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# RESEARCH METHODOLOGY IMPLICATIONS IN AUTOMOTIVE PRODUCT-SERVICE CONTEXT: A LITERATURE REVIEW

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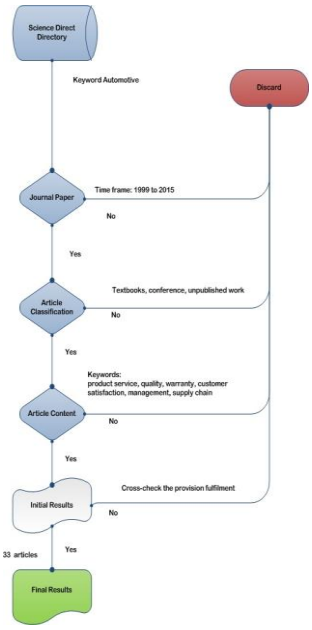
## Graphical abstract




## Abstract

This article discusses the state of the art of the automotive product-service system (PSS) approaches by conducting a critical and comprehensive review of papers published from 1999 to 2015; it investigates the research methodologies employed to tackle the automotive product-service discipline by analyzing the benefits and drawbacks of each research methodology. It is evident that the quantitative methodology is more popular than other research methodologies and this is attributed to the empirical nature of the collected data and the wide use of various statistical tools. This review forms an immense contribution for the researchers and practitioners who are conducting studies in automotive product-service field as this paper provides insight into the research methods and paradigm.

Keywords: Automotive; quality management; after-sales service; research methodologies

## Abstrak

Artikel ini membincangkan mengenai keupayaan sistem perkhidmatan-produk automotif, *(automotive product-service system, PSS)* dengan menjalankan kajian secara kritikal dan menyeluruh ke atas kertas kerja yang diterbitkan anatara 1999-2015; ianya mengkaji kaedah penyelidikan yang digunakan untuk menangani disiplin perkhidmatan-produk automotif dengan menganalisis kebaikan dan keburukan setiap kaedah penyelidikan. Adalah jelas bahawa kaedah kuantitatif lebih terkenal daripada kaedah penyelidikan yang lain dan ini adalah disebabkan oleh sifat empirikal data yang dikumpul dan penggunaan yang luas pelbagai alat statistik. Penulisan ini dapat memberikan satu sumbangan yang besar kepada para penyelidik dan pengamal yang menjalankan kajian mengenai perkhidmatan-produk automotif dari segi kaedah penyelidikan dan paradigma.

Kata kunci: Automotif; pengurusan kualiti; perkhidmatan selepas jualan; kaedah penyelidikan



## 1.0 INTRODUCTION

Product-service systems PSSs are a combination system of products, services, networks and utilities developed to meet certain criteria of competitiveness and a high rate of customer satisfaction taking into account the environmental impact issues [1]. The revolution in communication and information technologies plays a noticeable role in improving the concept of product orientation to service orientation; this leads to focus on customer

demands and enlarging the market share[2]. Hence, the majority of automakers have changed their attention to the product-service business portrayed as after-sales services. Whilst previous studies have presented that the after- sales market size is five times larger than the new product market size[3], and the after-sales services have the potential to increase by three times the revenue of new products throughout their life span [4].

In this regard, three families of research methods addressing the product-service systems discipline are reported: quantitative, qualitative and mixed methods, where the latter method combines both, qualitative and quantitative methods. All these methods are systematic in conducting research and adopting specific instruments for obtaining the required information for the research. Furthermore, these methods should conform to certain logical steps by which the researcher can scrutinize results and generate conclusions[5].

Qualitative studies have achieved maturity during the last two decades; researchers try to understand how people interpret their perceptions and assess their experiences. In this regard, the case study is the most common data collection instrument used to retrieve information from the research respondents [5]. Nevertheless, quantitative studies utilize numeric values by depending on samples and using specific data collection instruments (e.g. survey, observations and experiments) in addition to adopting certain statistical methods to examine these data. As a result, the data collection method cannot be a decisive tool in determining whether the study is quantitative or not; instead, quantitative studies rely on the data type and the data analyzing tools employed for this study. Contrary to qualitative studies, which don't permit the researchers to use statistical tools to analyze the results rather than for segmenting and categorizing measurements [6].

This paper provides some valuable insight into the adopted research methods in the studies tackling the automotive product service discipline dating from 1999 to 2015. The authors classify the reviewed articles in terms of the adopted research methodologies in the manner scrutinized and examined in depth. The remainder of the paper is organized as the following: quantitative and qualitative methods followed by subtitles that describe the data collection techniques and the most used data analysis tools. In addition, critique and evaluation are addressed for each type of the research methodologies in such a manner to explore the positive and negative features.

This study is designed to provide a better understanding of the research methodologies adopted in automotive PSS context, thus this review investigates 33 articles published from 1999 to 2001 that are mainly retrieved from ScienceDirect database directory. Certain keywords are used to filter the published articles: Automotive, product service, after sales, supply chain, warranty and customer satisfaction. As shown in Figure 1. The main thrust is on providing a comprehensive discussion about the adopted methodologies with deep critics on the pros and cons of each employed research methodology, in addition to investigating the most used data collection instruments and data analysis tools. Therefore, the authors follow the literature review steps of Subramoniam *et al*. [7] to conduct this study by which the following questions are to be answered: 1) What are the main research methodologies employed in automotive PSS? 2) What are the main data collection instruments and the main analysis tools? 3) What are the implications of this study?

## 2.0 QUALITATIVE METHODOLOGY

### 2.1 Qualitative Studies in Automotive Product Service System

The main characteristic of qualitative research is inductive, which is defined as the ability to construct theories and develop hypotheses through making observations and interpretations, hence the typical qualitative conclusions are the shape of themes, typologies, categories, concepts and tentative particular theories [5].

In the automotive PSS discipline, the majority of studies fall into two categories: basic qualitative and grounded theory, whereas the remaining approaches are not frequently used. In the basic qualitative research, the researchers attempt to perceive the phenomenon they are investigating and then interpret their related meanings, while the data are collected by conducting interviews, analysing documents and observing incidents and. In the grounded theory, the primary data source is the researcher himself who adopts an inductive stance and extracts the results from the collected information to develop a theory; therefore, it is named a grounded theory. Nevertheless, the uniqueness of qualitative research is that the focus on building theories whereas collecting data ranges from conducting interviews, making observations to using other documentary materials [5].

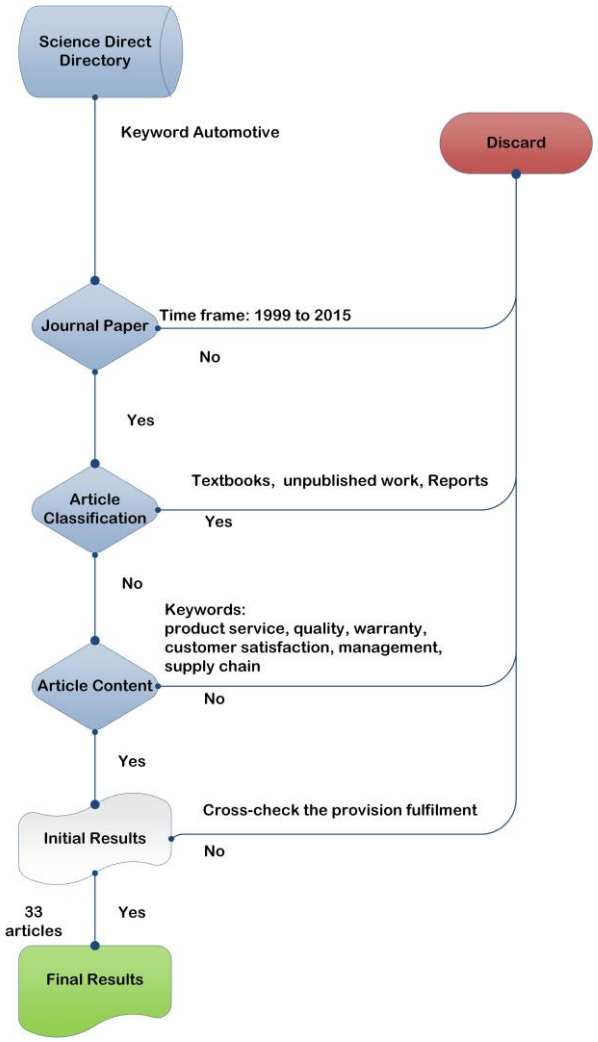



**Figure 1** Articles selection frame work

## 2.2 Case Study

A case study is a deeply descriptive and analytical study in a bounded system, it investigates a current problem in a reality context with empirical nature, as the boundaries between the reality context and the examined phenomenon are ambiguous [8]. Furthermore, certain researchers grouped case studies according to the objectives of the research: observational vs. historical, intrinsic vs. instrumental and single vs. multiple case studies [5]. In the historical type, researchers examine specific experience in an extensive descriptive analysis over a certain period of time in association with a historical point of view, while in the observational type; the data are retrieved from respondent observations coherently with informal interviews or documents. Nonetheless, the intrinsic research is adopted due to the interest in investigating specific phenomenon with a minor focus on building a theory or perceiving the case itself. The case itself forms a secondary interest and it is usually conducted in accompany with the multiple case study type; in this type of study, the data are collected and analysed from many cases that can contain embedded sub-cases. The results of such types of case study have the ability to increase the generalizability and validity of the findings [5]. Table 1 shows the case study types in the automotive PSS discipline [9].

**Table 1** Case study types in PSS context

| Case study type | Author |
|---|---|
| Observational case study + questionnaire | [10] |
| Observational case study | [9] |
| Observational case study | [11] |
| Observational case study | [12] |
| Observational case study | [13] |
| Observational case study | [14] |
| Intrinsic case study | [15] |
| Intrinsic case study | [16] |
| Intrinsic case study (Semi- structure interview) | [17] |
| Intrinsic case study (Semi- structure interview) | [18] |
| Two Intrinsic case studies | [19] |
| Single intrinsic embedded case study | [20] |
| Instrumental research case | [21] |
| Instrumental case study (semi-structure interviews) | [7] |
| Multiple case study | [22] |
| Multiple exploratory case studies | [23] |
| Multiple exploratory case studies | [24] |
| Exploratory multiple case study | [25] |

Overall, it is evident that the historical case study is not very preferred in the automotive product-service domain, while observational types are more common in addressing automotive PSS problems; however, a lack of generalizability is the primary drawback from which the observational case study type suffers; thus practitioners tend to strengthen the results retrieved by carrying out a survey to meet the required validity. On the other hand, the intrinsic and instrumental case studies are very frequent in the automotive PSS sector; they concern about outlining remanufacturing processes and testing production systems. The intrinsic type provides deep insights to explain the studied cases once the researcher has picked the right respondent, however and conforming to the goal of the intrinsic case studies, the results produce rich description of the case without implying rigorous hypotheses or generate applicable conclusions, hence some phenomena require quantitative research to reinforce and validate their findings in interpreting conclusions; Whereas, the instrumental type produces robust results supported with theoretical background. However, the individuality of the studied approaches prevents the researchers to imply their findings in a

wide scope; consequently, the practitioners are requested to carry out more case studies and to conduct questionnaire surveys to validate the hypothesis developed from their studies. In this regard, a multiple case study demonstrates a good tool to increase the generalizability of the study; it is usually used to investigate national incidents in a specific country, (e.g. VW in Germany, the automotive market in Malaysia and alternative fuel in Brazil). Several scholars chose to conduct a single embedded case study as they have a sub-analysis unit for scrutinizing the findings that are supported by a survey, but still the lack of generalizability is the primary drawback in this kind of studies.

### 2.3 Grounded Theory

In this type of qualitative study, the main focus is on building a theory rather than figuring a rich description. The data are extracted from interviews, observations and documentary materials [5]. Table 2 shows the grounded theory research in the automotive PSS.

**Table 2** Grounded theory cases in automotive PSS

| Qualitative research type | Author |
|---|---|
| Grounded theory / observational documentary | [26] |
| Grounded theory / observational classification | [1] |

As a result, the grounded theory method is a useful tool for examining cases their processes change over time, it is mainly employed in case of observing phenomena, hence it requires a high volume of data to build theories; However, the data analysis is restricted to perform comparative studies and detect interdependencies among pre-assumed variables. Furthermore, the applicability of research findings is still ambiguous due to a lack of performing validation in most of approaches.

To conclude, qualitative studies are well employed in the automotive PSS context in such manner that they provide deep insights into specific problems; nevertheless, the authors detect a clear tendency to adopt only two types of qualitative methods, basic qualitative research and grounded theory, meanwhile the other qualitative methods (e.g. phenomenology, narrative analysis, ethnography and critical research) are somewhat neglected by researchers. This is attributed to the practicality and the scientific nature of the product-service paradigm, which encompasses the decision making to avoid adopting these methodological types, besides, the availability of data plays a noticeable role in piloting the researchers into picking the proper method. Moreover, the case study tool is the most preferable data collection tool that can be reinforced with a survey or a Delphi study to validate the results and improve the implications of the developed hypotheses, meanwhile, the text-mining tool is primarily used in the case of a huge amount of verbatim text data being available, as this tool is effectively tokenizing texts and assigning odes for the purpose of grouping and analysing data trends. On other hand, qualitative methods, and especially case studies, still suffer from individuality and a lack of generalizability, which urge the researchers to strengthen their studies with numerical evidences.

## 3.0 QUANTITATIVE METHODOLOGY

"Quantitative research is 'Explaining phenomena by collecting numerical data that are analysed using mathematically based methods in particular statistics"[27]. Quantitative methods are characterized by handling numeric data and applying statistical based methods to scrutinize the data and produce results [28]. Comparing to qualitative methods, quantitative researcher employ objective methods to discover the truth while qualitative researcher are subjective, besides, quantitative research focuses on increasing the generalizability of results and expanding the objectives as it concerns about extracting values and drawing trends. The primary goal of quantitative studies is to test hypotheses developed from data collected by certain methods (e.g. survey) to find answers to the relevant research questions. The quantitative methods are delineated by deductive nature; hence they adopt single truth assumption [29].

### 3.1 Quantitative Methods

Quantitative methods have a deductive nature as numeric data and mathematical tools are noticeably employed to analyse results and draw conclusions. Quantitative methods are divided into, surveys, observational studies and experiments [5]; however, in the automotive product-service context, the quantitative study methods is limited to surveys and observational research.

#### *3.1.1 Survey*

A survey is a quantitative method used to collect information from the research respondents by posing questions and distributing questionnaires that meet the objectives of the conducted research[30]; furthermore, in quantitative methods, it is typical to utilize structural close- ended questions, contrary to the qualitative methods, which pose unstructured and open ended questions.

In the automotive product-service context, the survey tool is utilized to investigate the relationships among the variables constructed by researchers to

study certain phenomena, (e.g. quality, customer satisfaction, enterprise performance and supply chain), with the help of several statistical tools that not only support the researchers in drawing conclusions and building theories, but also, in providing a scientific validation of the findings. Table 3 shows the survey-based research in automotive PSS.

On the other hand, the primary drawback to carrying out surveys is the noticeable low response rate[25]. In this regard, Comoglio and Botta [31] achieve 45% response rate by distributing their survey on 45 Italian automotive companies, whereas Thun and Hoenig [32] reach 44% response rate out of 67 German automotive companies and only 17% feedback rate can be obtained by Alejandro *et al*. [33] from 122 studied Brazilian automotive companies. To minimize the impact of the low response rate, the researchers tend to strengthen their studies with qualitative data or by employing certain data analysis techniques.

**Table 3** Survey-based research in automotive PSS

| Topic / Author | EMS | Environment Performance | Supply chain risk management | Enterprise / Operation Performance | Customer loyalty / Satisfaction | LM / HR | QMS | Innovation | Reman |
|---|---|---|---|---|---|---|---|---|---|
| [31] | x | x | | | | | | | |
| [32] | | | x | x | | | | | |
| [33] | | | | x | x | | | | |
| [34] | | | | | x | | | | |
| [35] | x | x | | x | | x | | | |
| [36] | x | | | | | | x | | |
| [37] | | | | x | | | | x | |
| [38] | | | | | | | | | x |
| [39] | | | x | x | | | | | |
| [40] | | | | | x | | | | |
| [41] | | | | | x | | x | | |

### 3.1.2 Observational Studies

In the observational studies, the researchers develop hypotheses through analysing data and applying mathematical tools (algorithms). In some cases, the utilization of sophisticated mathematical methods is not necessary; for instance, Aboltins and Rivza [42] examine the automotive after-sales market's development and the integration with the contemporary economy and technology by studying the trend line of a product development coherent with the after-sales market. In this regard, Salleh, *et al*.[43] conduct a case study in a Malaysian automotive company to examine the adaptation of four models TQM, LM , TPS and ISO / TSI 16949 in the interest of improving customer satisfaction with the help of Delmia Quest software. Nevertheless, the quantitative observational studies seek to develop theories from data collected either by carrying out case studies or documentary observations; the first falls under the case study classification that lacks generalizability, whilst the latter requires the collection a huge number of data and applies mathematical tools to help in interpreting the findings.

As a result, the data analysis techniques utilized in the automotive PSS context are diverse and multi-purpose. Structural equation modelling SEM and multivariate cluster analysis are used for examining relationships among variables being regarded research constructs, whereas SEM develops equations by scrutinizing multiple measurements concurrently; cluster analysis creates a set of multivariate analysis tools of which the major goal to form groups of objects (products ,respondents or other identities) that share similar features[44]. The related performed studies are survey-based studies with a noticeably high number of respondents to

validate the analysis process. Nevertheless, fuzzy logic, Bayesian decision making and Weibull distribution are estimation tools derived from the probability theory, while fuzzy logic handles cases involving uncertainty for decision making and grouping purposes [45]. By means of fuzzy AHP, researchers can rank the decisions. Weibull distribution is based on the probability theory, thus it is employed to forecast failure occurrence and a product life's span [46]. Whereas Bayesian decision making tool calculates the probability in more precise way by combining two types of probabilities: actual and estimated. However it needs a high number of respondents [44]. Furthermore, K-means and SOM are utilized for clustering the collected data by applying an iterative process to break down a huge volume of data and to present trends [47]. Hence, the required high volume of numeric data entails using either the observational documentation or the case study data collection instruments. On the other hand, Kano model is especially utilized to prioritize customer needs, whilst, QFD (Quality function deployment) converts these needs by developing a matrix by which the studied items are explicitly displayed and ranked [48], contrary to Simons levers of control, which builds a business strategy perception through developing four main business constructs: boundary, diagnostic, belief and interactive control systems [49]. Lastly, linear programming tackles optimization problems in which the constraints and the variables have a linear relation [50]. The main requirement for employing the aforementioned tools is a large volume of data thus the observational documentation and the case study instruments are the primary data collection tools, whereas the inapplicability of the developed models to a wide range of industries is still the major pitfall.

Bearing in mind, quantitative studies are increasingly attracting scholars due to their flexibility and diversity of applying statistical methods in the analysing stage of the research, as well as the deductive purpose is the dominant feature of quantitative research, additionally the simplicity of quantitative methods entails only two data collection methods: survey and observational documentary in which the statistical tools provide an empirical explanation to the relationships among the variables even to cases with uncertainty status. On the other hand, the primary drawback is still the validity of the collected data and the ability to generalize the results to build hypothesis.

## 4.0 CONCLUSION

The review of qualitative studies show that the grounded theory and basic qualitative research classes are the most utilized qualitative methods in the product-service context; similarly, the case study method is the primary instrument for collecting data for the basic qualitative type. Moreover, the historical type of case study is not frequently adopted due to the scientific and industrial nature of the data retrieved from the product-service discipline, contrary to the observational case study type, which is more preferred due to its flexibility in employing a number of data analysis techniques used in qualitative research. Nevertheless, the intrinsic and instrumental qualitative research types are frequently used with a remarkable bias to use the instrumental type as it has the ability to build theories and produce results as well as maintaining an impartial attitude towards the researcher preconceptions. The primary limitation of qualitative studies is the lack of generalizability that prompts several scholars to reinforce their findings by carrying out surveys or conducting a multiple case study type. The latter type demonstrates a robust solution to the generalizability issue; however, the time consuming and data complication represent a critical challenge for the researchers.

On other hand, quantitative methods show more flexibility in tackling the automotive PSS paradigm; this is attributed to the nature of the collected data, which are numeric in the majority of cases. The survey tool is the most utilized data collection instrument; whilst the observational documentary method is adopted in some studies, especially in the after- sales warranty service, for which scholars tend to apply different types of algorithms to investigate the relationships among the constructed variables. Both tools, survey and observational documentary, could fix the generalizability limitation with the help of several statistical tools that provide scientific validation of the research results; nevertheless, the low response rate, respondent misperception and responding time are the major drawbacks to conducting surveys, compared with observational studies that require a high volume of data as well as wide knowledge in statistics and mathematics fields. The quantitative data analysis tools are wide and versatile, so choosing one specific tool depends on the data nature and the research objectives.

To conclude, the automotive industry has proven to be the most blooming industry in the world; hence the product-service sector is experiencing remarkable development to maintain rigorous relationships with buyers and support the perpetual selling process. This paper provides a critical review of previous research tackling the automotive product-service discipline; it reports two types of applied methodologies: qualitative and quantitative methods and demonstrates the state of the art of published articles in this discipline. The authors adopt a conventional review methodology in categorizing the papers according to the research methodologies employed and provide a critical analysis for each research method in parallel with an overview on the most used analysis tools in these approaches.

This review makes a meaningful contribution to the researchers tackling the automotive product-service context that it forms a guideline for choosing the right research methodology. Nevertheless, the authors seek to deepen the understanding of academic research methodologies to provide a potential contribution in their future research.

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## References

[1] Williams, A. 2007. Product Service Systems in the Automobile Industry: Contribution to System Innovation?. *Journal of Cleaner Production*. 15: 1093–1103.
[2] Boehm, M. and Thomas, O. 2013. Looking Beyond the Rim of One's Teacup: A Multidisciplinary Literature Review of Product-Service Systems in Information Systems, Business Management, Engineering & Design. *Journal of Cleaner Production* 51: 245–260.
[3] Bundschuh, R. G. and Dezvane, T. M. 2003. How to Make After-Sales Services Pay Off. *McKinsey Quarterly*. 4: 116–127.
[4] Wise, R. and Baumgartner, P. 1999. Go Downstream The New Profit Imperative in Manufacturing. *Harvard Business Review*. 77(5): 133–141.
[5] Merriam, S. B. 2009. *Qualitative Research: A Guide to Design and Implementation*. Francisco. A Willey Imprint.
[6] Yu, C. H., Jannasch-Pennell, A. and DiGangi, S. 2011. Compatibility between Text Mining and Qualitative Research in the Perspectives of Grounded Theory, Content Analysis, and Reliability. *The Qualitative Report*. 16(3): 730
[7] Subramoniam, R., Huisingh, D. and Chinnam, R. B. 2009. Remanufacturing for the Automotive Aftermarket-Strategic Factors: Literature Review and Future Research Needs. *Journal of Cleaner Production*. 17(13): 1163–1174.
[8] Hancock, D. R. and Algozzine, B. 2006. *Doing Case Study Research*. New York and London: Teachers College Columbia University.
[9] Zapata, C. and Nieuwenhuis, P. 2010. Exploring Innovation in the Automotive Industry: New Technologies for Cleaner Cars. *Journal of Cleaner Production*. 18(1): 14–20.
[10] Gaiardelli, P., Saccani, N. and L. Songini. 2007. Performance Measurement of The After-Sales Service Network—Evidence from The Automotive Industry. *Computers in Industry*. 58(7): 698–708.
[11] Koplin, J., Seuring, S. and Mesterharm, M. 2007. Incorporating Sustainability into Supply Management in the Automotive Industry – The Case of the Volkswagen AG. *Journal of Cleaner Production*. 15(11–12): 1053–1062.
[12] Mayyas, A., Qattawi, A., Omar, M. and Shan, D. 2012. Design for Sustainability in Automotive Industry: A Comprehensive Review. *Renewable and Sustainable Energy Reviews*. 16(4):1845–1862.
[13] Seuring, S. and Müller, M. 2008. From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management. *Journal of Cleaner Producion*. 16(15): 1699–1710.
[14] Beuren, F. H., Gomes Ferreira, M. G. and Cauchick Miguel, P. A. 2013. Product-Service Systems: A Literature Review on Integrated Products and Services. *Journal of Cleaner Production*. 47: 222–231.
[15] Aoki, K., Staeblein, T. and Tomino, T. 2014. Monozukuri Capability to Address Product Variety: A Comparison between Japanese and German Automotive Makers. *International Journal of Production Economics*.147: 373–384.
[16] Saranga, H. 2009. The Indian Auto Component Industry – Estimation of Operational Efficiency and its Determinants Using DEA. *European Journal of Operational Research*. 196(2): 707–718.
[17] Bergenwall, A. L., Chen, C. and White, R. E. 2012. TPS's Process Design in American Automotive Plants and Its Effects on the Triple Bottom Line and Sustainability. *International Journal of Production Economics*. 140: 374–384.
[18] Marksberry, P., Badurdeen, F. and Maginnis, M. A. 2011. An Investigation of Toyota's Social-Technical Systems in Production Levelling. *Journal of Manufacturing Technology Management*. 22(5): 604–620.
[19] Saavedra, Y. M. B., Barquet, A. P. B., Rozenfeld, H., Forcellini, F. A. and Ometto, A. R. 2013. Remanufacturing in Brazil: Case Studies on the Automotive Sector. *Journal of Cleaner Production*. 53: 267–276.
[20] Amelia, L., Wahab, D. A., Che Haron, C. H., Muhamad, N. and Azhari, C.H. 2009. Initiating Automotive Component Reuse in Malaysia. *Journal of Cleaner Production*. 17(17): 1572–1579.
[21] Williams, A. 2005. Product-service systems In The Automotive Industry: The Case of Micro-Factory Retailing. *Journal of Cleaner Production*.14: 172–184.
[22] Kurdve, M., Zackrisson, M., Wiktorsson, M. and Harlin, U. 2014. Lean and Green Integration into Production System Models – Experiences from Swedish Industry. *Journal of Cleaner Production*. 85: 180–190.
[23] MacBryde, J., Saccani, N., Songini, L. and Gaiardelli, P. 2006. The role and Performance Measurement of After-Sales in the Durable Consumer Goods Industries: An Empirical Study. *International Journal of Production Performance Management*. 55(3/4): 259–283.
[24] Wuest, T., Liu, L., Lu, S. C. Y. and Thoben, K. D. 2014. Application of the Stage Gate Model in Production Supporting Quality Management. *Procedia CIRP*.17: 32–37.
[25] Saccani, N., Johansson, P. and Perona, M. 2007. Configuring the After-Sales Service Supply Chain: A Multiple Case Study. *International Journal of Production Economics*. 110(1–2): 52–69.
[26] Juehling, E., Torney, M., Herrmann, C. and Droeder, K. 2010. Integration of Automotive Service and Technology Strategies. *CIRP Journal of Manufacturing Science and Technology*. 3(2): 98–106.
[27] Muijs, D. 2010. *Doing quantitative research in education with SPSS*. London UK: SAGE Publication.
[28] Cohen, L., Manion, L. and Morrison, K. 2000. *Research Methods in Education*. USA. Routledge Falmer.
[29] Harwell, M. R. 2011. *Research Design In Qualitative/Quantitative / Mixed Methods*. Los Angelos, USA. University of Minnesota.
[30] Creswell, J. W. and Knight, V. 2009. *Research Design*. USA: SAGE Publication.
[31] Comoglio, C. and Botta, S. 2012. The Use of Indicators and the Role of Environmental Management Systems for Environmental Performances Improvement: A Survey on ISO 14001 Certified Companies in the Automotive Sector. *Journal of Cleaner Production*. 20(1): 92–102.
[32] Thun, J. H. and Hoenig, D. 2011. An Empirical Analysis of Supply Chain Risk Management in the German Automotive Industry. *International Journal of Production Economics*.131(1): 242–249.

[33] Alejandro, T. B., Souza, D. V., Boles, J. S., Ribeiro, Á. H. P. and Monteiro, P. R. R. 2011. The Outcome of Company and Account Manager Relationship Quality on Loyalty, Relationship Value and Performance. *Industrial Marketing Management.* 40(1): 36–43.
[34] Ahmad, S. and Butt, M. M. 2012. Can After Sale Service Generate Brand Equity. *Marketing Intelligence and Planning.* 30(3): 307–323.
[35] Jabbour, C. J. C., Jabbour, A. B. L. de S., Govindan, K., Teixeira, A. A. and Freitas, W. R. de S. 2013. Environmental Management and Operational Performance in Automotive Companies in Brazil: The Role of Human Resource Management and Lean Manufacturing. *Journal of Cleaner Production.* 47: 129–140.
[36] Santos, G., Mendes, F. and Barbosa, J. 2011. Certification and Integration of Management Systems: The Experience of Portuguese Small and Medium Enterprises. *Journal of Cleaner Production.* 19(17–18): 1965–1974.
[37] Atalay, M., Sarvanc, F. and Anafarta, N. 2013. The Relationship between Innovation and Firm Performance: An Empirical Evidence from Turkish Automotive Supplier Industry. *Procedia Social and Behaviour Sciences.* 75: 226–235.
[38] Zhou, J., Huang, P., Zhu, Y. and Deng, J. 2012. A Quality Evaluation Model of Reuse Parts and Its Management System Development for End-of-Life Wheel Loaders. *Journal of Cleaner Production*. 35: 239–249.
[39] Sánchez, A. M. and Pérez, M. P. 2005. Supply Chain Flexibility and Firm Performance: A Conceptual Model and Empirical Study in the Automotive Industry. *International Journal of Operation and Production Management*. 25(7): 681–700.
[40] Liang, Y. H. 2010. Integration of Data Mining Technologies to Analyze Customer Value for the Automotive Maintenance Industry. *Expert Systems with Applications*. 37: 7489–7496.
[41] Yadav, O. P. and Goel, P. S. 2008. Customer Satisfaction Driven Quality Improvement Target Planning for Product Development in Automotive Industry. International *Journal of Production Economics.*113(2): 997–1011.
[42] Aboltins, K. and Rivza, B. 2014. The Car Aftersales Market Development Trends in the New Economy. *Procedia Social and Behaviour Sciences*.110: 341–352.
[43] Salleh, N. A. M., Kasolang, S. and Jaffar, A. 2012. Simulation of Integrated Total Quality Management (TQM) with Lean Manufacturing (LM) Practices in Forming Process Using Delmia Quest. *Procedia Engineering.* 41:1702–1707.
[44] Hair, J. J. R. F., Black, W. C., Babin, B. J. and Andersson, R. E. 2009. *Multivariate Data Analysis* 7th Edition. Upper Saddle River. Prentice Hall.
[45] Rouse, M. 2006. *Fuzzy logic*. WhatIs.Com retrieved November 10, 2015 from http://whatis.techtarget.com/definition/fuzzy-logic.
[46] Reliawiki, 2012. *The Weibull Distribution*. ReliaWiki.com retrieved November 13, 2015 from http://reliawiki.org/index.php/The Weibull_Distribution.
[47] Kohonen, T. 2001. *Self-organizing maps*. 30. Springer Series in Information Sciences.
[48] Kano Model Analysis. 2014. Retrieved November 16, 2105 from http://people.ucalgary.ca/~design/engg251/First Year Files/kano.pdf.
[49] Simons, R. 2013. *Levers of control: how managers use innovative control systems to drive strategic renewal*. Harvard Business Press.
[50] Glover, F. 1986. Future Paths for Integer Programming and Links to Artificial Intelligence. *Computers & Operations Research*. 13(5): 533–549.