Maintenance Culture in the Automotive Industry in the era of Industry 4.0: challenges and state of readiness

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Abstract

This research is aimed at finding out challenges of vehicle maintenance system in development nations, and to proffer solutions to vehicle maintenance challenge by finding out the synergy between the vehicle owners and repairers. The research methodology used in this study was done using structured questionnaires, with one hundred and fifty (150) questionnaires sent out across Nigeria, one hundred (100) received and sixty-three (63) being usable. Exploratory Factor Analysis (EFA) was carried out to analyze the questionnaire to show validity and reliability of factors considered using Statistical Package for the Social Sciences (SPSS) software. The result from the questionnaire shows that the Maintenance Culture in the Automotive Industry still faces serious challenges ranging from extortion from customers, lack of funds to set up standard automobile workshops, low engagement of the younger masses in the automotive industry, low use of vehicles due to financial issues, high charges from the advanced auto-workshops, circulation of foreign-used vehicles and fairly used parts in the auto-industry. Conclusively, solutions such as scheduled maintenance should be carried out frequently on vehicles, the use of try by error technique should be reduced because most times it creates more problems to the existing ones, service personnel are encouraged to employ the use of diagnosing tool/machines to ease means of identifying problems for accuracy and adequate government policy should be ensured.

Keywords
Automotive Industry, Maintenance Culture, Factor Analysis, Automobile, Car diagnosis

1. Introduction

In developing nations, automobiles are at the increase which ranges from various model and type ploughing most roads in the country on a daily basis. Most of the users of these cars dedicate little or no attention to constant maintenance of their vehicles except there is a huge mechanical fault on the vehicle (Omosule et al. 2017). Some of these faults probably might be averted if constant measure of maintenance were put in place. The design of most modern vehicles requires scheduled and adequate maintenance as described by the manufacturers of the vehicles, unfortunately, the users of these vehicles are less concerned about the proper maintenance culture after purchasing such vehicle. Automobiles are consumer goods; the more they are used, the more maintenance is required, and the costs of usage continue to increase(Lee and Chung, 2013). This implies that consumers should take maintenance service into consideration when purchasing new vehicles. As important as these vehicles are in the development of any nation, they become problematic when not properly maintained. Vehicle maintenance poses a serious challenge to the owners, whether individual or corporate organization even government establishment are not left out (Ng et

al., 2012; Uma et al. 2014; Usman et al. 2012). The modern vehicle is not different from the human body in which correct fuel and lubricant must be used to ensure that the engine and other components function to their maximum capacity and reducing the risk of damage or mal-function (Agbo 2011).

1.1 Objectives

The aim of this paper is to assess the problems of our automotive industries and lapses in maintenance system and how to curb them. This paper tends to study the maintenance culture of vehicles in a developing nation by examining the challenges and maintenance approach adopted by both owner and repairer of these vehicles. This study tends to proffer solutions to vehicle maintenance challenges by finding a synergy between the vehicle owners and repairers.

2. Literature Review

Records of maintenance culture that was carried out by Eti, et a.l 2006 and Omotehinshe et al. 2015 had given an insight on the deteriorating state of government facilities such as street lights which was installed years back by past governments for the purpose of beautification and illumination in our society, but due to lack of proper maintenance culture such as fixing of minor faults and scheduled maintenance practices has turned our roads to death traps and hubs of illicit games. In the automotive industry, another major challenge is the lack of skilled vehicle repairers and high patronage of cheap labor, which are consequences of the economic meltdown often faced by developing nations. We, therefore, as agents of national development for improving the quality of vehicle maintenance in our society, need to evaluate the state of readiness and the challenges of vehicle maintenance policy in the automotive industries in developing nations, with Nigeria as a case study. It is on this note that, the paper addresses causes and effects of poor maintenance and way out of the menace in order for our country to realize her dream.

3. Methods

A logical approach is needed to analyze the data of the research which will successively lead to the research end. The data was analyzed by using both qualitative and quantitative methods which are divided into two;

3.1 Mean Item Score

The mean item score is used in this research for a 5-point Likert scale(Tijani, Adeyemi, & Omotehinshe, 2016). The index of Mean Item Score of a specific influence that contributes to the result is the sum of respondents' real scores (on the five-point scale) given by all the respondents as a fraction of the sum of all the highest conceivable scores on the five-point measure that all the respondents might give to that standard. Allowance was designated to each feedback ranging from 1 to 5 for the feedback of 'agree' to 'strongly disagree'. This is articulated mathematically below. The Mean Item Score index was calculated for each item as follows:

$$\text{MIS}= \frac{1n1+2n2+3n3+4n4+5n5}{\sum N}$$

Where; n1 = Number of respondents for 'agree';
n2 = Number of respondents for 'strongly agree';
n3 = Number of respondents for 'neutral';
n4 = Number of respondents for 'disagree';
n5 = Number of respondents for 'strongly disagree'
N = Total number of respondents
The criteria were then graded in descending order of their mean item score (from the highest to the lowest) after mathematical computations.

3.2 Factor Analysis

Factor analysis is a statistical technique for identifying which underling factors are measured by a (much larger) number of observed variables. Such underlying factors are often variables that are difficult to measure. There are two steps to factor analysis which are exploratory and confirmatory. Exploratory factor analysis is frequently used in the preliminary stages of research to assemble information about the interrelationships amongst a set of variables. Confirmatory factor analysis is an extra composite and sophisticated set of methods used later in the research procedure to confirm precise hypotheses or theories regarding the structure marking a set of variables. This section is aimed at collecting demographical information from respondents. It includes demographics such as age, gender, education, the field of study and experience. This questionnaire sent out shows that 88.9% of those who responded are males while 11.1% of those who responded are females as it is shown in Figure 1a. This implies that the automotive industry is male dominated, and exposure should be given out to females who have interest in vehicle

maintenance to facilitate the workforce and increase manpower in the industry. From the questionnaire sent out, 3.2% of respondents are from South-East region, 23.8% from the South-South, 42.9% from the South-West and 30.2% from North Central as shown in Figure 1b. This distribution denotes that a large percent of information was gotten from the South-West and North Central region, and all the regions in within the understudied country were covered to improve the reliability of this study.

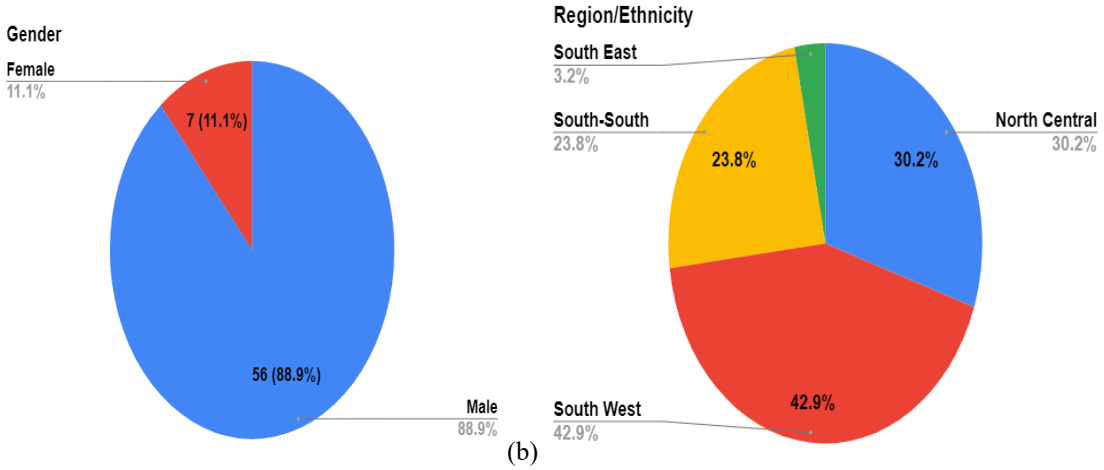


Figure 1. Distribution of sample showing, (a) Gender, (b) Ethnicity

For the age group, 12.7% of the population of the respondents are between 20-24 years (Figure 2), 12.7% between 25-29 years, 15.9% between 30-34 years, 15.9% between 35-39 years, 15.9% between 40-44 years, 15.9% between 45-49 years, 9.5% between 50-54 years and 1.6% between 55 years and above, as shown in Figure 2 (a). The age group from 30-49 years in total have high involvement in the automotive industry either ranging from vehicle owners or vehicle repairers. The younger age group should have a high involvement in this sector as they have more physical strength and this could result in a higher increase in manpower and adequate technical knowhow. The qualification of respondents with Post-Graduate degree are 6.8%, 28.8% with Bachelor's degree, 10.2% with SSCE (Senior Secondary School Certificate of Education), 22.0% with OND/HND (Ordinary National Diploma/Higher National Diploma), 10.2% with NCE (National Certificate Education), 13.6% with Primary school and 8.5% with Diploma. A huge number of respondents in the automotive industry have bachelor's degree with an adequate knowledge of basic principle of operations of vehicles and how to identify faults, and the current trends in technology.

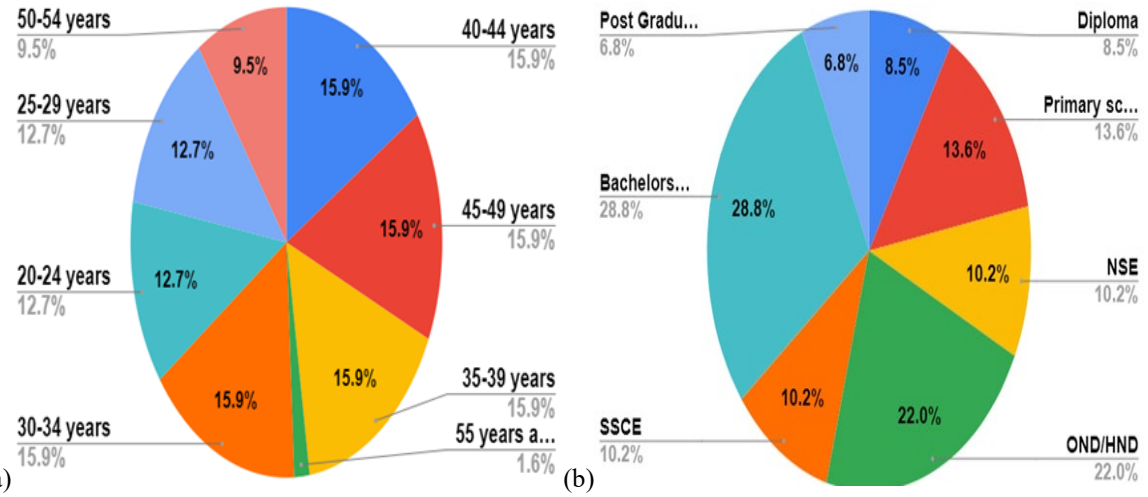
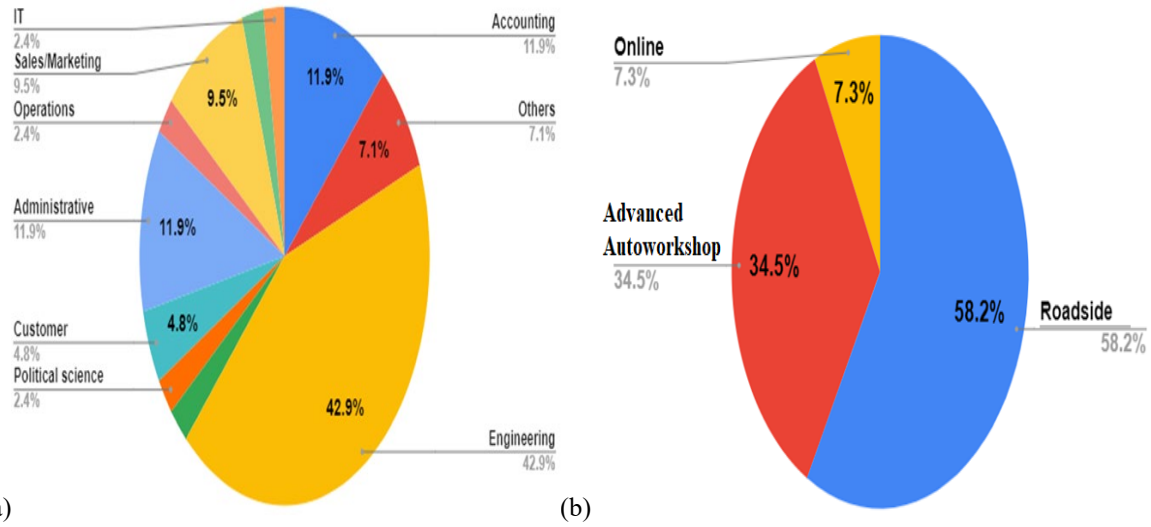


Figure 2. Sample Distribution showing (a) Age group, (b) Academic Qualification

Figure 3(a) shows the field of study of respondents. Those in Information and Technology have a population of 2.4%, Sales and Marketing 9.5%, Operations 2.4%, Administrative 11.9%, Customer 4.8%, Political science, 2.4%, Engineering 42.9%, Accounting 11.9%, and Others 7.8%. The number of respondents who study Engineering are not up to 50%, knowing that engineering plays a major role in assembling/servicing of vehicles, the readiness of the automotive industry is Nigeria is not optimum due to little knowledge on the core areas in Engineering. For the types of workshop being operation in the understudied nation, 7.3% of respondents have online workshop, while 34.5 are advanced auto workshop and 58.2% are roadside mechanics as shown in Figure 3b. A huge amount of the companies that responded are said to be roadside mechanics who probably just set up workshops with little or no advanced tools used in working. The Auto-industry needs to improve more on Advanced Auto-workshops with advanced tools and technical know-how.



(a) (b)

Figure 3. Sample distribution showing, (a) Field of Study, (b) Types of Workshop

Table 1 shows the 6 variables denoted as 'SD1', 'SD2', 'SD3', 'SD4', 'SD5', 'SD6' that are to be analyzed using Exploratory Factor Analysis.

Table 1: Definition of identified Variables

Scheduled maintenance of vehicles is important (i.e scheduled car servicing and checking of various mechanical parts)	SD1
Will good economic improve vehicle maintenance culture of both individuals and repairers?	SD2
Extortions are significant with the advanced auto-workshop compared to the road side mechanic?	SD3
Most road mechanics are try by error hence cause more damage to the vehicle than actual repair	SD4
Tokunbo parts last more than brand new parts	SD5
Bad roads are major cause of vehicle repair	SD6

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were conducted on the data to ascertain its suitability for Exploratory Factor Analysis(EFA) as shown in Table 2. KMO measure of

sampling adequacy returned a value of 0.512 which is above the prescribed value of 0.5-0.6 while Bartlett's test of sphericity returned a value of 0.016 which is below 0.5 as prescribed. From this test, it is established that EFA can be carried out on the data (table 2).

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.512
Bartlett's Test of Sphericity	Approx. Chi-Square	29.108
	Df	15
	Sig	0.016

4. Data Collection

Data was collected via questionnaires. The questionnaires were dispersed to the respondents by mail and also hard copy by physical interaction of roadside mechanics. An aggregate of one hundred and fifty (150) questionnaires sent out across the studied nation, one hundred (100) received and sixty-three (63) being usable.

5. Results and Discussion

5.1 Exploratory Factor Analysis

Table 3 shows the descriptive statistics of the responses given with SD1 having a mean of 4.63 and standard deviation of 0.655, SD2 with a mean score of 4.52 and standard deviation of 0.737, SD3 with mean of 3.54 and standard deviation of 1.378, SD4 with mean of 3.10 and standard deviation of 1.364, SD5 with mean of 3.44 and standard deviation of 1.280, SD6 with mean of 3.73 and standard deviation of 1.153. This means that more people replied to SD1, SD2, SD6, SD3, SD5 and SD4 in that order which shows the rate of importance these questions mean to the respondents and their major concerns.

Table 3: Descriptive Statistics

	Mean	**Standard Deviation**
SD1	**4.63**	**0.655**
SD2	**4.52**	**0.737**
SD3	**3.54**	**1.378**
SD4	**3.10**	**1.364**
SD5	**3.44**	**1.280**
SD6	**3.73**	**1.153**

Table 4 shows the correlation matrix for the variables. The correlation matrix revealed the presence of coefficients above 0.3 which is suitable for Exploratory Factor Analysis. Additional tests were performed on the data to confirm its suitability for factor analysis. In relation to maintenance culture, this correlation matrix shows the relationship each question has with each other, their links and their responses are well related and nothing out of context. EFA is carried out to show the factors with strong validity and reliability.

Table 4: Correlation Matrix

	SD1	SD2	SD3	SD4	SD5	SD6
SD1	1.000	0.402	0.240	-0.015	0.139	0.060
SD2	0.402	1.000	0.209	-0.275	-0.080	0.074
SD3	0.240	0.209	1.000	-0.054	0.200	-0.069
SD4	-0.015	-0.275	-0.054	1.000	0.068	0.170

SD5	0.139	-0.080	0.200	0.068	1.000	-0.114
SD6	0.060	0.074	-0.069	0.170	-0.114	1.000

From Table 5, it shows that the communalities of the variables were determined with their extraction values not less than 0.300. This indicates that all the variables fit well with other variables in their component and there is no variance in the variables. With none of them having a low extraction value, the factors SD1-SD6 can be relied upon and are important factors to be considered in the auto-industry.

Table 5. Communalities

	Initial	Extraction
SD1	1.000	0.647
SD2	1.000	0.749
SD3	1.000	0.515
SD4	1.000	0.737
SD5	1.000	0.684
SD6	1.000	0.730

Table 6 shows the eigenvalues of the variables in the data set. The Kaiser's criterion which suggests retaining factors with eigenvalues that are above 1.0 was used. Hence, three factors with eigenvalues greater than 1 were retained. The eigenvalues of the retained factors are 1.661, 1.229 and 1.174 which explains 27.687%, 20.480% and 19.561% of the variance respectively. These three clusters of factors represent 67.728% of the total variance and which highlights the importance of all 6 variables measured. The important components of the factors analysed that have a strong reliability above 1.0 are being retained and kept for further analysis to show total usefulness and validity in the automotive sector.

Table 6. Total Variance Explained

Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	1.661	27.687	27.687	1.661	29.687	27.687	1.609
2	1.229	20.480	48.167	1.229	20.480	48.167	1.269
3	1.174	19.561	67.728	1.174	19.561	67.728	1.207
4	0.740	12.338	80.066				
5	0.712	11.860	91.925				
6	0.484	8.075	100.000				

Figure 4 shows the scree plot for the data set which highlights the eigenvalues for all the 6 variables analysed. The scree plot shows that three factors are above 1 on the eigenvalue axis which are the important factors considered in the automobile industry according to analysis done on the response rate of the questions asked. Further inspection of the scree plot reveals the last significant break on the plot was on the third factor which confirms the extraction of three factors. The steeper portion of the slope shows the large factors while the gradual trailing off shows the rest of the factors that have an eigenvalue lower than 1.

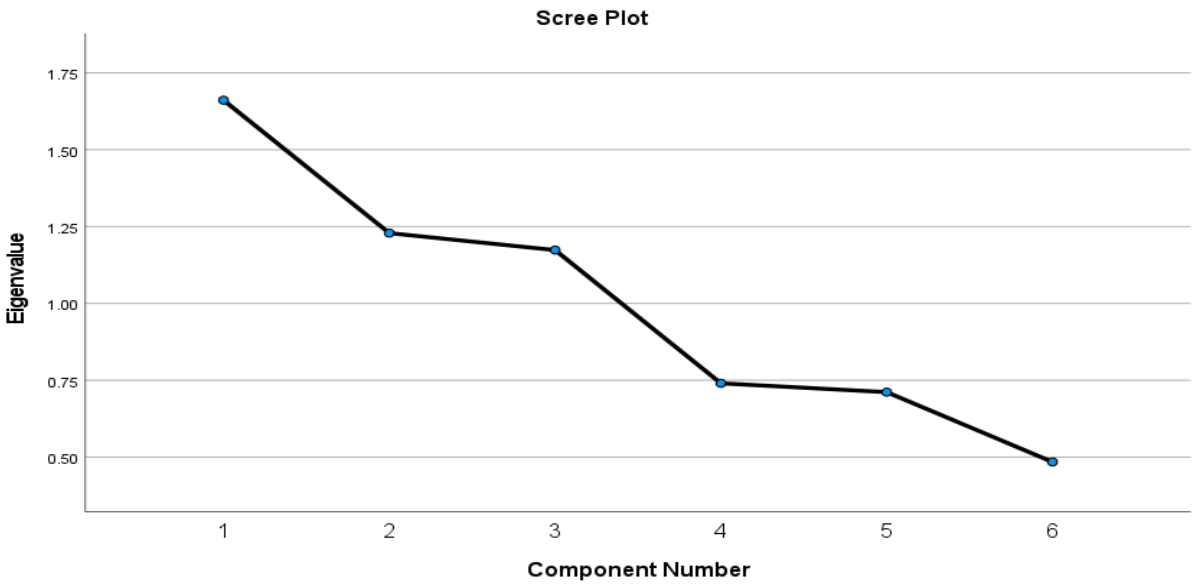


Figure 4. Scree Plot

Table 7 shows the un-rotated loading of each of the items on the three components, using the Kaiser criterion i.e retaining all components with eigen values above 1. It is shown that most items loaded strongly (above 0.4) on the first component and very few loading on components 2 and 3.

Table 1. Component Matrix

	Component		
	1	2	3
SD2	0.759	-0.415	
SD1	0.731		0.334
SD3	0.605	0.386	
SD5		0.798	
SD6		-0.361	0.773
SD4	-0.370	0.372	0.680

Table 8 shows the items loading on the three factors with three items loading above 0.3 on component 1, three items loading on component 2 and two items loading on component 3. This solution is said to be optimal because two components has at least three items loading. This rotation is done using Oblimin method of rotation. This rotation shows that SD2,SD1 and SD5 still retain a strong validity after being rotated to find out which factors are still more important, valid and reliable.

Table 4.2. Pattern Matrix

	Component		
	1	2	3
SD2	0.831		
SD1	0.747		
SD5		0.828	
SD3	0.444	0.532	
SD4			0.762
SD6		-0.350	0.747

Structure matrix in Table 9 provides information about the correlation between variables and factors still using Oblimin method of rotation on three factor solution. The structure matrix further proves the importance of the factors SD2, SD1 and SD5 on this EFA.

Table 3. Structure Matrix

	Component		
	1	2	3
SD2	0.829		
SD1	0.749		
SD5		0.826	
SD3	0.472	0.553	
SD4			0.773
SD6		-0.344	0.736

Table 10 shows the correlation matrix between the components that have been rotated using Oblimin method of rotation after obtaining pattern matrix, structure matrix and component matrix. It shows that in our automotive industry, these components relates so well with each other and have a common relationship, you cannot tackle one problem disregarding the other problem and it shows these are issues still underlying in the automotive industry.

Table 4. Component Correlation Matrix

Component	1	2	3
1	1.000	0.044	-0.049
2	0.044	1.000	-0.009
3	-0.049	-0.009	1.000

5.2 Economic Effects on Automotive Industry

From the results of the EFA, it should be noted that in Maintenance Culture in Automotive Industry in a developing nation, the factors 'SD2' which denotes the question 'Will good economy improve vehicle maintenance culture of both individual and repairers?', SD1 which denotes 'Scheduled maintenance of vehicles is important(i.e scheduled car servicing and checking of various mechanical parts)' and SD3 which denotes 'Extortions are significant with the advanced auto-workshop compared to the road side mechanics?' are factors that are interrelated, valid and reliable to always checkmate while dealing with automobiles because they have been tested using SPSS (Statistical Package for Social Sciences). Also, the response rate of those that believed economic factor affects the automotive industry are 89.7% against 10.3 that disagreed. This must have been a result of the poor economy with a minimum wage of 30,000, most people can barely afford brand new cars and even foreign used, some can manage locally used cars and they do not have the financial capability of maintaining a car frequently. This is a setback in the automobile industry and government can encourage locally made assembly and spare parts manufacturing plants to reduce cost of vehicles and vehicle parts for an average citizen.

6. Conclusion

The maintenance culture of the automotive industry in a developing nation in Africa has been studied, the challenges, state of readiness and the economic effects have been investigated so as to proffer a possible solution. From the research methodology and the Exploratory Factor analysis carried out in this study, it is concluded that government should set up a training institution for the automobile sector to train and recruit service personnel's who will head start assembly plants that would be revived in future. Also, the government should reduce the importation of foreign vehicles into the country as most of these vehicles do come with faults that can cause damage to the user and the vehicle itself. Furthermore, scheduled maintenance should be carried out frequently on a vehicle, while the use of try by error technique should be reduced because most times it creates more problems to the existing ones, as a result, service personnel's should encouraged to use diagnosing tool/machines to ease means of fault identification for more accuracy. Additionally, the government should revive and encourage assembly plants within the country for local car manufacturer and great reduction in the importation of vehicles and its parts. Lastly, Government should establish a policy that regulates the price/charges of spare parts, and a policy to regulate the minimum entry requirement to this Industry.

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