

Determining the Product Mix that Maximizes Profitability: A Sample Model Belonging to a Flour Mill

¹A. Alagoz, ²A.O. Dundar and ¹M. Bezirci

¹Department of Business Administration,

²Akoren Vocational School, Selcuk University, Konya, Turkey

Abstract: The aim of this study was to obtain output through certain mix proportions of multiple raw material input and to determine the optimal product mix that maximizes profitability in the flour industry in which products are obtained using the mixtures of these outputs. To this end, a multi-product linear programming model which is based on hypothetical data was developed under the constraint of resources and this model was analyzed using computer software and the results were evaluated.

Key words: Production planning, linear programming, profit maximization, data, out put, flour

INTRODUCTION

In the phase of preparing production plans, production managers are to make various important decisions that directly influence the firm's profitability, productivity and the production quality such as altering the amounts of raw materials, semi-finished and finished products in stocks; working undercapacity, increasing the capacity, working overtime and purchasing from outside. The fact that the number of factors that need to be considered in the decision making phase is high and the degree these factors affect one another have rendered inevitable the use of various scientific approaches. Linear programming is among the operational research techniques that ensure the most efficient use of limited resources in order to accomplish an objective and the most optimal distribution amongst different alternatives. Linear programming models consist of three components: objective function (profit maximization/cost minimization), alternative options and various resource limitations. In profit maximization problems, the profit impact of products on the model is used in the objective function. However in this study, it was attempted to attain maximum profitability by subtracting the firm's costs from its revenues in the objective function.

In a flour mill in which flour is produced which is the raw material for bread that is intensively consumed in underdeveloped and developing countries, it was aimed to formulate a linear programming model which is practicable for all firms in the industry and is based on hypothetical data in order to determine the optimal product mix that maximizes profits.

LITERATURE REVIEW

In the literature, there are many applications in which solutions are sought for firms' decision making problems using linear programming.

Thomas (1971) developed a profit-maximizing Linear Programming Model (LPM) with the aim of determining production and advertising levels. Grant and Hendon (1987) in their study on the optimal distribution of business resources developed a LPM in order to determine how the advertising budget of a private hospital should be spent in a way to maximize the number of people to whom the advertisements would reach. Eroglu and Omurbek developed a LPM that would maximize profitability in a beverage production factory. Acar *et al.* (2000) developed 13 different LPMs that minimize the costs of extracting products from sections in forest management.

Karayilmazlar in their study aiming at optimizing product mix, developed a LPM that maximizes the profitability of a particleboard factory. Stapleton *et al.* (2003) developed a revenue-maximizing LPM in order to determine the business volume the firm should create in the markets of different countries. Bircan and Kartal (2003) developed a LPM to determine the most suitable capacity for a cement plant operating in Sivas. Cankurt and Konak (2004) with the aim of optimizing the product mix, developed a LPM that maximizes profitability in the farm of the Agricultural Faculty at Adnan Menderes University.

Bircan and Kartal (2004) developed a market constraint model for optimal capacity usage in a cement

plant and using this model, determined the units causing bottlenecks and the unused capacities of the plant in process. Yusuf and Olowofeso (2007) examined the different combinations of the lines used by three big telecommunication firms in Nigeria as call center firms under defined operation resource constraints in a way to maximize profitability.

Adeosun and Adetunde (2008) developed a LPM that could help managers in decision making processes on the subject of mank portfolio management, especially in periods in which the economy is restructured.

The literature contains only one study that focuses on the production planning problem in flour mills. In the study conducted by Secme, a production planning model was developed that maximizes the monthly profit in a flour mill, the model was analyzed using classical and fuzzy linear programming and the results were compared.

In this study, different from the study carried out by Secme, the flour produced in the flour mill is the one used to produce whole-wheat bread and thus is subjected to a production process that is different from normal flour. Energy costs which constitute a large proportion of the costs in the industry and raw material constraints were added to the model. In addition, the capacity is formulated as the capacity of the machines to process wheat rather than as labour hours.

APPLICATION OF A FLOUR MILL

In this study in the flour industry producing wheat to be used in whole-wheat bread production, it was aimed to develop a multi-product linear programming model which is based on hypothetical data under the constraint of resources in order to determine the optimal product mix that would maximize profitability.

Flour production process: Flour mills make wheat purchasing decisions based on the results of wheat analysis. Wheat analyzed is classified and stored in dry wheat granaries according to properties. Products can be stored in firms’ silos mostly for months and sometimes until the next harvest.

Foreign objects in wheat are roughly cleaned out through purifiers and airlocks. Wheat processed in a purifier is classified into different qualities through dry wheat silo conveyor and stored in wheat silos. A mill might receive different properties of wheat. They can be mixed in certain proportions to obtain wheat mixes in desired properties. Mixture of wheat in different

qualities in different proportions to obtain a desired mixture is called blending. The production of flour with the desired properties is contingent upon the usage of good and healthy wheat that is free from foreign objects. Therefore, undesired foreign objects should be cleared out before the milling process. Wheat tempering is the process of bringing the rate of moisture of the wheat to be milled into a certain level and ensuring the homogeneous distribution of moisture among wheat kernels. Tempering before milling makes the physical structures of wheat kernels suitable for milling. High moisture causes the decline of yield whereas low moisture decreases quality as the amount of cinder within flour would be high. The process of milling starts as the cleaned-out and tendered wheat comes to the breaking system in a steady flow. The aim in milling what is to separate endosperm of the wheat kernel from skin and germ as much as possible and flouring the endosperm by resolving it. The process of milling indeed consists of breaking, crumbling, separating and classifying. Breaking and crumbling operations are made using roller mills.

Model formulation: In this model that is based on hypothetical data, the flour producing firm uses four types of wheat and stores each type in dry wheat silos having 500 ton storage capacities. The firm produces two types of blending for the production of two types of flour. From the sales data of Konya Commodity Exchange Market for December 29, 2009, minimum and maximum prices of wheat types were randomly selected and by taking their arithmetic means, wheat costs (purchasing prices) were determined. Wheat costs to the firm are shown in Table 1 whereas the mix proportions of blends are shown in Table 2.

During the production, the cleaning process reduces the blend weight by 3% whereas the tempering process increases it by 6%. That is the blend weight passing through the silo B1 rises by 3%. During the milling process, a 3% moisture loss occurs in the blend weight

Table 1: Wheat purchasing prices

Wheat type	Price movements of goods sold		Wheat purchasing price (ton/“)
	Min. price	Max. price	
B ₁ -AHMETAGA	464,000	464,000	464,00
B ₂ -BEZOSTAJA	454,000	570,000	512,00
B ₃ -ESPERIA	535,000	535,000	535,00
B ₄ -GEREK	445,000	490,000	467,50

Table 2: Mix proportions of wheat types in blends

Wheat type	Blend 1(P ₁)	Blend 2(P ₂)
B ₁ -AHMETAGA	25%	30%
B ₂ -BEZOSTAJA	-	60%
B ₃ -ESPERIA	50%	-
B ₄ -GEREK	25%	10%

due to the heat. The output of the milling process is distributed as follows: white flour (75%), dark flour (3%), fine bran (5%), rasmole (5%) and coarse bran (12%). By mixing the outputs in certain proportions, the flour used in producing whole-wheat bread is obtained. In producing flour 1; 100% of the yielded white flour, 100% of the dark flour, 60% of the fine bran, 60% of the rasmole and 25% of the coarse bran are used. In producing flour 2 on the other hand, 100% of the white flour, 100% of the dark flour, 100% of the fine bran, 100% of the rasmole are used while the coarse bran is not used at all. The capacity in flour mills is determined based on the roller mills that the flour mill owns. Each roller mill has the capacity to break wheat at a rate of 15 ton/24 h. It was assumed that the firm had eight roller mills and that the firm makes production in two shifts of 8 h every day.

For the costs of the firm rise in time periods of a day when electricity is more expensive. Therefore, the firm is reluctant to operate in expensive hours. The night shift is from 22:00 to 06:00 and the day shift is from 06:00 to 14:00. The firm consumes 60 kW of electricity for each ton of blend passing from the silo B1 before the milling and after the tempering (Table 3). Electricity prices shown here are the prices published by Turkish Electricity Distribution Company for the year of 2010. For each ton of blend produced before the cleaning stage; 30 is added to the general production costs. By assuming that the firm operates 8 h in a day, 7 days in a week and 4 weeks in a month for each shift; each shift is capable of milling 960 ton of wheat in a month.

Table 4 shows the amounts of demand for and prices of the flour types produced and the prices of products that are produced but not used in the production of flour such as fine bran, rasmole and coarse bran.

Under the light of the hypothetical data above, the aim is to determine the optimal product mix that would maximize the firm's monthly profit. To the solution of this production planning problem, the linear programming model was used and it was coded in WinQSB Version 1.0 for Windows software. The model was solved in 70 iteration steps.

Table 3: Electricity purchasing prices

Day (kr kWh ⁻¹)	Peek (kr kWh ⁻¹)	Night (kr kWh ⁻¹)
15,209	26,221	7,290

In this list, day covers the period of 06:00 to 17:00, peek 17:00 to 22:00 and night 22:00 to 06:00

Table 4: Amounts of demand for and prices of the products

Products	Amount of demand (ton)	Selling price (ton/)
Flour 1	850	800
Flour 2	500	830
Fine bran	--	400
Rasmole	--	380
Coarse bran	--	230

Definition of decision variables parameters:

- GNB_{ik} = The amount of k type of wheat in i type of blend produced in the day shift
- GCB_{ik} = The amount of k type of wheat in i type of blend produced in the night shift
- GNB_k = Total amount of k type of wheat used in the day shift
- GCB_k = Total amount of k type of wheat used in the night shift
- GNP_i = The amount of i type of blend produced in the day shift
- GCP_i = The amount of i type of blend produced in the night shift
- B1GNP_i = The amount of i type of blend (after tempering) passing through the silo B1 in the day shift
- B1GCP_i = The amount of i type of blend (after tempering) passing through the silo B1 in the night shift
- B1GNPT = The total amount of blend passing through the silo B1 in the day shift
- B1GCPT = The total amount of blend passing through the silo B1 in the night shift
- GNSC_i = The amount of final output obtained from i type of blend (after milling) in the day shift
- GCSC_i = The amount of final output obtained from i type of blend (after milling) in the night shift
- GNBU_i = The amount of i type of white flour produced in the day shift
- GCBU_i = The amount of i type of white flour produced in the night shift
- GNEU_i = The amount of i type of dark flour produced in the day shift
- GCEU_i = The amount of i type of dark flour produced in the night shift
- GNIK_i = The amount of i type of fine bran produced in the day shift
- GCIK_i = The amount of i type of fine bran produced in the night shift
- GNR_i = The amount of i type of rasmole produced in the day shift
- GCR_i = The amount of i type of rasmole produced in the night shift
- GNKK_i = The amount of i type of coarse bran produced in the day shift
- GCKK_i = The amount of i type of coarse bran produced in the night shift
- GNUN_i = The amount of i type of flour produced in the day shift
- GCUN_i = The amount of i type of flour produced in the night shift

UNT _i	=	The total amount of i type of flour produced in the day and night shifts	ke	=	The ratio of coarse bran not used in the final flour in the day and night shifts
KIK	=	The total amount of remaining fine bran not used in the production of flour	UTM	=	The amount of demand for the flour 1
KR	=	The total amount of remaining rasmole not used in the production of flour	UTN	=	The amount of demand for the flour 2
KKK	=	The total amount of remaining coarse bran not used in the production of flour	gne	=	The selling price of 1 kW of electricity used in the day shift
B1GNP K	=	The amount of capacity used in the day shift	gce	=	The selling price of 1 kW of electricity used in the night shift
B1GCP K	=	The amount of capacity used in the night shift	gum	=	The general production cost per ton of blend (produced before cleaning and tempering) in the day and night shifts
BKM _i	=	The total amount of i type of wheat used in the day and night shifts	un _i	=	The selling price for a ton of i type of flour
Bk _i	=	The cluster of wheat types that compose the i type of blend	kr	=	The selling price for a ton of rasmole
P _k	=	The cluster of blend types that include k type of wheat	b _k	=	The selling price for a ton of i type of flour
bo _{ik}	=	The proportion of k type of wheat in i type of blend in the day and night shifts	kik	=	The selling price for a ton of fine bran
ft	=	The rate of blend to be obtained after the tempering process in the day and night shifts	kkk	=	The selling price for a ton of coarse bran
sc	=	The ratio showing the moisture loss of blends during milling in the day and night shifts	BSK	=	The capacity of the wheat silos
bu	=	The rate of turning to white flour for the final output obtained after milling in the day and night shifts			
eu	=	The rate of turning to dark flour for the final output obtained after milling in the day and night shifts			
ik	=	The rate of turning to fine bran for the final output obtained after milling in the day and night shifts			
r	=	The rate of turning to rasmole for the final output obtained after milling in the day and night shifts			
kk	=	The rate of turning to coarse bran for the final output obtained after milling in the day and night shifts			
ui	=	The rate of blending into the final flour for the amount of fine bran produced in the day and night shifts			
ur	=	The rate of blending into the final flour for the amount of rasmole produced in the day and night shifts			
uk	=	The rate of blending into the final flour for the amount of coarse bran produced in the day and night shifts			
ir	=	The ratio of fine bran and rasmole not used in the final flour in the day and night shifts			

DISCUSSION

The following conclusions were drawn following the analysis of Appendix that includes the model analysis results. Of the wheat number 1 (Ahmetaga); 260,2095 ton were consumed in the day shift (GNB₁) and 233,0097 ton were consumed in the night shift (GCB₁); totalling (BKM₁) 493,2192 ton. The firm still has 6,7808 ton of it ready to use. Of the wheat number 2 (Bezostaja); 500 ton were consumed in the day shift (GNB₂) and 0 ton was consumed in the night shift (GCB₂); totalling (BKM₂) 500 ton. It appears that all of it was consumed. Of the wheat number 3 (Esperia); 20,4190 ton were consumed in the day shift (GNB₃) and 466,0194 ton were consumed in the night shift (GCB₃); totalling (BKM₃) 486,4384 ton. The firm still has 13,5616 ton of it ready to use. Of the wheat number 4 (Gerek); 93,5428 ton were consumed in the day shift (GNB₄) and 233,0097 ton were consumed in the night shift (GCB₄); totalling (BKM₄) 326,5525 ton. The firm still has 173,4475 ton of it ready to use. Of the blend 1 prepared for the production of flour 1; 40,8379 ton were prepared in the day shift (GNP₁) and 932,0388 ton were prepared in the night shift (GCP₁). Of the blend 2 prepared for the production of flour 2; 833,3333 ton were prepared in the day shift (GNP₂) and 0 ton was prepared in the night shift (GCP₂).

In maximization problems, the aim is to produce at a level that maximizes the profitability. Therefore as insofar as the resources and constraints permit, the model tries to utilize the entire capacity. In the day shift (B1GNPT) 900,3964 ton of wheat were milled leaving 59,6036 ton of wheat processing capacity idle. In the night shift

(B1GCPT) on the other hand, it is seen that the entire wheat processing capacity of 960 ton was used. The reason the night shift's entire capacity was used is low electricity prices. Electricity consumption constitutes an important portion of the firm's costs. In the model when the electricity costs in the day and night shift consumed per ton passing through the silo B1, the electricity cost in the day shift for the firm was 8.3322690 and in the night shift was 4.1990400, 3568 ton of flour 1 were produced in the day shift (GNUN₁) and 81,432 ton were produced in the night shift (GCUN₁); totalling (UNT₁) 850 ton which is the lower limit of demand.

On the other hand, 73,645 ton of flour 2 were produced in the day shift (GNUN₂) and no flour 2 was produced in the night shift which then suggests that the total amount produced (73,64,500 ton) is above the quantity demanded (500 ton). The reason flour 2 was produced more is its higher profit contribution to the model.

The firm produced 195,402 ton of fine bran (KIK), 1,95,402 ton of rasmole (KR) and 18,83,560 ton of coarse bran (KKK) which were not used in producing flour 1 and 2. Under the light of these data; the highest possible profit of the firm is 385.33760 per month in the model. When shadow prices are reviewed; it is seen that if the total amount of Bezostaja (BKM₂) is increased by 1 ton, its profit contribution to the model would be 38,08,998.

If the capacity of the night shift (B1GCP K) is increased by 1 ton, its profit contribution to the model

would be 48,800 and an increase in the total amount of FLOUR 1 produced (UNT₁) by 1 ton would increase the profit by 22,37,681.

CONCLUSION

As the analysis of the model that was formed in the study is reviewed, it is seen that the entire capacity could not be utilized.

The reason of this is the limited capacities of the silos where the wheat is stored. If these capacities are increased, the firm could operate in fulfilment of its full capacity.

Future studies can consider financial constraints by adding the budget constraint to the model and all costs by adding packaging unit to the model. The decision to prepare blend is related to obtaining the desired flour quality by reviewing wheat analysis results. If wheat analyses are added to the model in order to find the most suitable blend mixture rates; the model could be improved to a level in which it includes all production decisions.

This model which is aimed at the optimal utilization of available resources can be used by those firms which operate in the flour industry and have similar constraints in order to determine the profit-maximizing one among different alternatives according to their capitals. It will be of guiding significance for such firms in terms of both administration and future planning.

APPENDIX

Formulation of the objective function:

Max

$$\sum_{i=1}^I un_i (GNUN_i + GCUN_i) + kik KIK + kr KR + kkk KKK - \sum_{k=1}^K b_k (GNB_k + GCB_k) - gne B1GNPT - gce B1GCPT - \sum_{i=1}^I gum (GNP_i + GCP_i) \quad (1)$$

Constraining conditions:

$$GNB_{ik} = bo_{ik} GNP_i, GCB_{ik} = bo_{ik} GCP_i \quad (i=1, \dots, I) \quad (2)$$

$$GNB_k = \sum_{i \in P_i} GNB_{ik}, GCB_k = \sum_{i \in P_i} GCB_{ik} \quad (k=1, \dots, K) \quad (3)$$

$$GNB_i = \sum_{k \in BK} GNB_{ik}, GCB_i = \sum_{k \in BK} GCB_{ik} \quad (i=1, \dots, I) \quad (4)$$

$$B1GNP_i = ft GNP_i, B1GCP_i = ft GCP_i \quad (i=1, \dots, I) \quad (5)$$

$$GNSC_i = sc B1GNP_i, GCSC_i = sc B1GCP_i \quad (i=1, \dots, I) \quad (6)$$

$$GNBU_i = bu GNSC_i, GCBU_i = bu GCSC_i \quad (i=1, \dots, I) \quad (7)$$

$$GNEU_i = eu \text{ GNSC}_i, GCEU_i = eu \text{ GCSC}_i \quad (i=1, \dots, I) \tag{8}$$

$$GNIK_i = ik \text{ GNSC}_i, GCIK_i = ik \text{ GCSC}_i \quad (i=1, \dots, I) \tag{9}$$

$$GNR_i = r \text{ GNSC}_i, GCR_i = r \text{ GCSC}_i \quad (i=1, \dots, I) \tag{10}$$

$$GNKK_i = kk \text{ GNSC}_i, GCKK_i = kk \text{ GCSC}_i \quad (i=1, \dots, I) \tag{11}$$

$$GNUN_1 = GNB_1 + GNEU_1 + ui \text{ GNIK}_1 + ur \text{ GNR}_1 + uk \text{ GNKK}_1 \tag{12}$$

$$GCUN_1 = GCB_1 + GCEU_1 + ui \text{ GCIK}_1 + ur \text{ GCR}_1 + uk \text{ GCKK}_1$$

$$GNUN_2 = GNB_2 + GNEU_2 + GNIK_2 + GNR_2 \tag{13}$$

$$GCUN_2 = GCB_2 + GCEU_2 + GCIK_2 + GCR_2$$

$$KIK = ir (GNIK_1 + GCIK_1) \tag{14}$$

$$KR = ir (GNR_1 + GCR_1) \tag{15}$$

$$KKK = ke (GNKK_1 + GCKK_1) + GNKK_2 + GCKK_2 \tag{16}$$

$$GNB_i + GCB_i \leq BSK \quad (i=1, \dots, I) \tag{17}$$

$$B1GNPT = \sum_{i=1}^I B1GNP_i \quad (i=1, \dots, I) \tag{18}$$

$$B1GCPT = \sum_{i=1}^I B1GCP_i \quad (i=1, \dots, I) \tag{19}$$

$$GNUN_1 + GCUN_1 \geq UTM \tag{20}$$

$$GNUN_2 + GCUN_2 \geq UTN \tag{21}$$

Supplementary 1: Analysis results

Decision variables	Solution values	Unit cost or profit c(j)	Total contribution	Reduced cost	Basis status	Allowable min. c(j)	Allowable max. c(j)
GNB1	260,2095	-464,0000	-120.737,2000	0	Basic	-M	-443,8944
GNB2	500,0000	-512,0000	-256.000,0000	0	Basic	-M	M
GNB3	20,4190	-535,0000	-10.924,1500	0	Basic	-M	-524,9472
GNB4	93,5428	-467,5000	-43.731,2700	0	Basic	-M	-447,3944
GCB1	233,0097	-464,0000	-108.116,5000	0	Basic	-484,1056	0
GCB2	0	-512,0000	0	0	Basic	-M	M
GCB3	466,0194	-535,0000	-249.320,4000	0	Basic	-545,0528	0
GCB4	233,0097	-467,5000	-108.932,0000	0	Basic	-487,6056	0
GNP1	40,8379	-30,0000	-1.225,1380	0	Basic	-M	-24,9736
GNP2	833,3333	-30,0000	-25.000,0000	0	Basic	-M	M
GCP1	932,0388	-30,0000	-27.961,1600	0	Basic	-35,0264	M
GCP2	0	-30,0000	0	0	At bound	-M	M
B1GNPT	900,3964	-9,2540	-8.332,2690	0	Basic	-M	-4,3740
B1GCPT	960,0000	-4,3740	-4.199,0400	0	Basic	-9,2540	M
GNUN1	35,6800	800,0000	28.544,0000	0	Basic	-M	805,7530
GNUN2	736,4500	830,0000	611.253,5000	0	Basic	-M	M
GCUN1	814,3200	800,0000	651.456,0000	0	Basic	794,2470	M
GCUN2	0	830,0000	0	0	Basic	-M	M
KIK	19,5402	400,0000	7.816,0920	0	Basic	-M	M
KR	19,5402	380,0000	7.425,2870	0	Basic	-M	M
KKK	188,3560	230,0000	43.321,8900	0	Basic	-M	M
Objective	Function	(Max.) =	385.337,6000			(Alternate solution exists)	
Constraint	Left hand side	Dirac.	Right hand side	Slack or surplus	Shadow price	Allow. min. RHS	Allow. max. RHS
BKM1	493,2192	≤	500,0000	6,7808	0	493,2192	M
BKM2	500,0000	≤	500,0000	0	380,8998	339,4664	513,5616
BKM3	486,4384	≤	500,0000	13,5616	0	486,4384	M
BKM4	326,5525	≤	500,0000	173,4475	0	326,5525	M
B1GNP K	900,3964	≤	960,0000	59,6036	0	900,3964	M
B1GCP K	960,0000	≤	960,0000	0	4,8800	900,3964	1.002,0630
UNT1	850,0000	≥	850,0000	0	223,7681	814,3200	873,6975
UNT2	736,4500	≥	500,0000	236,4500	0	-M	736,4500

REFERENCES

- Acar, H., U. Gul and S. Gumus, 2000. Bolmeden cikarma calismalarinda toplam maliyetin minimizasyonu icin dogrusal programlama kullanimi. *Turk. J. Agric. For.*, 24: 383-391.
- Adeosun, O.O. and I.A. Adetunde, 2008. On the linear programming to bank portfolio management. *Int. Bus. Manage.*, 2: 71-77.
- Bircan, H. and Z. Kartal, 2003. Dogrusal programlama tekniği ile kapasite planlamasi yaklami ve cimento isletmesinde bir uygulaması. *Uludag Universitesi Iktisadi ve Idari Bilimler Fakultesi Dergisi*, Cilt XXII, Sayı 1: 213-232.
- Bircan, H. and Z. Kartal, 2004. Dogrusal Programlama Tekniği İle Kapasite Planlaması Yaklaşımı ve Cimento İşletmesinde Bir Uygulaması. *Cumhuriyet Universitesi İktisadi ve İdari Bilimler Dergisi*, 5: 131-149.
- Cankurt, M. and K. Konak, 2004. ADU ziraat fakultesi uygulama çiftliğinde tarla bitkileri subesi üretim planlaması. *Adnan Menderes Üniversitesi Ziraat Fakultesi Dergisi.*, 1: 51-56.
- Grant, E.W. and F.N. Hendon, 1987. An application of linear programming in hospital resource allocation. *J. Health Care Marketing*, 7: 69-72.
- Stapleton, D.M., J.B. Hanna and D. Markussen, 2003. Marketing strategy optimization: Using linear programming to establish an optimal marketing mixture. *Am. Bus. Rev.*, 21: 54-62.
- Thomas, J., 1971. Linear programming models for production-advertising decisions. *Manage. Sci.*, 17: B474-B484.
- Yusuf, T.T. and E.O. Olowofeso, 2007. An optimal profit linear programming model for business call center's operators in Nigeria. *Res. J. Applied Sci.*, 2: 17-21.