APPLICATION OF MATHEMATICAL MODELING IN MANAGEMENT ACCOUNTING

Jiaxin Wang*
Donglin Wang
Department of Basic Education Beijing
Polytechnic Beijing
China
wjiaxin086@163.com

Abstract. Mathematics as a basic science plays an important role in the field of economic management field. In processing management accounting business, the combination of mathematical models and the actual condition of enterprises and public institutions can effectively solve various management problems and evade different operational risks, which is of great significance to the prediction, planning and control of enterprise operation activities. This study analyzed five common mathematical models associated to management accounting, made analyses with examples, and pointed out the innovation direction of management accounting based on internet development, aiming to provide a reference for the improvement of management accounting level.
Keywords: Mathematical models, management accounting, economic management.

Management accounting is a subject with strong practicability involving management accounting theory, methodology and practice. Management accounting theory includes contingency theory, management control system theory and agency theory. With the development of social economy and the establishment of national legal systems in recent years, enterprises have paid more and more attentions to internal control management. In the perspective of finance, a feasible management accounting system can provide effective evidences for the inspection of enterprise operation condition and the formulation of management decisions. But according to the modern financial and accounting management theory, scientific management accounting is not post-management, but need the establishment of highly-adaptive mathematical models according to certain mathematical management ideas and principles to measure relevant parameter indexes, solve various difficult problems relating to enterprise management, and achieve effective management.

1. Category of mathematical models in management accounting

Mathematical models involved in management accounting provides evidences for management decisions by making quantitative and qualitative analyses on the correlation between different economic normality factors through mathe-

∗. Corresponding author

matical language and thinking logic in the objective perspective and reflecting the objective states of the economic factors based on the scientificity and rigorousness of mathematical logical thinking. Considering the practical operation and practices of enterprise management, the mathematical models involved in enterprise management accounting mainly include general mathematical model, mathematical analysis model, input-output model, linear planning model and probability statistic model (Table 1). General mathematical models which are mainly used for calculating enterprise break-even point and carrying out financial and accounting analysis with algebraic formulas are the most common application models. Mathematical analysis models combine multiple functions with management accounting practice and applied elastic analysis and marginal analysis in management accounting. Input-output models are applied to control enterprise system management and comprehensive balance. Linear planning models and probability statistic models are used for performing mathematical analysis on enterprise related data and solving problems based on the characteristics of management accounting. As a result, enterprise management staffs can scientifically and intuitively understand organization operation condition and capital chain risk level to improve organization management level.

Number	Category	Model characteristics
1	Mathematical analysis model	Mathematical calculus theory is applied to calculate the enterprise product marginal effect to guide the correlation matching between cost and products. Moreover, an elastic model can also be used to measure and calculate the correlation between internal and external market price and enterprise product supply quantity.
2	General mathematical model	Financial data are input into a break-even mathematical model to find out the break-even point of some kind of product/service of an enterprise, thus to provide a decision basis for the preservation of the product/service.
3	Linear planning model	Integer programming, linear planning, non-linear planning and analytic hierarchy models all belong to this category, aiming to analyze organizational management data and clarifying development planning.
4	Probability statistic model	Models are established based on mass data. Mathematical analysis is made after the internal and external attributions are clarified. The influence of matter variation rules on organization operation and management is measured and calculated.
5	Input-output model	It aims to control the input-output ratio of different business units. Linear algebra theory is used to establish a mathematical model and reasonably allocate the cost, budget and daily work plan of organizations.

Figure 1: The common mathematical models in management accounting

2. Empirical cases

According to the five common mathematical models in management accounting and considering the practical operation characteristics of management accounting, the application of mathematical models in management accounting was analyzed using examples.

Application of mathematical analysis models

Considering the characteristics of enterprise management accounting practice, functions with regard to cost, profit, supply and demand are extremely common. The management and analysis of those factors require the concept of derivative as well as margin models and elastic models. In modern enterprise management, only when business accounting was performed through fine management and the influence of total cost on yield variation was clarified can enterprises carry out overall planning or fine adjustment in the perspective of cost. The process needs the analysis using enterprise marginal cost models established based on derivatives. Elastic analysis is to measure the sensitivity of product supply quality or demand quality to price based on price variation. Actually, it aims to provide a basis for the decision making of enterprise inventory planning based on derivatives.

Example 1. marginal cost analysis

The changes of enterprise yield could induce the changes of cost. Yield was defined as 1, incremental change as Δq, unit price as p, total cost as C (fixed cost $C0$ + variable cost CV), and cost variation as ΔC. The cost function was $C = C(q)$.

With the changes of yield increment, the average increment of the total cost was $\frac{\Delta C}{\Delta q} = \frac{C+(q+\Delta q)-C(q)}{\Delta q}$.

If there was $\lim_{\Delta q \to 0} \frac{\Delta C}{\Delta q}$, then the marginal cost $C(q)$ when the enterprise yield was q could be obtained.

In the comparison of marginal cost and unit price, C(q) ¡ p suggested the market feedback on the yield was favorable, demand exceeds supply, and the yield could be increased; otherwise, the yield should be reduced to control cost. Similarly, price elastic analysis reflected the product price variation induced by market demand and supply.

Application of general mathematical models

In the process of development, enterprises usually need to find out the critical points of operation and management, i.e., break even state. The state can guide enterprises to reasonably allocate resources and achieve stable and healthy development though it is not the ultimate purpose of enterprise operation. Management accounting requires the application of break-even models to systematically check the factors such as sales income, cost and profit and find out the critical state when the total cost is equal to the total profit, thereby

scientifically and reasonably allocate enterprise organization cost, price, sales volume and profit and enhance management efficacy.

Example 2: Suppose enterprise operation only include two steps, i.e., production and sales, the extra factors such as tax and nonoperating revenue and expenditure were not taken into account, and enterprise operation profits were only influenced by cost and profits. The following basic variables were defined.

Yield was defined as Q, profit as L, unit price as P, profit as R, unit variable cost as V, and total cost as C (fixed cost $C0$ and variable cost CV). Then the premise of enterprise operation was $L = R - C > 0$.

The critical condition was $L = 0$. At that moment,

$$\begin{pmatrix} R = P * Q \\ C = C_v + C_0 \\ C_v = Q * V \\ R = C \end{pmatrix},$$

the sales volume at the critical point was obtained through simultaneous equations.

$Q0 > 0$ meant enterprises were in a profitable state and its advantage in profit could be extended continuously.

$Q0 < 0$ meant enterprises were at a loss and the proportion of $C0, P$ and V should be adjusted to improve profit.

Certainly, in practical operation, the influence factors for different break-even critical states are different. But general mathematical models can combine mathematical logical thinking with management accounting to provide a reference for enterprise scientific decision-making.

Mathematical planning models

In economic management activities, extreme values such as maximum profit, maximum yield, minimum cost and minimum input are usually obtained under certain limitation conditions for the purpose of best effect of profit maximization. For the requirements of extreme value measurement and calculation in this kind of management, the linear planning model can be used.

Example 3. Linear planning analysis

A chemical engineering enterprise in Shanxi mainly produces product A and C. Input of a certain amount of manpower, electric power and coal resources are required in the process of production. The resources that are needed in the production of unit product are as follows.

The above table demonstrates the input that is needed in the production of product A and B and net output value. Then how to match the yield of product A and B to obtain the maximum net output value when the enterprise owned 600 staffs, 400 degrees of electronic power and 720 tons of coal. It is a common topic in enterprise management. Achieving maximum profit by scientifically and

Category	Manpower/n	Electric power /degree	Coal/ ton	Net output value /yuan
A	6	8	18	1400
B	20	10	8	2400

Figure 2: The resources that are needed in the production of unit product in the case enterprise

reasonably allocating internal resources is the target of most of enterprises when resources are limited. Answer was given to solve the case.

Suppose the output of product A and B as XA and XB.

The constraint conditions were

$$\left\{\begin{array}{l} 18X_A + 8X_B \leq 720 \\ 8X_A + 10X_B \leq 400 \\ 6X_A + 20X_B \leq 600 \\ X_A X_B \geq 0 \end{array}\right\}.$$

Objective function was: $Max(X_A, X_B) = 1400X_A + 2400X_B$.

According to the mathematical planning model function, the output of product A and B was 20 and 24 respectively, and the total net output value was 85,600 yuan.

Therefore, enterprises can scientifically and directly determine how to achieve profit maximization through systematic analysis using linear planning function when resources are limited. Moreover, it can also help the decision-making level to figure out how to achieve cost minimization with the consumption of the least resources. Thus enterprises can implement scientific management through applying mathematical models in management accounting during annual strategic planning. Analytic Hierarchy Process is also a common mathematical planning model which is applicable for the situation that multiple influence factors are involved. Using the model, multiple influence factors (indexes) are graded, weight is set, and quantitative data are used for calculation, in order to achieve visual management of numerous influence factors, scientifically determine the correlation between different influence factors and the importance of the factors, and provide management decision making with reference and basis.

Probability statistic model

Throughout various processes involved in organizational management, we find mathematical models not only can solve judgment in decision caused by definite factors, but also can help enterprises scientifically analyze multiple random factors and predict the changes and development of internal and external environment. The application of mathematical models in management accounting can help enterprise managers to predict capital management risks, toler-

ance capacity for internal and external environment changes and future market changes.

Different probability models may be applied when probability was determined in different occasions. The influence factors of enterprises should be considered before selecting models. Among the factors, some are definite factors, some are random factors, and some are between definite factors and random factors as time goes by. Certainly, in the prediction of future, single use of probability models is not enough; relevant data should be statistically analyzed by management accounting to reduce capital risks. Those data include both real data generated by enterprises in the past and referenced data. In this process, budget planning and preparation should be done firstly; the statistical regularity hidden behind random variables, i.e., correlation between variables, should be searched by a large number of tests and observations. Thus, the regression forecasting analysis method can be applied in probability statistics.

Application of input-output models

In the macroscopic view, the operation and management of enterprises need the input of manpower, material resources and financial resources. National economic chain is composed of multiple units, products generated from every unit need raw materials or semi-finished products, and those raw materials or semi-finished products originate from other units. In the supply chain, the raw materials or semi-products which are input for the generation of single department are called input, and the produced final products are called output. In enterprise management accounting practice, the application of input-output models can help scientifically decide issues such as compound interest and annuity in advance. In the perspective of financial input and output, different funding means for the same event may result in different values or significantly different actual input generated by reverse deduction. This study defined the future value of a certain amount of currency (converted according to bank rate) as currency future value. Interest rate was set as r, present value of currency as P, future value of currency as F, and currency cycle as t.

If the number of interest accrual per week was n, then future value of currency $F = Pert$. Thus it could be deduced that, $P = Fe - rt$.

Example 3. Input-output analysis

A mechanical manufacture factory in Shanghai has planned to introduce a set of production line in 2017. Considering the requirements of the seller, two payment schemes have been formulated.

Scheme 1: one-off payment, totally 2.4 million yuan.

Scheme 2: installment payment (six installment), 480 thousand yuan each installment, totally 2.88 million yuan.

The interest rate on borrowings in bank r was supposed as 9%. The input-output effect was analyzed to help the enterprise select the optimal payment scheme.

Scheme 1 was one-off payment; scheme 2 was payment in six installment which spans a long time (six years), which needed to take the input of interest into account. Scheme 2 involved annuity in advance. The selection of the optimal scheme needed the comparison of input of annuity in advance and ordinary annuity increment input. Then we have $P{=}F\frac{1-(1+r)^{-t}}{r}(1+r){=}480000*\frac{1-(1+0.09)^{-6}}{0.09}(1+0.09)\approx 2347032.6$ yuan

$2400000-2347032.6=52967.4>0$, suggesting the total input of scheme 1 was higher than that of scheme 2 when the output was the same. In the perspective of management accounting and to reduce input cost, scheme 2 was better for the enterprise.

The latest research thought

With the rapid development of big data technology, the application of mathematical modeling in management accounting has become increasingly deeper. It is developing in the following three aspects.

Cloud computation of big data: combination of mathematical thinking and management accounting Currently, Made in China 2025 has been the new trend for the optimization and upgrading of industrial structure. Under the background of internet+, enterprise management accounting has been more diversified and intelligent and no longer been limited to mathematical models. Mathematical thinking is integrated with management accounting through cloud computation of big data, which adds new blood to management accounting tools. Integrating internet thinking and mathematical theoretical models with management accounting tools has been a new model which manifests local characteristics and trans-boundary integrative thinking. The butt joint between internet+ and enterprise is closer. Traditional mathematical theories will be constantly deepened and mined. High requirements are proposed to the feasibility and accuracy of management accounting. Moreover, enterprise customized management accounting will be the main trend under the assistance of big data analysis and cloud computation platform. Enterprise customized management accounting is not only beneficial to market resource integration, but also provides a guarantee for the scientificity and accuracy of enterprise management accounting.

Contextual characteristics: optimization of investment decision-making and risk prediction

When Chinese economy develops rapidly, many economic new normal characteristics become obvious and the optimization and upgrading of industrial structure and policy adjustment change quickly, which proposes new development requirements for information acquisition and control inside and outside enterprises. To survive and develop in the market, enterprises should make every investment decision and do risk analysis properly. Those decisions should not be rude behaviors but management decisions which are adapt to the time and area as well as the internal and external development requirements. In the perspective of management accounting, it means applying multi-situation

analysis model and combining qualitative and quantitative to avoid risks and improve decision accuracy.

Transition management: constant innovation of management accounting under mathematical theories

In the new circumstances, the innovation of management accounting is an eternal topic. There is neither changeless mathematical model nor everlasting management mode. Therefore, the thought of transition management is needed to promote system reformation and constant innovation off management accounting. It requires enterprises to focus on investigating management with structural different and optimizing management accounting system. Moreover, in the perspective of system integration, multiple resource channels can be integrated to break the limitation of traditional software and hardware. Accounting management system with high adaptability and practicality and applicability should be established through constant studying.

3. Conclusions

Management accounting plays an important role in enterprise and public institutions and provides important bases for management decision making, risk control and organization development planning. Mathematical models can provide management accounting with important management carriers and scientific basis. Different organizations can apply mathematical models for systematic and scientific management in management accounting or other management processes.

References

[1] J.X. Wang, *Mathematical models in management accounting*, Business, 2016, (05), 80-80.

[2] R.S. Kaplan, *Advanced management accounting*, Dongbei Univ. Finan. Econ. Press, 2011, 18-23.

[3] Q.S. Zhang, *Application of mathematical modeling in management accounting*, J. Jiamusi Edu. Inst., 2015, (03), 408-409.

[4] S.E. Gao, *Study and practice of integrating higher vocational management accounting with mathematical modeling idea*, China Manag. Inform., 2013 (08), 105-106.

[5] J.T. Wang, *Mathematical models in management accounting*, Account. Learn., 2016, (01), 89-90.

[6] D. Lin, *Application of mathematical models in management accounting*, N. Econ. Trade, 2015, (03), 90-92.

Accepted: 9.06.2017