Data Mining and Statistical Analysis for Available Budget Allocation Pre-procurement of Manufacturing Equipment

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ABSTRACT

In a situation where a decision maker faces problems of allotting the available budget on the strategic decisions in a manufacturing industry, data information plays an important role to maintain long run profit in the industry. Statistical analysis was incorporated to determine the correlational strength between the number of years and each of the strategic decisions, their confidence level, and the predicted values. This study identified the strategic areas of addressing the issues which are machine (A_1), accessory (B_1), spare part (C_1) and miscellaneous (D_1), exploring the hidden data of the selected strategic decisions from International Brewery Plc, Ilesha and statistical analysis between the number of years and each of the selected strategic decisions. The model used in this work is simple linear regression while Statistical Analysis Software "SAS" was used for its applications. After exploring the hidden data from a case study, the suggested cost of procurement for machines, accessories, spare-parts and miscellaneous are: ₦119,975,000.00; ₦127,968,000.00; ₦134,965,000.00 and ₦33,491,500.00 respectively. From appendix, the probability of each of the strategic decision is less than 0.05 which implies that the Null-Hypothesis is rejected. The number of years has significant effect on Machines, Accessories, Spare-parts and Miscellaneous. As the number of years increases, the cost of procurement of the strategic decisions increases due to high rate of demand and

consumption of their products. However, the cost of procurement may fall depending on the level of demand and maintenance culture. Besides, management of the company may ask decision maker to maintain the cost before procurement. This result may be used for further research on optimization of the available budget for equipment procurement.

Keywords: Data mining; statistical analysis; pre-procurement; budget allocation; manufacturing equipment.

1. INTRODUCTION

Allocation of limited available budget on the strategic decisions has been a major problem in industry. However, information plays an important role to maintain long run profit in the industry. Thus, data Mining (DM) and Statistics are the two disciplines which are commonly used in data analysis and knowledge extraction. Though Statistics is a traditional branch that has evolved from applied Mathematics while Data Mining is a multidisciplinary branch that has evolved from computer science, but both are used for the same purpose [1]. The growth of data mining has been massive in past decade. Its application has increased with the increase of data generation as more and more data being captured through various means of Information Technology like internet. There is a growing research in the area of databases with the help of data mining. Since data mining can be used in advance data research analysis and is capable of extracting valuable knowledge from large data sets [2].

It has emerged as a new scientific and engineering discipline to meet such requirements. Data Mining is commonly quoted as “solving problems by analysing data that already exists in databases”. In addition to the mining of structured and numeric data stored in data warehouses, more and more interest is now being experienced in the mining of unstructured and non-numeric data such as text and web in recent times [3].

DM is a combination of computational and statistical techniques to perform exploratory data analysis (EDA) on rather large and mostly not very well cleaned data sets (or data bases). In recent times, the issue of capturing data is not considered to be a major issue but since a huge amount of data does not convey any information, screening of useful and non-useful data has become a major challenge. Most modern problems can electronically deal with the cumulative data from many years ago [4]. This leads to a requirement for training the data miners in statistics or statistics graduates in data mining [5].

1.1 Major goals of data mining

There are different goals of data mining method for statistical analysis, but [6] identified the two types as follows:

a. Verification of user's hypothesis

b. Discovery of new patterns that can be used for *prediction* and *description*

Data mining methods seek to discover unexpected and interesting regularities, called patterns, in presented data sets. Statistical significance testing also called as Hypothesis testing can be applied in these scenarios to select the surprising patterns that do not appear as clearly in random data. As each pattern is tested for significance, a set of statistical hypotheses are considered simultaneously. The multiple comparisons of several hypotheses simultaneously are often used in Data Mining [7].

[8] added that prediction involves using some variables or fields in the database to forecast unknown or future values of other variables of interest. Description focuses on finding human-interpretable patterns describing the data.

Various complexities in the stored data (data interrelations) have limited the use of Verification–Driven Data Mining in decision-making. It must be complemented with the discovery-driven data mining. Furthermore, in the context of Data Mining, description tends to be more important than prediction. This is contrast to pattern recognition and machine learning applications where prediction is often the primary goal [9]; [10].

[11] defined Statistics in different ways but the most suitable for this work is as illustrated below:

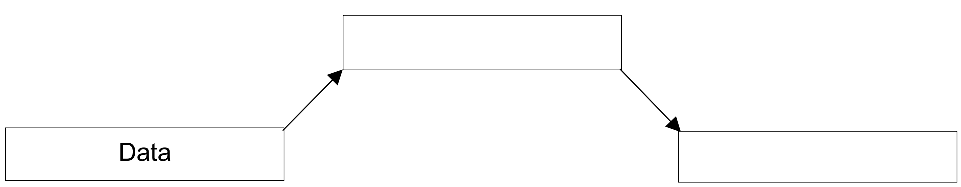

Figure 1: Analysis of Information through Data [11].

Data: Facts, especially numerical facts, collected together for reference or information [11]; [12].

Statistics: Knowledge communicated concerning some particular facts. Statistics is a way to get information from data. It is a tool for creating an understanding from a set of numbers [11]; [13].

1.2 Major Approaches in Statistics

Table 1: Major Approaches for Solving Statistical Problems.

S/No.	Statistics Technique	Description
1	Descriptive Statistics	Central Tendency Dispersion Shape (Graphical Display)
2	Regression -Linear -Logistic -Non linear	-Prediction -Modelling -Association
3	Correlation Analysis -Pearson correlation -Spearman correlation	
4	Probability Theory -Marginal -Union -Joint -Conditional	Prediction of the behaviour of the system defined
5	Probability Distribution -Discrete Probability Distribution -Continuous Probability Distribution	
6	Bayesian Classification	Bayes' Theorem and Naïve Bayesian classification
7	Estimation Theory	-Model Selection -Estimating Confidence

		interval and significance level -ROC Curves
8	Analysis of Variance (ANOVA)	Test equality of more than two groups mean
9	Factor Analysis (FA)	Reduction of large no. of variables into some general ones, also known as Data reduction Technique
10	Discriminate Analysis	Predict a categorical response variable
11	Time series analysis -Moving Average Method -Exponential smoothing -Auto regression method	Forecasting trends and seasonality
12	Quality Control Charts -Attributes Charts -Variable charts	Display the spread of individual observation with reference to mean
13	Principal Component Analysis	Data Reduction
14	Canonical Correlation Analysis	
15	Cluster Analysis -Hierarchal -Non Hierarchal	
16	Sampling -Random Sampling -Non Random Sampling	

Source: [14].

A decision maker needs to be aware of the limited available resources. However, in order to minimize shortages, the past procurement records must be critically analysed to prevent unforeseeable occurrences. Hence, the development of the model on machines cost, accessories cost, spare parts cost and miscellaneous cost. The study would help to determine the cost of purchase of any selected strategic decisions beforehand and create a room for adjustment due to flexibility of the developed model and software. The study proposed to use Statistical Analysis Software (SAS) to analyse the extracted data of the key strategic decisions used in International Brewery Plc, Ilesha, Nigeria, and determine the level of confidence, error terms and to predict the cost of parameters (i.e. machines cost. accessories cost, spare parts cost and miscellaneous cost) with the available budget allocation before procurement.

2. METHODOLOGY

In order to analyse the extracted data for pre-procurement of manufacturing equipment, the International Brewery Plc, Ilesha was visited to explore past procurement records. These are the following steps taken:

i. Identification of the equipment procurement such as machines cost, accessories cost, spare parts cost and miscellaneous cost.

ii. Historical data from a case study International Brewery Plc, Ilesha, Nigeria to determine the correlational strength between the number of years and each of the strategic decisions, their confidence interval, and to predict the cost for each parameter.

iii. Modified adopted models for prediction of the cost of purchase of each strategic decision.

iv. Determination of the hypothesis of (iii) above.

2.1 Strategic Decisions for Model Development

In this study for proper analysis, four strategic decisions were identified for pre-procurement of manufacturing equipment. They are:

a) **Machine (A):** A machine is a tool that consists of one or more parts, and uses energy to meet a particular goal e.g. labeller, washer, filler, pasteurizer etc.

b) **Accessories (B):** An accessory aids the performance of a machine e.g. beer spoon, beer paddle, beer siphon etc.

c) **Spare parts (C):** Spare part is an interchangeable part that is kept in an inventory and used for the repair or replacement of failed parts e.g. hose tail, cask racking spear, female equal tee etc.

d) **Miscellaneous (D):** Other costs not planned for but can still occur.

2.2 Statistical Analysis of the Data

2.2.1 Simple Linear Regression Analysis from Data Set

The models below explain the simple linear regression of the relationship between the number of years of procurement and each of the strategic decisions (i.e. machine, accessory, spare-part and miscellaneous).

[15] expressed the general form of a simple linear regression analysis as:

$\hat{y} = \beta_0 + \beta_1 x + e_t$ … 2.1

Where:

$\hat{y}$ is the predicted value for machine, accessory, spare-part and miscellaneous.

x is the independent variable (i.e. number of years)

β_0 is the intercept of the regression

β_1 is the slope

e_t is error term or residual

Where:

$\beta_0 = \frac{\sum y - m(\sum x)}{n}$ … 2.2

$\beta_1 = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$ … 2.3

2.2.2 Correlational Strength between the Number of Years of Procurement and the Strategic Decisions

[16] made known that, in calculating a correlation coefficient, three different sums of squares (SS) are needed. The sum of squares for variable X, the sum of square for variable Y and the sum of the cross-product of XY.

The sum of squares for variable X is:

$SS_{XX} = \sum (x_i - \bar{x})^2$ … 2.4

Where:

SS_{XX} is the sum of squares for variables X

$\bar{x}$ is the average value of X

x_i denotes data point

The sum of squares for variable Y is:

$SS_{YY} = \sum(y_i - \bar{y})^2$ … 2.5

The sum of the cross-products (SS_{XY}) is:

$SS_{XY} = \sum(x_i - \bar{x})(y_i - \bar{y})$ … 2.6

Therefore, Pearson's correlation coefficient is given by:

$r = \frac{SS_{XY}}{\sqrt{(SS_{XX})(SS_{YY})}}$ … 2.7

[15] added that coefficient of determination established a relationship between two variables which determines their best of fits:

$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}}$ … 2.8

2.2.3 Rule of Thumb

To test the hypothesis, let the null hypothesis represents $\mu_1 = \mu_0$ which means that there is no significant

difference and alternate hypothesis represents $\mu_1 \neq \mu_0$ shows that there is significant difference between the number of years and each of the strategic decisions. If probability $P_r \leq 0.05$, "reject null hypothesis".

The hypothesis can be tested with a t-statistic:

$t_{stat} = \frac{r}{se_r}$ … 2.9

Where:

se_r represents the standard error of the correlation coefficient.

$se_r = \sqrt{\frac{1-r^2}{n-2}}$ … 2.10

[16] stated that under null hypothesis, t-statistics has $n-2$ degrees of freedom but test results are converted to P_r before conclusions are drawn.

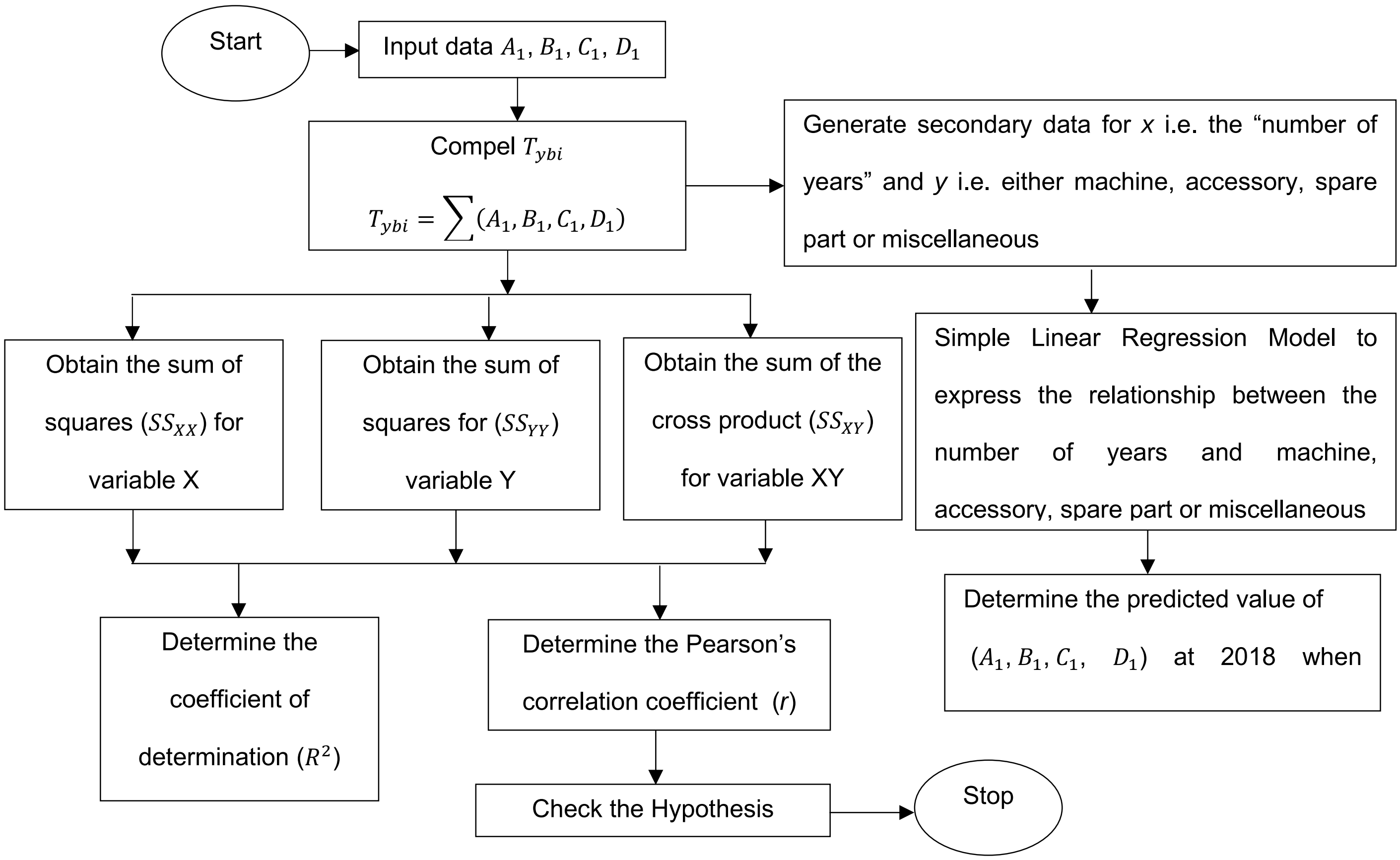

Fig. 2: Flowchart for Statistical Models Developed

Table 2: Available Data from International Brewery, Ilesha Nigeria

Date	**Number of Years**	**Machine (A_1)**	**Accessory (B_1)**	**Spare parts (C_1)**	**Miscellaneous (D_1)**	**TOTAL**
1971	1	2,000,000	1,000,000	1,700,000	500,000	5,200,000
1978	8	2,500,000	1,500,000	2,000,000	600,000	6,600,000
1980	10	2,600,000	1,600,000	2,100,000	650,000	6,950,000
1981	11	2,600,000	1,600,000	2,100,000	650,000	6,950,000
1982	12	2,600,000	1,600,000	2,100,000	650,000	6,950,000
1983	13	2,600,000	1,600,000	2,100,000	650,000	6,950,000

1985	15	2,650,000	1,700,000	2,300,000	1,000,000	7,650,000
1986	16	2,650,000	1,700,000	2,300,000	1,000,000	7,650,000
1988	18	3,000,000	5,500,000	8,000,000	2,000,000	18,500,000
1989	19	3,000,000	5,500,000	8,000,000	2,000,000	18,500,000
1991	21	5,500,000	6,000,000	10,000,000	2,500,000	24,000,000
1992	22	5,500,000	6,000,000	10,000,000	2,500,000	24,000,000
1993	23	7,300,000	6,500,000	10,500,000	3,000,000	27,300,000
1994	24	32,200,000	40,000,000	45,000,000	10,000,000	127,200,000
1995	25	32,200,000	40,000,000	45,000,000	10,000,000	127,200,000
1996	26	32,200,000	40,000,000	45,000,000	10,000,000	127,200,000
1997	27	32,200,000	40,000,000	45,000,000	10,000,000	127,200,000
1998	28	32,200,000	40,000,000	45,000,000	10,000,000	127,200,000
2001	31	42,000,000	45,500,000	50,550,000	10,500,000	148,550,000
2002	32	42,000,000	45,500,000	50,550,000	10,500,000	148,550,000
2007	37	82,000,000	85,000,000	95,000,000	20,000,000	282,000,000
2008	38	82,000,000	85,000,000	95,000,000	20,000,000	282,000,000
2009	39	82,000,000	85,000,000	95,000,000	20,000,000	282,000,000
2013	43	95,000,000	96,000,000	100,000,000	25,000,000	316,000,000
2014	44	95,000,000	96,000,000	100,000,000	25,000,000	316,000,000
2017	47	120,000,000	128,000,000	135,000,000	33,500,000	416,500,000

TOTAL	**845,500,000**	**907,800,000**	**1,009,300,000**	**232,200,000**	**2,994,800,000**

Source: International Brewery Plc, Ilesha, 2017

3.0 RESULTS and DISCUSSION

3.1 Application of Simple Linear Regression Model between the Number of Years and the Strategic Decisions

In order to predict or forecast the costs of procurement of machines, accessories, spare parts and miscellaneous for the year 2018, the method below suggests the amount to be spent for each of them before procuring them:

3.1.1 Predicted Value for Machines

Machine= $\beta_0 + \beta_1$(Number of years)

Machine = 119,975,000.00

Standard Error:

$se_r = \sqrt{\frac{1-r^2}{n-2}}$

$se_r =$ 11,171,425

95% Confidence Limits

95% C.I. = predicted $\pm$ S.E (2.064)

Upper bound = 141,870,591.60

Lower bound = 98,079,408.40

To determine how well the model fits the data: variables machine and number of years:

$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}}$ = 0.8589

3.1.2 Predicted Value for Accessories

Accessories = $\beta_0 + \beta_1$(Number of years)

Accessories = 127,968,000.00

Standard Error:

$se_r = \sqrt{\frac{1-r^2}{n-2}}$

$se_r =$ 12,446,682

95% Confidence Limits

95% C.I. = predicted $\pm$ S.E (2.064)

Upper bound = 152,363,049.30

Lower bound = 103,572,950.70

To determine how well the model fits the data: variables accessory and number of years:

$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}} = 0.8716$

3.1.3 Predicted Value for Spare-parts

Spare-parts = $\beta_0 + \beta_1$(Number of years)

Spare-parts = 134,965,000.00

Standard Error:

$se_r = \sqrt{\frac{1-r^2}{n-2}}$

se_r = 13,392,197

95% Confidence Limits

95% C.I. = predicted $\pm$ S.E (2.064)

Upper bound = 161,213,224.30

Lower bound = 108,716,775.70

To determine how well the model fits the data: variables spare-part and number of years:

$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}} = 0.8808$

3.1.4 Predicted Value for Miscellaneous

Miscellaneous = $\beta_0 + \beta_1$(Number of years)

Miscellaneous = 33,491,500.00

Standard Error:

$se_r = \sqrt{\frac{1-r^2}{n-2}}$

se_r = 3,087,991.40

95% Confidence Limits

95% C.I. = predicted $\pm$ S.E (2.064)

Upper bound = 39,543,851.93

Lower bound = 27,439,148.06

To determine how well the model fits the data: variables miscellaneous and number of years:

$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}} = 0.8727$

After exploring the hidden data from a case study, the suggested cost of procurement for machines, accessories, spare-parts and miscellaneous are: ₦119,975,000.00; ₦127,968,000.00; ₦134,965,000.00 and ₦33,491,500.00 respectively. From the appendix table A2, B2, C2 and D2, the probability of each of the strategic decision is less than 0.05 which means that the Null-Hypothesis has to be rejected. The coefficient of determination between the number of years and each of the strategic decisions has strong correlations and 95% C.I. (confidence interval) means that the amount proposed for budgeting is within the range of upper bound and lower bound which implies that the amount sets cannot exceed the upper bound but falling under the limit is good while the amount sets for lower bound cannot fall under but exceeding the limit is fine. The amount predicted is within the range of the upper and lower bound.

4. CONCLUSION and RECOMMENDATION

4.1 Conclusion

The model used in this work was simple linear regression while Statistical Analysis Software "SAS" was used for its applications. Having explored the data or past equipment procurement records, this study helped to determine the cost of purchase of each strategic decisions and create a room for adjustment due to flexibility of the developed model and software. The result may be used for further research work on optimization of the available budget for equipment procurement. The number of years has significant effect on Machines, Accessories, Spare-parts and Miscellaneous. As the number of years increases, the cost of procurement of those strategic decisions increases due to high rate of demand and consumption of their products. However, the cost of procurement may fall depending on the level of demand and maintenance culture. Besides, management of the company may ask decision maker to maintain the cost before procurement, this would help the decision maker with data exploration to know exactly the amount before procurement.

4.2 Recommendation

As it is stated, data mining is the extraction of hidden information in the company. This study made use of old records for pre-procurement of the manufacturing equipment (such as machine, accessory, spare-part and miscellaneous) for available budget allocation which will subsequently be used for budgeting with the limited available budget. Therefore, this work is recommended that the procedures developed with the software "SAS" be used for budgeting, to determine the cost of procurement beforehand with the use of past procurement data and the limited available budget. This would further assist decision maker to forecast the amount to be spent on them using another tools.

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Appendices

Table A

Pearson Correlation Coefficients, N = 26 Prob > |r| under H0: Rho=0					
	years	**Machine**	**Accessory**	**Spare_Part**	**Miscellaneous**
years	1.00000	0.92678 <.0001	0.93359 <.0001	0.93849 <.0001	0.93421 <.0001
Machine	0.92678 <.0001	1.00000	0.99682 <.0001	0.99450 <.0001	0.99454 <.0001
Accessory	0.93359 <.0001	0.99682 <.0001	1.00000	0.99894 <.0001	0.99681 <.0001
Spare_Part	0.93849 <.0001	0.99450 <.0001	0.99894 <.0001	1.00000	0.99366 <.0001
Miscellaneous	0.93421 <.0001	0.99454 <.0001	0.99681 <.0001	0.99366 <.0001	1.00000

The SAS System

The REG Procedure

Model: MODEL1

Dependent Variable: Machine

Table A1

Number of Observations Read	26
Number of Observations Used	26

Table A2

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	2.922218E16	2.922218E16	146.11	<.0001

Error	24	4.800132E15	2.000055E14		
Corrected Total	25	3.402232E16			

Table A3

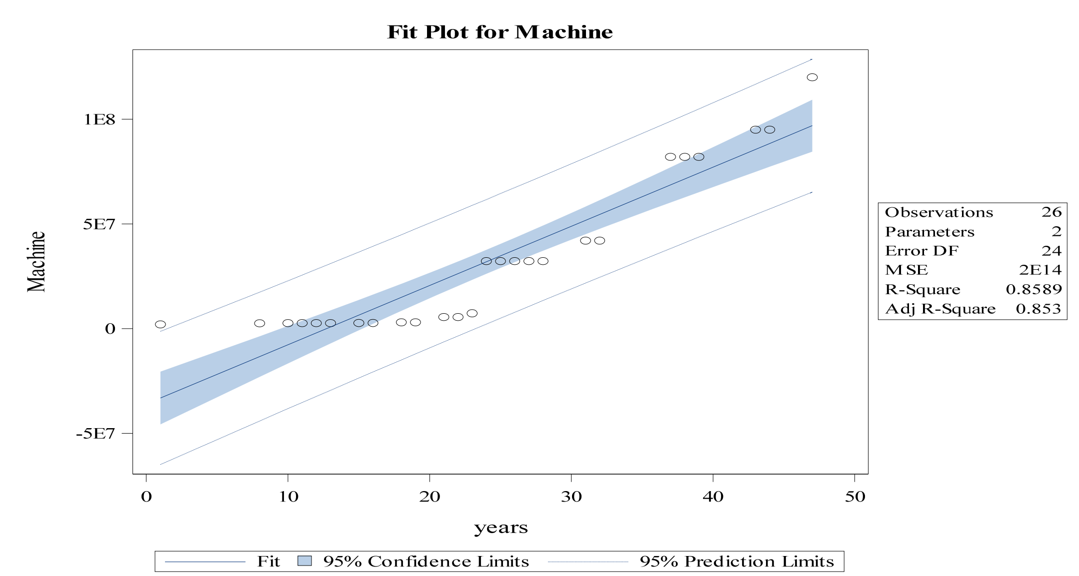
Root MSE	14142330	**R-Square**	0.8589
Dependent Mean	32519231	**Adj R-Sq**	0.8530
Coeff Var	43.48913		

Table A4

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-35979715	6309256	-5.70	<.0001
years	1	2826941	233874	12.09	<.0001

Table A5

Forecasts for Variable Machine					
Obs	**Time**	**Forecasts**	**Standard Error**	**95% Confidence Limits**	
48	**2018**	119975000.0	11171425	98079408.4	141870591.6
49	**2019**	119975000.0	15790884	89025436.0	150924563.9
50	**2020**	119975000.0	19336579	82076001.5	157873998.5



The SAS System

The REG Procedure

Model: MODEL1

Dependent Variable: Accessory

Table B1

Number of Observations Read	26
Number of Observations Used	26

Table B2

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	3.236141E16	3.236141E16	162.90	<.0001
Error	24	4.767925E15	1.986635E14		
Corrected Total	25	3.712933E16			

Table B3

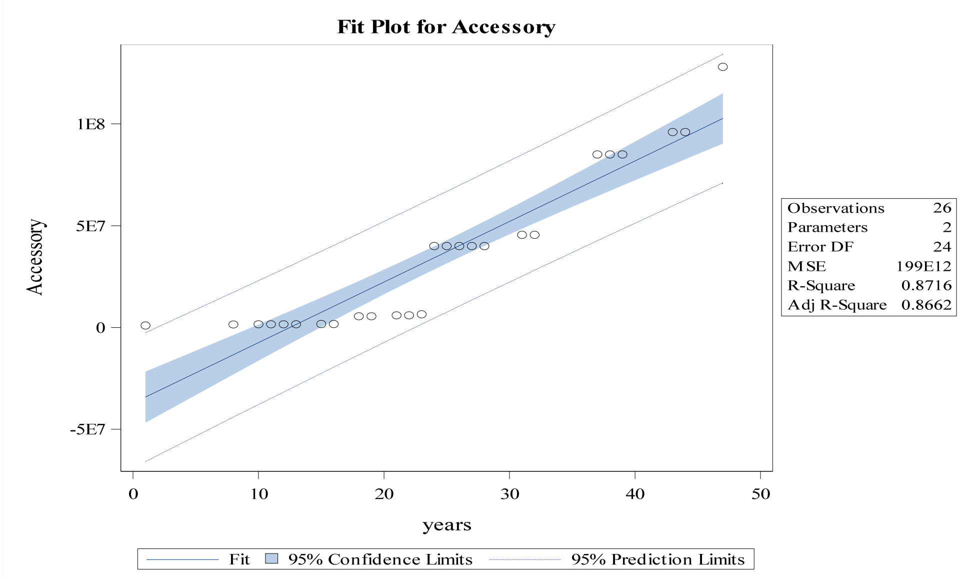
Root MSE	14094805	**R-Square**	0.8716
Dependent Mean	34915385	**Adj R-Sq**	0.8662
Coeff Var	40.36847		

Table B4

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-37169013	6288054	-5.91	<.0001
years	1	2974912	233088	12.76	<.0001

Table B5

Forecasts for Variable Accessory					
Obs	**Time**	**Forecasts**	**Standard Error**	**95% Confidence Limits**	
48	**2018**	127968000.0	12446682	103572950.7	152363049.3
49	**2019**	127968000.0	17593468	93485436.0	162450564.0
50	**2020**	127968000.0	21543917	85742699.4	170193300.6



The SAS System

The REG Procedure

Model: MODEL1

Dependent Variable: Spare-part

Table C1

Number of Observations Read	26
Number of Observations Used	26

Table C2

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	3.684116E16	3.684116E16	177.28	<.0001
Error	24	4.987551E15	2.078146E14		
Corrected Total	25	4.182872E16			

Table C3

Root MSE	14415777	**R-Square**	0.8808
Dependent Mean	38819231	**Adj R-Sq**	0.8758
Coeff Var	37.13566		

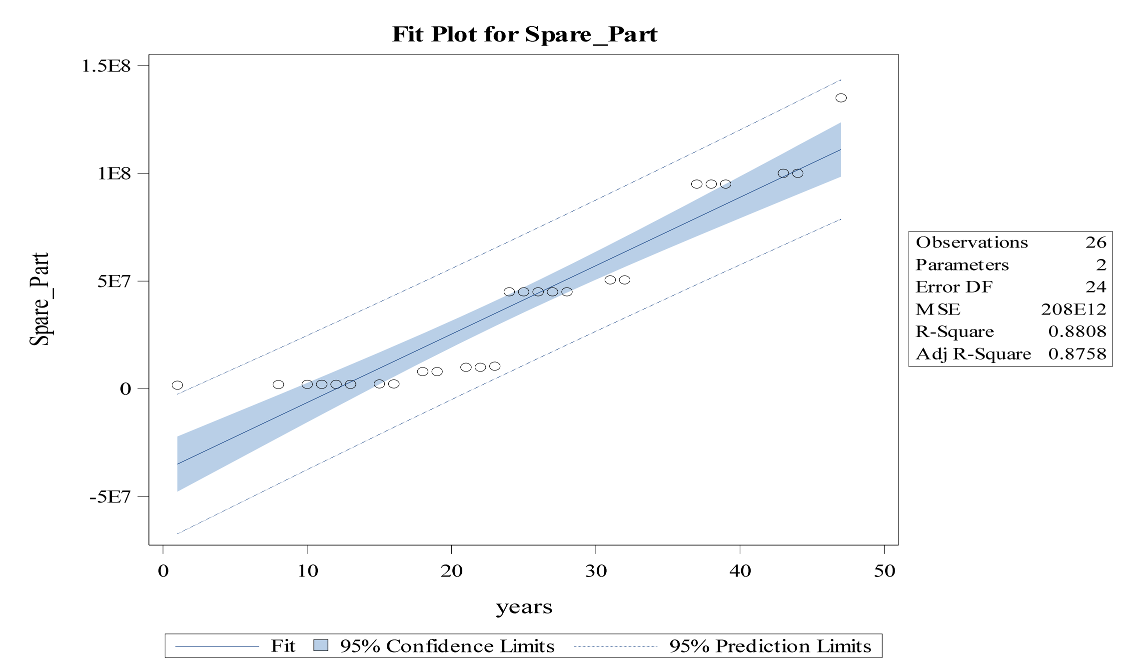
Table C4

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**

Intercept	1	-38092792	6431248	-5.92	<.0001
years	1	3174147	238396	13.31	<.0001

Table C5

Forecasts for Variable Spare_Part					
Obs	**Time**	**Forecasts**	**Standard Error**	**95% Confidence Limits**	
48	**2018**	134965000.0	13392197	108716775.7	161213224.3
49	**2019**	134965000.0	18929960	97862960.8	172067039.2
50	**2020**	134965000.0	23180505	89532045.7	180397954.3



The SAS System

The REG Procedure

Model: MODEL1

Dependent Variable: Miscellaneous

Table D1

Number of Observations Read	26
Number of Observations Used	26

Table D2

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.966149E15	1.966149E15	164.60	<.0001
Error	24	2.86676E14	1.194483E13		
Corrected Total	25	2.252825E15			

Table D3

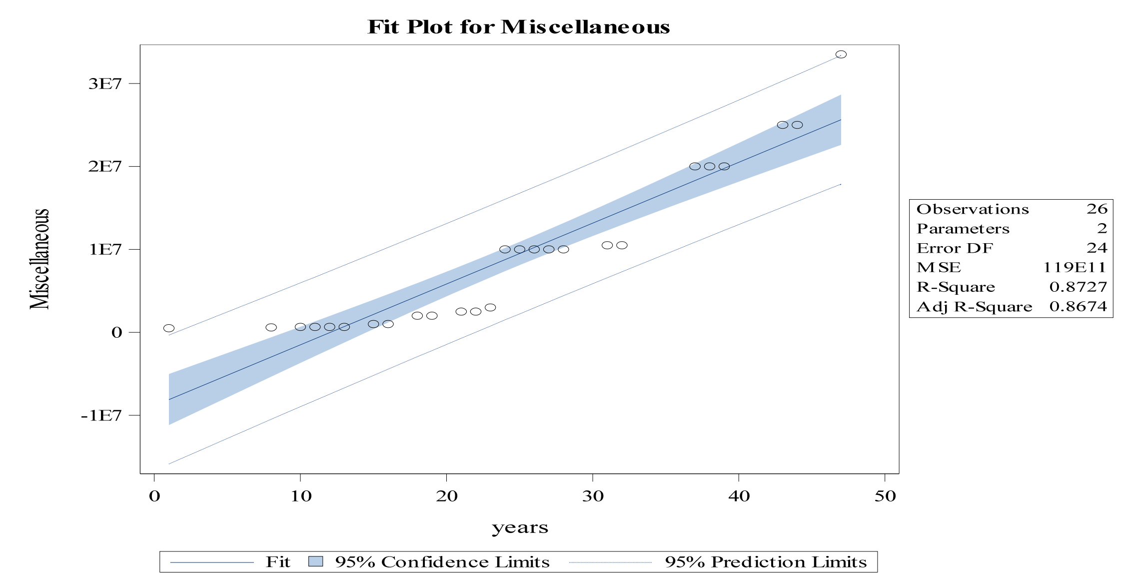
Root MSE	3456130	**R-Square**	0.8727
Dependent Mean	8930769	**Adj R-Sq**	0.8674
Coeff Var	38.69913		

Table D4

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-8837119	1541868	-5.73	<.0001
years	1	733278	57154	12.83	<.0001

Table D5

Forecasts for Variable Miscellaneous					
Obs	Time	Forecasts	Standard Error	95% Confidence Limits	
48	**2018**	33491500.00	3087991.4	27439148.06	39543851.93
49	**2019**	33491500.00	4364896.3	24936460.39	42046539.60
50	**2020**	33491500.00	5344992.9	23015506.42	43967493.57


Fit Plot for Miscellaneous
3E7
2E7
1E7
0
-1E7
Miscellaneous
0
10
20
30
40
50
years
Observations 26
Parameters 2
Error DF 24
MSE 119E11
R-Square 0.8727
Adj R-Square 0.8674
Fit
95% Confidence Limits
95% Prediction Limits