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Application of Linear Programming to Analyze Profit of Flour Factory, in the Case of Sanate Flour Factory, at Robe Town

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Abstract

The purpose of this study was to analyze the total production and profit of Sanate flour factory located in Ethiopia, Oromia regional state, Bale zone, Robe town, by applying linear programming. A factory is situated within Robe town about 430 KM, from Addis Ababa (Capital of Ethiopia). Today linear programming was the most popular method of manipulating a large amount of data. Hence, Different studies bring out the necessity of using quantitative techniques for utilization in the factory. So, in this paper to analyze the production and profit of this factory, the study incorporates different steps; the first step is collecting data. A data collecting formats prepared and circulated among factory staff to executive managers, co-managers, sellers, machine operators, and technicians to determine the production, sales, and profit during five months of November 30, 2018- June 18, 2019. In the second step, a collected data is modeled to mathematical form, particularly modeled to linear program. In the third step the mathematical modeled data was solved (analyzed). Finally, depending on the empirical results (the solution of a modeled data) some problem facing the factory was indicated and the solution for the problem has been recommended.

Keywords: Application of Linear Programming; Optimization Mathematical model.

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1. Introduction

1.1 Background of the study

Linear programming is useful in organizing and manipulating large amounts of data. Today, the subject of linear programming is one of the most important and powerful tools in Mathematics which has found applications to a very large number of disciplines such as Engineering, Business, and Economics, statistics. Several studies incorporate the applications of linear programming in the analysis of factory production and profit maximization. The term linear programming and a method called the simplex method; was developed and first used by Dantzig (1914–2005) in 1947. Ideally suited to computer use, the simplex method is used routinely on applied problems involving thousands of variables and problem constraints [2]. Thus, linear programming involves the planning of activities to obtain an optimal result. The Babcock and Wilcox applied the linear programming to help plan a major expansion of the company's Tubular Products Division (TPD) in Pennsylvania. Owen [5] has also used the linear programming method to design antenna array patterns that suppress interference from certain directions. Hence, linear programming problems are concerned with planning and making decisions, such as selecting an optimal production plan. Since, the factory aims to obtain high profit by minimizing cost, to decide how many units of each product from a choice of (distinct) products it should make, it may face a shortage of resources and manpower. To solve such types of problems, we can model the product and profit of the factory to linear programming.

1.2 Statement of the Problem

Linear programming is a set of methods that can use in improving management decisions. Also, it has great importance solving problems such as production planning; allocating resources. Wijeratne and Harris [7] proposed that the linear programming model is used by the managers to determine the most economical arrangement of finance, to arrange the best times to start and finish projects, and to select projects to minimize the total net present cost of capital. In Ethiopia's factories, the use of linear programming is not habited. Hence, it is initiated by the author to conduct an assessment of the application of linear programming in this particular factory as a case study. Even though, Sanate flour factory which is located in Robe town in the area reached by Wheat, the customers demand and the price of the distinct products of this factory does not meet each other. Especially, the prices in which the peoples purchase the products of this factory are very expensive (luxurious). So, the technique of linear programming is one possible method that might be used to organize and consider simultaneously the pertinent information for their production and profit decision. The technique of linear programming to an operating production firm is to determine the problem facing them to maximize their profit and satisfy the need of their customers by increasing supply and optimizing cots. It was felt that if linear programming could be used by management to increase the total production and profits of a factory, benefits would accrue to peoples surrounding.

1.3 Significance of the study

It helps to understand the best way of making decisions by using linear programming to analyze the total production and profit of the factory. To other researchers of similar interest to analyze the production and profit of any factory by the application of linear programming technique, this research document can be used as a secondary information source.This study was conducted to analyze the total production and profit of the factory by using linear programming and advances the knowledge of linear programming. Since, the objective of the factory is to maximize overall its profit, by producing different products. Hence, the study contributes to a factory has to decide how many units of each product from a choice of different types of products it should make to increase its production and maximize its profits. Also, to analyze problems facing the Factory and give the possible solution to optimize their profit and meet the need of their customers and the peoples surround them by their supply and price optimization.

1.4 Objectives of the Study

The general objectives of this paper are:

To analyze the total production and profit of a collected data from this factory, we can model to a linear programming problem. Accordingly, the following specific objectives are drawn to address the study:

- To analyze the total production and profit of the factory.
- To analyze their current production and sold products of the factory
- To analyze problems decreasing their total production and profits.

1.5 Research Questions

In this study, the following research questions are posed to be addressed:

- How the factory manages its Manpower, time allocated and their duty (responsibility) machine per day?
- The Capacity of production of its Machine per month?
- Whether the habited in its production and profit analysis is effective or not?
- Whether the available raw material is sufficient for production?
- How is the factory currently deciding on the allocation of resources for the production of its Products to maximize its sales and profit?
- What types of research methodology does the factory use to make a decision?

1.6 Delimitation of the study

The area of the research problem is limited depend on the objective. Since the general objective is to analyze the production and profit of the factory by modeling to linear programming. This study will be delimited to Sanate flour factory at Robe Town, which is selected purposefully as a study area for this research. Since the factory produces distinct products, this is suitable for the application of Linear Programming techniques to analyze production and profit.

2. Method of Data Analysis

2.1 Study area

The study was carried out on Sanate flour factory, which is located in Robe town, Bale zone, Oromia Region of Ethiopia. In Robe town, there are three Flour Factories are their; Sanate, Yadot, and Yetebaberut flour factories. Hence, Sanate flour factory is selected purposefully to conduct this research. Since the three factories are producing similar products. Hence, to analyze the profit and production of the three factories that are producing the same product by the method of linear programming is game theory. That is game theory means since they are manufacturing a similar product to analyze their market it is competitive. The Literature cited suggests that Linear Programming techniques can be beneficial in minimizing production costs to realize larger profits. Sanate flour factory was established in 2010. The factory has around 76 man powers and only one functional machine which can operate for 24 hours per day. The machine was producing two distinct products; two types of Flour; Hard Flour and Soft Flour and wheat meal.

2.2 Linear Programming model of a collected data

Sanate flour factory was producing two distinct types of products two types of flour and wheat meal. Hence, to collect data two sources of data are used. Those are primary and secondary data. Especially to get information on the production and profit analysis of the factory understudy, an interview was conducted with the manufacturing manager, co-managers, persons working on Machine, laboratory and electricity technician, labor workers and the sales managers of the factory and data collected on the unit costs of production of the products, the unit selling price of the products and also contacted the sales and the purchasing, production and marketing managers of the factory. The secondary data sources were obtained from document analysis of the factory production from its establishments up to now. Therefore, the study aims to analyze the total production and profit of this factory by solving a mathematical modeled to a linear programming problem. Hence, the targeted research population is 37 persons are selected; those have direct influence (factors) on the production of this factory. Hence, a collected data were transformed into a linear programming model and the modeled data was solved by the method of simplex algorithm or by using AMPL software or MS-Excel solver to analyze total production and profit of the factory within the available scarce resources. The software AMPL was preferred (purposely selected) for accuracy purposes and easy to use in the solution (to analyze) the mathematical modeled data with single inequalities and limited constraints. Linear programming optimizes (maximizing or minimizing) a dependent variable subject to a set of independent variables in a linear relationship, given a number of linear constraints of independent variables. The value of dependent variables which is the value obtained from solving the problem is subject to the independent variables set by the decision-maker (or determined by solving the problem). The independent variables in linear programming are known as variables of unknown value, and the decision-maker has to calculate the value of such variables by solving the problem. Thus, a general form of a linear programming problems fo ‘n' decision variables and ‘n' constants can be written as follows;

Maximize $P = a_1x_1 + a_2 x_2 + \cdots + a_n x_n$

Subject to $b_{11}x_1 + b_{21}x_2 + \cdots + b_{n1}x_n \leq d_1$

$$\ldots \quad \ldots \quad \ldots \quad \ldots$$

$$b_{12}x_1 + b_{22}x_2 + \cdots + b_{n2}x_n \leq d_2$$

$$b_{1m}x_1 + b_{2m}x_2 + \cdots + b_{mn}x_n \leq d_m$$

With, $x_1, x_2, x_3, \ldots, x_n \geq 0$.

3. Model and Data Description

The principal objective of the research is to the analysis of the interaction between production rates and profit of Sanate flour factory. The collected data of this factory to a linear programming model is necessary to analyze the potential impact of changes in wheat costs. The system also requires that capacity of machine production per day, man-hour available per day and the selling capacity (demand for their products) per day be specified. This section is divided into two sections. The first section details sources, assumptions, and processes used in collecting and deriving the data used in the research. The second section presents a discussion of the linear programming of Products produced in ton and profit model, the Man-power model and the market model of Sanate flour factory.

3.1 Mathematical Model of a factory

Data were taken from an interview with the machine operator, salesman, manager, and co-manager of the factory and direct observation during the production of its products. The machine operators gave the capacity and current production of their machine in tons per hour for each Product. The salesman gave the number of soled products and their profits, whereas the manager and co-managers gave general information about their factory production and profits from their record. The model's of Products in ton and the profit of Sanate flour factory contains the cost of wheat, manpower, and capacity of machine production per day in the production of different products Flour and wheat meal (Animal feed). Inequality constraints are specified quantity of flour produced and quantity of wheat meal (animal feed) produced. The profits obtained from each product constraints specify maximum available production. To conduct this research work, I focused on the production capacity and current production of this factory, the current supply of this factory and their market from November 30, 2108, to June 18, 2019. Sanate Flour factory allocated 240 hours per month on its production. The factory takes wheat as a raw material (input) and can produce two types of finished products; these two types of products are two types of flour and wheatmeal. Due to different problems affected the production time of this factory cannot the allocated time properly and they cannot manufacture them according to their plan. So their average current and capacity production and sold products of this factory in ton per month is given in table (3.1).

Table 3.1: Current and Average capacity production of Sanate flour factory

Product type	Current production in ton per month	Capacity of production in ton per month
Flour	183.3	243.36
Wheat meal	61.1	81.12
Total product	243.36	324.48

Table 3.2: Sold products and profit of each product of Sanate flour factory

Product type	Sold products per month in ton	Profit per ton
Flour	131.976	650 Birr
Wheat meal	56.212	1068 Birr

Since Sanate Flour factory is allocated 240 hours per month to produce its products. Hence, if this factory is producing for 240 hours per month, how many tons of Flour, and wheatmeal should be produced to get high profit? Let tons of Flour and wheat meal to be produced are the decision variables whose values we must determine to maximize profits so that the desired values of the variables can be determined systematically. Hence, from the given information in the tables above: (table 3.1 and 3.2), Sanate Flour factory production is modeled by using linear programming as follows. Thus let represent 'x_1' for the number of tons of Flour to be produced and 'x_2' for the number of tons of Wheat meal to be produced. However, the total hour to produce all these tons is obtained multiplying hours to manufacture tons of flour and multiplying hours to manufacture tons of wheat meal and sum up. The total allotted hours of this factory is not more than the number 240 hours per month. Such that, month per ton is the reciprocal of the tons per month given above; so, we have a constraint on the variables and we can write mathematically as follows:

$$\frac{1}{183.3}x_1 + \frac{1}{61.1}x_2 \leq 240$$

$$\Leftrightarrow \frac{10}{1833}x_1 + \frac{10}{611}x_2 \leq 240$$

The current production capacity of this factory is not more than 183.3 tons of flour and 61.1 tons of wheat meal per month for different problems. Thus, production limits are;

$$0 \leq x_1 \leq 183.3$$

$$0 \leq x_2 \leq 61.1$$

In the statement of the problem above, the upper limits were specified and since there is no negative production the lower limits were assumed to be greater than or equal to zero. Since the objective of a factory is to maximize its profit by minimizing cost, however, the maximum profit is obtained by multiplying the profit of each by bits number of tons and sum up.

That is, $P = 650x_1 + 1086x_2$

Finally writing the above all equations together, we obtain the following mathematical form, which is a linear program problem as follows;

Maximize $P = 650x_1 + 1086x_2$

Subject to;

$$\frac{10}{1833}x_1 + \frac{10}{611}x_2 \le 240$$

$$0 \le x_1 \le 183.3$$

$$0 \le x_2 \le 61.1$$

$$x_1, x_2 \ge 0$$

Due to insufficient electric power, this factory cannot produce its production fully for the allotted time. That means production is not executed fully for 240 hours per month. However, if the products manufactured for 240 hours per month, they can produce 243.36 tons of flour and 81.12 tons of wheat meal. Hence, the constraint on the variables with respect to time is given by;

$$\frac{1}{243.36}x_1 + \frac{1}{81.12}x_2 \le 240$$

$$\Leftrightarrow \frac{100}{24336}x_1 + \frac{100}{8112}x_2 \le 240$$

Again the maximum production limits of this factory in the allotted 240 hours per month are;

$$0 \le x_1 \le 243.36$$

$$0 \le x_2 \le 81.12$$

In the statement of the problem above, the upper limits were specified and the lower limits were greater than or equal to zero. Again, the goal of a factory is to maximize its profit by minimizing cost, however, the maximum profit is obtained by multiplying the profit of each by bits number of tons and sum up. That is, $P = 650x_1 + 1086x_2$, So writing the above all equations together, we obtain the following mathematical form, which is a linear program problem as follows;

Maximize $P = 650x_1 + 1086x_2$

Subject to:

$\frac{100}{24336}x_1 + \frac{1000}{8112}x_2 \le 240$

$0 \le x_1 \le 243.36$

$0 \le x_2 \le 81.12$

$x_1, x_2 \ge 0$

Also, due to the market problem, this factory sold 131.976 tons of flour and 56.212 tons of wheat meal within 240 hours per month. Hence, we obtain a constraint on the variables as;

$$\frac{1}{131.976}x_1 + \frac{1}{56.212}x_2 \le 240$$

$$\Leftrightarrow \frac{1000}{131976}x_1 + \frac{1000}{56212}x_2 \le 240$$

Such that, the production limits are restricted to;

$0 \le x_1 \le 131.976$

$0 \le x_2 \le 56.212$

Again, the goal of a factory is to maximize its profit by minimizing cost, however, the maximum profit is obtained by multiplying the profit of each by bits number of tons and sum up.

That is, $P = 650x_1 + 1086x_2$

Therefore, writing the above all equations together, we obtain the following mathematical form, which is a linear program problem as follows;

Maximize $P = 650x_1 + 1086x_2$

Subject to $\frac{1000}{131976}x_1 + \frac{1000}{56212}x_2 \le 240$

$0 \le x_1 \le 131.976$

$0 \le x_2 \le 56.212$

$x_1, x_2 \ge 0$

3.2 Empirical Results of Sanate flour factory by using AMPL Software

1) 3.2.1 Empirical results of capacity production and profit

ampl: var X1; # amount of X1;

ampl: var X2; # amount of X2;

ampl: maximize Profit: 650 * X1 + 1086 * X2;

ampl: subject to time: (100/24336) * X1 + (100/8112) * X2 <= 240;

ampl: subject to X1_limit: 0 <= X1 <= 243.36;

ampl: subject to X2_limit: 0 <= X2 <= 81.12;

ampl: solve;

MINOS 5.51: optimal solution found.

1 iterations, objective 246,280.32

ampl: display X1, X2;

X1 = 243.36

X2 = 81.12

3.2.2 Empirical Results of current production and Profit

ampl: var X1; # amount of X1;

ampl: var X2; # amount of X2;

ampl: maximize Profit: 650 * X1 + 1086 * X2;

ampl: subject to time: (10/1833) * X1 + (10/611) * X2 <= 240;

ampl: subject to X1_limit: 0 <= X1 <= 183.3;

ampl: subject to X2_limit: 0 <= X2 <= 61.1;

ampl: solve;

MINOS 5.51: optimal solution found.

2 iterations, objective 185,499.6

ampl: display X1, X2;

X1 = 183.3

X2 = 61.1

3.2.3 Empirical results of sold products and profit

ampl: var X1; # amount of X1;

ampl: var X2; # amount of X2;

ampl: maximize Profit: 650 * X1 + 1086 * X2;

ampl: subject to time: (1000/131976) * X1 + (1000/56212) * X2 <= 240;

ampl: subject to X1_limit: 0 <= X1 <= 131.976;

ampl: subject to X2_limit: 0 <= X2 <= 56.212;

ampl: solve;

MINOS 5.51: optimal solution found.

2 iterations, objective 146,830.632

ampl: display X1, X2;

X1 = 131.976

X2 = 56.212

4. Conclusion and Recommendation

4.1 Conclusion

The research took the existing market structure and then determined the optimal profit and the products within the existing system. Results generated by the base model described reviewing types of production, sold products and gained profit from each product. The base model objective function was to analyze their production and profit of this factory per month. The maximized objective function value reflected the profit of distinct products sold. Results indicated that three basic problems were influencing the production capacity and profit of Sanate flour factory.

1. The first factor that affected the production capacity and profit of this factory was an Electricity

problem. Due to insufficient Electric power, Sanate flour factory lost 80.08 tons of products and 60,780.72 Birr profit per month.

2. The second basic problem that influenced the production and profit of this factory was the Market. The problem of the market reduced the production of Sanate flour factory to 56.212 tons and lost a profit of 38,668.968 Birr per month. As the findings of the research revealed their market problem stems from unskilled manpower and the absence of a research-based plan of the factory on their market management. Again the impact of Electric power and market problem influenced the production hours of this factory was to limited hours. But, their machine can produce 24 hours per day continuously.
3. The third factor that affected the production capacity and profit of this factory was the quality of wheat. The quality of wheat reduced the total production of Sanate flour factory by 4.277 tons and lost a profit of 3,046.446 Birr per month. The problems stem from their market management and farmers because now a day farmers supply their wheat to market soon harvesting from their farmland to sale. However, it has a great impact on the quality of wheat. The Wheat is supplied to the factory with Straw (oversize waste) and weed (unwanted plant seed).

In general, Sanate flour factory lost 140.569 tons of total products and 102,496.134 Birr of total profit per month. As a result, Sanate flour factory is currently selling 188.188 tons from its production and gaining a profit of 139,919 Birr per month.

4.2 Recommendation

In this research, by applying linear programming certain problems facing the factory is identified and some solution to the problem is stated from the empirical results (solution) obtained from the mathematically modeled data. Therefore, by applying the techniques of linear programming total production and profit were analyzed for decision making of managers, especially where there are restrictions or constraints in the decision-making process is important. Then the following three major recommendations have been suggested as follows;

1. To improve their Electric power, the factory owner or manager of the factory has to contact with electric power station to get a fixed unique electric line.
2. To improve their market problem, they must have to be managed by skilled manpower and have to have a research-based plan. Such that this factory has to employee skilled manpower who have a deep concept about business and their market departments have to differentiate which constraints affect their production and profit and must have a continuous plan based mathematical computed.
3. To keep the of quality of wheat, they have an authority to buy the best quality of wheat and notice their wheat suppliers to keep the quality wheat by their suppliers to avoid Straw (oversize waste) and weed (unwanted plant seed) during their production before they can supply for the market.

In general, if the managers and their market management used linear programming in their operating production firm and planned to depend on mathematically computed data, this factory was determined the problem facing them to maximize their total production and profit. Such that the total production and profits of this factory were increased and benefits accrue.

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