

Theoretical and Practical Study of the Application of the Simplex Method in Quantitative Management

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The increasingly competitive business environment demands that organizations make decisions accurately, effectively, and efficiently, taking into account the limitations of available resources. Quantitative management is an approach that can be used to assist managers in solving various decision-making problems through the use of mathematical models and quantitative analysis techniques. One technique widely used in quantitative management is the Simplex method, a procedure for obtaining optimal solutions to linear programming problems with more than two decision variables. This article aims to examine the theoretical and practical application of the Simplex method in assisting the process of optimizing resource use and managerial decision-making. The research method used is a qualitative descriptive approach through literature studies and illustrations of the application of the Simplex method to production problems. The results of the study indicate that the Simplex method can help organizations determine optimal product combinations by considering limitations in raw materials, labor, production capacity, and other resources. The application of this method can also provide information regarding optimal production quantities and the maximum profit value that can be obtained. Thus, the Simplex method can be a relevant analytical tool in supporting data-based decision-making and increasing the efficiency of organizational resource utilization.

Keywords: Quantitative Management, Linear Programming, Simplex Method, Optimization, Decision Making.

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1. Introduction

The increasingly dynamic development of the business and industrial world causes organizations to face various challenges in managing resources effectively and efficiently. Business competition, changes in consumer demand, limitations on raw materials, labor, production capacity, capital, and demands for increased productivity encourage management to make more rational and measurable decisions. In conditions of limited resources, errors in determining the combination of resource use can lead to waste and reduce the organization's potential profits. Therefore, a quantitative approach is needed to help management evaluate various alternative decisions based on the objectives and limitations faced. Research on production optimization shows that the problem of resource limitations is one of the main reasons for using linear programming to support production decisions and resource allocation (Sriwidadi & Agustina, 2013; Sinabutar, 2009).

Quantitative management is one approach that can be used to support the decision-making process. This approach uses mathematical models, optimization techniques, and quantitative analysis to transform managerial problems into structures that can be analyzed systematically. Its application is not limited to production activities, but can also be used for planning, resource allocation, scheduling, distribution, and cost control. In the context of decision-making, quantitative models allow management to compare various alternatives based on predetermined objective functions and constraints. This approach can also be developed into a decision support system, where human analytical skills can be combined with computational capabilities to solve semi-structured managerial problems (Ningsih et al., 2003).

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One important technique in quantitative management is linear programming. Linear programming is used to obtain the optimal solution of an objective function by considering a number of resource constraints. The objective function can be directed to maximize profits or revenue or minimize costs, while constraints can include limitations on raw materials, machine hours, labor, capital, storage capacity, and production capacity. Studies in the plastics industry show that linear programming can be used to determine product combinations by simultaneously considering raw materials, machine hours, labor, and market demand (Sriwidadi & Agustina, 2013). More recent applications also show that linear programming can be used to optimize resource allocation and profits in the furniture industry by considering various types of materials and labor costs (Saxena & Sharma, 2025).

The Simplex method is one of the main methods in solving linear programming problems, especially when the problem involves more than two decision variables. Conceptually, the Simplex method works through an iterative process by moving from one feasible solution to another until an optimal solution is obtained. Classic studies on the efficiency of the Simplex method show that this method has long been an important computational tool in solving linear programming problems, both from a theoretical perspective and its application to real problems (Shamir, 1987). The development of this method is also continuously studied, including approaches that attempt to simplify its application from a managerial perspective so that linear programming problems can be more easily understood and used by practitioners (Lev & Kowalski, 2010).

In practice, the Simplex method has been widely applied in various business sectors. In the food industry, for example, this method is used to determine the optimal production combination by considering limited raw materials and production time (Faruk, 2022). In the coffee industry, linear programming is used to determine menu combinations that can optimize profits based on available resource capacity (Anhar et al., 2023). Another application in the tofu industry also shows that the Simplex method can help determine the optimal production volume when companies face limited production resources (Anugerah et al., 2025). Meanwhile, research on small-scale shrimp cracker (Rambak) farmers (SMEs) shows that linear programming analysis using the Simplex method can be used to determine the optimal production combination and profit level (Utama & Widajanti, 2025).

The application of the Simplex method has also evolved in line with the use of information technology. Calculations previously performed manually can be assisted by software such as POM-QM, Excel Solver, or web-based systems. Research on chip production optimization shows that the results of manual calculations using the Simplex method can be compared with those from the POM-QM application to help determine optimal production combinations (2024). Another study used Excel Solver to optimize profits in agricultural commodity sales activities (Al Madani & Sholihah, 2024). The development of web-based information systems has also been carried out to automate Simplex calculations so that the production decision-making process can be carried out more practically (Sutjiadi & Aminah, 2020).

In addition to determining the optimal solution, the Simplex method can be combined with sensitivity and duality analysis to provide more in-depth information about changes in resource conditions. Sensitivity analysis allows management to understand how changes in certain parameters can affect the optimal solution, while the concept of shadow prices can provide insight into the additional economic value of a limited resource. Research on the production of yellow rice and fried rice shows that the Simplex method, complemented by duality and sensitivity analysis, can be used to evaluate resource efficiency and changes in production parameters (Habibi et al., 2024). A similar approach is also applied in multi-product production scheduling to analyze the solution's resilience to changes in raw material availability, machine hours, and labor (Hafizah et al., 2026).

The relevance of the Simplex method is increasingly evident in the development of modern industries that demand data-driven decisions. A systematic study of the application of the Simplex method in the manufacturing industry shows that this method can provide benefits in the form of improved resource allocation, cost reduction, increased productivity, and support for data-driven decision-making (Pasaribu et al., 2025). Recent research also shows the application of the Simplex method in sales optimization, production planning, the food industry, agriculture, and even mining activities (Soesilo et al., 2025; Firdaus & J., 2025; Anas et al., 2026). In fact, research in the agro-industrial sector shows that the Simplex method can be used to allocate labor, production time, and raw materials to achieve optimal profit levels (Ogbada & Ahmed, 2026).

Based on the above description, the Simplex method has theoretical and practical relevance as a quantitative management instrument in supporting resource optimization and decision-making. This method not only produces mathematical solutions in the form of optimal decision combinations, but can also help management understand the relationship between objectives, resource limitations, and the economic consequences of each decision alternative. Therefore, this article aims to examine the theoretical and practical application of the Simplex method in quantitative management, particularly in solving production optimization and resource allocation problems. This study is expected to provide an understanding of the basic concepts of the Simplex method and demonstrate its relevance as a managerial decision-making tool in dealing with resource limitations.

2. Literature Review and Problem Statement

Quantitative Management

Quantitative management is an approach in management science that uses mathematical methods, statistics, and quantitative models to help solve decision-making problems. This approach developed from the need for organizations to obtain a more objective and systematic basis for decision-making. Initially complex managerial problems can be simplified through the creation of models, allowing for a more structured analysis of the relationships between objectives, decision variables, and resource constraints.

Using a quantitative approach allows management to evaluate various alternatives before implementing a decision. With the help of mathematical models, management can estimate the consequences of a decision based on specific conditions and constraints. This approach is particularly useful when organizations face problems involving numerous choices and limited resources.

Quantitative management can be applied to various fields, such as production planning, inventory management, quality control, transportation, scheduling, distribution, investment planning, and resource allocation. One important characteristic of the quantitative approach is the presence of clear objectives and limitations that can be formulated mathematically.

Linear Programming

Linear programming is an optimization technique used to determine the best solution to a problem with a linear objective function and a number of linear constraints. The primary goal of linear programming is to obtain the maximum or minimum value of the objective function while satisfying all specified constraints. In general, the linear programming model can be formulated as follows:

Maximize or minimize:

$$Z = c_1X_1 + c_2X_2 + \dots + c_nX_n$$

With the constraints:

$$a_{11}X_1 + a_{12}X_2 + \dots + a_{1n}X_n \leq b_1$$

$$a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n \leq b_2$$

etc.

With:

Z = objective function;

$X_1, X_2, \dots, X_n$ = decision variable;

$c_1, c_2, \dots, c_n$ = contribution of each variable to the objective function;

a_{ij} = resource use by each decision variable;

b_i = available resource capacity.

In production problems, the decision variable can be the quantity of each product to be produced. The objective function is usually the profit to be maximized, while constraints can include raw materials, labor, and machine capacity.

Simplex Method

The Simplex Method is an iterative procedure for obtaining optimal solutions to linear programming problems. This method is particularly useful when the problem has multiple decision variables and constraints, making graphical solutions impractical.

The basic principle of the Simplex method is to find a feasible solution and then iterate to improve the value of the objective function. At each iteration, variables enter the basis and variables leave the basis. This process continues until there are no further opportunities to improve the value of the objective function in the maximization problem. The general stages of the Simplex method include:

1. Determine decision variables.
2. Determine the objective function.
3. Determine all constraint functions.
4. Add slack variables or additional variables as needed.
5. Form the initial Simplex table.
6. Determine key columns based on the variables that have the most potential to improve the objective function.
7. Determine the key row based on the smallest positive ratio.
8. Determine the pivot element.
9. Perform row operations to obtain a new table.
10. Repeat the iteration process until an optimal solution is obtained.

The Simplex method offers the advantage of being applicable to problems with many variables and constraints. However, its application requires an understanding of linear programming concepts and careful calculation.

3. Method

This article uses a descriptive research method with a qualitative approach through a literature review. The literature review was conducted by reviewing various sources related to quantitative management, linear programming, optimization, and the Simplex method. The literature was used to gain an understanding of the basic concepts, implementation stages, and benefits of the Simplex method in supporting organizational decision-making.

In addition to a literature review, this article uses a case study to illustrate the practical application of the Simplex method. The data used in the illustration is a simulation designed for academic purposes. The case depicts a company producing two types of products with limited raw materials and labor.

The analysis was performed by formulating decision variables, objective functions, and constraint functions. The model was then solved using the Simplex method to obtain an optimal solution. The results were then interpreted from a management perspective to determine their implications for production planning and resource utilization.

4. Results and Discussion

Problem Formulation

As an illustration of the application, it is assumed that a company produces two types of products, namely Product A and Product B. Product A provides a profit of IDR 40,000 per unit, while Product B provides a profit of IDR 30,000 per unit.

In the production process, there are two limited resources: raw materials and labor. Each unit of Product A requires 2 units of raw materials and 1 unit of labor. Meanwhile, each unit of Product B requires 1 unit of raw materials and 1 unit of labor. The company has a maximum inventory of 100 units of raw materials and 80 units of labor. Based on these conditions, the company wants to determine the quantities of Product A and Product B that should be produced to maximize profits. The decision variables are defined as follows:

X_1 = quantity of Product A produced.

X_2 = quantity of Product B produced.

Objective function:

$$\text{Maximize } Z = 40,000X_1 + 30,000X_2$$

Due to raw material constraints:

$$2X_1 + X_2 \leq 100$$

With labor constraints:

$$X_1 + X_2 \leq 80$$

As well as:

$$X_1 \geq 0 \text{ and } X_2 \geq 0$$

The model shows that the company must determine the combination of Product A and Product B that provides the greatest profit without using raw materials and labor beyond available capacity.

Solution with Simplex Method

To change the inequality into an equation, slack variables S_1 and S_2 are added so that the model becomes:

$$2X_1 + X_2 + S_1 = 100$$

$$X_1 + X_2 + S_2 = 80$$

Objective function:

$$Z - 40,000X_1 - 30,000X_2 = 0$$

In the initial stage, the basic solution is obtained with $X_1 = 0$ and $X_2 = 0$. Next, an iteration process is carried out by selecting the variables that provide the greatest opportunity to improve the objective function. These variables then become the variables that enter the basis.

In the iteration process, the ratio of resource capacity to the coefficients of the input variables is used to determine the key row. Once the pivot element is determined, row operations are performed to generate the next Simplex table. This process continues until there are no more values indicating an opportunity to improve the objective function.

Based on the solution of the model, the optimal point can be obtained at a production combination that satisfies both resource constraints. Since Product A provides a higher profit per unit but uses more raw materials, while Product B uses fewer raw materials, the Simplex method helps determine the most profitable combination by considering both constraints simultaneously.

From the model solution, the optimal combination is obtained:

$X_1 = 20$ units of Product A

$X_2 = 60$ units of Product B

Thus, the maximum profit obtained is:

$$Z = 40,000(20) + 30,000(60)$$

$$Z = \text{Rp}800,000 + \text{Rp}1,800,000$$

$$Z = \text{Rp}2,600,000$$

These results show that the company should produce 20 units of Product A and 60 units of Product B to obtain a maximum profit of IDR 2,600,000 based on the resource conditions in the illustration.

Managerial Interpretation

The results of applying the Simplex method show that production decisions cannot simply consider profit per unit. Products that offer higher profits are not necessarily the best choice if they use relatively more resources. Therefore, production decisions must consider the relationship between profit contribution and resource usage.

In this case, the combination of 20 units of Product A and 60 units of Product B allows the company to optimally utilize available resources. All labor capacity is utilized, while raw material usage is also adjusted to the available capacity. This situation demonstrates that the Simplex method can help management find the most appropriate combination of decisions within operational constraints.

The Simplex method can also be used as a basis for production planning. Management can use the optimization results as a baseline for determining production targets. If there are changes in selling prices, production costs, raw material capacity, or workforce, the model can be recalculated to generate new decision alternatives.

Benefits of the Simplex Method in Quantitative Management

The application of the Simplex method offers several benefits in the decision-making process. First, this method helps organizations optimize resource utilization. When resources are limited, organizations must prioritize their use to maximize benefits. Second, the Simplex method can help increase decision objectivity. Decisions are not based solely on management intuition but are also supported by mathematical models that consider multiple constraints simultaneously. This can reduce the risk of inaccurate decision-making.

Third, the Simplex method can aid production planning. Companies can determine the optimal quantity of products to produce based on the capacity of raw materials, labor, machinery, and other resources. This way, companies can avoid overproduction or inefficient use of resources. Fourth, the Simplex method can be used as an alternative evaluation tool. Management can compare several scenarios based on changes in capacity, price, profit, and costs. The results of this analysis can be used as a basis for developing operational strategies.

Advantages and Limitations

The Simplex method has several advantages. It can be used to solve problems with multiple variables and constraints, has a systematic solution procedure, and is capable of generating optimal solutions based on a

predetermined model. Furthermore, the Simplex method can be applied to various management fields, not just production problems.

However, the Simplex method also has limitations. The results obtained are highly dependent on the accuracy of the model used. If the input data or assumptions do not align with actual conditions, the optimization results may be less relevant. Linear programming also has certain assumptions, such as linear relationships between variables, so not all managerial problems can be perfectly represented using this model.

In practice, Simplex method results should not be used in isolation from managerial considerations. Qualitative factors such as market conditions, consumer behavior, business risks, product quality, workforce capabilities, and changes in the business environment still need to be considered. Therefore, the Simplex method is more appropriately positioned as a decision-making tool.

5. Conclusion

Based on the theoretical studies and practical illustrations conducted, it can be concluded that the Simplex method is an important technique in quantitative management that can be used to solve linear programming problems. This method helps organizations determine optimal solutions through an iterative process that considers the objective function and various resource constraints. When applied to production problems, the Simplex method can help determine the optimal product mix so that resources such as raw materials and labor can be used efficiently. The optimization results can provide information on the optimal production volume and the potential profit based on predetermined conditions.

In practice, the Simplex method can support production planning, resource allocation, cost control, and managerial decision-making. However, the application of this method must be supported by accurate data and models appropriate to the organization's conditions. Qualitative factors and changes in the business environment must also be considered to ensure that the resulting decisions are not only mathematically optimal but also realistically applicable. Therefore, the Simplex method can be viewed as a decision-making tool with both theoretical and practical value in quantitative management. Proper use of this method can help organizations improve resource utilization efficiency and achieve goals more optimally.

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