process Management Journal, 22*(2), 420-434. doi:10.1108/BPMJ-05-2015-0076

Hinchcliffe, D. (2018, January 5). *Digital Transformation in 2018: Sustainably Delivering on the Promise at Scale*. Retrieved from On Digital Strategy: https://dionhinchcliffe.com/

Huikkola, T., Kohtamaki, M., & Rabetino, R. (2016, July-August). Resource Realignment in Servitization. *Research-Technology Management*, 30-39.

Lafuente, E., Vaillant, Y., & Vendrell-Herrero, F. (2017). Territorial servitization: Exploring the virtuous circel connecting knowledge-internsive services and new manufacturing businesses. *International Journal of Production Economics, 192*, 19-28.

Lasi, H., Kemper, H.-G., Fettke, P., Feld, T., & Hoffman, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, 239-242.

Letaifa, S. B. (2014). The uneasy transition from supply chains to ecosystems: the value-creation/value-capture dilemma. *Management Decision, 52*(2), 278-295.

Lightfoot, H., Baines, T., & Smart, P. (2013). The servitization of manufacturing: A systematic literature review of interdependent trends. *Journal of Engineering Manufacturing, 33*(11/12), 1408-1434.

Luftenegger, E., Comuzzi, M., & Grefen, P. (2013). The Service-Dominant Ecosystem: Mapping a Service Dominant Strategy to a Product-Service Ecosystem. *PRO-VE International Federation for Information Processing AICT, 408*, 22-30.

Moore, J. F. (1993, May-June). A New Ecology of Competition. *Harvard Business Review*, 75-86.

Prajogo, D., Oke, A., & Olhager, J. (2016). Supply chain processes: Linking supply logisitics, supply performance, lean processes and competitive performance. *International Journal of Operations and Production Management, 36*(2), 220-238.

Rabetino, R., Harmsen, W., Kohtamaki, M., & Sihyonen, J. (2017). Structuring servitization-related research. *International Journal of Operations and Production Management*, In publication.

Rehse, O., Hoffman, S., & Kosanke, C. (2016). *Tapping into the Transformative Power of Service 4.0.* BCG The Boston Consulting Group.

Remane, G., Hanelt, A., Nickerson, R. C., & Kolbe, L. M. (2017). Discovering digital business models in traditional industries. *Journal of Business Strategy, 38*(2), 41-51.

Rowe, F. (2014). What literature review is not: diversity, boundaries and recommendations. *European Journal of Information Systems, 23*(3), 241-255.

Rubmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015, April). *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries.* BCG The Boston Consulting Group.

Strange, R., & Zucchella, A. (2017). Industry 4.0, global value chains and international business. *Multinational Business Review, 25*(3), 174-184. doi:10.1108/MBR-05-2017-0028)

Urmetzer, F., Matinez, V., & Neely, A. (2016, July). *The ecosystem value framework: Supporting managers to understand value exchange between core businesses in service ecosystems.* Retrieved from University of Cambridge Cambridge Service Alliance: https://cambridgeservicealliance.eng.cam.ac.uk/resources/Downloads/Monthly%20Papers/2016DecPaperEcosystemValueFramework.pdf

Vandermerwe, S., & Rada, J. (1988). Servitization of Business: Adding Value by Adding Services. *European Management Journal, 6*(4), 314-324.

Vendrell-Herrero, F., & Wilson, J. R. (2017). Servitization for territorial competitiveness: taxonomy and research agenda. *Competitiveness Review: An International Business Journal, 27*(1).

Vendrell-Herrero, F., Bustinza, O. F., Parry, G., & Georgantzis, N. (2017). Servitization, digitization and supply chain interdependency. *Industrial Marketing Management, 60*, 69-81.