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Multiple Linear Regression Approach for Strategic Decisions on Industrial Productivity under Limited Available Budget

Oluwaseun Oluwagbemiga Ojo[1*], David Ifeoluwa Oladapo[2], Abiola Olufemi Ajayeoba[3], Basil Olufemi Akinnuli[4] and Temitayo Daniel Omotayo[5]

[1]Department of Mechanical Engineering, Adeleke, Nigeria.
[2]Department of Mathematical Sciences, Adeleke University, Nigeria.
[3]Department of Mechanical Engineering, Ladoke Akintola University of Technology, Nigeria.
[4]Department of Industrial and Production Engineering, Federal University of Technology Akure, Nigeria.
[5]Department of Agricultural Engineering, Federal University of Technology Akure, Nigeria.

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 DIO and AOA managed the analyses of the study. Authors BOA and TDO managed the literature searches. All authors read and approved the final manuscript.

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Abstract

Proper planning and improved productivity is highly desired in industrial settings to optimize the available resources when there is limited resources and to control excessive spending in time of surplus. Productivity is achievable by good levels of Materials, Time and Labor inputs which needs to be measured scientifically in order to maintain long run profit. This study explored processing data and incorporated Statistical Package for Social Science (SPSS) to find the relationship and predict the response of the available budget with the inputs of Materials, Time and Labor using Olam Cocoa Processing Industry, Nigeria as case study. The analyses were done using Multiple Linear Regression Model developed (i.e. $AV_{Budget} = 1540540.5 + 216216.2M - 1367117.1T + 655405.4L$), it was discovered that the inputs of the selected strategic decisions collectively affected the response of the available budget with F-value of 88.48 but each of them cannot reduce or increase the amount of budget except for manpower which has 0.069 or 93.1 % significant effect on the available budget. Also,

**Corresponding author: E-mail: ojo.oluwaseun@adelekeuniversity.edu.ng;*

Coefficient of determination established a strong fitness of the relationship between the strategic decisions and the available budget with the value of 0.974 (or 97.4 %). It is recommended that the project manager should subject his decisions making into scientific measures rather than brainstorming so as to increase productivity in the company.

Keywords: Multiple linear regression; strategic decisions; industrial productivity; limited available budget; coefficient of determination.

1 Introduction

According to Jhamb [1], Productivity improvement is to do the right things better and make it a part of continuous process. Therefore it is important to adopt efficient productivity improvement technique so as to ensure individuals and organization's growth in productivity. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people [2]. The productivity of a certain set of resources (input) is therefore the amount of goods or services (output) which is produced by them. Land and building materials, machines, manpower (labor), technology etc. are the resources at the disposal of a manufacturing company. Therefore higher (improved) productivity means that more is produced with the same expenditure of resource i.e. at the same cost in terms of land, materials, machine, time or labor, alternatively, it means same amount is produced at less cost in terms of land, materials, machine, time or labor that is utilized [3,4]. To improve productivity, products must be designed to satisfy customers' need with optimum consumption of resources without waste in the manufacturing process [5]. Shivalingaiah [6], introduced clearly the 'Labor Productivity through Method study' in Fig. 1.

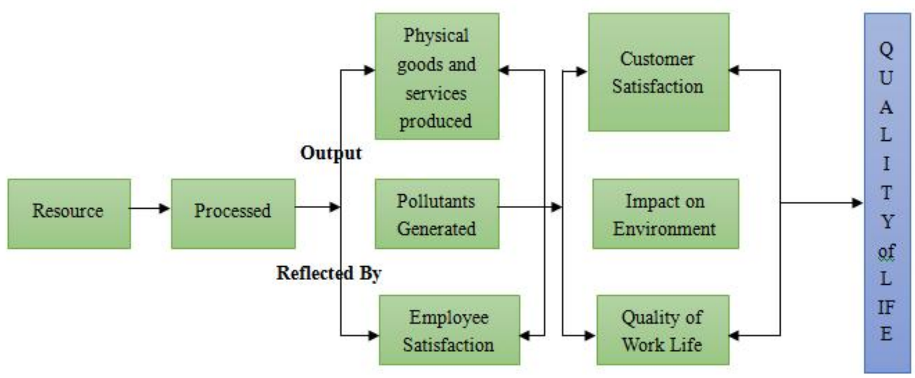

Fig. 1. Labor productivity through method study
Source: [6]

Proper planning as stated by Adegbuyi and Asapo [7], involves decisions and choices about alternative ways of using available resources with the aim of achieving a particular product at some time in the future. While planning, Banjoko [8], also added that Budgeting needs to be introduced and defined it as a conscious and systematic allocation of resources prepared in advance, relating to a future period based on a forecast of key variables adopted to achieve certain policy objectives. In view of this, statistics is a scientific based knowledge communicated concerning some particular facts. It is a way to get information from data and also a tool for creating an understanding from a set of numbers [9,10]. Ojo et al., [11], used statistical analysis to determine the correlational strength between the years of procurement of the machines, accessories, spare-parts and miscellaneous and the amount spent on the selected decisions, they also find their confidence level, and predicted the values for subsequent procurement using Statistical Analysis Software (SAS). Yongwei et al., [12], identified the effectiveness of a particular set of important management programs in improving construction labor productivity. While Egbe et al., [13], applied multi-linear regression analysis model for predicting soil properties in Calabar South to offer a technical guide and solution in foundation designs problems in the area, Mohammad et al., [14] described the development of a multi-linear regression model to predict the effect of building shape on total energy consumption in two different climate regions (i.e. cold-dry and warm-marine). The objective of this work is to find the relationship between the selected strategic decisions (i.e. Materials, Time, Labor) and the budget available for the productions, and predict the response of the available budget with the inputs of the independent variables of materials, time and labor for the subsequent production in order to maintain sustainability, improve productivity, and boost the economy growth of the industry. Most decision makers brainstorm based on the experience they have, to predict on the quantity of products they would likely produce using available resources without subjecting it to scientific measures. This may directly affect the quality and quantity of the products and eventually leads the industry to bankruptcy. The developed software would help the decision maker to pre-determine the quantity of materials to be used for production, the number of manpower and the available time in order to meet up with the customers' demands and due to the flexibility of the software, the decisions can be adjusted beforehand based on the available budget.

2 Methodology

In order to improve productivity, two companies were visited to know the areas of strategic decisions and to forecast the required cost for the budgeting. Eventually, one of the companies was selected based on its organized record system, hence, its records were vetted and required data were collected. Different magnitudes input elements of the Materials (M) with different Time interval (T) and Labor (L) for production were considered to determine the available budget for the year. The data collected were processed and used to forecast and determine the responses of the available budget with respect to the inputs (M, T, L). Therefore, the procedure of identifying the strategic decisions; statistical analysis of the strategic decisions; model development; integration of the model to form a logic of the model (flow chart) for the required program; development of software package for decision making were then applied.

2.1 Procedure of identifying strategic decisions for model development

After thorough literature review and questions posed to the available workers in the industry, this study considered some strategic decisions which have major effects on the productivity of the industry. These decisions have basic influence on the budget for certain years because they regulate the amount of products to be produced based on demands of their customers and determine the output of the company's product based on the degree of input. Listed below are the selected strategic decisions:

a) Materials (Kg): Material is used in its conversion into finished products. Its productivity depends upon the input and the total output. It is measured in Kilogram.
b) Time (Hr): The time allowed for manufacturing of raw materials into finished products is determined by the amount of finished products per time. It could be measured in seconds, minutes or hour.
c) Labor (Manpower): An organization may decide to increase the manpower based on the quantity of materials to be produced, or a project manager may like to maintain the employee level to maximize profit. However, its productivity is measured by the total output with the labor input.

2.2 Statistical analysis of the strategic decisions

Multiple Linear Regression approach was used to predict the cost with the input of Materials, Time and Labor using Statistical Package for Social Science (SPSS) software to process the data available from Olam Cocoa Processing Industry, Nigeria.

2.2.1 Rule of thumb

Multiple linear regression analysis was carried out at the level of $P_r \leq 0.05$ to determine whether there is a significant difference between the selected decisions and the available budget. The null and alternate hypothesis are stated as:

Null hypothesis: This means that there is no significant difference between the strategic decisions and the available budget (i.e. $\mu_1 = \mu_o$). Therefore, hypothesis would be accepted.

Alternate hypothesis: This means that there is significant difference between the decisions and the available budget (i.e. $\mu_1 \neq \mu_o$). Therefore, hypothesis would be rejected. This can be tested with a t-statistics:

$$t_{stat} = \frac{r}{se_r} \tag{1}$$

Where:

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

Where:

t_{stat} is t-statistics
r is the correlation of coefficient
se_r is the standard error of the correlation coefficient.
n is the number of items

According to Witten and Frank [15], under null or alternate hypothesis, t-statistics has $n - 2$ degrees of freedom but the test results are converted to P_r before conclusions are drawn.

2.3 Model development (Multiple linear regression analysis from the data)

Since the selected strategic decisions (materials, time and labor) determine the available budget for production on yearly basis, Stock and Mark [16], expressed the basic regression model as:

$$AV_{Budget} = \beta_o + \beta_1 M + \beta_2 T + \beta_3 L \tag{3}$$

Where:

$$\beta_o = \frac{\sum AV - m(\sum M)}{n} \tag{4a}$$

$$\beta_o = \frac{\sum AV - m(\sum T)}{n} \tag{4b}$$

$$\beta_o = \frac{\sum AV - m(\sum L)}{n} \tag{4c}$$

$$\beta_1 = \frac{n(\sum MAV) - (\sum M)(AV)}{n(\sum M^2) - (\sum M)^2} \tag{5a}$$

$$\beta_2 = \frac{n(\sum TAV) - (\sum T)(AV)}{n(\sum T^2) - (\sum T)^2} \tag{5b}$$

$$\beta_3 = \frac{n(\sum LAV) - (\sum L)(AV)}{n(\sum L^2) - (\sum L)^2} \tag{5c}$$

The sum of squares for variable M is:

$$SS_{MM} = \sum(M_i - \bar{M})^2 \tag{6a}$$

The sum of squares for variable T is:

$$SS_{TT} = \sum(T_i - \bar{T})^2 \tag{6b}$$

The sum of squares for variable L is:

$$SS_{LL} = \sum(L_i - \bar{L})^2 \tag{6c}$$

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

$$SS_{MAV} = \sum(M_i - \bar{M})(AV_i - \overline{AV}) \tag{7a}$$

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

$$SS_{TAV} = \sum(T_i - \bar{T})(AV_i - \overline{AV}) \tag{7b}$$

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

$$SS_{LAV} = \sum(L_i - \bar{L})(AV_i - \overline{AV}) \tag{7c}$$

Where:

AV is the dependent variable for available budget
β_o is the intercept of the regression
β_1, β_2 and β_3 are the slopes
M, T, L are the independent variables for Materials, Time and Labor respectively.
SS_{MM} is the sum of squares for variable M
$\bar{M}$ is the average value of M
M_i denotes data point
SS_{TT} is the sum of squares for variable T
$\bar{T}$ is the average value of T
T_i denotes data point
SS_{LL} is the sum of squares for variable L
$\bar{L}$ is the average value of L
L_i denotes data point

Equations (6a), (6b) … (7c) are the sum of squares and sum of the cross-products needed to calculate the correlation coefficient. Pearson's correlation coefficient measures the degree of relationship between the two variables and is given by:

$$r = \frac{SS_{XY}}{\sqrt{(SS_{XX})(SS_{YY})}} \tag{8}$$

Where:

X stands for either variable Materials, Time or Labor
Y stands for Available budget (AV_{Budget})

According to Zhang [17], coefficient of determination (R^2) finds the best of fits between two variables. This is mathematically expressed as:

$$R^2 = \frac{S^2{}_{XY}}{S_{XX}S_{YY}} \tag{9}$$

Fig. 2 integrates the model to form a logic of the model for the required program.

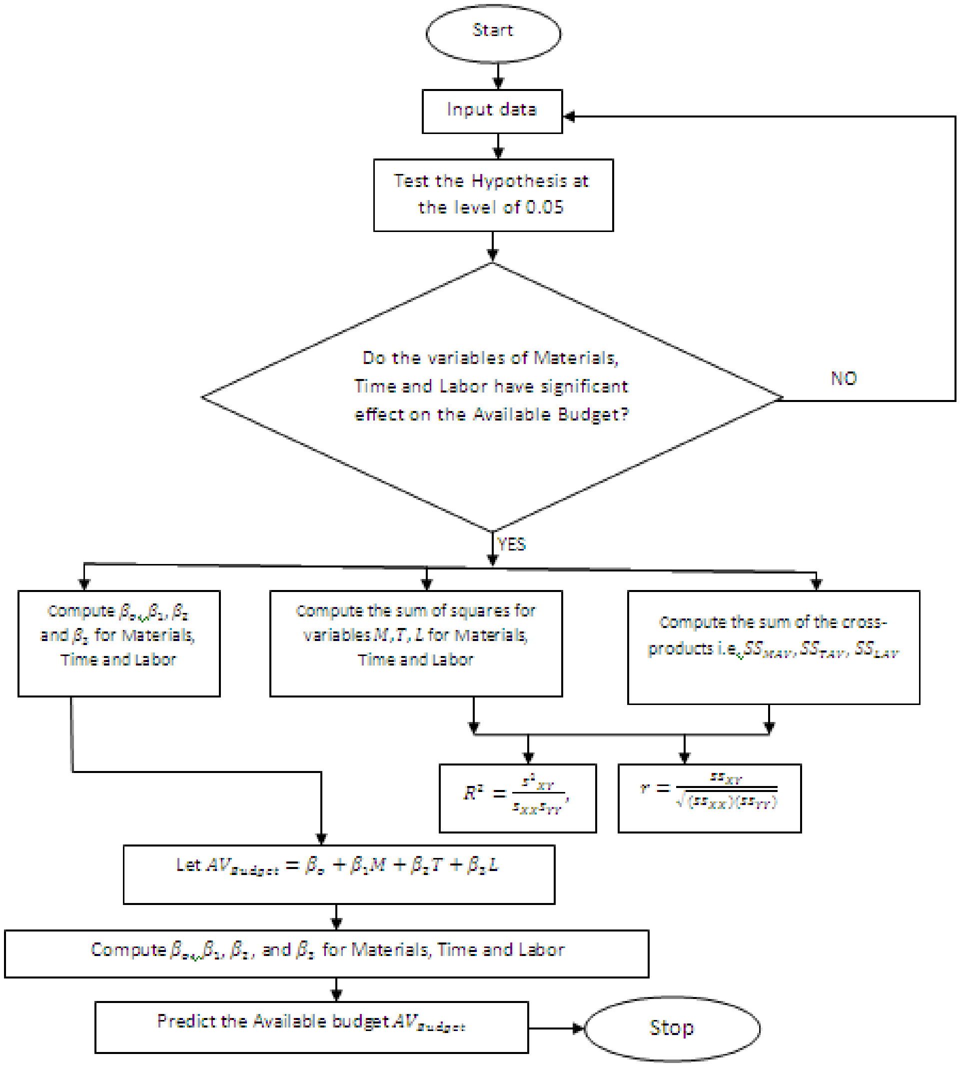

Fig. 2. Flowchart for statistical models developed

2.4 Olam cooperative cocoa factory, Nigeria

Olam Cooperative Cocoa Factory is the cocoa processing division of the Olam Nigeria Limited and are into the processing and supplies of a wide range of cocoa products and more. Olam Nigeria Limited as the country arm of Olam International Limited (hereafter referred to as 'Olam' or 'Olam International') is a supplier of raw and processed agricultural commodities. The main goal of the company is to maximize value for its shareholders and keep the company in business by increasing the capital base of the enterprise, increasing its rate of profitability, ensuring growth, and extending the competitive advantage it has over other competitors in the agribusiness sector to be able to sustain its growth over time. The company's business portfolio cuts across the total product supply chain from procurement of farm products to distribution, using a network of local buying agents, primary processing facilities and logistics. Established in 1989, Olam International sources its products from countries where it operates and sells these products worldwide to over 6,500 customers in 55 end markets. Olam International is highly diversified with direct presence across 60 countries and the business operations are organized around 17 products/business-units. The data extracted were collected and subjected to scientific measures of predicting the available budget with respect to Materials, Time and Labor. The available data is as shown in Table 1.

Table 1. Available data from olam cooperative cocoa factory, Nigeria

Year of Production	Materials (M) (Kg)	Time (L) (Hour)	Labor (L) (Manpower)	Available Budget (AV_{Budget})
2010	50(20)	3	5	5,000,000
2011	50(25)	3:30	5	5,500,000
2012	50(27)	3:45	6	6,000,000
2013	50(30)	4	6	6,500,000
2014	50(35)	4:30	6	7,000,000
2015	50(37)	4:45	6	7,000,000
2016	50(39)	5	7	7,500,000
2017	50(42)	5:15	7	8,500,000
2018	50(45)	5:30	7	8,500,000
2019	50(48)	5:45	7	8,500,000
2020	50(50)	6	7	8,500,000
TOTAL				78,500,000

Source: Study, 2020

3 Results and Discussion

3.1 Development of software package

Multiple linear regression model approach for predicting the response of the available budget with the inputs of the Materials, Time and Labor has been developed, and application of software package for decision making were developed using Statistical Package for Social Sciences (SPSS). Table 2 showed the level of significance of Materials (L), Time (T) and Labor (L) on the available budget for the execution of the project while Table 3 showed the coefficients of the constant, the strategic decisions and their level of significance.

Table 2. Level of significance of materials, time and labor on the available budget

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16120341932841.941	3	5373447310947.313	88.480	.000[b]
	Residual	425112612612.608	7	60730373230.373		
	Total	16545454545454.549	10			

With F-value of 88.480, it implies that the inputs of M, T and L generally affect the amount of budget on yearly basis for production. Therefore, quantity of materials and time of production with number of manpower determine the available budget (money) for the execution of the project.

Table 3. Coefficients of the strategic decisions and their significance

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Beta	Std. Error	Beta		
1	(Constant)	1540540.541	2067787.839		.745	.481
	Materials (Kg)	216216.216	229180.204	1.648	.943	.377
	Time (Hour)	-1367117.117	2429584.914	-1.038	-.563	.591
	Labor (Manpower)	655405.405	305871.872	.401	2.143	.069

Considering the values of 0.377 and 0.591 for Materials and Time respectively in Table 2, it implies that the effect of Materials and Time used do not have any significant effect on the available budget as they do not fall within the range of 0.001 to 0.05 to 0.1 (or 99.9%, 95% and 90%). Only Labor (i.e. Manpower) has significant effect at 0.069 or 93.1% on the available budget which means that the number of manpower may affect the amount of budget dispensed for the execution of the project. Normally, when materials are increasing gradually, manpower would automatically increase but the time of production may either be increased or maintained depending on the number of manpower. Also, coefficient of determination explains the fitness of the strategic decisions on the available budget as shown in Table 4.

Table 4. Model summary of the coefficient of determination (R^2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.987[a]	.974	.963	246,435.33276

From Table 4, "R Square" (R^2) established a strong fitness of the relationship between the strategic decisions and the available budget. With the value of 0.974 (or 97.4 %), this means that equation 10 is fit and the strategic decisions (Materials, Time and Labor) can determine the value of the available budget. Also, since the difference between the "Adjusted R Square" and "R Square" is not much, it means the model is fit.

$$AV_{Budget} = F(Material, Time, Labor) \tag{10}$$

Equation 10 indicates that available budget is a function of Materials, Time and Labor. It depends on the amount of materials, Time and Labor dispensed for production in a particular or current year.

Therefore, from equation 3:

$$AV_{Budget} = \beta_o + \beta_1 M + \beta_2 T + \beta_3 L$$

Therefore,

$$AV_{Budget} = 1540540.5 + 216216.2M - 1367117.1T + 655405.4L \tag{11}$$

Equation 11 is called Multiple Linear Regression Model. It depicts the reality of the effects of Materials, Time and Labor on the available budget. These decisions would determine the amount of money that would be allotted for the production for a particular year.

4 Conclusions and Recommendations

This study was able to analyze the relationship and predict the response of the available budget with the explanatory variables of Materials, Time and Labor using multiple linear regression model and Statistical Package for Social Science (SPSS) for software package. From the result obtained, this study emphasized that the inputs of the selected decisions can collectively determine the amount that could be used for production, and these decisions were being used to measure the degree of productivities in a particular year. It was shown that without the inputs of these decisions, budget cannot be correctly made and there could be a lot of errors in taking the decisions which consequently may affect the production level and economy growth of the industry. The results also illustrated that each of these decisions cannot standalone to predict the available budget except for the labor, whose value is 0.69 or 93.1 %. This means that manpower has significant effect on the decision making for budget because the higher the number of manpower for the project, the higher the allocation of budget. However, the level of manpower can be maintained in order to minimize budget and maximize profit. It is recommended that project manager should subject his decisions making into scientific measures rather than brainstorming or applying trial and error method as this may affect the quality or quantity of the products. The software used is flexible enough to pre-determine the amount of inputs for the project before production commences. Goal programming model can be explored for further study to determine the efficiency of major machines equipment being used for production processes in the industry with the consideration of “Materials” used for a particular period of “Time” with the number of manpower “Labor” for each project.

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The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

Competing Interests

Authors have declared that no competing interests exist.

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