

Prior and Future Research on Quality-Driven Product Service Systems: A Literature Review

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ABSTRACT

The role of services in manufacturing is increasing. Service becomes a value addition to the products offered. A product-service system (PSS) is a tangible manifestation of the integration of services and products. However, the integration of products and services must still ensure the quality of PSS. This paper aims to review the development of research related to the quality of PSS where products and services are considered as an integral part of the integration results. Previous research investigations were carried out by collecting journals discussing PSS. The quality of PSS was then discussed, and its mapping to the quality dimension. The mapping shows the research clusters that can be examined for emerging trends in research and potential future research. Those potential future researches are related to the dimension of reliability, durability, serviceability, aesthetic, and perceived quality.

CCS CONCEPTS

• **General and reference** → Document types; General literature.

KEYWORDS

The quality of PSS, PSS future research, literature review

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1 INTRODUCTION

Along with the increasing trend of servitization, The Product-Service System (PSS) also experienced a proportional increase. During the last thirty years, Servitization and The Product-Service System (PSS) have become interesting topics to be developed [1]. Manufacturing businesses have a tendency to integrate services into the tangible goods, a practice known as servitization [2]. The

Product-Service System (PSS) is how this integration actually manifests itself [3]. In general, PSS can be defined as an integrated system of products, services, support networks, and infrastructure designed to meet customer needs, increase competitiveness, and have a lower environmental impact than traditional business models [4]. Based on this definition, PSS consists of product and service aspects. The dominance of product and service integration will shape the category and character of PSS. Individually, products and services have different characteristics. If these two aspects are integrated, there will be interactions that can influence the development of innovation between the two [5].

Therefore, managing PSS throughout its life cycle will be a challenge for the company. Companies will also face challenges in the case of having to control the quality of products and services simultaneously. The existence of integration between products and services often causes vague boundaries between product and service itself [6]. Consequently, quality control policies on product and service integration are becoming more complex. However, company must ensure the quality of PSS. The goal of this paper is to look at how research on the quality of PSS has changed over time, where products and services are seen as an important part of the integration results.

2 METHODOLOGY

Based on the background that has been described, previous research investigations were carried out by collecting journals discussing PSS. Additionally, journal filtering is conducted. Thirty journals addressing PSS quality were identified from the filtered results. Understanding each journal's contribution to the growth of PSS quality research, the journals have been mapped into eight quality aspects. There are eight quality dimensions used for the journal mapping process, namely performance, features, reliability, conformance, durability, serviceability, aesthetic and perceived quality [7]. Garvin, (1996) states that a product or service may score highly on one aspect of quality while scoring poorly on another, because one aspect of quality may be improved at the expense of another. This quality dimension is also used for service quality dimensions [8] and products [9]. With the addition of time to the research mapping, it becomes easier to see how past research has changed over time. Furthermore, journal clustering is carried out based on the topics discussed. This journal cluster can be used to see in detail research topics related to the quality dimension

3 LITERATURE REVIEW

PSS as a manifestation of servitization can be a new strategy in business innovation. Service involvement in manufacturing provides a

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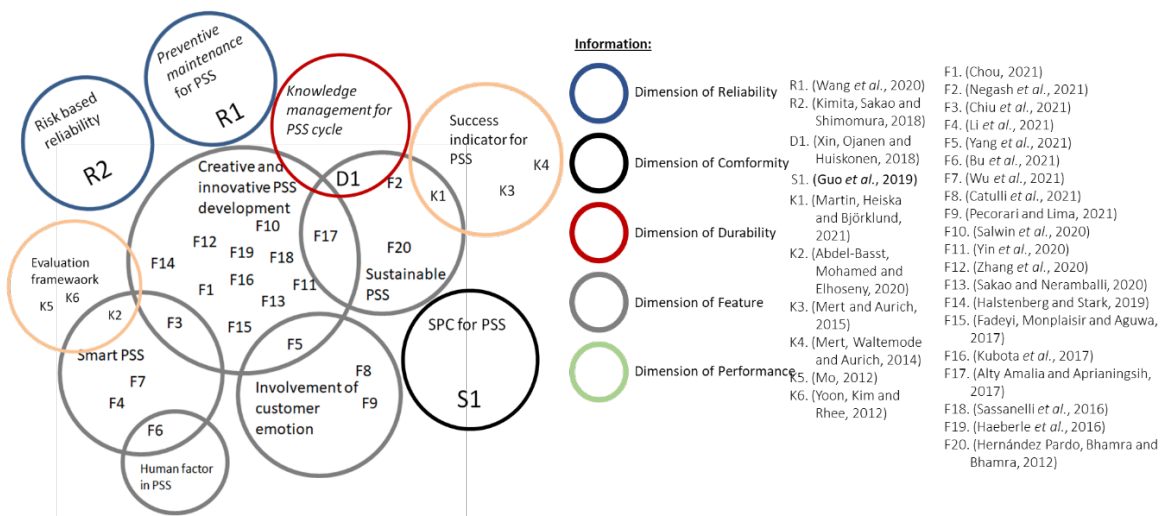


Figure 1: Previous Research Mapping ([22]; [23]; [24]; [25]; [26]; [27]; [28]; [29]; [30]; [31]; [13]; [32]; [12]; [10]; [33]; [20]; [21]; [34]; [35]; [36]; [37]; [16]; [17]; [14]; [15], [38], [18]; [19]; [39])

new package of offerings to customers in which the integration of products with services is inseparable [10]. The second definition of PSS that is widely used in the literature is the marketable set of products and services that are able to meet the user's needs [4]. The integration of products and services also changes how companies guarantee the quality of their products and services stays high. Customers also always want qualified PSS. Therefore, a literature review on the development of PSS research related to quality needs to be done. This is an effort by the company to follow business developments based on the development of customer taste.

Previous research reviews were carried out by reviewing relevant journals and clustering based on quality dimensions. The final goal of this paper is to find future research opportunities based on clusters of past research. Clustering of previous research can be done based on 8 dimensions of quality for products or services initiated by Garvin (1996). The results of the clustering of thirty journals are as Figure 1. On the feature dimension, there are 20 studies about PSS quality that can be grouped into 5 research topics: creative and innovative PSS development, sustainable PSS, customer emotional involvement, taking human factors into account in PSS, and smart PSS.

The densest cluster discusses how to develop PSS in unique ways, such as design by involving technology [11], personalization [12], and by using the TRIZ method, which emphasizes innovation [13]. PSS design can also be done by conducting system modeling [14, 15], optimization [16], and the use of big data [17]. From this cluster, it was found that the design of service integration with products should be carried out as early as possible in the early stages of design [18] and the selection of service parameters should be carried out systematically on existing product design methods [19].

The next cluster in this dimension is smart PSS, which involves technology features. This cluster has a wedge with the creative and innovative PSS development cluster. These slices are research that

discusses the development of smart PSS by personalizing [12] and research that discusses human factors in PSS [20]. Other research on smart PSS clusters is the development of smart PSS by considering cyber-physical resources [11], and optimizing smart PSS with function orientation [21].

The next two clusters are the sustainable PSS and the customer's emotional involvement in the PSS. Negash et al. (2021) developed a sustainable PSS, taking into account the uncertainties in the pharmaceutical industry. Meanwhile, two other studies in the sustainable PSS cluster discuss the design of PSS for small and medium enterprises [39], such as in herbal medicine companies [38]. Meanwhile, research to explore emotional needs was carried out by Catulli et al. (2021) through a social experiment; Pecorari & Lima, (2021) through testing the relationship between experience and customer acceptance; and Yang et al., (2021) through exploring emotional needs on smart PSS. The next dimension is performance, which consists of two clusters, namely PSS success indicator and evaluation framework. Research on the PSS success indicator cluster discusses the evaluation of PSS by capturing several success measures, such as the environmental impact indicators provided [26], key performance indicators of the PSS development project [28], and quality measures of the PSS development project. PSS [29]. Research on the evaluation framework cluster provides a management for evaluating PSS, such as a framework for evaluating innovation value propositions (IVP) on smart PSS [27], a framework for engineering PSS using complex engineering products and service systems [30], and a framework for designing new PSS [31].

The next dimension is reliability, which consists of two studies. The first study is related to efforts to create a reliable PSS through failure analysis [23]. The second study is related to preventive maintenance for PSS [22]. In this study, there will be an adjustment of the method for the service aspect and its integration with the product aspect.

Table 1: Summary Information of Research Mapping

No	Dimension of Quality	Research Topic	Amount	Implication
1	Reliability	Risk based reliability	1	High opportunity to be investigated
		Preventive maintenance for PSS	1	High opportunity to be investigated
2	Conformity	Statistical Process Control for PSS	1	High opportunity to be investigated
3	Durability	Knowledge management for PSS cycle	1	High opportunity to be investigated
4	Feature	Creative and innovative PSS development	13	Variative research topic but congestion
		Sustainable PSS	2	Trending research concern
		Involvement of customer emotion	2	Trending research concern
		Human factor in PSS	1	Trending research concern
		Smart PSS	2	Trending research concern
5	Performance	Evaluation framework	3	Expanded research area for PSS
		Success indicator for PSS	3	Expanded research area for PSS
6	Aesthetic	-	-	Explorable new research area for PSS
7	Service-ability	-	-	Explorable new research area for PSS
8	Perceived quality	-	-	Explorable new research area for PSS

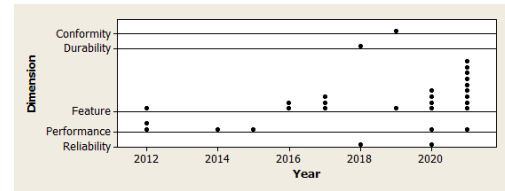
Another quality dimension is durability and suitability. This dimension gets the smallest percentage value. A study on the durability dimension discusses the application of knowledge management in the entire PSS life cycle [24]. Meanwhile, a study on the dimensions of conformity was carried out by Guo et al. (2019), who used turtle diagrams to analyze discrepancies that occurred in PSS, both in product and service aspects. If there is a discrepancy, it can be said that the PSS that has been designed is of poor quality and must be repaired immediately to make it better. When viewed from the year of research, this research is still relatively new. Thus, it can be said that the development of research for the dimension of suitability is still relatively slow.

4 RESULT AND DISCUSSION

Each quality dimension has a different focus. As a result, these variations become reason why research on each of its dimensions has developed differently. While each dimension has an impactful role in the running of the company. This mapping will be useful to know the development of research from time to time for each dimension. Furthermore, research opportunities can be identified to complement slow research progress. This previous research mapping can also be used to evaluate research equity on the topic of PSS quality. Tabular 1 provides a summary of the information that can be acquired from Figure 1.

Deployed research on the topic of PSS quality will be needed for the availability of references that can support the development of PSS itself. Thus, it is important to do a literature review to see the development of research on PSS quality. The results of adding the time variable to journal mapping are presented in Figure 2.

The intensity of the research is seen in the dimensions of the features, so that information can be obtained that research related to how to design or develop PSS to obtain appropriate features develops from time to time, with an increasing trend in 2021. Based on the 30 journals reviewed, it is also seen that research on PSS reliability only appeared in 2018 and another study reappeared in 2020. This shows the lack of research that wants to be conducted on PSS reliability. This dimension shows a very sharp decrease in

**Figure 2: Timeline of previous research**

the number of studies compared to the features and performance dimensions. This can be used as a good research opportunity to be developed. There are many research areas in the reliability of PSS that have not been discussed. Previous studies can be used as stepping stones for further research. Some of the things that can be studied are the reliability of PSS and the preventive maintenance efforts for some PSS characters.

Research developments in the dimensions of conformity and durability have the same character. Of the 30 journals reviewed, there was only one study dating to 2018. This shows that research on the topic of durability for PSS is a rare topic with slow research progress. It is clear that studies about the durability of PSS only began to be published in 2018, and until now there has still been no research that discusses the durability of PSS. Existing research on topics like the role of knowledge management in making PSS last longer and how to control PSS conformity can lead to new research ideas in this area. Other research opportunities can also be carried out on the dimensions of serviceability, aesthetics, and perceived quality. Based on the mapping of 30 previous studies that have not been seen, research related to PSS that discusses serviceability, aesthetics, and perceived quality.

5 CONCLUSION

Based on the literature review and mapping of previous PSS quality research, it can be concluded that PSS quality research is dominated by the feature dimension, which means a lot of research on how to design and develop PSS so that it can be accepted by customers.

In addition, the slow development of research is shown in the dimensions of reliability, durability, serviceability, aesthetics, and perceived quality. Thus, future research can be focused on these dimensions.

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REFERENCES

- [1] Abdel-Basst, M., Mohamed, R. and Elhoseny, M. 2020. A novel framework to evaluate innovation value proposition for smart product-service systems. *Environmental Technology and Innovation*. 20, (Nov. 2020). DOI:https://doi.org/10.1016/j.eti.2020.101036.
- [2] Alty Amalia, F. and Aprianingsih, A. 2017. Business Model of Jamu as Indonesian Traditional Herbal Medicine in New Economy. *The Asian Journal of Technology Management*. 10, 1 (2017), 19–28. DOI:https://doi.org/10.12695/ajtm.2017.10.1.3.
- [3] Annarelli, A., Battistella, C., Costantino, F., di Gravio, G., Nonino, F. and Patriarca, R. 2021. New trends in product service system and servitization research: A conceptual structure emerging from three decades of literature. *CIRP Journal of Manufacturing Science and Technology*. Elsevier Ltd.
- [4] Bu, L., Chen, C.H., Ng, K.K.H., Zheng, P., Dong, G. and Liu, H. 2021. A user-centric design approach for smart product-service systems using virtual reality: A case study. *Journal of Cleaner Production*. 280, (Jan. 2021). DOI:https://doi.org/10.1016/j.jclepro.2020.124413.
- [5] Catulli, M., Sopjani, L., Reed, N., Tzilivakis, J. and Green, A. 2021. A socio-technical experiment with a resource efficient product service system. *Resources, Conservation and Recycling*. 166, (Mar. 2021). DOI:https://doi.org/10.1016/j.resconrec.2020.105364.
- [6] Chiu, M.C., Huang, J.H., Gupta, S. and Akman, G. 2021. Developing a personalized recommendation system in a smart product service system based on unsupervised learning model. *Computers and Industrial Engineering*. 128, (2021), 103421. DOI:https://doi.org/10.1016/j.compind.2021.103421.
- [7] Chou, J.R. 2021. A TRIZ-based product-service design approach for developing innovative products. *Computers and Industrial Engineering*. 161, 1 (2021), 107608. DOI:https://doi.org/10.1016/j.cie.2021.107608.
- [8] Fadeyi, J.A., Monplaisir, L. and Aguwa, C. 2017. The integration of core cleaning and product serviceability into product modularization for the creation of an improved remanufacturing-product service system. *Journal of Cleaner Production*. Elsevier Ltd.
- [9] Garvin, D.A. 1996. Competing on the eight dimensions of quality. *IEEE Engineering Management Review*. 24, 1 (1996), 15–23.
- [10] Guo, H., Zhang, R., Chen, X., Zou, Z., Qu, T., Huang, G., Shi, J., Chen, M., Gu, H., Lun, Y., Li, J. and He, Z. 2019. Quality control in production process of product-service system: A method based on turtle diagram and evaluation model. *Procedia CIRP* (2019), 389–393.
- [11] Haase, R.P., Pigosso, D.C.A. and McAloone, T.C. 2017. Product/Service-System Origins and Trajectories: A Systematic Literature Review of PSS Definitions and their Characteristics. *Procedia CIRP*. 64, (2017), 157–162. DOI:https://doi.org/10.1016/j.procir.2017.03.053.
- [12] Haeblerle, D., Imran, S., van Husen, C. and Droll, C. 2016. A New Approach for the Development of Services for Industrial Product-Service Systems. *Procedia CIRP* (2016), 353–357.
- [13] Halstenberg, F.A. and Stark, R. 2019. Study on the feasibility of modelling notations for integrated product-service systems engineering. *Procedia CIRP* (2019), 157–162.
- [14] Hernández Pardo, R.J., Bhamra, T. and Bhamra, R. 2012. Sustainable product service systems in Small and Medium Enterprises (SMEs): Opportunities in the leather manufacturing industry. *Sustainability*. 4, 2 (2012), 175–192. DOI:https://doi.org/10.3390/su4020175.
- [15] Kimita, K., Sakao, T. and Shimomura, Y. 2018. A failure analysis method for designing highly reliable product-service systems. *Research in Engineering Design*. 29, 2 (Apr. 2018), 143–160. DOI:https://doi.org/10.1007/s00163-017-0261-8.
- [16] Li, X., Lyu, M., Wang, Z., Chen, C.H. and Zheng, P. 2021. Exploiting knowledge graphs in industrial products and services: A survey of key aspects, challenges, and future perspectives. *Computers in Industry*. 129, (2021), 103449. DOI:https://doi.org/10.1016/j.compind.2021.103449.
- [17] Li, X., Wang, Z., Chen, C.H. and Zheng, P. 2021. A data-driven reversible framework for achieving Sustainable Smart product-service systems. *Journal of Cleaner Production*. 279, (Jan. 2021). DOI:https://doi.org/10.1016/j.jclepro.2020.123618.
- [18] Mahut, F., Daaboul, J., Bricogne, M. and Eynard, B. 2015. Survey on product-service system applications in the automotive industry. *IFAC-PapersOnLine*. 28, 3 (2015), 840–847. DOI:https://doi.org/10.1016/j.ifacol.2015.06.188.
- [19] Martin, M., Heiska, M. and Björklund, A. 2021. Environmental assessment of a product-service system for renting electric-powered tools. *Journal of Cleaner Production*. 281, (Jan. 2021). DOI:https://doi.org/10.1016/j.jclepro.2020.125245.
- [20] Mert, G. and Aurich, J.C. 2015. A software demonstrator for measuring the quality of PSS. *Procedia CIRP* (2015), 209–214.
- [21] Mert, G., Waltemode, S. and Aurich, J.C. 2014. Quality assessment of technical product-service systems in the machine tool industry. *Procedia CIRP* (2014), 253–258.
- [22] Mo, J.P.T. 2012. Performance assessment of product service system from system architecture perspectives. *Advances in Decision Sciences*.
- [23] Mustafa, M., Sivarajah, U., Ziaee, A. and Misi, F. 2020. Servitization implementation in the manufacturing organisations: Classification of strategies, definitions, benefits and challenges. *International Journal of Information Management*. 55, July (2020), 102206. DOI:https://doi.org/10.1016/j.ijinfomgt.2020.102206.
- [24] Negash, Y.T., Calahorrano Sarmiento, L.S., Tseng, M.L., Jantarakolica, K. and Tan, K. 2021. Sustainable product-service system hierarchical framework under uncertainties: The pharmaceutical industry in Ecuador. *Journal of Cleaner Production*. 294, (2021), 126188. DOI:https://doi.org/10.1016/j.jclepro.2021.126188.
- [25] Nijssen, E.J., Hillebrand, B., Vermeulen, P.A.M. and Kemp, R.G.M. 2006. Exploring product and service innovation similarities and differences. *International Journal of Research in Marketing*. 23, 3 (2006), 241–251. DOI:https://doi.org/10.1016/j.ijresmar.2006.02.001.
- [26] Pecorari, P.M. and Lima, C.R.C. 2021. Correlation of customer experience with the acceptance of product-service systems and circular economy. *Journal of Cleaner Production*. 281, (Jan. 2021). DOI:https://doi.org/10.1016/j.jclepro.2020.125275.
- [27] Rondi, E., de Massis, A. and Kraus, S. 2021. Servitization through open service innovation in family firms: Exploring the ability-willingness paradox. *Journal of Business Research*. 135, (2021), 436–444. DOI:https://doi.org/10.1016/j.jbusres.2021.06.040.
- [28] Sachdev, S.B. and Verma, H.V. 2004. Relative Importance of Service Quality Dimensions: A Multisectorial Study. *Journal of Services Research*. 4, 1 (2004), 93–116.
- [29] Sakao, T. and Neramballi, A. 2020. A product/service system design schema: Application to big data analytics. *Sustainability (Switzerland)*. MDPI AG.
- [30] Salwin, M., Kraslawski, A., Lipiak, J., Gołbiewski, D. and Andrzejewski, M. 2020. Product-Service System business model for printing houses. *Journal of Cleaner Production*. 274, (Nov. 2020). DOI:https://doi.org/10.1016/j.jclepro.2020.122939.
- [31] Sassanelli, C., Pezzotta, G., Pirola, F., Terzi, S. and Rossi, M. 2016. Design for Product Service Supportability (DfPSS) Approach: A State of the Art to Foster Product Service System (PSS) Design. *Procedia CIRP* (2016), 192–197.
- [32] Wang, N., Ren, S., Liu, Y., Yang, M., Wang, J. and Huisingh, D. 2020. An active preventive maintenance approach of complex equipment based on a novel product-service system operation mode. *Journal of Cleaner Production*. 277, (Dec. 2020). DOI:https://doi.org/10.1016/j.jclepro.2020.123365.
- [33] Withers, B. and Diego, S. 2000. Does ISO 9000 Certification Affect the Dimensions of Quality Used for Competitive Advantage? *European Management Journal*. 18, 4 (2000), 431–443.
- [34] Wu, C., Chen, T., Li, Z. and Liu, W. 2021. A function-oriented optimising approach for smart product service systems at the conceptual design stage: A perspective from the digital twin framework. *Journal of Cleaner Production*. 297, (May 2021). DOI:https://doi.org/10.1016/j.jclepro.2021.126597.
- [35] Xin, Y., Ojanen, V. and Huiskonen, J. 2018. Knowledge Management in Product-Service Systems - A Product Lifecycle Perspective. *Procedia CIRP* (2018), 203–209.
- [36] Yang, X., Wang, R., Tang, C., Luo, L. and Mo, X. 2021. Emotional design for smart product-service system: A case study on smart beds. *Journal of Cleaner Production*. 298, (May 2021). DOI:https://doi.org/10.1016/j.jclepro.2021.126823.
- [37] Yin, D., Ming, X., Liu, Z. and Zhang, X. 2020. A fuzzy ANP-QFD methodology for determining stakeholders in product-service systems development from ecosystem perspective. *Sustainability (Switzerland)*. 12, 8 (Apr. 2020). DOI:https://doi.org/10.3390/SU12083329.
- [38] Yoon, B., Kim, S. and Rhee, J. 2012. An evaluation method for designing a new product-service system. *Expert Systems with Applications*. 39, 3 (Feb. 2012), 3100–3108. DOI:https://doi.org/10.1016/j.eswa.2011.08.173.
- [39] Zhang, Z., Xu, D., Ostrosi, E. and Cheng, H. 2020. Optimization of the product-service system configuration based on a multilayer network. *Sustainability (Switzerland)*. 12, 2 (Jan. 2020). DOI:https://doi.org/10.3390/su12020746