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

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Authors’ contributions

This work was carried out in collaboration among all authors. Author OOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BOA and PKF managed the analyses of the study. Author PKF managed the literature searches. All authors read and approved the final manuscript.

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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].

Jure Leskovec [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].

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

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

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

![Fig. 1. Analysis of information through data [11]](image)

#### Table 1. Major approaches for solving statistical problems

| S/No. | Statistics Technique                  | Description                                      |
|-------|--------------------------------------|--------------------------------------------------|
| 1     | Descriptive Statistics               | Central Tendency                                 |
|       |                                      | Dispersion                                       |
|       |                                      | Shape (Graphical Display)                        |
| 2     | Regression                           | Prediction                                       |
|       | -Linear                              | -Modelling                                       |
|       | -Logistic                            | -Association                                     |
|       | -Non linear                          |                                                  |
| 3     | Correlation Analysis                 |                                                  |
|       | -Pearson correlation                 |                                                  |
|       | -Spearman correlation                |                                                  |
| 4     | Probability Theory                   | Prediction of the behaviour of the system defined |
|       | -Marginal                            |                                                  |
|       | -Union                               |                                                  |
|       | -Joint                               |                                                  |
|       | -Conditional                         |                                                  |
| 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       |
| S/No. | Statistics Technique                      | Description                                           |
|-------|------------------------------------------|-------------------------------------------------------|
| 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                     | Forecasting trends and seasonality                     |
|       | - Moving Average Method                  |                                                       |
|       | - Exponential smoothing                  |                                                       |
|       | - Auto regression method                 |                                                       |
| 12    | Quality Control Charts                   | Display the spread of individual observation with reference to mean |
|       | - Attributes Charts                      |                                                       |
|       | - Variable charts                        |                                                       |
| 13    | Principal Component Analysis             |                                                       |
| 14    | Canonical Correlation Analysis           |                                                       |
| 15    | Cluster Analysis                         | Data Reduction                                        |
|       | - Hierarchal                             |                                                       |
|       | - Non Hierarchal                         |                                                       |
| 16    | Sampling                                 |                                                       |
|       | - Random Sampling                        |                                                       |
|       | - Non Random Sampling                    |                                                       |

Source: [14].

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.

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).

Shen et al. [15] expressed the general form of a simple linear regression analysis as:

\[ \hat{y} = \beta_0 + \beta_1 x + \epsilon_t \]  

(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)
\( \beta_0 \) is the intercept of the regression
\( \beta_1 \) is the slope
\( \epsilon_t \) is error term or residual

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)

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

\[ R^2 = \frac{SS_{XY}}{SS_{XX}SS_{YY}} \]  

(2.8)

Fig. 2. Flowchart for statistical models developed
Hypothesis, t-Test

Witten and Frank [16] stated that under null hypothesis, t-statistic has \( n - 2 \) degrees of freedom but test results are converted to \( P_t \) before conclusions are drawn.

3. 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

\[
\text{Machine} = \beta_0 + \beta_1 (\text{Number of years})
\]

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 ± 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:

\[ R^2 = \frac{s^2_{xy}}{s^2_{yy}} = 0.8589 \]

3.1.2 Predicted value for accessories
Accessories = \( \beta_0 + \beta_1 \) (Number of years)
Accessories = 127,968,000.00

Standard Error:

\[ se_r = \frac{1-r^2}{n-2} \]

se_r = 12,446,682

95% Confidence Limits
95% C.I. = predicted ± 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:

\[ R^2 = \frac{s^2_{xy}}{s^2_{yy}} = 0.8716 \]

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:

\[ se_r = \frac{1-r^2}{n-2} \]

se_r = 13,392,197

95% Confidence Limits
95% C.I. = predicted ± 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:

\[ R^2 = \frac{s^2_{xy}}{s^2_{yy}} = 0.8808 \]

3.1.4 Predicted value for miscellaneous
Miscellaneous = \( \beta_0 + \beta_1 \) (Number of years)
Miscellaneous = 33,491,500.00

Standard Error:

\[ se_r = \frac{1-r^2}{n-2} \]

se_r = 3,087,991.40

95% Confidence Limits
95% C.I. = predicted ± 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:

\[ R^2 = \frac{s^2_{xy}}{s^2_{yy}} = 0.8727 \]

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 flexiblity 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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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          | 1.0000 | 0.92678       | 0.93359       | 0.93849       | 0.93421       |
| Machine        | 0.9268 | 1.00000       | 0.99682       | 0.99450       | 0.99454       |
| Accessory      | 0.9336 | 0.99682       | 1.00000       | 0.99894       | 0.99681       |
| Spare_Part     | 0.9385 | 0.99450       | 0.99894       | 1.00000       | 0.99366       |
| Miscellaneous  | 0.9342 | 0.99454       | 0.99681       | 0.99366       | 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   | <.001|
| years        | 1  | 2826941             | 233874         | 12.09   | <.001|

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 | 21543917       | [152363049.3, 170193300.6] |
| 49  | 2019 | 127968000.0 | 21543917       | [152363049.3, 170193300.6] |
| 50  | 2020 | 127968000.0 | 21543917       | [152363049.3, 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
| 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 |
| Coeff Var     | 37.13566 |

Table C4
| Variable | DF | Parameter estimate | Standard error | t Value | Pr > |t| |
|----------|----|--------------------|----------------|---------|------|-----|
| Intercept| 1  | -38092792          | 6431248        | -5.92   | <.0001 |
| years    | 1  | 3174147            | 238936         | 13.31   | <.0001 |

Table C5
| Obs | Time | Forecasts | Standard error | 95% Confidence limits |
|-----|------|-----------|----------------|-----------------------|
| 48  | 2018 | 134965000.0 | 108716775.7 | 161213224.3 |
| 49  | 2019 | 134965000.0 | 97862960.8 | 172067039.2 |
| 50  | 2020 | 134965000.0 | 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 |
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