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Application of Simplex Method in Accounting Management

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Abstract: This paper explores the application of the simplex method in accounting management. The research background is rooted in the pivotal role of optimization methods in modern financial theory and practice, particularly the significance of linear programming in cost minimization and resource allocation. The study focuses on addressing optimization challenges in enterprise production and agricultural cultivation through two case studies. Here, the first is a linear programming model for enterprise production costs, and the second is a tomato cultivation area and output allocation problem for a processing plant by maximizing output under land and order constraints. By employing the simplex method and iteratively optimizing vertex solutions, the author successfully derives the optimal production plans and cultivation configurations in different models. The results demonstrate that the simplex method effectively handles resource optimization problems with multiple constraints, providing quantifiable decision-making support for enterprises and agriculture, thereby highlighting its practical value in enhancing efficiency and reducing costs.

Keywords: Simplex method, Optimization problem, Accounting management.

1. Introduction

The application of optimization methods in the financial field has become a core pillar of modern financial theory and practice, with its origin traceable to the pioneering research of Harry Markowitz in the 1950s. The mean-variance portfolio optimization theory proposed by Markowitz quantified the trade-off between risk and return through mathematical programming methods, laying the foundation for quantitative finance. Since then, optimization techniques have gradually become indispensable tools in asset allocation, risk management, algorithmic trading, and derivative pricing.

For decades, the field of financial optimization has been evolving with advancements in mathematical models, computing power, and data availability. Early on, it was dominated by linear and quadratic programming. Subsequently, methods such as stochastic programming, robust optimization, and dynamic programming were introduced to address uncertainty and multi-period decision-making problems. The rise of high-frequency trading and big data has further driven innovations in convex optimization, integer programming, and novel optimization approaches that integrate machine learning.

In the work by Wang [1], the linear programming simplex method is used to optimize the ore and rock transportation, and the mathematical model is established to reduce the transportation cost and improve the efficiency. The research results show that the method can effectively reduce the transportation distance and cost, improve the utilization rate of resources, and provide scientific decision-making basis for mine transportation management [2]. In addition, people also propose a

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path planning algorithm for Service Function Chains (SFC) based on the simplex method, aiming to optimize network resource allocation and reduce latency. By modeling the problem as a linear program, the algorithm minimizes deployment costs while meeting QoS constraints. Experimental results demonstrate that it effectively improves resource utilization and reduces service latency, outperforming traditional heuristic approaches [3].

The current academic research hotspots are focused on the following frontier challenges: (1) High-dimensional data-driven optimization methods, combined with machine learning to handle large-scale portfolio problems; (2) Robust optimization and distributionally robust optimization to deal with model misspecification and tail risks; (3) Multi-agent game theory models for decentralized finance and strategic trading analysis; (4) Real-time stochastic optimization to support dynamic asset-liability management; (5) The application of quantum computing to solve complex financial optimization problems that are difficult for traditional computing. These directions reflect the transformation of the field towards adaptive, scalable, and risk-resistant methodologies to cope with increasingly complex market environments and regulatory requirements.

The rest of this paper is organized as the follow. Section 2 will introduce the application of simplex method in accounting management and give an example to illustrate how to use this method to calculate the optimization problem.

2. Method and theory

2.1. Introduction of optimization methods

In the realm of corporate finance and accounting, cost minimization is a central objective driving strategic decision-making and operational efficiency [4]. With the advancement of computational technologies and optimization theories, businesses are increasingly leveraging sophisticated mathematical models to achieve this goal. Linear Programming is a mathematical optimization technique that aims to maximize or minimize a linear objective function while satisfying a set of linear constraints. The typical example of linear programing is shown in Figure 1. In enterprise financial accounting, linear planning is widely used in problems such as cost minimization, profit maximization, resource optimization and allocation. Its core idea is to transform complex financial problems into computable optimization problems through mathematical modeling [5].

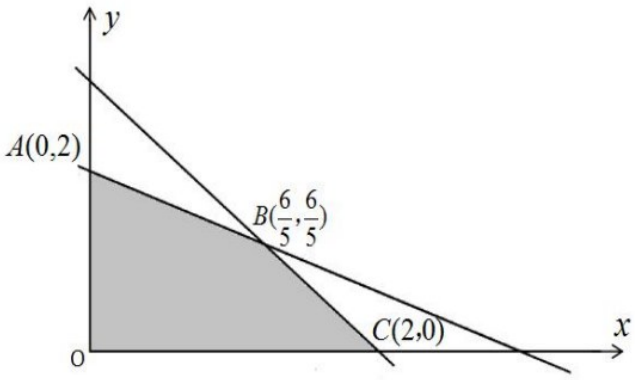


Figure 1: Illustration of an optimization problem [5]

The basic forms of linear planning include decision-making variables, objective functions and constraints. Decision variables represent variables that enterprises can control (such as production volume, purchase volume, etc.), target functions usually represent costs or profits, while constraints reflect resource limitations (such as budget, production capacity, etc.). The theoretical basis of linear

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planning is convex optimization theory, which ensures that there is a global optimal solution in the feasible domain [6]. Simplex Method, Interior Point Method and Projection Method are the three main calculation methods for solving linear planning problems.

The simplex method is applied to small and medium-scale problems by iterating to find the optimal solution on the vertex of the feasible domain; the inner point method is applicable to large-scale problems by approaching the optimal solution within the feasible domain; the projection law is applied to linear planning problems with special structures by gradually optimizing the current solution to the feasible domain. These methods have their own advantages and disadvantages. The choice of the appropriate method depends on the scale, structure and availability of computing resources of the problem. The simplex method is the most classic linear planning solution method. Its core idea is to move on the vertex of the feasible domain through iteration and gradually approach the optimal solution. In enterprise financial accounting, the simple method is often used to optimize production plans. For example, enterprises can use the simplex method to solve the optimal production scheme by building a linear planning model, minimizing production costs as the target function, and taking production capacity, raw material supply, etc. as constraints. The inner point law is another efficient linear planning solution method, which is especially suitable for large-scale problems [7]. Unlike the simplex method, the inner point method avoids the inefficiency of the simplex method in high-dimensional space by approaching the optimal solution inside the feasible domain. In corporate financial accounting, the inner point method can be used for complex portfolio optimization problems, such as choosing the best combination in multiple investment projects to maximize returns.

Projection method is an optimization method based on geometric ideas, which is gradually optimized by projecting the current solution to the feasible domain [8]. The projection method is suitable for linear planning problems with special structures, such as problems with equation constraints. In corporate financial accounting, the projection method can be used for budget allocation issues, such as the allocation of budgets between multiple departments to meet the overall financial objectives. By modeling the budget allocation problem as a linear planning problem and using the projection method to solve it, enterprises can achieve the optimal allocation of resources.

2.2. Simplex methods

The Simplex Method, proposed by American mathematician George Dantzig in 1947, is an algorithm for solving Linear Programming (LP) problems. It is used to optimize the objective function under multiple linear constraints, such as maximizing profit or minimizing cost [9].

The core idea is to use the simplex method and iteratively search the vertices of the feasible solution space (i.e., the corner points of the "simplex") to gradually approach the optimal solution. The first step is Initialization. Finding an initial feasible solution (usually by the artificial variable method or the two-phase method). Secondly, the Iterative optimization includes checking optimality, determine if the current solution is optimal (all non-basic variable test numbers ≤ 0). Selecting entering basic variable, if not optimal, choose a non-basic variable that improves the objective function to enter the basis (usually the one with the largest positive test number). Selecting leaving basic variable, determine the leaving basic variable through the Ratio Test to ensure the feasibility of the solution. Lastly, update the simplex table. Generate a new basic feasible solution through Gaussian elimination. Regarding the termination condition, when all test numbers are non-positive, the current solution is the optimal solution. If the problem is unbounded, the algorithm will detect the unbounded direction.

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3. Results and application

3.1. Production costs for business

This subsection aims to construct a linear programming model to optimize the production costs for a business. The decision variables in the model are x_1 and x_2 representing the production quantities of Product A and Product B, respectively. The objective function is to minimize the total cost $Z = 2x_1 + 3x_2$, where 2 and 3 are the costs of producing one unit of Product A and Product B, respectively. The constraints include a time constraint $x_1+2x_2 \leq 100$, indicating that the total time required for producing A and B cannot exceed 100 hours, and a material constraint $2x_1+x_2 \leq 80$, indicating that the total material required for producing A and B cannot exceed 80 kilograms. Additionally, x1 and x2 must be non-negative to ensure the feasibility of the production quantities. By solving this model, the business can determine the optimal production mix to achieve cost minimization [10]. By using the Simplex Method to solve a linear programming to minimize production costs for a business. Below is the detailed solution process [11].

The first to do is to establish the following mathematical model. There are two decision Variables. One is x1 that represent the production quantity of Product A. The other is x_2 that represent the production quantity of Product B. The Objective Function is to minimize $Z=2x_1+3x_2$, where 2 and 3 are the costs of producing one unit of Product A and Product B, respectively. Besides, the constraints include time constraint is $x_1+2x_2 \leq 100$. Material constraint is $2x_1+x_2 \leq 80$. Non-negativity constraint is $x_1, x_2 \geq 0$. The second is to convert the inequality constraints into equality constraints, the author introduces slack variables x_3 and x_4. The time constraint is $x_1+2x_2+x_3=100$.The Material constraint is $2x_1+x_2+x_4=80$.The objective function remains unchanged, $Z = 2x_1+3x_2$. To proceed, one needs to construct the Initial Simplex tableau, see Table 1.

Table 1: The constraints and objective function in the form of a simplex tableau

Basic variable	x_1	x_2	x_3	x_4	
x_3	1	2	1	0	100
x_4	2	1	0	1	80
Z	-2	-3	0	0	0

In the first iteration, one needs to select entering variable by choosing the variable with the smallest coefficient in the objective function, x_2 (coefficient of -3). One also needs to select leaving variable, which is determined by using the minimum ratio test. For x_3: $100 \div 2=50$ and for x_4: $80 \div 1=80$, the minimum ratio is 50, so x_3 leaves the basis. In addition, one should update the simplex tableau by replacing x_3 with x_2 as the basic variable. Therefore, one can perform row operations to make other elements in the x_2 column zero, see Table 2.

Table 2: Updated simplex tableau in the first iteration

Basic variable	x_1	x_2	x_3	x_4	
x_2	0.5	1	0.5	0	50
x_4	1.5	0	-0.5	1	30
Z	-0.5	0	1.5	0	150

In the second iteration, one also needs to select entering variable by choosing the variable with the smallest coefficient in the objective function, x_1 (coefficient of -0.5). Next, one need to determine the leaving variable using the minimum ratio test. For x_2: $50 \div 0.5= 100$ and for x_4: $30 \div 1.5 = 20$, the

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minimum ratio is 20, so x_4 leaves the basis. Then, one can update the simplex tableau by replacing x_4 with x_1 as the basic variable. One then performs row operations to make other elements in the x_1 column zero, see Table 3 for details.

Table 3: Updated simplex tableau in the second iteration

Basic variable	x_1	x_2	x_3	x_4	
x_2	0	1	0.6667	-0.3333	40
x_1	1	0	-0.3333	0.6667	20
Z	0	0	1.3333	0.3333	160

After the second iteration, all coefficients in the objective function Z are non-negative, indicating that the optimal solution has been reached. The optimal solution is: x_1=20 (production quantity of Product A) and x_2=40 (production quantity of Product B). Therefore, the minimum cost Z = 160.

3.2. Tomato planting and production

In another work, the study focuses on the planting and production issues of a tomato factory [12]. By using a linear programming model, it optimizes the planting areas of three types of tomatoes (Shihong No. 2, Shihong No. 3, and Xinfan No. 9) and the output allocation of two production lines. The objective is to maximize the total output under the constraints of land availability (4,000 square meters, with at least 300 square meters for Xinfan No. 9) and order demands (50,000 tons for Line 1 and 100,000 tons for Line 2).

Model establishment and solution are shown as below. The first is for the variables and constraints. Taking the planting areas (x_1, x_2, x_3) and production line outputs (y_1, y_2) as decision variables, a linear programming model is constructed that includes land limitations, minimum output requirements, and lower limits for the planting of each variety. The second is for the standardization and slack variables. By introducing slack variables (such as s_1), the inequalities are transformed into equalities, forming a standard linear programming form. The third is for the solution using the Simplex method. After iterative calculations, the optimal solution is obtained: 200 square meters of Stone Red No. 2 (meeting the minimum requirement), 3,500 square meters of Stone Red No. 3 (fully utilizing the land), and 300 square meters of New Fan No. 9 (satisfying the dedicated land constraint). The remaining slack variables indicate the utilization of resources (for example,s_j=3,400 indicates that the land is not fully utilized). The final objective function value is Z= 207,798 (the unit needs to be confirmed based on the model), and all test numbers $\sigma_i \leq 0$, verifying the optimality.

4. Conclusion

This paper systematically explores the application of the simplex method in accounting management, demonstrating its effectiveness in resource allocation and cost control through theoretical analysis and case studies. The research first establishes the pivotal role of linear programming in modern financial management and elaborates on the fundamental principles and computational procedures of the simplex method. Two case studies—enterprise production cost optimization (minimizing $Z=2x_1+3x_2$) and tomato cultivation planning (maximizing output)—validate the method's efficiency under multiple constraints, yielding optimal solutions (x_1=20, x_2=40, Z=160; 3,500 m² for Shihong No. 3 and 300 m² for Xinfan No. 9). The results confirm that the simplex method provides scientifically quantifiable decision-making support for businesses and agriculture, significantly enhancing resource utilization efficiency and reducing costs.

The study highlights the versatility and practicality of the simplex method across diverse fields, offering actionable mathematical tools for managerial decision-making. However, limitations remain:

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the case studies were small-scale and did not address high-dimensional data or dynamic constraints; the computational efficiency of the algorithm was insufficiently discussed, lacking comparative analysis with other optimization methods (e.g., interior-point methods). Future research could expand in the following directions: Integrating machine learning to tackle large-scale optimization problems; exploring real-time optimization strategies under dynamic constraints; and comparing the performance of different algorithms in complex financial models to further enhance adaptability and practicality.

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