The Application of Operations Research in the Decision-making of Enterprise Procurement Scheme

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Abstract: Many branches of operations research, widely used, improve the social production efficiency, created huge economic benefits. However, in practical production and living problems, there are usually multiple goals that need to be realized and variable factors that affect the realization of goals are of different importance. Therefore, this paper studies a branch of operations research -- linear goal programming, and establishes a multi-objective 0-1 programming model to solve the decision-making problem of procurement solutions, and gives application examples.

Keywords: multi-objective; programming; 0-1 planning; production scheme decision; making optimal utilization of resources

1 INTRODUCTION

1.1 The history of operations research

The term operations research was originally coined in the late 1930s.[1]In the second World War, in order to prevent enemy air raids, the United Kingdom convened many experts to form a multidisciplinary research group, namely the earliest operational research group in the world, to study "the best use of air force and the latest invention of radar to defend the country", the group mainly carried out "application research". The results of the research significantly improved the Level of British air defense and effectively resisted Nazi German air raids in the subsequent war.

From the mid-1940s to the early 1950s, it was the founding period of operations research, during which the discipline of operations research was basically established and formed. G.B. Dantzing, an American mathematician, studied the mathematical model of general linear programming in 1974 and used simplex method to solve it. After the Second World War, in order to quickly recover the domestic economy, Britain vigorously promoted operations research from military industry to many fields of civil industry. The establishment of Operations Research Quarterly in 1950 marked the real birth of the discipline of operations research. The American Society for Operational Research was founded in 1952. Later, operational research societies were established in many countries around the world.

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In the early 1950s, belongs to the development of the operational research mature period in the late 1950 s, coincides with the rapid development of computer technology, using computer technology to achieve operational research in many algorithms, make people see the effectiveness of operational research to solve problems, operational research got great popularization and applications. In 1959, the International Federation of Operations Research was founded to promote the international exchange of operations research knowledge.

Since the 1960s, operations research has entered a period of rapid development. With the rapid rise of electronic computer technology, the field of problems solved by operations research has been expanded and the scale of problems has become larger. Operations research has better auxiliary tools, and the research depth and scope have become deeper and broader. Nowadays, operations research is faced with cross-application research with other disciplines.

1.2 Development and application of operations research in China

As early as in ancient times, the thought of operational research appeared in some allusions in Our country. In the story of horse racing in Tian Ji, the whole optimal thought of operational research was reflected in the race between dismounted horses and mounted horses, between mounted horses and dismounted horses, and between mounted horses and dismounted horses. It is a typical game problem that Sun Bin encircled Wei and saved country Zhao. It is recorded in the 《Records of the Historian》 that Liu Bang, the first emperor of the Han Dynasty, praised Zhang Liang, a famous strategist: "Your husband strategies well and wins the battle thousands of miles away."

In the 1950s, the discipline of operations research began to rise and develop gradually in China. China's first operations research group was born in 1956. In 1957, operation research was translated as "operations research". Since 1950s, operational research has been widely used and developed rapidly in textile production, transportation, agricultural production, civil water conservancy, post and telecommunications, etc. In 1960, Chinese scholars studied and put forward the "Chinese postal road problem". In the 1970s, LuoGeng Hua, the "mathematician of the people", proposed the excellent selection Method,[2] which has been widely used in all walks of life across the country and created remarkable economic benefits.

Now, with the rapid development of economy in our country big data, Internet, wisdom, the rapid rise of the modern information technology such as urban construction, operational research as an applied science method, scheme optimization and decision of discipline, gradually in transportation, economic management, production scheduling, engineering design application promotion, provides scientific basis for the decision of society in various fields, brought huge economic benefits to the society. Operations research has developed into a new interdisciplinary subject, which will be more applied to comprehensive problem solving.

2 Materials and Methods

2.1 The theoretical study

Operations research can be subdivided into ten branches, this paper studies one of the branches - linear programming problem in production scheme decision and used to solve practical problems, achieve optimal utilization of resources, in order to obtain the maximum economic profit, has important significance in the field of economic management and production management.

2.1.1 0-1 programming

0-1 programming, also known as binary variables, is a special class of integer programming models. The value of variables can only be 0 or 1. This model can transform some nonlinear problems into problems related to integer programming for solving, usually using branch and bound method to solve 0-1 programming problems. Literature [3] proposed a continuous solution method for linear programming problems. Literature [4] studied the sensitivity of 0-1 programming model

The standard form of 0-1 programming mathematical model[5]is:

$$min\, z = \sum_{j=1}^{n} c_j x_j \tag{1}$$

$$\begin{gathered} c_j \geq 0(j = 1,2,\cdots,n) \\ Q_i = -b_i + \sum_{j=1}^{n} a_{ij} x_j \geq 0(\mathrm{i} = 1,2,\cdots,m) \\ x_j = 0\mathrm{or}1(j = 1,2,\cdots,n) \end{gathered} \tag{2}$$

2.1.2 Multi-objective programming

Multi-objective programming model on display is found in the 1990 s operational research branch of a certain type model, different from the single objective function, the multi-objective function problem of multiple targets, each target and there is a conflict between different units of measurement, solve the problem because of the importance of each target is different, can according to the empowerment of the importance of a variety of methods for target, cent gives your priorities, step by step optimization, priority focus on the goal of implementation. Literature [6] proposed a variety of calculation methods for multi-objective programming problems. Because in solving practical problems, objective determination and constraint conditions are based on many aspects, so multi-objective linear programming is more consistent with practical problems.

Multi-objective programming can be solved by graphical method and sequential algorithm.

2.1.3 Assign different weights to variables that affect the objective function

There are often many different variables that will affect the realization of the objective function. Entropy weight method, principal component analysis and other evaluation methods can be used in advance to assign different weights to multiple influencing factors, so as to make the model solution more objective and fit the reality.

3 RESULTS & DISCUSSION

3.1 Question raising

A construction company has three kinds of raw materials for production: A, B and C. The production time of the enterprise is 48 weeks per year, and the procurement plan of raw materials (ordering and shipping) is made 24 weeks in advance. The weekly production capacity is 28,200 cubic meters. We know the supply quantity and order quantity of 402 suppliers in the past five years, as well as the transportation loss rate data of 8 transporters in the past five years. Each supplier can provide A, B and C raw materials. Each has a capacity of 6000 m3 / week. According to the existing data, the analytic hierarchy process (AHP) can be used for quantitative analysis to determine the 50 most important suppliers to ensure the production of enterprises. It is required to select at least how many transporters can meet the production demand, and formulate the most economical raw material ordering scheme and the transport scheme with the least loss for the next 24 weeks.

3.2 Question assumptions

In the first week of the production enterprise, the storage of raw materials A, B and C were 0.

The manufacturer needs to maintain a production inventory of not less than two weeks.

In order to meet the production demand of the enterprise, its order quantity should exceed the actual supply quantity.

The enterprise accepts all the raw materials provided by the supplier.

3.3 Data processing

Integrate the raw material information according to the initial data given by the topic. According to the data of transportation attrition rate of 8 transporters in recent 5 years, the weekly transportation attrition rate of each transporter is predicted by using the prediction model, taking the next 24 weeks and 5 weeks as an example.

Raw material information and transportation attrition rate are predicted as follows:

TABLE 1 INFORMATION OF 3 RAW MATERIALS1

Raw material type	*Raw materials consumed to produce 1m³ products (m³)*	*Weekly capacity (m³)*	*Purchase unit price of raw materials*	*The cost of transportation*	*Storage costs*
A	0.6	28200	1.20	1.00	1.00
B	0.66		1.10	1.00	1.00
C	0.72		1.0	1.00	1.00

TABLE 2 PREDICTED VALUES OF TRANSPORT LOSSES IN THE FIRST 5 WEEKS OF THE NEXT 24 WEEKS FOR 8 TRANSPORTERS2

Transshipment business ID / weekly	*1*	*2*	*3*	*4*	*5*
T1	0.8829	0.8204	0.7849	0.7384	0.5319
T2	0.2197	0.2056	0.0859	0.1344	0.1428
T3	0.0000	0.0000	0.0000	0.0000	0.0000
T4	0.1226	0.0313	0.0173	0.0018	0.0000
T5	0.0000	0.0000	0.0000	0.0000	0.0000
T6	0.0000	0.0000	0.0000	0.0000	0.0000
T7	0.0884	0.0905	0.1894	0.1454	0.1576
T8	0.0000	0.0000	0.0000	0.0000	0.0004

3.4 Problem analysis

This question can be divided into two sub-questions. The first question is: how many suppliers are needed to meet the production demand. The 0-1 planning model can be established according to the raw material production information table and solved by MATLAB. Second question: According to these suppliers, make the most economical purchase plan for the next 24 weeks with the least transport loss. This small question is a multi-objective linear programming problem, which can be solved by establishing 0-1 linear programming model based on the predicted values of transport losses of 8 transporters and the first small question. There are two objective functions:

First, the enterprise hopes that the ordering plan is the most economical, that is, the total purchase cost of the three raw materials is the least.

Second, the enterprise wants to minimize transportation wastage.

3.5 The establishment and solution of model

3.5.1 First question: establish 0-1 programming model

402 suppliers were numbered as $x_{i1}, x_{i2}, x_{i3}, \cdots \cdots x_{i402}$,that is, the number of supplier j isx_{ij}, subscript i indicates the raw material type,$i = A, B, C$,$j = 1,2,3, \cdots 402$。At least the number of selected suppliers is N。$M_A$is the supply quantity of A raw materials，M_B is the supply quantity of B raw materials. Set $G_{ij}$is the maximum weekly quantity of supplier j.

Introducing the 0-1 variable,

$$x_{ij} = \begin{cases} 0\text{，No. j supplier hasn't received No. i order in the next 24 weeks} \\ 1\text{，No. j supplier has received No. i order in the next 24 weeks} \end{cases} \quad (3)$$

Objective function:

$$min\, N = \sum_{i=1}^{50} x_{\text{ij}} \quad (4)$$

Constraints:

$$\begin{cases} \frac{M_A}{0.6} + \frac{\mathrm{M_B}}{0.66} + \frac{\mathrm{M_C}}{0.72} \geq 28200 * 2 \\ M_A = \sum x_{Aj} G_{Aj} \\ M_B = \sum x_{Bj} G_{Bj} \\ M_c = \sum x_{Cj} G_{Cj} \end{cases} \quad (5)$$

Using MATLAB to solve the above model: at least 96 suppliers are needed.

3.5.2 Second question: establish multi-objective 0-1 programming model

The most economical procurement scheme was regarded as the first priority objective function with a weight of 0.6, and the minimum transportation loss rate was regarded as the second priority objective function with a weight of 0.4.

Since the specific value of the objective function is not known, the deviation variable is not considered. According to the known data, the average transportation loss rate of the transporter can be calculated as 1.4%. Considering the loss rate in the transportation process, the total cost of purchasing raw materials is set asW,the cost of purchasing A raw materials isW_A, the cost of purchasing B raw materials is W_B, and the total cost of purchasing C raw materials is W_C.

First priority objective function:

$$\mathrm{minW} = 1.2\mathrm{W_A} + 1.1\mathrm{W_B} + \mathrm{W_C} \quad （6）$$

Constraints:

$$\begin{cases} \frac{M_A}{0.6*0.986}+\frac{\mathrm{M_B}}{0.66*0.986}+\frac{\mathrm{M_C}}{0.72*0.986} \geq 28200*2 \\ M_A=\sum x_{Aj}G_{Aj} \\ M_B=\sum x_{Bj}G_{Bj} \\ M_c=\sum x_{Cj}G_{Cj} \end{cases} \tag{7}$$

Taking the minimum economic cost and the minimum attrition rate as the objective function, a multi-objective programming model is established. Set the loss of supplier No. m is $\mathrm{E_m}$, the total loss is E. Introduce the 0-1 variable $\mathrm{x_m}$, $\mathrm{m}=1,2,3,\cdots,8$.

$$\mathrm{x_m}=\begin{cases} 0,\text{The No. m transporter was not selected} \\ 1,\text{The No. m transporter was selected} \end{cases} \tag{8}$$

Second priority objective function:

$$\begin{cases} \mathrm{minQ}=1.2\mathrm{W_A}+1.1\mathrm{W_B}+\mathrm{W_C} \\ \mathrm{minE}=\sum_{\mathrm{m}=1}^{8}\mathrm{E_m} \end{cases} \tag{9}$$

$$\begin{gathered} M_A=\sum x_{Aj}G_{Aj} \\ M_B=\sum x_{Bj}G_{Bj} \\ M_C=\sum x_{Cj}G_{Cj} \\ x_m=0\text{or}1 \end{gathered} \tag{10}$$

MATLAB software is used to solve the above model, taking the ordering plan in the first week of the next 24 weeks as an example:

TABLE 3 SOLUTION RESULTS OF THE EXAMPLE PROBLEM MODEL

Vendor ID	***01 weeks***	***Vendor ID***	***01 weeks***
S007	71	S152	6
S064	6	S157	5

S075	12	S221	6
S086	479	S307	3430
S139	3853	S332	46
S140	8009	S338	792

4 CONCLUSION

In the actual production process, there are many conflicting objectives in the decision-making of the optimal procurement scheme due to the numerous factors affecting the production economic benefits of enterprises, so it is necessary to give priority to each objective. There are multiple objective functions in the multi-objective line planning problem, and the importance of each objective is different, which is more in line with the actual situation of the enterprise. When 0-1 variable exists in the decision-making variables, the establishment of multi-objective 0-1 planning model can be more conveniently applied to the solution of practical problems, and the model can be solved by software.

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