Minimizing Shopping Mall Business Functions' Costs for Profit Maximization using Mathematical Programing Model

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Abstract

In this study, a typical shopping mall business was modeled as linear programming problem which was solved with the aid of computer software - LINGO. The results revealed that the supermarket operations can be optimized by enhancing her business functions, by minimizing the functions' costs, which eventually lead to profit maximization. Specifically it was observed, from the analysis, that among other costs, the following costs are very critical and can never be zero, no matter what; dating stock cost, management reporting cost, cash sales cost, ordering and delivery cost.

Keywords
Shopping Mall Business, Profit Maximization, Mathematical Programing Model.

1. Introduction (12 font)

Linear Programming is a mathematical programming model. Its algorithm has proven to be very effective in optimizing a mono objective problem (Agarana et al, 2019), (Agarana et al, 2017). In this study we assumed that the only objective of the system of supermarkets in Covenant University is optimizing profit making. The study, therefore, attempted to identify the main supermarket functions in order to optimize their costs in order to enhance profit maximization. Linear programming method was used to model the scenario (Agarana et al, 2014), (Hiller et al, 1995), (Lee, 1972).

One of the objectives of most businesses is profit maximization (Abbas, 2019), (Parlesak et al, 2016). A shopping Mall business is one of such businesses that usually have the objective of profit maximization. In order to achieve this objective, the functions of such shopping malls should be enhanced. Some of the important functions of a typical shopping mall include; Stock control, purchase, sales, marketing/pricing and decision on what stock to sell. In real life situations, decision making is a complex task (Lee, 1972). Linear programming algorithm (Agarana and Ayeni, 2015), (Agarana and Ehigbochie, 2015), was used to model the activities of the mall with the objective function of profit maximization (Agarana, 2003). Some of the constraints include; limited materials, labour hours, competitive pressures, energy consumptions and so many different economic, social as well as political factors (Ernst, et al, 2004), (Eiselt and Sandblom, 2007). The main objective of this study, therefore, is to optimize Covenant University' supermarket Business profit by minimizing the costs, in the face of many constraints and the assumption that the only objective of the business is to maximize profit, using Linear Programing Model.

2. Problem Modeling

2.1 The Supermarket Functions

The supermarket business can be divided up into five main category of functions. Each of them performs its own group of tasks in order to achieve the overall objectives. They are as follows:

2.1.1 Stock Control

Involves the following tasks: New Stock Delivery, Unsold Stock Disposal, Stock Levels Monitoring, and Management Reports Provision

2.1.2 Finance

The Finance Unit is responsible for the following tasks: Suppliers' Payments, Customer Payments Acceptance, Customer Accounts Management, and Financial Reports Preparation

2.1.3 Purchasing

The Purchasing Department is responsible for the following tasks: Order new stock items**,** Up-date stock item/supplier details**,** Monitor deliveries**,** Management reporting

2.1.4 Sales

The Sales Department is responsible for the following tasks: Record cash sales, Record account sales, Record orders and make deliveries, Sales reporting

2.1.5 Marketing/Pricing

The Marketing/Pricing (M/P) Department carries out these tasks: Decide what stock to sell, Setting prices, discounting prices, advertising campaigns

2.2 Modelling Supermarket Business

2.2.1 Representation of Supermarket Business Components

Let X1 represents cost of Stock control, and
X11 = Cost of taking delivery of new stock
X12 = Cost of disposing unsold stock
X13 = Cost of monitoring stock levels

X14 = Cost of providing management reports

Let X2 represent cost of Finance, and
X21 = Cost of making supplier payments
X22 = Cost of accepting customer payments
X23 = Cost of managing customer accounts
X24 = Cost of preparing financial reports

Let X3 represent cost of purchasing, and
X31 = Cost of ordering new stock items
X32 = Cost of up-dating stock item/supplier details
X33 = Cost of monitoring deliveries
X34 = Cost of management reporting

Let X4 represent cost of Sales, and
X41 = Cost of recording cash sales
X42 = Cost of recording account sales
X43 = Cost of recording orders and make deliveries
X44 = Cost of sales reporting

Let X5 represent cost of Marketing/Pricing
X51 = Cost of deciding what stock to sell
X52 = Cost of setting prices
X53 = Cost of discounting prices
X54 = Cost of advertising campaigns

2.2.2 Representation of the Objective of Supermarket Business

The overriding objective of a typical supermarket is to optimize their operations in order to enhance profit. This can be achieved by minimizing costs or maximizing profits
So the objective is to Optimize X1, X2, X3, X4, and X5. To achieve these, in this case, is to Minimize X1, X2, X3, X4, and X5.
From the data gathered from the supermarket, as shown in table 1, the contributions of the cost factors, in percentages, towards the total cost of the supermarket are as follows:

C_1= 5, C_2 = 30, C_3 = 30, C_4 = 20, C_5 = 15.

Where,
C_1 represents the contribution towards the cost of stock control
C_2 represents the contribution towards the cost of finance.
C_3 represents the contribution towards the cost of purchasing.
C_4 represents the contribution towards the cost of sales
C_5 represents the contribution towards the cost of marketing/pricing

The values of the contributions, in percentage, towards the total cost are as follows;

C_1 = 10% contribution to total cost
C_2 = 30% contribution to total cost
C_3 = 25% contribution to total cost
C_4 = 25% contribution to total cost
C_5 = 10% contribution to total cost

The objective function can be written as;

Minimize $Z = C_1 X_1 + C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5$

By expansion, it gives;

Minimize Z = C_1[X11 + X12 + X13 + X14] + C_2[X21 + X22 + X23 + X24] +C_3[X31 + X32 + X33 + X34] + C_4[X41 + X42 + X43 + X44] + C_5[X51 + X52 + X53 + X54].
This can be written concisely as follows;

That is; Minimize Z = $\sum_{i=1}^{5}\sum_{j=1}^{4} C_i X_{ij}$

2.3 The Constraints

The constraints are the possible impediments or limitations. They always stands against the achievement of the business objectives. For a typical world class university supermarket business, the limitations include the following: Location, Pilferage, spoilage, customer service, among others. The data collected from Covenant University supermarket used as a case study revealed the following constraints:

Table 1: Shows the available money and unit cost for achieving the variables objectives with respect to the constraints

Cost/ Variables	Location (‘000)	Pilferage (‘000)	Spoilage (‘000)	Customers’ Service (‘000)
X_{11}	20	05	30	10
X_{12}	15	10	40	0
X_{13}	25	10	05	0
X_{14}	0	0	0	10
X_{21}	20	0	0	0
X_{22}	10	0	0	0
X_{23}	0	0	0	0
X_{24}	0	0	0	0
X_{31}	30	20	10	0
X_{32}	0	0	0	10
X_{33}	10	30	20	0
X_{34}	0	0	0	10
X_{41}	0	0	0	0
X_{42}	0	0	0	0
X_{43}	40	30	30	10
X_{44}	0	0	0	0
X_{51}	0	0	0	10
X_{52}	0	20	20	20
X_{53}	0	0	0	10
X_{54}	0	0	0	15
Available Money	500	300	200	100

2.4 Representing the Constraints

From table 1 the constraints of the linear programming model can be represented as follows:

$20X11 + 15X12 + 25X13 + 20X21 + 10X22 + 30X31 + 10X33 + 40X43 \geq 500$
$5X11 + 10X12 + 10X13 + 20X31 + 30X33 + 30X43 + 20X52 \geq 300$
$30X11 + 40X12 + 5X13 + 10X31 + 20X33 + 30X43 + 20X52 \geq 200$
$10X11 + 10X14 + 10X32 + 10X34 + 10X43 + 10X51 + 20X52 + 10X53 + 15X54 \geq 100$
$Xij \geq 0$, i =1, 2, 3, 4, 5; j = 1, 2, 3, 4

Representing the constraints in a concise form;

$$\sum_{i=1}^{5}\sum_{j=1}^{4} X_{ij} = b_k, k = 1,2,3,4$$

$$X_{ij} \geq 0, i = 1,2,3,4,5; j = 1,2,3,4$$

3. The Model

The linear programming model for the problem under consideration is as follows;

$$\text{Minimize Z} = \sum_{i=1}^{5}\sum_{j=1}^{4} C_i X_{ij}$$

Subject to;

$$\sum_{i=1}^{5}\sum_{j=1}^{4} X_{ij} = b_k, k = 1,2,3,4$$

$$X_{ij} \geq 0, i = 1,2,3,4,5; j = 1,2,3,4$$

The model can be written in more expansive form, with the values of the contributions. as follows:

Minimize Z = 10[X11 + X12 + X13 + X14] + 30[X21 + X22 + X23 + X24] +25[X31 + X32 + X33 + X34] + 25[X41 + X42 + X43 + X44] + 10[X51 + X52 + X53 + X54].

Subject to,

20X11 + 15X12 + 25X13 + 20X21 + 10X22 + 30X31 + 10X33 + 40X43 ≥ 500
5X11 + 10X12 + 10X13 + 20X31 + 30X33 + 30X43 + 20X52 ≥ 300
30X11 + 40X12 + 5X13 + 10X31 + 20X33 + 30X43 + 20X52 ≥ 200
10X11 + 10X14 + 10X32 + 10X34 + 10X43 + 10X51 + 20X52 + 10X53 + 15X54 ≥100

Xij ≥ 0, i =1, 2, 3, 4, 5; j = 1, 2, 3, 4 .

4. Model Solution and Discussion

A computer software – LINGO, was used to solve the resulting mathematical model, the following results were obtained: Updating stock cost (X32) = 1234.568, Management Reporting Cost (X34) =1653.614, Cash Sales cost (X41) = 1234.568 and Ordering and delivery Cost (X31) = 1680.865. Other cost were zero. This implies that, in order to achieve the goal of ultimately maximizing the profit of the shopping mall, most of the costs of the business functions, which form the decision variables, must be zero. That implies that the aim of profit maximization would not be achieved, if they attract any cost. This is almost impossible in practical terms except the management of the shopping have alternative ways of sourcing for some of the inputs without incurring any cost. However, the shopping mall's profit would be maximized if the following critical cost units taken care of such that the values are not exceeded.

In particular it was observed that all the costs under marketing/pricing are to be zero if the mall is to maximize her profit. These costs include: Cost of deciding what stock to sell, Cost of setting prices, Cost of discounting prices, and Cost of advertising campaigns

One good explanation to this is that the business environment is such that there is no completion. The business is monopolistic in nature. The shopping mall is purely run by the University where it is situated. So there will be any need for incurring any of the following costs: Cost of deciding what stock to sell, Cost of setting prices, Cost of discounting prices, and Cost of advertising campaigns, for obvious reasons.

5. Conclusion

The study was all about modelling Covenant University' Shopping Mall Business using linear programming algorithm, with the single objective of maximizing profit. The business Functions' Costs were minimized in order to achieve the maximization of profit.
It was observed that some cost should not be considered at all if the objective of profit maximization is to be achieved. This idea is line with fact that the supermarket business in Covenant University is without competitors. Therefore costs like advertisement cost, marketing cost, discounting cost, cost of setting prices and so on, should be zero. This is because the university community is bound to buy, most of the time, whatever is available, with little or influence on the price of the items. The system is monopolistic in nature. However four major costs are very significant in order to achieve the objective of profit maximization. These costs include: Updating stock cost, Management Reporting Cost, Cash Sales cost, and Ordering and delivery Cost. If the values indicated by the results obtained from the solution provided using LINGO computer software, are anything to go by, then not exceeding those cost values would enhanced, to a large extent the possibility of maximizing the profit of the supermarket business in Covenant University.

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References

Agarana, M. C., Ajayi, O. O., and Akinwumi, I. I., Integer programming Algorithm for Public Transport System Sub-Saharan African Cities. *WIT Transactions on the Built Environment 182,* pp 339 – 350, 2019.

Agarana M. C., Bishop S. A., and Agboola, O. O., Minimizing Carbon Emissions from Tranpotation Projects in Sub –Saharan African Cities using Mathematical Model: A Focus on Lagos, Nigeria. *Procedia Manufacturing*, vol. 7, pp. 576 – 601, 2017.

Agarana M. C., Anake T. A., and Adeleke O. J., Application of Linear Programming Model to Unsecured Loans and Bad Debt Risk Control in Banks, *International Journal of Management, Information Technology and Engineering,* vol. 2(7), pp 93-102, 2014.

Hiller, F.S., Lieberman G. J., and Liebeman G., Introduction to Operations Research, *New York: McGraw-Hill,* 1995.

Lee, S.M., Goal Programming for Decision Analysis. *Philadelphia: Auerback Publishers*, 1972.

Abbas A, How to successfully run a Supermarket Business, Available: https://yourstory.com/mystory/seven-ways-to-successfully-run-a-supermarket-and-m?utm_pageloadtype=scroll, 2019

Parlesak A, Tetens I, Dejgård Jensen J, Smed S, Gabrijelčič Blenkuš M, Rayner M, et al. Use of linear programming to develop cost-minimized nutritionally adequate health promoting food baskets. *PLoS ONE* 11, 2016.

Ferguson E. L., Darmon N, Briend A. and Premachandra I. M., Food-based dietary guidelines can be developed and tested using linear programming analysis. *J Nutr.* Vol. 134, pp: 951–957, 2014.

Kawaguchi A. and Nagel A., Linear Programming in Database, *In Tech Open Publication*, pp 340-342, 2008.

Eiselt H. A. and Sandblom C. L, Linear Programming and its Applications*, Springer-Verlag Berlin Heidelberg Publication*, pp 80-81, 2007.

Ernst A. T., Jiang H., Krishnamoorthy M., and Sier D., Staff Scheduling androstering, A review of application, methods and models, *European Journal of Operational Research*, vol. 153, pp 3-27, 2004.

Agarana, M. C., An Application of Goal Programming Technique to Loan Portfolio in the Banking industry, M.Sc Project, University of Lagos, Nigeria, 2003.

Ferguson, E. L, Darmon, N, Briend, A, Premachandra, I. M., Food-based dietary guidelines can be developed and tested using linear programming analysis. *J Nutr*, vol. 134, pp 951–957, 2004.

Agarana M. C. and Ayeni F., Maximizing Operations Processes of a Potential World Class University Using Mathematical Model, *American Journal of Applied Mathematics,* vol. 3(2): pp. 59-63, 2015.

Agarana M. C. and Ehigbochie A. I., Optimization of Student's Academic Performance

in a World-Class University Using Operational Research Technique*, International Journal of Mathematics and Computer Applications Research,* Vol. 5(1), pp 43-50, 2015.