



The Effect of Computer Simulation, Linear Programming for Industrial Projects

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Department of Mathematics, College of Science

University of Diyala, Diyala, Iraq.

wadhahabdulelah@uodiyala.edu.iq

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Abstract

Using the effect of computer simulation linear programming models with many objectives in operations research. The maximum profits were calculated for companies in the ministry of Industry in Iraq accurate. The Dual Model method was used for the conflicting objectives of the model. This is done by using the corresponding model and then finding the optimal solution for each objective function, which represents the profits and under the same restrictions. Then extracting the average of the optimal solution for the multiple objective functions. And by building a linear model with one objective that achieves maximizing profits for the factory. Also we used modern computer simulation using WIN QSB programs to built according in Steps to solving a multi-objective model.

Key words: Simulation, multi-objective linear model, the Dual Model, average optimal solution.

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تأثير المحاكاة الحاسوبية والبرمجة الخطية للمشروعات الصناعية

وضاح عبدالاله حسين

قسم الرياضيات, كلية العلوم, جامعة ديالى, ديالى, العراق

الخلاصة

استخدام نماذج البرمجة الخطية المحاكاة الحاسوبية ذات الأهداف المتعددة في بحوث العمليات. تم احتساب اقصى ارباح لشركة في وزارة الصناعة العراقية بشكل دقيق. تم استخدام طريقة جديدة للنموذج المقابل للأهداف المتضاربة للنموذج. يتم ذلك باستخدام النموذج المقابل ثم إيجاد الحل الأمثل لكل دالة موضوعية والتي تمثل الأرباح وتحت نفس القيود. ثم استخراج متوسط الحل الأمثل لوظائف الهدف المتعددة. وذلك ببناء نموذج خطي بهدف واحد يحقق أكبر قدر من الأرباح للمصنع. كما استخدمت محاكاة الكمبيوتر الحديثة باستخدام برامج WIN QSB لبنائها وفقاً لذلك.

الكلمات المفتاحية: المحاكاة ، النموذج الخطي متعدد الأهداف ، النموذج المزدوج ، متوسط الحل الأمثل.

Introduction

Using mathematical methods to calculate the profits of a group of companies with the highest accuracy through linear programming and the formation of a linear model for the objective function and constraints. It gives efficiency and accuracy in calculating profits [1].

1. Objective Functions Models

The goal function is the mathematical formula or the mathematical equation that shows the measurement of the total impact of profit if it is a goal function of type max or cost if the goal function is of type min for the variables related to decision-making, which determines the amount of total profit or the amount of total cost [2].

1.1 Linear Programming Simplex Method

The simplex method is based on the property that the optimal solution to a linear programming problem, if it exists, can always be found in one of the basic feasible solutions. The simplex

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method is quite simple and mechanical in nature. The iterative steps of the simplex method are repeated until a finite optimal solution, if exists, is found. If there is no optimal solution, the method indicates that no finite solution exists [1]. In the simplex method, the number of corner points to be tested is greatly reduced by using a very efficient algorithm which leads us to the optimal solution point in only a few iterations[1]. This process stops when we reach one of the following cases:

1. Obtaining a final solution, which is the optimal solution and includes the case of multiple solutions and the case of dissolution.
2. Determine an infinite number of solutions.
3. The problem has infeasible solution.

1.2 Big - M Method

The big m method is a modified version of the simplex method in linear programming (LP) in which we assign a very large value (M) to each of the artificial variables. Define the principle of Big M (simple form method) After adding the artificial variables to the constraints of the linear programming system, the considered term M or a parameter needs to be added to the objective function accordingly. In the maximization problem, a synthetic variable M is assigned as its parameter; In the minimization problem, a synthetic variable M is set as a parameter, and M is an arbitrarily large (not infinite) positive number. Regarding M as an algebraic symbol to participate in the process, it is solved by the simplex method, so this method is called the big M method, which can also be called the penalty factor method.

1.3 Artificial Variable Method

Using this method is simpler than big (M) method in finding the optimal solution for linear programming (L.P) in the case of minimization, as it is possible to obtain the optimal solution for the model after making sure that there is a solution to the model, by obtaining the value of a function. The new target is equal to zero [4]. That is, ($r = 0$) and without it, there is no solution to the model, and the solution is carried out according to this method in two basic stages, as follows: a. The first stage Includes the following steps:

1. Convert the Linear Programming (LP) model from the legal form to the standard form and then add the synthetic variables (R1) for the model constraints only [4].

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2. Formulation of a new objective function \otimes based on synthetic variables ($R1$), that is, if:
 $\text{Min. } (r = R1 - R2 - \dots - Rn)$
3. Design a table that includes the initial solution, depending on the coefficients of the variables S_i, X_j, R_i in the constraints of the model, and the new objective function r [4].
4. We follow the previous steps, until we get the value ($0 = r$). Which means there is a solution of the model, and all coefficients of the objective function \otimes are associated in a universe ($0 > C_j$) [4].

1.4 The second phase

1. Adopt the final basic solution in step (4) of the first stage, after excluding. Synthetic variables (R_i), and the objective function [4].
2. Adopt the original objective function [4].

2.1 Mathematical Model

To seek to take the optimal decision to achieve a set of goals facing the decision maker, these goals should be formulated in a way that works to find effective results, and the general formula for linear multi-objective programming is as follows:

$$\text{Optimization } Z = (\text{Max } Z_1, \text{Max } Z_2, \dots, \text{Max } Z_r, \text{Min } Z_{r+1} \dots \text{Min } Z_s)$$

Subject to:

$$AX = b$$

$$X \geq 0$$

since:

r = is the number of goal functions to be maximized.

s = the number of goal functions to be minimized and maximized.

X = is the vector of the decision variables.

B = is the vector of the right-hand side (the constants).

$(s - r)$ = is the number of goal functions to be reduced, A = is an array ($m \times n$) of operator.

2.2. The corresponding model (equivalent) The Dual Model

Sometimes it is necessary to convert the linear programming model to the standard form and to convert the objective functions or constraints to go with the solution and to get the optimal solution to the problem, as it is possible to convert the objective function to any model Linear programming from type Max to type Min and vice versa, as the conversion is by multiplying the function by (-1) , that is, if the function is of type $(\text{Max } (z))$, then converting it to the

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corresponding function or its equivalent will be in the form (Min) $-z$ and any solution to the function Of type Max, it will in turn be a solution to its equivalent function, which is Min. The same method is used for constraints, as it can be converted according to the requirements of the model and according to the nature of the constraint, where if the constraint is of a type greater or equal to (k), it can be converted to the other type which is less or equal to (2) by multiplying it by (-1) [8].

2.2.1 Steps to solving a multi-objective model

1. Determine the goal of the problem and formulate the model according to the objectives [9].
2. Conversion of the type of objectives (i.e. their standardization as either Minimization or Maximization [10].
3. Modifying and transforming constraints according to the type of function that was converted at 2 [9].
4. Solve each objective function separately and under the same constraints to obtain the optimal solution for each function in the multiple model [9].
5. Determining the resultant of the optimization goal function from the optimization solution for goal functions of type Max, as it is symbolized by the symbol m_2 [5].
6. Determining the resultant of the optimization goal function from the optimization resultant for goal functions of type Min, as it is symbolized by the symbol m_2 [7].
7. Finding the average of the optimal solution (OAV), since:

$$O_{AV} = \frac{m_1 + m_2}{2}$$

8. Formulate the new linear model (Dual Mathematical Model) and a target function of type Max or of type Min under the same restrictions, as the model will be as follows [9]:

$$\text{Maximization } Z = \frac{\sum_{j=1}^s z_j}{OAV} \text{ or Minimization } Z = \frac{\sum_{j=1}^s z_j}{OAV}$$

$$AX = b, X \geq 0 .$$

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Table 1: The model will be built with four main objectives, namely

The Factory	Products	variable Symbol	Profit Per Unit (I.D)	Cost Per Unit (I.D)	Production Time of One Unit Per Hour
Baghdad Textile Factory	Cotton Fabrics	X_1	86	1312	0.043
Medical Dressing Factory	Medical Cotton	X_2	721	6779	0.0065
	Gauze Rolls	X_3	844.5	6155.5	0.12
	Masks	X_4	107	134	0.19
Plastic Bags Factory	Standard Plastic Bags	X_5	20	191	0.245
	Lined Plastic Bags	X_6	82	587	0.245

2.3. Applied side

A cotton factory is one of the factories of the General Company for Textile and Leather Industries, and the factory consists of several from factory (Baghdad textile, medical bandage, plastic bag factory), as the last factory is the latest factory of the factory, as it produces two types of plastic bags, which are (standard plastic bags, standard plastic lined bags), and the medical bandage factory produces several products. The most important of them are (medical cotton, gauze and bandage rolls of different sizes, masks), and the Baghdad Textile Factory produces (cotton fabrics of all kinds).

2.3.1 Building the multi-objective linear model

Maximizing profits for the factory, achieving the (expected) annual demand, reducing the total cost of production and reducing working hours based on the current conditions. It also shows the time taken to produce one of the mentioned products.

Table 2: Profit, production costs and time to produce one unit of products

Source: Table prepared by the researcher according to planning records, cost accounts and factories.

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Table 2: Available design capacity for each product

The Factory	Products	variable Symbol	Measuring Unit	Design Energy	Available Energy
Baghdad Textile Factory	Cotton Fabrics	X ₁	1000M ²	67120	34270
Medical Dressing Factory	Medical Cotton	X ₂	1Ton	449	331
	Gauze Rolls	X ₃	1000M ²	25000	19000
	Masks	X ₄	1000 piece	15495	15495
Plastic Bags Factory	Standard plastic Bags	X ₅	1000 Bags	12000	10000
	Lined plastic bags	X ₆	1000 Bags	12000	10000

The constraints will also be the constraints of raw materials, as the factory faces a challenge in providing the raw materials needed to produce the products and meet the demand. Table (2) shows the design capacity and available for each product according to the factory data. Table (3) shows the raw materials involved in making the products and the quantity of available materials one of the raw materials in factories.

Table 3: shows quantity per product from factories.

The Factory	Products	Measuring Unit	Raw Materials	Quantity Per Product
Baghdad Textile Factory	Cotton Fabrics	Meter	Cotton	
Medical Dressing Factory	Medical Cotton	Meter	Hair Cotton	
	Gauze Rolls	Meter	Raw Gauze Woven Raw Gauze	
	Masks	Piece	Fabric mss	
Plastic Bags Factory	Standard Plastic Bags	Piece	PP Granules	0.95
			Color Granules	0.02
			Grains kc	0.03
	Lined Plastic Bags	Piece	Polyethylene pe	0.2
			PP Granules	0.75
			Color Granules	0.02
			Grains kc	0.03

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From the above data, the mathematical model will be as follows:

$$\text{Max. } z_1 = 86x_1 + 721x_2 + 844.5x_3 + 107x_4 + 20x_5 + 82x_6$$

$$\text{Max. } z_2 = x_1 + x_2 + x_3 + x_4 + x_5 + x_6$$

$$\text{Min. } z_3 = 1312x_1 + 6779x_2 + 6115.5x_3 + 134x_4 + 191x_5 + 587x_6$$

$$\text{Min. } z_4 = 0.043x_1 + 0.0065x_2 + 0.12x_3 + 0.19x_4 + 0.245x_5 + 0.245x_6$$

Subject to:

$$63.13x_1 \leq 2163500$$

$$50x_2 \leq 16550$$

$$50x_3 \leq 950000$$

$$x_4 \leq 1549.5$$

$$0.95x_5 + 0.75x_6 \leq 20587.5$$

$$0.02x_5 + 0.02x_6 \leq 505$$

$$0.03x_5 + 0.03x_6 \leq 757.5$$

$$0.02x_6 \leq 3400$$

The constraints represent the available raw materials and the proportion of the material needed by each product after building the model. The problem is solved using **Win QSB program**, as the results will be as follows: The function of maximizing profits amounted to (214,67720) thousand dinars compared to the profits of the company, which amounted to (19043881) thousand dinars, while the function of reducing costs amounted to (175572919) thousand dinars compared to the manufacturing costs of the company, which amounted to (178430700) thousand dinars, and the total time of the time reduction function was (10) hours per day. The average work was 12 hours per day, and the optimal product production amount was as follows:

Table 4: shows the values of the variables

Products	Measuring unit	Variable symbol	Optimum production values
Cotton Fabrics	Meter	X ₁	34270550
Medical Cotton	Meter	X ₂	331000
Gauze Rolls	Meter	X ₃	19000000
Masks	Piece	X ₄	1549500
Standard Lined Plastic Bags	Piece	X ₆	25250000

When using the method of unifying the objectives and following the mentioned steps, the optimal rate was determined, as its value amounted to (45318.745) and after building the model and solving it using the Win QSB program, the total profits of the company under the same

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restrictions for the raw materials amounted to (44129421) thousand dinars with the same production quantities values shown in Table (4).

Conclusions and Recommendations:

1. The use of this method gives better results by win QSB program.
2. Building the model helped to maximize profits for the factory through the use of the best available resources and raw materials.
3. The model worked to reduce the total costs compared to the cost of the factory.
4. Using a multi-objective model and transforming it into a corresponding model to unify the objectives is one of the best ways to choose the appropriate decision for production, improve profits and reduce costs.
5. The model worked to reduce the total production time by distributing work during the year according to demand and production.

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