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MODEL OF CYBER PHYSICAL SYSTEM IN THE CUSTOMER SATISFACTION OF AUTOMOBILE INDUSTRY IN INDIA

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Abstract. The most important thing to improve the customer service and customer satisfaction is to identify the demands to the customer. Automobile industries need to find the significant factors, which will meet the demands of the customer to a greater extent. The present research includes identification of important cyber physical system factors from the factorial analysis. Descriptive analysis used for the data analysis of the survey results. The relations between the important factors were evaluated and model of the cyber physical system factors in the customer satisfaction of automobile industry is suggested. We conclude the Cyber physical systems factor with the important 5 factors such as Safety, Energy-saving, E-receipts, Inbuild Multi-dimensional human machine interactive systems, and Smart Recycle, manufacture and redesign are the crucial aspects in the customer service.

Keywords: customer service, customer satisfaction, Customer relationships management, Automobile companies, Industry 4.0, Smart product service systems, Cyber physical systems.

JEL Classification: D24, O14, L21, M21, C44, E24.

Introduction

Automobile industries can be considered as one of the most important industrial sectors throughout the whole world. The turn of the twentieth century is considered as the dawning of the automobile industry. Though the sales of the automobile have been falling off to 70 million units in 2021, which was almost like 80 million units in the end of 2017. These reductions can be considered because of the pandemic. China is considered as world's largest automobile markets based on the sales and production. North America, Europe and Asia have also made significant contribution in many automobile products and process. The automobile maintenance escalated comparatively during the recent years, and these have made the automobile industries to stay at the top comparing to the other industrial sectors. Now-a-days we can say that automobiles are the most valuable to the customers after the household products.

Considerably we can also see a boost in the automobile markets in India. India is expected to become the world's third largest passenger vehicle market by 2021. In 2019, India sold more 3.99 million units of automobiles. The sales of passenger vehicles were also improved. And the statistics tending to improve by the end of 2021.

The most important thing to improve the customer service and customer satisfaction is to identify the demands to the customer. Automobile industries need to find the significant factors, which will meet the demands of the customer to a greater extent. The demands of the customer totally vary from time to time, so it is always necessary for the car industries to be updated with the same. We know that the digitalization plays a prominent role in introducing new technological innovations which in turn meets the demands of the customer. Hence, we can say that digitalization is very important factor for the automobile industries.

The paper aims to create a model of Cyber physical systems in the customer satisfaction of automobile industry. The data sample for the research is collected from two Indian states mainly Gujarat and Kerala. The main reason to select India for the study are the increasing use of digitalization methods in India, increasing demands of customer satisfaction and competition in India.

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Research is identifying the Cyber physical system factors involved in the customer satisfaction of automobile industry and suggesting a model of Cyber physical systems.

1. Importance of digitalization in the industrial sectors

New industries are adopting service business models (servitization), to offer not only physical products but also services to meet the demands of the customer. Such a combinations of both digitalization and servitization has triggered the use of more smart product service systems. Pai Zheng in his research paper (Zheng et al., 2019b) has mentioned the use of such Smart PSS to improve the servitization of the products of different industries. Recent developments of information and communication technologies (ICT), such as Internet-of-Things (loT), Cyber physical systems (CPS), which can collect, communicate, process, and produce information, have made many considerable changes in the field of servitization thereby improving the customer satisfaction. The terms Internet of things (IoT) and Industrial internet of things (IIoT) have been very common in today's world and both of the technologies are been same quite the same, the only difference is that Internet of things mainly focuses on industrial, manufacturing and agricultural applications but IIoT stresses on improving connectivity between devices, saving time, efficiency optimization and other possible benefits. (Senthil Kumar & Iyer, 2019)

These developments also made the changes in the products value by embedding IT into the product and providing value added e-services which is known as digital servitization. Valencia in their conference paper (Valencia Cardona et al., 2014) mentioned IT-driven business paradigm called Smart PSS (Smart Pro Surveillance System) as "the integration of smart products and e-services into single solutions delivered to market to satisfy the needs of individual customers". According to Pai zheng, the introduction of such smart products proposed the ideas of new systems like Digitalized PSS and Cyber physical PSS. Industrial machinery and industrial capital goods are traditionally consisting of both mechanical and the electrical parts, there is always a possibility of breakdown of such parts, and which results in downtime. However due to the use of many digital technologies, it is possible to avoid such losses for the smooth running of the business. Base on the case studies conducted by Matthias in his research paper, he identified the main seven impacts of CPSs for the service business, the overview of the affordance is shown in the Table 1 (Herterich et al., 2015):

The research paper also summarized the usage of various Smart PSS in different engineering lifecycle stages such as design stage, manufacturing stage, distribution/logistic stage, usage stage and end-of-life stage (Table 2).

Table 1. Overview of affordance (source: Herterich et al., 2015)

Service Affordance	Description
Engineer better equipment by leveraging operational performance data	Data from the industrial equipment of the current installed base can be used for engineering future version of the equipment
Optimization of equipment operations	Operation of the equipment can be optimized based on historic operational data. Breakdowns can be prevented. Based on historic usage patterns, operations can be optimized
Control and manage equipment remotely	Having the ability that CPSs can receive control information, dedicated functionality of the equipment can be controlled manually via remote service centres. A reset of CPSs can be conducted to eliminate faults remotely
Predict and trigger service activities	Continuous data collection based on CPSs might be used to trigger and predict service activities. For example, routine maintenance activities can take place based on usage or wear and tear of the equipment. Efficiency increases are not only possible by conducting the service activities efficiently but also by scheduling them in an efficient yet effective way
Remote diagnostics and replace field service activities	In many cases, maintenance or even repair can be accomplished remotely. Comprehensive service centres are set up and experienced staff diagnoses or solves problems remotely. Experienced service agents can be utilized more effectively, as travel is no longer necessary. Initial diagnosis is accomplished remotely
Empower and optimize field service	Industrial CPSs can be used to optimize and enhance efficiency of existing service processes and particularly field service activities. Based on CPSs, field service activities can be performed faster, and service quality could be increased. Field service technicians can be supported by remote experts to solve problems faster and more effectively
Information and data-driven services	Data as well as insights obtained from CPSs can be used as an asset to realize unexpected information and data-driven service opportunities. For instance, in case that the manufacturer is the owner of the data, data can be sold to other stakeholders via standardized interfaces. This data can be leveraged for the service business

1.1. Bibliometric analysis of Cyber physical systems in the automobile industry

In this paper, focus is made on the customer value and satisfaction factors related to the use of Cyber physical systems in the automobile industry. There is only a limited number of research being conducted on the customer satisfaction factors of cyber physical systems. The importance of the cyber physical systems and smart product

Table 2. Use of Smart PSS in different engineering lifecycles (Zheng et al., 2019b)

Stage	Task Category	Specification
Design stage	Requirement management Smart design	Requirements capture & evaluation Product development Service development/innovation
Manufacturing stage	Smart production Smart inspection	Resource management Production planning Production process control/reconfiguration
Distribution/logistic stage	Smart logistic	Logistics and packaging
Usage stage	Smart operation/maintenance Smart reconfiguration	Performance assessment Monitor, maintenance, diagnosis Engineering change management Product reconfiguration
End-of-life stage	Smart reuse Smart recycling Smart remanufacturing	Product reuse Product remanufacturing Product recycling

systems in the field of servitization of various industries is already discussed in the above sections. So, the major focus was given to the customer satisfaction factors.

The literature search was conducted from 4th of March to the 7th of March and the main aim of the search is to find out the governing factors for the questionnaire and to form a model of cyber physical systems for customer satisfaction. For narrowing the search, bibliometric analysis of the research papers is conducted. The papers for the analysis are collected from the database of Scopus. In the preliminary search, the main keywords are "Cyber physical systems" AND "Customer satisfaction" and it resulted only 22 documents, which was not enough for the bibliometric analysis. To improve the search results, different search keywords like "Cyber physical systems" AND "Customer Satisfaction", "Cyber physical systems" AND "Customer relations", "Cyber physical systems" AND "Customer service", "Cyber physical systems" AND "Service" AND "Automobile", "Cyber physical systems" AND "Customer relationships", "Industry 4.0" AND "Customer Service", "Industry 4.0" AND "Service" AND "Automobile", "Industry 4.0" AND "Customer Satisfaction", "Industry 4.0" AND " Customer Value" , "Industry 4.0" AND "Customer Relationship", "Smart product service systems" AND "Service", "Smart PSS" AND "Customer Satisfaction" were used for the second search and got 268 research papers for this search. These research papers were filtered by taking only the Open Access, English, and Articles from the obtained results and the search for the Literature review was narrowed to 101 Papers. All the information's and visualizations for the analysis was obtained from the analysis results in Scopus and from the VOS viewer. To narrow down the number of articles, it is important to evaluate and categorize the articles obtained in the primary search – Figure 1.

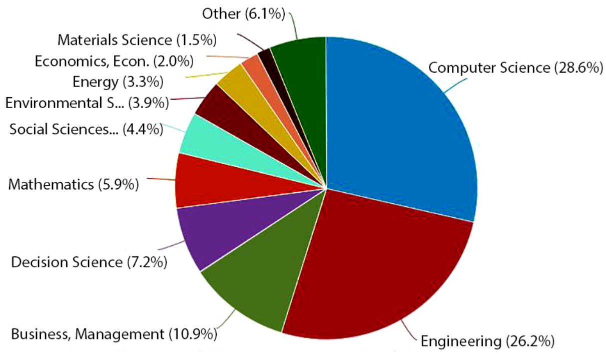


Figure 1. Documents by subject area (source: Scopus data base)

It is clearly indicated that almost 10 authors have been contributed and the major number of contributions by Chen C. H. and Zeng. P. They have been contributed about 30 documents on Figure 2.

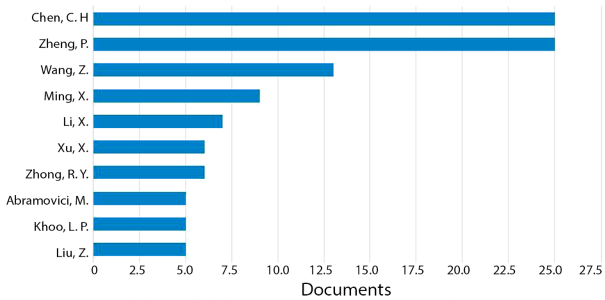
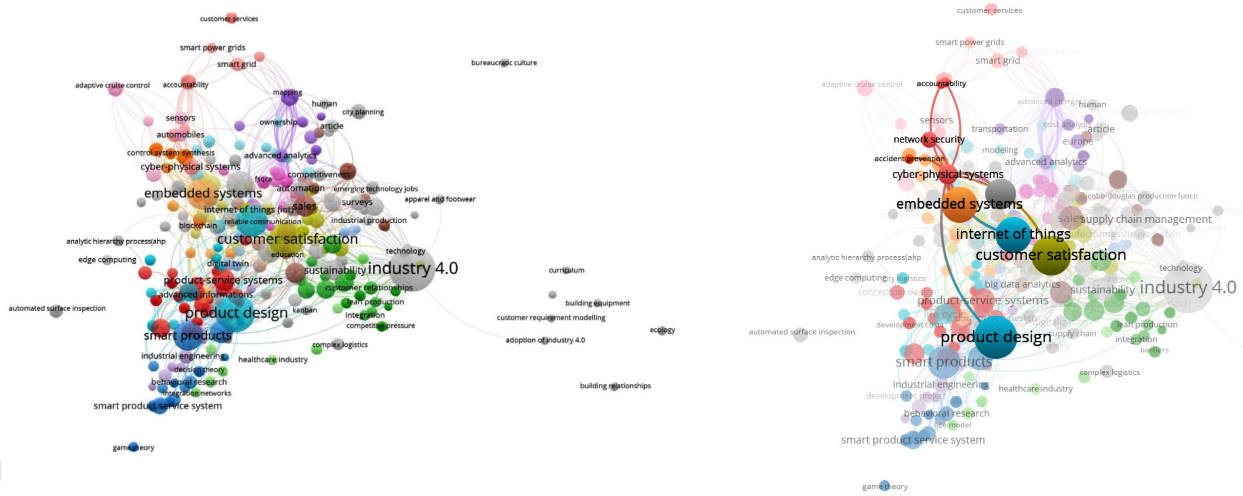


Figure 2. Documents by authors (source: Scopus data base)

Majority of the articles were published in China, 11 articles with 12 links which is represented by green cluster and Germany with 6 articles and 9 links represented by red cluster. The rest of the countries were made by the countries like Egypt, Singapore, Netherlands, Italy, Pakistan, South Korea, United States, Taiwan, Spain, Slovakia, Czech Republic, Hungary, Austria, Indonesia, Poland, Vietnam, and India. These countries are represented by using different colour clusters. The Figure 3 shows the cluster of keywords obtained from VSOS viewer, we found 13298 links and 35 clusters with 1037 items.

The cluster associated with the item "Cyber Physical Systems" IS selected as relevant for forming the framework. The cluster shown in the Figure 4 represents the keywords chosen for analysis. We see that there are 10 clusters with 97 links. The important keywords for forming the framework were found as "Customer Satisfaction", "Customer Satisfaction", "Internet of things" and "Product Design". The application of Internet of things in factories and industries are mentioned by Y. Shahzad in research paper (Shahzad et al., 2020). The main applications of IoT mentioned are Automation, Smart robotics, Logistics Management and Supply Chain, Predictive maintenance, Integration of Smart Tools, Safety, Tracking and Smart transportation.



a) b)

Figure 3. a) Cluster of keywords (source: by VosViewer in Scopus); b) Cluster of critical keywords (source: by VosViewer in Scopus)

The aim is to find the relevant factors for improving the customer satisfaction in product design of automobile through Cyber physical systems and Internet of things: Industry 4.0. 26 relevant papers are selected and 19 is selected for the analysis and the important criteria are found out. The relevant factors obtained from the articles of the bibliometric analysis is given in the Table 3.

In the framework (Figure 4), we can see that the focus is given to the Customer satisfaction and Product design of the automobile. As we know that we know that the fourth industrial revolution is more concerned to manufacturing and production processes, it is more important to consider the entire value chain.

Table 3. Important digitalization factors (created by authors)

	Product Design	Author and Journal
Smart product service system	Virtual reality, Augmented reality, User centric smart service of spare parts, Real time customer feedback, Global positioning systems (travel assist), On board diagnostics, Smart customization and personalization, Smart car showrooms	(Cong et al., 2020b), (Bu et al., 2021), (Zheng et al., 2018), (Liu et al., 2019), (Cong et al., 2020a), (Cebe et al., 2018), (Chen et al., 2020b), (Munir & Koushanfar, 2020)
Autonomous Technologies	Autonomous driving, Predictive maintenance, Artificial intelligence (Auto braking), Smart maintenance, Traffic Planning, Energy saving solutions, Smart transportation, Steer by wire, Operation optimization (driving modes energy efficiency), User behaviour analysis, Smart Update	(Llopis-Albert et al., 2021), (Chen et al., 2020c), (Cebe et al., 2018), (Chen et al., 2020b), (Shahzad et al., 2020), (Munir & Koushanfar, 2020), (Chen et al., 2020a)

End of Table 3

	Product Design	Author and Journal
Cloud services	Personalization data, Safety information, Smart data analytics, Mobile cloud computing, E-receipt, Data oriented sharing, Remote diagnostics	(Aheleroff et al., 2020), (Gavrila Gavrila & de Lucas Ancillo, 2021), (Chen et al., 2020b), (Chen et al., 2020a), (Kohtamäki et al., 2020), (Liu et al., 2019), (Mora et al., 2017)
Environmental Sustainability	Fuel consumption Monitoring, Emission monitoring, Electric vehicle, Smart recycle, Smart remanufacturing, Smart redesign	(Li et al., 2021), (Liu et al., 2020), (Zheng et al., 2018), (Zheng et al., 2019a), (Llopis-Albert et al., 2021)
Security, Compliance, Risk	Customer data security, Personalized product design safety, Data analytics, Data processing and protection, Event data recorders, Roadside units	(Kiraz et al., 2020), (Cebe et al., 2018), (Saniuk et al., 2020)
Market and Customer access, Customer satisfaction. CRM – Customer Relations System	Human-Machine interactive infotainment, Driving safety alert, Battery consumption monitor	(Chen et al., 2020c), (Aheleroff et al., 2020)
Globalization/Big scale/Scalability	Smart logistics, eCommerce	(Kiraz et al., 2020), (Gavrila Gavrila & de Lucas Ancillo, 2021), (Chen et al., 2020c), (Llopis-Albert et al., 2021)

Offline Smart product service systems recognize specific user scenario with context awareness and adjust itself to that specific scenario using the self-learning software built in it (Li et al., 2021; Zheng et al., 2018).

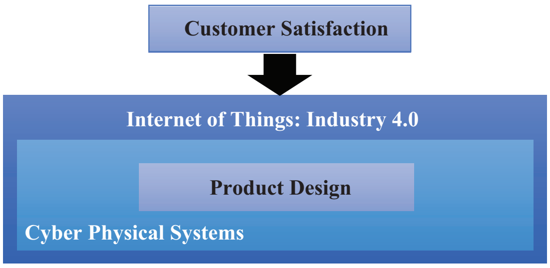


Figure 4. Framework of the research
(source: created by authors)

The co-development processes of the Smart product service systems includes four phases mainly requirement co-generation, function co-design, process co-implementation and performance co-monitor (Liu et al., 2020).

Smart Product service systems can be considered as a bundle of smart connected products and their e-services provide by the industries to provide customers with satisfying experiences. The best example of this can be automatic guided vehicles in the industries which makes the material handling tasks easy and also allows the users to check the status of these materials with the help of embedded sensors and microprocessors (Liu et al., 2019).

Internet of things have introduced many new technologies which enables collection of data from vehicles for many applications. The best example can be Onboard diagnostics (OBD) ports in the vehicles which helps in gaining the vehicle controller diagnostics. These ports are also having Bluetooth, Wi-Fi, or serial connections for the transfer of data. Modern automobile also consists of various Electronic control units (ECUs) to implement various distributed control applications. The new generation automobiles also improve the usage of ECUs to implement various new and exciting control and infotainment applications. The most important tool for communication among the ECUs in these automotive Cyber Physical systems applications are Control area network (CAN). These feature have been already implemented in the modern devices and long-lived transportation systems (Cebe et al., 2018; Munir & Koushanfar, 2020). Zhihua Chen mentions in his paper about the advancement and development of smart technologies like cloud computing, Industrial internet of things, big data analytics, artificial intelligence, virtual reality, augmented reality etc. These technologies help many of the manufacturing companies to improve the servitization of the products and have also made them shift towards the Smart product service systems. Smart technologies have also improved capabilities of various components of the Smart products service systems such as connectivity, communicability, diagnostic ability, predictability, controllability, and cognitive ability (Chen et al., 2020a; Chen et al., 2020b).

2. Research methodology and results

Current *Empirical research* a quantitative approach is used for the research. The digitalization factors involved for customer satisfaction are collected with the help of the bibliometric analysis of the research papers and questions for the survey for the primary data collection was formed with the help of these factors.

Primary data collection for this research shall be carried out with the help of online survey developed with the help of google forms. The questions for the survey are developed with the help of the factors obtained from the bibliometric analysis. The survey questionnaire mainly aims to understand the attitude and perspectives of the focus group towards the obtained digitalization factors. The online survey is conducted through the online platforms like Facebook, Instagram, and WhatsApp.

The main methods of data analysis used in the research are descriptive analysis and factorial analysis.

2.1. Profiles of respondents and descriptive statistics

The survey which was conducted to collect the primary data consists of major 39 questions which include 28 questions about the factors obtained from bibliometric analysis (Table 3), 11 questions about respondent opinion on popular factors (Appendix 1) and additionally 6 personal questions like name, email, age, sex, occupation and usage of automobiles. The total number of responses received is 151 and in which 76.2% of respondents are of 18 to 25 age group, 23% are of 26 to 40 years, and 0.8% of them are between 41 and 60. The data contained 93.4% of the responses from male and 6.6% from female. About 66.1% of the respondents frequently used automobiles, 19% used only once in a week and 8.3% in a month. Also, 5.8% of the responses are from the people who used vehicles rarely and there was one respondent who don't use vehicle at all. The data obtained from the respondent who never use vehicle at all was neglected to get more accurate results for the analysis. There are 28 factors involved in this research and the responses of 15 factors are analysed and explained in the below sections.

The results obtained for the fuel consumption monitoring factor has a mean of 4.04 and standard deviation of 0.687. Among 150 respondents, 37 of them rated the fuel consumption monitoring very highly and 77 of them rated high, while there were also 36 neutral responses for the factor. The bar chart shown in the Figure 5 shows that majority of the responses was positive. Around 54.4% of the responses were high and 23% were very high. The mean and standard deviation of responses obtained for the factor Predictive and smart maintenance are 3.90 and 0.733 respectively. It is evident that none of the responses obtained were negative, all the respondents find predictive and smart maintenance helpful.

About 48 responses obtained was neutral. The main aim of the predictive and smart maintenance features in the automobiles is to collect the data to identify the time that the equipment of vehicles is likely to fail, and it also helps in forecasting the problems that could occur in the future and helps in reducing it. It also helps in improving the energy consumptions to a great extent. To evaluate the usefulness of the predictive and smart maintenance in the long-time usage of vehicles, the question "Is the predictive and smart maintenance features in automobiles helpful for long term usage of the vehicles" was added (Figure 5).

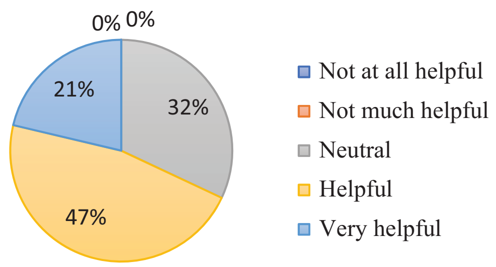


Figure 5. Response for predictive and smart maintenance (source: created by authors)

Other descriptive analysis could be found in Appendix 1.

2.2. Quantitative model for evaluation of customer satisfaction values and correlations analysis

The next important phase of the research is the development of a model. The results from the factor analysis in SPSS are presented below.

Table 4. Respondent statistics (source: research results)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.688
Bartlett's Test of Sphericity	Approx. Chi-Square	1210.117
	d_f	378
	Sig.	.000

The Table 4 displays that Kaiser-Meyer-Olkin measure of sampling adequacy achieved is 0.688 and it is higher than 0.50. This indicates that the generated data is suitable for factor analysis. The obtained value is of significance is less than 0.00 which is lower than 0.05 which implies the data can be subjected to reduction. From the table our obtained value 0.872 is in meritorious level.

The Appendix 2 shows the results shows the extracted results of the Principal Component Analysis. We can see that 10 factors were retained as the output of the analysis as we follow the rule of selecting the components having Eigenvalues more than 1.

The scree plots are formulated using SPSS, the graphs indicate that the first 10 components are having eigenvalues more than 1. This scree plots shows us that eigenvalues start to form a straight line after component 10. This implies that the remaining components only account for a very small ratio of the variances and hence they are not that significant. This helped us to consider the first 10 components that had the highest eigenvalues more than 1 (Figure 6).

The principal component analysis displayed the presence of 10 components with eigenvalues more than 1. The first 2 components explained the highest eigenvalues, 18.023% and 8.6% respectively (Appendix 2). Out of these 10 components, we select only the components having % of variance over 5. Therefore 6 components were chosen for further investigation (Appendix 3).

In this component analysis, we have taken into consideration the values over 0.5 in the component matrix. In the bar chart shown in the figure 3.17, we can see the values of the factors in the first component. The main factors representing the positive loadings are Fuel consumption Monitoring (0.662), Predictive and smart maintenance (0.598), Auto Braking (0.596), Automatic Driving mode recommendation (0.582), Driving safety Recommendations (0.557), Event data recorders (0.539), User Centric Smart service of Spare Parts (0.513), Roadside assistance (–0.518), and Smart car showrooms (0.392). The factors with the negative impact on the component 1 was Roadside units (–0.518), and Smart Car showrooms (–0.392).

The Figure 7 shows the internal factors in major Component 1 generated by SPSS software.

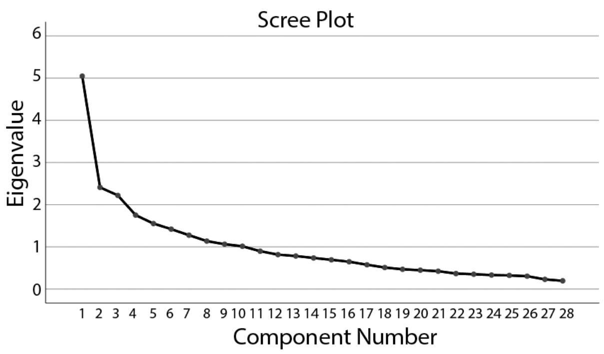


Figure 6. SPSS output for the scree plots generated (source: created by authors)

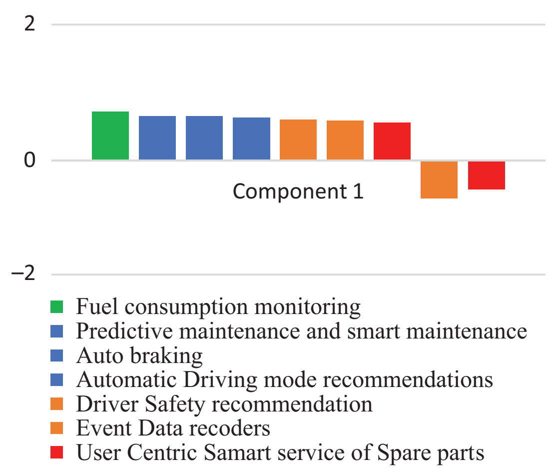


Figure 7. SPSS output for the scree plots generated (source: created by authors)

With the help of factor analysis, the total number of factors were reduced to fewer factors. Moreover, it helped us to determine the 5 major components that are discussed above. Key results from the analysis on each component were made. Mathematically we can represent the model for human factors and user experience in remote environment can be given as:

$$Y = 0.18\, C_1 + 0.08C_2 + 0.0792C_3 + 0.0526C_4 + 0.0554C_5 + 0.46C_n, \quad (1)$$

where: C_1 – Safety component; C_2 – Energy savings; C_3 – Automatic receipts; C_4 – Inbuilt Multidimensional interactive features; C_5 – smart recycle, manufacture and redesign; C_n – All other insignificant factors with less variances; Y –overall significance of customer satisfaction in automobile industry.

The model of the cyber physical factor is shown the Figure 8 proved that customers believe that energy saving factors are greater significant also the proved that customers value more safety related aspects of automobile. Therefore, it was evident the first two factors of customer service are Safety features and Energy saving factors. From the factorial analysis, it was evident that the most important factor in component 3 was E-Receipts also in component 4 and 5 it was respectively Inbuilt Multidimensional interactive features and smart recycle, manufacture and redesign. These factors are selected as the most important as these values had the positive factor loadings. Therefore, these 3 factors are chosen as the next important factors of customer satisfaction.

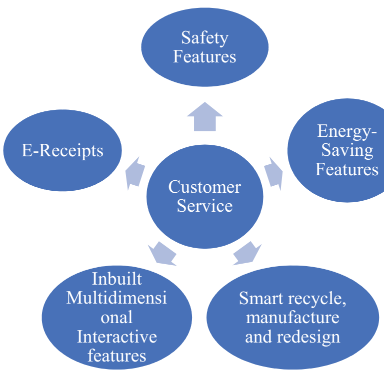


Figure 8. Model of Cyber physical systems factors that impact on customer satisfaction (source: created by authors)

We conclude the Cyber physical systems factor with the important 5 components such as Safety, Energy-saving, E-receipts, Inbuilt Multi-dimensional human machine interactive systems, and Smart Recycle, manufacture and redesign are the crucial aspects in the customer service.

Conclusions

The present paper has provided a detailed framework for prioritization of factors based on the empirical example for the specific situation in India.

In the competitive market of automobile industry to sustain, it is very important to satisfy the rising demands of the customer. With industry 4.0, we can say that demands of the customer have been increasing due to the invent of various digitalization techniques. The manufacturing industries and other industrial sectors should concentrate on these technological factors and improve their business models accordingly to develop good customer base. The primary step to improve the customer satisfaction includes obtaining the feedbacks and customer experiences. The needs and desires of the customer can be understood and evaluated with the help of these feedbacks. The upcoming generation provides the feedbacks and their personal experiences through the online platforms and social medias. The top data sources used by the companies are the customer satisfaction databases, digital channels, customer relation management systems (CRM systems), point-of-sale systems and social media sites these data help in developing and determining the important factors responsible for the customer satisfaction of the customers based on the industries. Currently we can see a strong race amongst the companies and industrial sectors to gather real-time insights about the customer satisfaction factors.

The aim of this research is to suggest the model of cyber physical systems in the customer satisfaction of automobile industries. The research involved identifying and defining various digitalization factors involved in the customer satisfaction of automobiles and suggesting the model of Cyber physical systems factors to improve the customer satisfaction in the automobile industry. Customer satisfaction in the automobile industries is high area of research due to the increase in competitions and globalization. The digitalization factors involved in the customer satisfaction of automobile industries are identified with the help of bibliometric analysis and survey questionnaire. The factors involved in the analysis is weighted with the help of factorial analysis. The model of Cyber physical system factors is developed with the help of descriptive analysis and factorial analysis of the obtained data.

The main conclusion that can be made from the research are:

- Customer service and customer satisfaction plays an important role in the automobile industrial sectors. The brand value and customer base totally depend on the level of customer service and customer satisfaction.
- With the advent of Industrial 4.0, the field of servitization has been constantly improving and customer demands are increasing.
- Cyber physical systems factors can be considered prominent for improving the field of servitization in the automobile industries.
- The important gap identified from the literature review is shortage of research focusing on the important cyber physical factors involved in the customer satisfaction of the industrial sectors mainly automobile industries.

– The relevant factors obtained from the bibliometric analysis are grouped into 7 categories such as Smart product service system, Autonomous technologies, Cloud services, Environment and sustainability, Security compliance and risk, market and customer access/Customer relations system, and Globalization/Scalability.

Descriptive analysis conducted helped in understanding the level of satisfactions each factor provided to the customers. Mainly the customer valued Fuel consumption monitoring, Predictive and Smart maintenance, Auto braking, automatic driving mode recommendations, Driver safety recommendations, Event data recorders, User centric smart service of automobiles, Road-side units, Smart car showrooms, Energy saving solutions, Smart personalization and customization, Personal data security, Data oriented sharing, Human machine interactive infotainment, Smart recycle, manufacturing and redesign, Smart logistics, User behaviour recommendations, E-receipts, Remote diagnostics, Autonomous driving, Virtual and augmented reality, On-board diagnostics, Global positioning systems, and Emission monitoring.

The factors explained based on the 5 components and these 5 components helped in forming the model of cyber physical systems factors for the customer satisfaction. The analysis conducted proved that customer value energy saving and safety-related factors more than other factors. The stereotype with the concern of the customers with the security personal data due to the excessive use of the digitalization was rejected hence we can say the customers are not that concerned with security of their personal data against the usage of cyber physical systems.

The following practical proposals can be made for the future from the research conducted. The mathematical forecast model developed from the factorial analysis can be used in the future by the automobile manufacturing as well automobile as base for improving the customer service and customer experience. The suggested model will also helps to develop business strategies. Important factors obtained from the factorial analysis like Automatic driving mode recommendations, Emission monitoring, and Road-side units requires further attention as these factors had alternate positive and negative loadings under different components could be used to access customer satisfaction. So, the qualitative research based on the experts' opinions can be conducted in future. Researchers can include a greater number of factors from this research, analyse and relate the factors based on different methods.

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APPENDIX 1

1. Response for Auto braking		
Are you satisfied by the auto braking feature of automobiles		
	Count	Percent %
1 (Not satisfied)	0	0
2	9	1.6
3	36	23.8
4	56	40.2
5 (Very Satisfied)	49	34.4
Mean	4.07	
Standard Deviation	0.781	
2. Response for Automatic driving mode recommendations		
Are you satisfied with the automatic driving mode recommendations feature available in the automobiles		
Not at all satisfied	0	0
Not satisfied	12	4.1
Neutral	54	38.5
Satisfied	64	46.7
Very satisfied	20	10.7
Mean	3.61	
Standard Deviation	0.760	
3. Response for Energy saving solutions		
Are the energy saving solution recommendations made by the automobiles helpful for long time usage		
Strongly Disagree	11	4.9

	Count	Percent %
Disagree	10	4.1
Neutral	54	39.3
Agree	55	40.2
Strongly Agree	20	11.5
Mean	3.51	
Standard Deviation	0.898	
4. Response for Personal data security		
What do you feel about the security of personal data due to the excessive use of digitalization		
Not all Secured	8	2.5
Not Secured	24	14.8
Neutral	52	37.7
Secured	48	34.4
Highly Secured	18	10.7
Mean	3.34	
Standard Deviation	0.992	
5. Response for Data oriented sharing		
Are you comfortable with the data sharing features of your vehicles		
Not at all Comfortable	10	4.1
Not comfortable	22	13.1
Neutral	48	34.4
Comfortable	54	39.3

	Count	Percent %
Highly Comfortable	16	9
Mean	3.33	
Standard Deviation	0.955	
6. Response for E-receipts		
What do you prefer the E-Receipt or the physical receipt for the purchase you make		
Physical Receipts	25	9
E-Receipt	125	91
Total (N)	150	100
Mean	1.12	
Standard Deviation	0.327	
7. Response for Global Positioning Systems (GPS)		
Do you find Global positioning systems (Travel assist) in vehicles helpful in your daily life		
Not at all	0	0
Not so much	8	0.8
Somewhat	21	11.5
Very	44	30.3
Extremely	77	57.4
Mean	4.41	
Standard Deviation	0.726	
8. Response for Roadside Units (RSU)		
Do you find the RSU in the automobiles helpful		
Yes	70	49.2
May be	62	43.2
No	18	7.4
Mean	1.89	
Standard Deviation	0.960	
9. Response for Smart personalization		
How much do you rate the feature of smart personalization and customization available for the automobiles		
1 (Very Low)	0	0

	Count	Percent %
2	10	2.5
3	43	29.5
4	53	37.7
5 (Very High)	44	30.3
Mean	4.07	
Standard Deviation	0.844	
10. Response for On-Board diagnostics		
Do you find On-board diagnostics (vehicle self-diagnostics) fascinating in your vehicles		
Not at all	0	0
Not so much	10	2.5
Neutral	35	23
Somewhat Fascinating	66	48.4
Very much Fascinating	39	26.2
Mean	3.96	
Standard Deviation	0.779	
11. Response for Emission Monitoring		
Do you think that the emission monitoring features of the automobile help in reducing pollution		
	Frequency	Percent %
Yes	111	79.5
No	39	20.5
12. Response for Virtual and Augmented Reality		
How much you would rate the introduction of digital technologies like Virtual and Augmented reality, in selection and examining the features of car, sitting at your home		
1 (Very Low)	7	1.6
2	9	3.3
3	29	18.9
4	65	48.4
5 (Very High)	40	27.9

APPENDIX 2

Total Variance – Principal component analysis (SPSS software)

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5.046	18.023	18.023
2	2.410	8.608	26.631
3	2.219	7.927	34.557
4	1.753	6.262	40.819
5	1.553	5.547	46.366
6	1.420	5.072	51.437
7	1.277	4.559	55.996
8	1.137	4.061	60.057

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
9	1.064	3.800	63.858
10	1.015	3.625	67.482
11	.897	3.205	70.687
12	.816	2.914	73.601
13	.784	2.798	76.400
14	.737	2.633	79.033
15	.694	2.477	81.509
16	.647	2.312	83.822

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
17	.576	2.058	85.879
18	.511	1.824	87.703
19	.468	1.672	89.374
20	.447	1.596	90.971
21	.423	1.512	92.483
22	.367	1.310	93.793
23	.352	1.256	95.049
24	.333	1.188	96.237
25	.323	1.154	97.392
26	.305	1.091	98.482
27	.230	.820	99.303
28	.195	.697	100.000

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
	Rotation Sums of Squared Loadings		
1	2.567	9.168	9.168
2	2.440	8.713	17.882
3	2.074	7.408	25.290
4	2.033	7.260	32.550
5	2.022	7.223	39.773
6	1.720	6.142	45.915
7	1.656	5.915	51.830
8	1.528	5.458	57.288
9	1.506	5.379	62.667
10	1.348	4.815	67.482

APPENDIX 3

Component Matrix – Principal Component Analysis (SPSS software)

	1	2	3	4	5	6
User centric smart service of spare parts	.513	–.036	.017	–.338	–.234	–.113
Global positioning systems	.356	.205	.293	.360	–.421	–.366
On-board diagnostics	.410	.222	.079	–.233	–.456	–.347
Virtual reality and Augmented reality	.496	.238	.109	–.387	.417	–.016
Smart personalization and customization	.407	.499	–.240	–.272	.254	.052
Real time customer feedback	.470	.388	.208	.241	.123	–.040
Smart car showrooms	–.392	.094	.063	.264	–.223	.028
Autonomous driving	.582	–.069	.066	–.216	.432	.119
Auto braking	.596	–.143	.307	–.010	.250	.247
Predictive maintenance and smart maintenance	.598	.077	–.200	–.015	–.358	–.193
Traffic planning	.459	.035	.395	.338	–.220	.172
Energy saving solutions	–.160	.528	.349	.065	.053	.005
Automatic driving mode recommendation	.389	–.542	.065	–.042	.086	–.070
User behaviour recommendation	.464	–.180	–.082	.492	.186	–.028
E-receipt	.065	.329	–.178	.405	–.186	.449
Data oriented sharing	.347	–.486	.291	.266	–.092	–.057
Remote diagnostics	–.302	–.166	.394	–.457	–.100	.354
Fuel consumption monitoring	.662	.215	–.118	.203	.431	.304
Emission monitoring	–.171	–.023	.144	.144	–.094	–.547
Electric vehicle	–.356	.301	.053	.013	–.095	–.033
Smart recycle,	–.240	–.127	.518	–.092	–.095	.431
Customer data security, personalized product design data	.462	–.552	.100	–.015	.002	.032
Driver safety recommendations	.557	.227	–.084	–.242	–.074	.102
Event data recorders	.539	–.337	.063	–.020	–.255	–.069
Road-Side units	–.518	–.143	.327	.164	.268	–.025
Human-Machine interactive infotainment	.010	.177	.754	–.018	–.012	–.091
Smart Logistics	.068	–.210	–.531	.250	.250	.222
E-commerce	–.303	–.349	–.167	–.179	–.208	–.133