The Application of Planning Model in Enterprise Investment

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Abstract: In the business operation, in order to maximize the profits of funds, managers often choose to invest idle funds. Different investment requirements and project characteristics will inevitably lead to different best investment plans. Therefore, this paper begins to solve the investment problem of enterprise management and operation research, in order to establish models for different stages and investment requirements to find the best scheme.

1. Introduction

According to the definition in the Encyclopedia of management in China, "operation research is to make overall arrangement of human, material and financial resources in the economic management system by applying the methods of analysis, experiment and quantification, so as to provide the decision-maker with the best scheme with basis, so as to realize the most effective management." Planning problem is an important branch of operational research, which develops rapidly and is widely used. It can help enterprises make scientific decisions in daily economic management. Especially in the enterprise investment, the purpose of any investment plan is to choose the best project portfolio in the existing constraints. Among them, dynamic planning was put forward by American mathematician Behrman in the 1950s, which can make investors realize the purpose of effectively dispersing risks and obtaining the maximum profits. As scholars Hu yuanmu and Bai Feng's "Application of dynamic programming model in stock portfolio" and Liu Rui's "enterprise investment decision model based on dynamic programming", establish a reasonable mathematical model and use dynamic programming to solve the problem of economic optimization.

However, in the current research, the integration of various plans to solve investment problems is rarely used, mainly for a specific planning model. But the single planning model is not enough to solve the complex and changeable investment conditions and meet various investment requirements. Therefore, in this paper, the investment plan design is often used to sort out the planning model, aiming at different stages of development and different investment requirements of enterprises to establish a mathematical model. Help enterprises choose better investment plans, reduce risks and increase profits.

2. Basic planning model

In the early stage of establishment, in order to quickly seize market share and increase the competitiveness of enterprises, enterprises will pay more attention to the high return of investment, so the planning model at this time chooses to maximize the return as the goal.

And because in practice, different investment projects will have different investment limit, which has both the maximum limit and the minimum limit. For the convenience of transaction, investment will be required in the form of integer. These constraints lead to the change of variables from continuous to discrete, so we build an integer programming model to further standardize the investment plan.

Assume that the company has N= {1, 2, ..., j}, (j≥1) existing investment projects.
Set the investment amount of each project as Xj.
The mathematical model is as follows:

$$MAXZ = \sum c_i X_i$$

S. t.
$$\sum_{j=1}^{n} a_{ij} X_j \le (=,\ge) b_i (i = 1,2,...,m)$$
$$X_j \ge 0 (j = 1,2,...,n)$$
$$X_j \le M_j Y_j$$
$$Y_j = 0 \ or 1$$

Ci is the coefficient of decision variable in objective function; aij is the coefficient of the decision variable in the condition constraint; bi is the constant term in the absolute constraint; Yj is the 0-1 variable, that is, the value of the variable is limited to 0 and 1; Mj is a large enough number.

When the scale of enterprise development is gradually expanding, in order to operate stably and capital flow smoothly, the enterprise will not only consider the income problem, but also regard the low risk as the primary goal. Therefore, we use the goal programming model (this model does not include the situation that the risk and income are positively related due to force majeure, national macroeconomic policies and other factors), introduce priority, and obtain the scheme by comparing the degree of enterprises' preference for risk and income.

It is still assumed that the company has N= {1, 2, ..., j}, (j≥1) existing investment projects.
Set the investment amount of each project as Xj.
The mathematical model is as follows:

$$\text{MINZ} = \sum_{l=1}^{L} P_l [\sum_{k=1}^{K} \omega_{lk}^{-} d_k^{-} + \omega_{lk}^{+} d_k^{+})]$$

S.t.
$$\sum_{j=1}^{n} a_{ij} X_j \le (=,\ge) b_i (i = 1,2,...,m)$$
$$\sum_{j=1}^{n} c_{kj} X_j + d_k^{-} - d_k^{+} = g_k (k = 1,2,...,K)$$
$$X_j \ge 0 (j = 1,2,...N)$$
$$d_k^{-}, d_k^{+} \ge 0 (k = 1,2,...,K)$$

Among them, P_l is the priority, i.e. the priority to be followed when there is a conflict between the target and the target; ω_{lk} is the penalty weight, i.e. the weight coefficient of each target corresponding to the priority; d_k is the deviation variable, i.e. the difference between the actual value and the target value; g_k is the expected target value of the k-th target constraint, a_{ij} is the coefficient of the decision variable in the absolute constraint; c_{kj} is the decision variable in the target constraint; b_i is a constant term in the absolute constraint.

Mature enterprises will face more complex investment environment, such as the relationship between investment amounts and benefit value changes from linear to non-linear, investment projects are related to the selection of new and old partners and so on. These complex environments make the role of the original planning model very limited. The flow of capital is often a dynamic process, each decision of investment depends on the current state, and then causes the state transfer. So we use the dynamic programming model to solve the optimization problem of multi-stage decision-making process.

(It is assumed that the investment background meets the three properties of dynamic planning: optimization principle, no aftereffect and overlapping sub problem).

Suppose the company has K projects. The investment decision of each project can be regarded as a stage, so it can be summed up as a dynamic planning problem of K stage.

The mathematical model is as follows:

Stage variable: K = 1, 2,..., K;

State variable: S_K - funds available for allocation in phase K;

Decision variable: X_K -- investment quantity in stage K;

Allowed decision set $D = \{X_K | 0 \leq X_K \leq S_K\}$

State transition law: $S_{K+1} = S_K - X_K$;

Stage index function: $r_k (X_K)$ - expected revenue function, as shown in the table;

Basic equation: $F_K (S_K) = \max \{r_k (x_K) + F_{K+1} (S_{K+1})\}$;

Boundary condition: when K = K + 1, $F_{K+1} (S_{K+1}) = 0$

3. Application of planning model in enterprise investment

In the initial stage of company A's establishment, in order to fully improve the capital income, it is considered to invest 4 million yuan in the next five years. Known project indicators are as follows:

Project A: from the first year to the fifth year, the bonds can be purchased at the beginning of each year and returned in the current year, with the principal and interest recovered by 110% at the end of the current year.

Project B: from the first year to the beginning of the fourth year, the investment can be made, and the principal and interest can be recovered by 125% at the end of the next year.

Project C: investment from the beginning of the third year and return of capital and interest 140% at the end of the fifth year.

Project D: investment from the beginning of the second year, with the principal and interest recovered by 155% at the end of the fifth year.

According to the measurement, the risk index of each investment of 10000 yuan is shown in Table 1.

Table 1. Project risk index.

Project	Risk index (10000 yuan for each investment)
A	1
B	2
C	3
D	4

It is required that the investment scheme meet the following conditions:

Project A: the investment amount is unlimited.

Project B: it is stipulated that the minimum investment in the first year shall not be less than 1.6 million yuan, and no restrictions shall be imposed in the second, third and fourth years.

Project C: it is stipulated that the annual maximum investment shall not exceed 2 million yuan and the minimum investment shall not be less than 1.2 million yuan.

Project D: the annual investment is either 800000, 1600000, 2400000 or 3200000.

Try to determine the investment plan to make the company have the largest amount of capital, capital and profit at the end of the fifth year.

Let X_{ij} be the amount invested in project J at the beginning of the I year (unit: 10000 yuan). Meanwhile, set Y_{iB} and Yi_C as 0-1 variables, and specify:

$$Yij = \begin{cases} 1, \text{ when j project is invested in the first year, i= 1, 3, j = B, C} \\ 0, \text{ when j project is not invested in year I,} \end{cases}$$

Let Y_{2D} be a non-negative integer variable, and specify:

Y_{2D} =

$$\begin{cases} 4. \text{ When 3.2 million yuan is invested in project D in the second year,} \\ 3. \text{ When 2.4 million yuan is invested in project D in the second year,} \\ 2. \text{ When 1.6 million yuan is invested in project D in the second year,} \\ 1. \text{ When the investment in project D is 800000 in the second year,} \\ 0, \text{ when project D is not invested in the second year,} \end{cases}$$

According to the conditions given in the background, table 2 can be obtained.

Table 2. Fund amount variable.

Project / Year	1	2	3	4	5
A	X_{1A}	X_{2A}	X_{3A}	X_{4A}	X_{5A}
B	X_{1B}	X_{2B}	X_{3B}	X_{4B}	
C			X_{3C}		
D		X_{2D}			

It can be obtained:

$$MAXZ=1.1X_{5A}+1.25X_{4B}+1.40X_{3C}+1.55X_{2D};$$
$$S.\ t.\ X_{1A+}X_{1B}=400,$$
$$X_{2A}+X_{2B}+X_{2D}=1.1X_{2A},$$
$$X_{3A}+X_{3B}+X_{3C}=1.1X_{2A}+1.25X_{1B},$$
$$X_{4A}+X_{4B}=1.1X_{3A}+1.25X_{2B},$$
$$X_{5A}=1.1X_{4A}+1.25X_{3B},$$
$$X_{1B}\geq 160Y_{1B},$$
$$X_{1B}\leq MY_{1B}, \text{ (M is a sufficiently large number)}$$
$$X_{3C}\geq 120Y_{3C},$$
$$X_{3C}\leq 200Y_{3C},$$
$$X_{2D}\geq 80Y_{2D},$$
$$X_{2D}\leq 4,$$
$$X_{ij}\geq 0,$$
$$Y_{IB} \text{ and } Y_{IC} \text{ are 0-1 variables,}$$
$$Y_{2D} \text{ is a non-negative integer variable.}$$

Using LINGO software, we can get the following results:

$X_{5A}=375$, $X_{1B}=400$, $X_{4B}=300$, $X_{3C}=200$, $Y_{1B}=1$, $Y_{3C}=1$, $Y_{2D}=0$.

After five years of development, the company's scale has been expanded and its operation is in good condition. Therefore, the enterprise has adjusted its investment target in the future. The investment plan is required to meet the requirements that the total investment risk is not more than 800 yuan, and the capital cost and profit at the end of the last year is not less than 6 million yuan.

Let X_{ij} be the amount invested in project j at the beginning of the i year (unit: 10000 yuan).

The mathematical model is as follows:

$$MINP_1 (d_1^+) +P_2 (d_2^-);$$
$$S.\ t.\ X_{1A+}X_{1B}=400,$$
$$X_{2A}+X_{2B}+X_{2D}=1.1X_{2A},$$
$$X_{3A}+X_{3B}+X_{3C}=1.1X_{2A}+1.25X_{1B},$$
$$X_{4A}+X_{4B}=1.1X_{3A}+1.25X_{2B},$$
$$X_{5A}=1.1X_{4A}+1.25X_{3B},$$
$$X_{1A}+X_{2A}+X_{3A}+X_{4A}+X_{5A}+2(X_{1B}+X_{2B}+X_{3B}+X_{4B}) +3X_{3C}+4X_{2D}+d_1^--d_1^+=1500,$$
$$1.1X_{5A}+1.25X_{4B}+1.40X_{3C}+1.55X_{2D}+d_2^--d_2^+=600,$$
$$X_1, X_2, d_1^-, d_1^+, d_2^-, d_2^+\geq 0.$$

Using LINGO software, we can get the following results:

$X_{1A}=315.789$, $X_{1B}=84.211$, $X_{3C}=105.263$.

When evaluating the plan, the company believes that the current capital flow demand of the company is large and the investment time of the above-mentioned projects is too long, which will not only hinder the flow of capital, but also lead to a high degree of risk. It is decided to add the fund to the short-term cooperative investment projects that the company is carrying out. 4 million yuan will be added to the three existing projects of E, F and G. The three projects can have different investment quota, and the corresponding income is shown in Table 3. Try to determine a scheme to maximize the total revenue.

Table 3. Investment amount and income value.

Project Benefit value Investment amount	0	100	200	300	400
E	47	51	59	71	76
F	49	52	61	71	78
G	46	70	76	88	88

The problem is divided into three stages according to the project, E, F, G, respectively numbered 1, 2, 3.

S_k = investment quota allocated to the k-th project to the 3-th project (k = 1, 2, 3).

X_K = amount of investment allocated to the k-th project.

From the definitions of S_K and X_K, we can see that $S_3 = X_3$,

Let's start from the third stage:

The third stage: obviously, when S_3 is totally allocated to the third project, that is, when $S_3 = X_3$, the indicator value of the third stage (that is, the benefit value of the third project) is the largest. Namely:

$MAXR_3 (S_3, X_3) = R_3 (S_3, S_3)$

Since the third stage is the final stage, there are:

$F_3 (S_3) = MAXR_3 (S_3, X_3) = R_3(S_3, S_3)$

Let X_3* denote the decision of X_3 when the optimal index value $F_3 (S_3)$ on three sub processes is taken as the optimal decision. As shown in Table 4.

Table 4. Income value of the third stage.

S_3	$R_3(S_3,S_3)$					$F_3(S_3)$	X_3*
X_3	0	100	200	300	400		
0	46	-	-	-	-	46	0
100	-	70	-	-	-	70	100
200	-	-	76	-	-	76	200
300	-	-	-	88	-	88	300
400	-	-	-	-	88	88	400

The second stage: for each S_2 value, there is an optimal scheme to make the maximum profit, that is, the optimal index function value of the optimal sub process is:

$F_2(X_2)=MAX[R_2(S_2,X_2)+F_3(S_3)]$

Because $S_3 = S_2-X_2$, the above formula can also be written as:

$F_2(X_2)=MAX[R_2(S_2,X_2)+F_3(S_2-X_2)]$

First stage: allocate S_1 (S_1 = 4 million yuan) to the first, second and third projects, with the maximum profit of

$F_1 (S_1)=F_1(400)=MAX[R_1(400, X_1)+F_2(400-X_1)]$

According to the calculation table, the optimal scheme is: $X_1*=300$, $S_2=S_1-X_1*=100$, $X_2 * = 0$, $X_3 * = S_3 = 100$.

That is to say, the optimal plan is to invest 3 million yuan in Project E, 0 in project F, and 1 million yuan in project g, with the highest total income of 1.9 million yuan.

4. Summary

In this paper, the basic models of linear programming (integer programming, goal programming) and dynamic programming are established, and the operation and development stages of an enterprise are linked. Let all kinds of planning models make up for each other, make rational use of resources, and choose the right investment plan. As one of the important means of operational research, planning model can not only make the investment decision more effective, but also optimize the daily economic management and resource utilization of enterprises, and promote the development of enterprises.

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