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Maturity Model Development for Digital Servitization of Manufacturing SMEs

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Abstract. Manufacturing businesses seek to increase their revenue streams through new business models. In the context of the continuing digitization of the manufacturing sector, new business models based on digital servitization offerings are at the centre of attention. However, due to the inherent complexity involved in devising such offerings and suitable business models, many companies struggle to embark on this new value-adding pathway that is not yet well understood. Current research has highlighted the general challenges and barriers faced by manufacturing businesses, along with developing tools and roadmaps for successful transition to digital servitization. However, most studies have only focused on servitization in general, omitting the specific "digital" aspect which brings about different challenges. Accordingly, the authors first introduce the concept of digital servitization in general terms, to then discuss different types of it, along with typical barriers to entry and implementation challenges. A critical element of any digital servitization endeavor is to first assess the current state of a business, to define the desired outcome of the process, and to identify the steps and actions required to accomplish the desired end goal. This is accomplished by means of maturity models that also help in terms of benchmarking current and future state against competitors. The authors introduce the research aims and questions, the research methodology and present results from a systematic review of the literature on maturity modelling, including an overview of the maturity modelling methods encountered and their respective dimensions and levels. Finally, conclusions are drawn along with the current state of the research and future work that will be conducted.

Keywords. Digital Servitization, Maturity Model, Manufacturing, Transformation Roadmap, Assessment, Descriptive

1. Introduction

In a hyper competitive business world and with the addition of emerging digital technologies, businesses are constantly searching for new avenues to improve their market share. Servitization is one such avenue, which involves providing a range of service to the end customer, such as predictive maintenance and condition monitoring services. Since the introduction of emerging digital technologies e.g., Artificial Intelligence (AI), Blockchain etc., the focus has recently shifted towards combining digital technologies and servitization into "Digital Servitization (DS)" which can be commonly defined as the development of new and/or current services using digital technologies[2]. This field has received greater attention within the research community, with increasing number of articles pertaining to DS being published since 2017 [2].

However, despite the increasing focus in this subject matter, the issue of creating roadmaps/guidelines for businesses, in particular Small-Medium-Enterprises (SMEs) to transition into a DS business model remains scarce [2-4]. To create a framework/roadmap for businesses to follow, first an analysis on the key dimensions/elements of a business to measure needs to be conducted. From the literature review, current research is lacking in creating a DS maturity model applied in industry. The main aim of this paper is to present a preliminary Maturity Model (MM) design, which will allow a business to measure its current DS maturity, compare themselves with businesses who have already implemented a DS business model and identify improvement measures. The following research questions will be partly addressed in this paper: RQ1: "How can the readiness level of a business looking to transition into a digital servitization business model be assessed?"

The structure of this paper is as follows: In section 2, a brief background on (digital) servitization and maturity modelling is reviewed. Section 3 details the chosen research methodology. Section 4 proposes the initial digital servitization maturity model as a result of the Systematic Literature Review (SLR). Finally, conclusions and future work are presented in Section 5.

2. Background

Digital Servitization as a concept has been looked at from different aspects in the current literature. This approach has been termed differently depending on the geographic regions [5], most common being "Product-Service-Systems" or "Industrial Product-Service-Systems" by Scandinavian authors and "servitization" by mainly UK, German and Swedish authors [6]. To transition into a digital servitization business model there are barriers that are needed to be overcome. The most common barrier is related to organization transition [2-4, 7] and providing roadmaps/platforms for businesses to transition into a digital servitization business model efficiently and effectively. Maturity Modelling can be used to achieve this goal and is a useful tool allowing businesses to view the maturity for a specific business element and creating an improvement roadmap [8]. Maturity Models can serve as a range of purposes such as descriptive, prescriptive, and comparative. ***Descriptive*** **MMs** provide the as-is situation of current capabilities of the business under investigation [9] and are used as a diagnostic tool. ***Prescriptive*** **MM's** can be used to identify desirable maturity levels and provide improvement guidelines [9]. ***Comparative*** **MM's** allow cross comparison between different companies in the same industry and provides internal and external benchmarking measures [8]. This research will conform to the Capability Maturity Model (CMM), originally developed by [10] and is the most widely accepted and used MM type within research and industry[11]. CMM aims to provide a framework to guide process improvement across either a project, division or entire organization [12]. All maturity models must consist of: ***Maturity Dimensions***. (Other terms include "Factors", "Capabilities" etc.) and ***Maturity Levels*** which describe the stages e.g. from level 1 to level X. The highest level/stage is the ideal state to be in, which signals the highest maturity of the business for a particular dimension.

3. Maturity Model Methodology

This study has applied the method of [8] to develop the maturity model, as it is a very popular model alongside [9] and outlines several phases to follow. ***Phase 1- Scope***- To obtain generalizability, this model incorporates both academic and industry practitioners from across the globe. ***Phase 2- Design*** - This phase involves deciding the design or architecture of the model. The design incorporates the needs of the audience and how the model can be applied. ***Phase 3- Populate***- The identification of the maturity dimensions and sub-dimensions initially resulted from a Systematic Literature Review (SLR) from the following databases: SCOPUS, Web of Science, Engineering Village, Google Scholar, IEEE Explore and ScienceDirect. The following keywords were used: ("servitization" OR "digital servitization" OR "product-service-system" OR "Product-Service-Systems" OR "servicification") AND ("maturity*" OR "Transition*" OR "readiness" OR "transformation" OR "Assessment"). The results yielded 2346 articles, however after screening title and abstract, then full papers, this resulted in 15 relevant papers to be analyzed in detail. A literature review alone will not be sufficient to populate the maturity model, therefore an additional exploratory technique is required. This research considers the Delphi survey technique as it has major advantages over alternative methods [8]. The Delphi suggested procedure is shown in **Figure 1**.

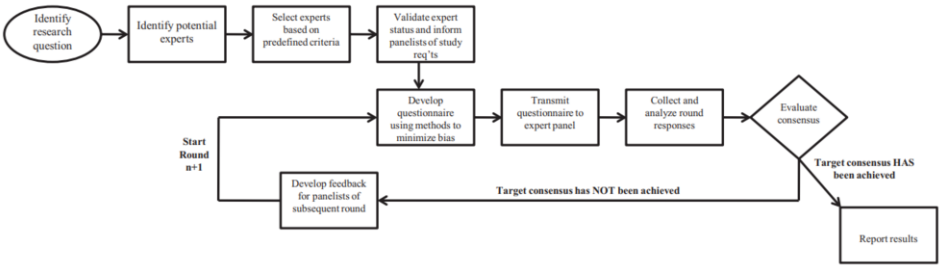

Figure 1. Suggested Delphi procedure [1]

Expert Panel Size. The general rule of thumb is 15-30 for a homogenous population (experts from the same discipline and same professional level) and 5-10 for a heterogenous population (experts on a specific topic but from different professional backgrounds e.g., professors, school teachers, academic etc.) [13-15]. Therefore, since this research is aimed at experts on a specific topic i.e., digital servitization from different backgrounds such as industry and academia, a sample size of 10 experts has been chosen. **Expert Panel Requirements**. Both academic and industry experts will be considered. **Number of Rounds**. The main objective of multiple rounds is to reach consensus from the experts. According to a summary of peer-reviewed articles the number of rounds ranges from two to six [16-20]. This research will apply six rounds of iterations with three rounds for maturity dimensions and another three rounds for maturity levels. ***Phase 4- Test-*** In the future, the maturity model will be tested for relevance and rigor by applying the developed model from Phase 3 within three manufacturing SME companies in different industries. ***Phase 5- Deploy***-This stage will involve the model to be "deployed" via a web-based MM to verify extent of model generalizability and allow SMEs to view their current state (***Descriptive***), compare against the industry average metric (***Comparative***) and identify areas of improvement (***Prescriptive***). ***Phase 6- Maintain***- A form of repository will be created to house the model and track its evolution and development.

4. Proposed Maturity Model

After analysing the results of the SLR the common dimensions found are shown in Table 1. The number of dimensions in the literature ranges from three to ten, with four and five dimensions being the most used. A summary of the maturity levels used within the current literature is shown in Table 2.

Table 1. Proposed Theory Based Maturity Dimensions

Dimensions	Sub-Dimensions	Author(s)
Strategy	Digital Resource Allocation	[21, 22]
	Digital Service Offering	[23]
	Business Model	[23-26]
	Feedback System/KPI	[24, 27]
Culture	Employee Commitment towards digital servitization	[21, 28, 29]
	Top-Down Leadership for digital servitization	[21, 23, 30]
	Employee skills and internal development training of digital technology	[23, 28, 29]
Customer	Customer Feedback	[23, 31]
	Customer Integration/Intimacy	[22, 26, 31, 32]
	Customer Real Time Data Integration	[22, 31]
	Knowledge of Customer Installed Base	
	Customer Training	[31]
Process/Practice	Internal Communication	[29]
	Performance Management	[27, 33]
	Standards/ Procedures	[22, 23, 25, 27, 33]
	Roles	[22, 27]
Market	Competition Identification	[22, 31]
	Market Trends Analysis	[23]
Network	Digital Service Ecosystem	[23]
Structure	Separation of internal service and product departments	[31]
	Internal and External Collaboration mechanism	[28]
	Capital Management	[28]

Table 2. Literature Review- Maturity Levels

Author	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
[28]	Pure Product	Product-Oriented PSS	Use-Oriented PSS	Result-Oriented PSS				
[34]	Product	Use	Result					
[22]	Incapable	Struggling	Truncated	Exhaustive				
[25]	Low (0 to 10)	Medium	High					
[33]	1=No Service Orientation	2	3	4	5=highest servitization maturity			
[30]	Exploration	Engagement	Expansion	Exploitation				
[26]	Products plus basic after sales	Products plus extended service	Integrated Solutions	Performance Based Solutions				

[23]	Beginner - Basic	Experienced- Intermediate	Leader- Advanced					
[35]	0	1	2	3	4	5	6	7
[29]	Very Poor=0	1	2	3	4	Very Good=5		
[32]	Purely Product							Purely Service
[31]	Initial	Repeatable	Defined	Managed	Optimizing			
[21]	Incomplete	Performed	Managed	Defined	Quantitatively Managed	Optimized		
[24]	Level 1	Level 2	Level 3	Level 4	Level 5			
[27]	Initial	Repeatable	Defined	Managed	Optimized			

5. Conclusions and Further Work

The proposed Maturity Model using the Delphi method is the first approach towards developing a digital servitization maturity model. This will assist academics by contributing to the current knowledge on business transitioning and will also help managers view the current state of the business, identify improvement measures and compare against industry average. As this research is still in progress, currently experts have been identified and an online survey has been created which contains questions on the maturity dimensions and levels identified in **Table 1**and **Table 2**. With six survey rounds to complete, round two is now in progress. Post-survey completion, the maturity model will be tested and applied in industry using case studies in multiple industries.

References

[1 Hallowell M, Gambatese J. Qualitative Research: Application of the Delphi Method to CEM Research. Journal of Construction Engineering and Management-asce - J CONSTR ENG MANAGE-ASCE. 2010;136.

[2] Favoretto C, Mendes G, Oliveira M, Cauchick-Miguel P, Coreynen W. From servitization to digital servitization: How digitalization transforms companies' transition towards services. Industrial Marketing Management. 2022;102:104-21.

[3] Raddats C, Kowalkowski C, Benedettini O, Burton J, Gebauer H. Servitization: A contemporary thematic review of four major research streams2019.

[4] Khanra S, Dhir A, Parida V, Kohtamäki MJJoBR. Servitization research: A review and bibliometric analysis of past achievements and future promises. 2021;131:151-66.

[5] Baines T, Lightfoot H, Benedettini O, Kay JM. The servitization of manufacturing: A review of literature and reflection on future challenges. Journal of Manufacturing Technology Management. 2009;20:547-67.

[6] Paschou T, Adrodegari F, Perona M, Saccani N. The digital servitization of manufacturing: a literature review and research agenda2017.

[7] Kohtamäki M, Rabetino R, Einola S, Parida V, Patel P. Unfolding the digital servitization path from products to product-service-software systems: Practicing change through intentional narratives. Journal of Business Research. 2021;137:379-92.

[8] de Bruin T, Freeze R, Kulkarni U, Rosemann M. Understanding the Main Phases of Developing a Maturity Assessment Model. Australasian Conference on Information Systems. 2005.

[9] Becker J, Knackstedt R, Poeppelbuss J. Developing Maturity Models for IT Management. Bus Inf Syst Eng. 2009;1:213-22.

[10] Paulk M, Curtis B, Chrissis M, Weber C. Capability Maturity Model, Version 1.1. Software, IEEE. 1993;10:18-27.
[11] Poeppelbuss J, Roeglinger M. What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management2011.
[12] ScienceDirect. Capability Maturity Model Integration ScienceDirect: ScienceDirect; 2016 [Available from: https://www.sciencedirect.com/topics/computer-science/capability-maturity-model-integration.
[13] GROUP TECHNIQUES FOR PROGRAM PLANNING: A GUIDE TO NOMINAL GROUP AND DELPHI PROCESSES Andre L. Delbecq, Andrew H. Van de Ven, and David H. Gustafson Glenview, III.: Scott, Foresman, 1975. xv plus 174 pp., $4.95, paperbound. INTERPERSONAL CONFLICT RESOLUTION Alan C. Filley Glenview, III.: Scott, Foresman, 1975. 180 pp., $4.95, paperbound. Group & Organization Studies. 1975;1(2):256-.
[14] Uhl NPJNDfIR. Using the delphi technique in institutional planning. 1983;1983:81-94.
[15] Goodman RM. Book Reviews : Group Techniques for Idea Building, Vol. 9, C. M. Moore. Newbury Park, California, Sage Publications, 1987. Need Analysis: Tools for the Human Services and Education, Vol. 10, J. McKillip. Newbury Park, California, Sage Publications, 1987. Health Education Quarterly. 1989;16(1):131-3.
[16] Dalkey N, Brown B, Cochran S. Use of self-ratings to improve group estimates: Experimental evaluation of delphi procedures. Technological Forecasting. 1970;1(3):283-91.
[17] Gupta UG, Clarke RE. Theory and applications of the Delphi technique: A bibliography (1975–1994). Technological Forecasting and Social Change. 1996;53(2):185-211.
[18] Linstone H, Turoff M. The Delphi Method: Techniques and Applications1975.
[19] Van de Ven AH, Delbecq AL. The effectiveness of nominal, delphi, and interacting group decision making processes. Academy of Management Journal. 1974;17(4):605-21.
[20] Pill J. The Delphi method: Substance, context, a critique and an annotated bibliography. Socio-Economic Planning Sciences. 1971;5(1):57-71.
[21] Gudergan G, Buschmeyer A, Krechting D, Feige B. Evaluating the Readiness to Transform Towards a Product-service System Provider by a Capability Maturity Modelling Approach. Procedia CIRP. 2015;30:384-9.
[22] Babaei M, Aghdassi M. Measuring the dimensions of quality in service innovation: A dynamic capability and organisational competency perspective. Total Qual Manag Bus Excell. 2020:1-33.
[23] Paschou T, Rapaccini M, Peters C, Adrodegari F, Saccani N, editors. Developing a Maturity Model for Digital Servitization in Manufacturing Firms2019.
[24] Neff AA, Hamel F, Herz TP, Uebernickel F, Brenner W, editors. Developing a maturity model for product-service systems in manufacturing enterprises. 17th Pacific Asia Conference on Information Systems, PACIS 2013, June 18, 2013 - June 22, 2013; 2013; Jeju Island, Korea, Republic of: Pacific Asia Conference on Information Systems.
[25] Andersen TC, Madsen M, Godmiuscheit R. KEY DIMENSIONS OF ASSESSING SERVITIZATION: TOWARDS A CONCEPTUAL MATURITY MODEL2020.
[26] Cui L, Su S-I, Feng Y, Hertz S. Causal or effectual? Dynamics of decision making logics in servitization. Industrial Marketing Management. 2019;82.
[27] Rapaccini M, Saccani N, Pezzotta G, Burger T, Ganz W. Service development in product-service systems: a maturity model. Serv Ind J. 2013;33(3-4):300-19.
[28] Häckel B, Huber R, Stahl B, Stöter M. Becoming a Product-Service System Provider–Toward a Maturity Model for Industry. 2021.
[29] Teso G, Walters A. Recognizing readiness in manufacturing firms2017.
[30] Dmitrijeva J, Schroeder A, Ziaee Bigdeli A, Baines TJPP, Control. Context matters: how internal and external factors impact servitization. 2020;31(13):1077-97.
[31] Alvarez RLP, Martins MR, Da Silva MT. Applying the maturity model concept to the servitization process of consumer durables companies in Brazil. Journal of Manufacturing Technology Management. 2015;26(8):1086-106.
[32] Exner K, Zimpfer R, Stark R, editors. Maturity Model and Action Recommendation: A PSS Capability Self-Assessment Tool for Companies. 50th CIRP Conference on Manufacturing Systems 2017, May 3, 2017 - May 5, 2017; 2017; Taichung, Taiwan: Elsevier B.V.
[33] Adrodegari F, Saccani N. A maturity model for the servitization of product-centric companies. Journal of Manufacturing Technology Research. 2020;ahead-of-print.
[34] Frederiksen TB, Pieroni MPP, Pigosso DCA, McAloone TC. Strategic Development of Product-Service Systems (PSS) through Archetype Assessment. SUSTAINABILITY. 2021;13(5).
[35] Elezović K. Implementing servitization: a framework for small and medium enterprises: University of Twente; 2019.