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# Optimizing Production and Profits Using Linear Programming in Small Industry of Wooden Furniture from Community Teak Forests

**John E.H.J. FoEh**[1]
[1]Faculty of Engineering, Bhayangkara Jaya University, Jakarta, Indonesia, john.foeh@dsn.ubharajaya.ac.id

Corespondent author: john.foeh@dsn.ubharajaya.ac.id[1]

**Abstract:** This research aims to determine the level of furniture production that enables optimal profits from MSMEs Wooden Furniture from Community Teak Forests. This industry is located in Jakarta and uses sawn teak wood which comes from community teak forests in West Java and its surroundings. This study utilizes secondary data from a small industrial business (CV. Meubel Jaya), along with interviews with management and technical staff regarding the production process, raw materials, supporting materials, and the production timelines for each type of furniture manufactured. The analysis is conducted using Integer Programming, with the aid of QM for Windows software version 5.3. The constraint functions considered include raw materials such as teak wood, various supporting materials for furniture production, and labor hours required to manufacture each product. The analysis reveals that only specific types of furniture can maximize profits for MSMEs specializing in People's Teak Wood Furniture. The recommended monthly production includes 4 single-door cupboards, 8 table sets with 6 chairs, 2 table sets with 4 chairs, and 1 bed measuring 180 x 200 cm, yielding an optimal profit of Rp. 43,200,000. This strategy demonstrates that focusing on these four furniture types increases profits by 158% compared to the current production of 11 furniture types, which generates only Rp. 27,225,000, resulting in a profit difference of Rp. 15,975,000.

**Keyword:** Small Wood Furniture Industry, Community Teak Wood Forests, Profit Optimization, Integer Programming, QM for Windows.

## INTRODUCTION

History records that since the beginning of Repelita I (The First Five Year Development Plan), Indonesia's natural forests began to be exploited on a large scale by foreign investors to generate foreign exchange other than petroleum. Government policy until the 1980s relied on log exports to support the national economy. This causes the forestry sector to rank strongly in the country's foreign exchange earner after oil and gas. Aware of equitable development and increasing the added value of forest products, in the early 80s the concept of an integrated wood industry was started. This policy resulted in a ban on the export of logs until in 1985 including teak wood which was included in the luxury wood category. Thus, -officially- Indonesia's log exports are equal to zero. As a result, the timber industry in Indonesia - even in the form of an oligopoly - developed rapidly and in turn caused Indonesia to become the number 1 plywood exporting country in the world until 1997 (FoEh, 2019).

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The success in the plywood industry has created many choices for commercial types of wood and many other types that are neglected or even categorized as lesser known species. Even though it is the largest exporter of tropical plywood, the price of Indonesian products is more controlled by buyers because of its dependence on capital, machinery and equipment from buyers, including experts who also come from importers. Realizing this, the Indonesian government began to develop Industrial Plantation Forests (timber estate). In line with this, forest degradation also occurs due to land and forest fires, conversion of forest areas into oil palm plantations and other uses according to regional development plans. Meanwhile, illegal logging, wood smuggling and other forest damage have also occurred which has caused the area and potential of production forests and other forest areas to decrease or even decline. In turn, many wood industry companies closed due to a lack of raw materials. Among the various causes of forest degradation, illegal logging and forest fires are the ones that damage forests the most (Ananda R.S., 2019).

When forest exploitation tightens and the expansion of plantation forest areas is slow, there is a shortage of raw materials for the primary and secondary wood industry. Secondary industries such as wooden furniture rely heavily on sawn wood, while competing with the housing industry which also requires large amounts of sawn wood. It can be said that the current need for wood raw materials can no longer be met from natural forests and plantation forests. This means there is a deficit so that efforts to fulfill wood raw materials must come from community forests and/or shipping between islands which still produce community-grown teak wood. The price of wood is finally very expensive and the furniture and housing industry is starting to switch to substitute goods such as other types of wood, plastic, light steel and others.

Wood processing companies, particularly those handling sawn wood, focus primarily on producing sizes and assortments that align with consumer demands. They offer a variety of sizes at sawn wood retail locations to cater to market needs. However, the wooden furniture industry, which relies on sawn wood as a raw material, faces challenges such as supply shortages and competition from other primary wood industries like sawn wood, plywood, and pulp. The advancement and growth of the business sector have intensified competition among wood entrepreneurs, making it increasingly difficult to secure limited raw materials.

The current situation requires wooden furniture entrepreneurs, particularly MSMEs, to work diligently and plan effectively to sustain their production and sales. To address the demand for sawn wood, local sawmill industries rely on log raw materials sourced from community plantations or forests nearby (Hardjanto and Suhardjito, 2000). Consequently, production and sales are primarily tailored to meet consumer demand or specific orders. This approach arises from the inability of community forests to deliver consistent yields, as the age classes of trees in these forests are unevenly distributed and incomplete (Mile, 2010).

To bridge the gap in raw material availability, industries, such as those in Jakarta, often import materials from outside their regions, using land or inter-island transportation within Indonesia. In this context, Sulaeli (2009) emphasizes that achieving industrial efficiency and optimization is essential, enabling companies to maximize profits by reducing operational costs and enhancing the benefits derived from processing activities.

Numerous studies have utilized linear programming methods to optimize profits and other objectives, but these are often applied to large companies or industries using teak wood or other class I/II wood raw materials. Such studies do not necessarily reflect the actual break-even point or current conditions when compared to scenarios using optimization approaches with linear programming.

In the context of production planning, achieving profitability and maintaining competitiveness amidst the fierce competition for wood raw materials is crucial. Many MSMEs operate below the capacity of their machinery, equipment, and workforce, focusing on at least reaching the break-even point (BEP). This underscores the need for dedicated research to determine the optimal profits that MSME furniture businesses can achieve through strategic production planning.

## LITERATURE REVIEW

### Micro, Small and Medium Entreprises (MSME) of Furniture Industries

Catriana and Rakhma (2020) reported that the Ministry of Cooperatives for Small and Medium Enterprises (Kemenkop UKM) and the Indonesian Furniture and Crafts Industry Association (HIMKI) have committed to collaborative efforts aimed at doubling the export volume of furniture and crafts. There are 10 recommendations proposed by HIMKI so that exports of furniture and crafts can double. The *first* is an adequate supply of raw materials, especially rattan and wood, as a guarantee of supply availability to the finished goods industry. *Second*, assistance or subsidies for rejuvenating production equipment and technology so that it can support the acceleration and efficiency of the production process. *Third*, innovation and design development (design center) and design protection through IPR (Intellectual Property Rights). *Fourth*, a reasonable loan interest rate policy can be a basis for competitiveness. *Fifth*, law enforcement regarding illegal logging which disrupts the stability of the supply of raw materials. *Sixth*, reduction in tax rates. *Seventh*, development of integrated modern clusters, especially in West Java, Central Java and East Java as centers for the furniture and crafts industry. *Eighth*, regulations and wage systems that are more equitable so as to support the sustainability of the furniture and crafts industry. *Ninth*, education and training to increase HR competency. *Lastly (tenth)*, promotion and marketing as well as market penetration as an effort to introduce products and improve the image of Indonesian products. The Ministry of Cooperatives and UKM supports the efforts made by HIMKI. The Ministry of Cooperatives and SMEs has announced plans to implement policies aimed at doubling the export targets for furniture and crafts. In addition to promoting bamboo-based products, the ministry will also support the development of furniture and crafts made from non-wood materials, such as water hyacinth and other shrub plants, which can be transformed into unique and high-value products.

Several sectors, including trade, industry, and manufacturing, are experiencing high demand from the public for new business opportunities and job creation. This has led to the growth of numerous micro, small, and medium enterprises (MSMEs) and cooperatives, which play a significant role in Indonesia's economy. Furniture, defined as movable home equipment such as chairs, tables, and cabinets, derives its name from the French word "meuble," which means "furnishing." Essentially, furniture encompasses all household items that occupants use for sitting, lying down, or storing belongings like clothes and utensils. Common materials for furniture production include wood, boards, leather, and screws. Beyond providing comfort and utility in homes, furniture also carries social significance that can reflect an individual's social status. For instance, minimalist designs can exude luxury when crafted from high-quality materials like large-diameter teak wood. Today, furniture has evolved into a fashionable lifestyle product. (https://id.wikipedia.org/wiki/meubel).

According to Law Number 20 of 2008 regarding MSMEs, these businesses are typically operated by individuals or small entities. MSMEs are classified based on criteria such as annual revenue, asset value, and employee count. In contrast, larger businesses are defined as those with net worth or annual sales exceeding the thresholds set for medium-sized enterprises; these may include state-owned enterprises and foreign businesses operating in Indonesia. MSMEs also engage in various segments of the forestry industry, including the wood trade. Research by Darusman (2018) indicates that the woodworking sector's MSMEs struggle with competition against larger firms due to a lack of strong networks that could help them access export markets effectively. The model of small and medium entrepreneurs is not new in Indonesia; studies by the IPB Forestry Faculty Team (1997) suggest that to achieve greater economic efficiencies and enhance production and marketing processes, both large and small MSMEs should collaborate and gradually advance towards more downstream operations. Such market networks have been successful since the 1970s in supplying a substantial portion of the international rattan market.

## Linear Programming and Optimization Calculation

According to Taylor III (2018), the primary objective of management science is to tackle decision-making challenges faced by managers in both public and private organizations. To tackle these issues, mathematical models are developed. Traditionally, various mathematical techniques have been employed to solve these models, each suited for specific types of problems. As a scientific discipline, management science relies heavily on mathematics, which can often make it appear complex and intricate.

Additionally, linear programming is defined as a method for corporate decision-making that is represented by a model incorporating multiple linear relationships, objectives, and resource constraints. Essentially, linear programming serves as a problem-solving strategy that utilizes mathematical or algebraic symbols to address the allocation of limited economic resources—such as machinery, labor, raw materials, and capital. The primary aim is to optimize outcomes, which can involve maximizing profits, sales, or welfare, or minimizing costs, losses, or time. The characteristics of linear programming (LP) include the following:

- The variables involved in the problem must be non-negative ($\geq 0$).
- A linear function of the variables is employed to define criteria for selecting the optimal value of the decision variable. This function, referred to as the objective function, is associated with goals such as maximizing revenue or profit, or minimizing costs.
- The operational guidelines governing the process can be depicted by a series of linear equations or inequalities. These are termed constraints, which signify the limitations imposed by available resources such as raw materials, labor, capital, and machinery. These constraints must be taken into consideration to attain the desired objectives.

According to Jay et al. (2019), many management decisions significantly impact organizational resources, which typically include machinery (for instance, airplanes in the airline industry), personnel (like pilots), financial resources, time, and materials (such as aviation fuel). These resources are crucial for the production of goods (such as machinery, furniture, food, or clothing) or services (including airline schedules, advertising strategies, or investment decisions). Linear programming (LP) is a widely used mathematical technique that aids operational managers in planning and making essential decisions related to resource allocation.

Heizer and Render (2019) emphasize that many management decisions significantly impact organizational resources, which commonly encompass machines (such as aircraft in the airline industry), labor (including professionals like pilots), monetary funds, time, and materials. These resources are pivotal for generating either physical products (like machinery, furniture, food, or clothing) or intangible services (such as airline timetables, advertising strategies, or investment plans).

Linear programming (LP) serves as a powerful mathematical tool that operational managers employ to strategically allocate these resources. LP enables managers to develop solutions that maximize revenues, profits, or welfare while minimizing costs and inefficiencies. By leveraging linear functions and constraints, LP provides a systematic approach to optimizing resource usage, thus aiding in the effective management of organizational resources. All problems in LP have 4 requirements: objectives, constraints, alternatives and linear, namely:

- Linear programming (LP) problems aim to either maximize or minimize a specific quantity, typically related to profits or costs. This focus is encapsulated in the objective function of the LP problem. Generally, a company's primary goal is to maximize long-term profits (financial value). For instance, in the context of distribution systems for trucks or airlines, the objective may shift to minimizing shipping costs.
- The existence of obstacles or constraints restricts our ability to fully pursue our goals. For instance, determining the number of units to produce for each product in a company's lineup is influenced by the availability of labor and machinery. Consequently, we aim to either maximize or minimize a specific quantity (the objective function) while taking into account the limitations imposed by these available resources (the constraints).
- There are various alternative actions available for decision-making. For instance, if a company manufactures three different products, management can utilize linear programming (LP) to determine how to allocate limited resources, such as labor and machinery. If no alternatives exist, the use of LP is unnecessary.
- Linear programming problems aim to either maximize or minimize a specific quantity, typically related to profits or costs. This focus is encapsulated in the objective function of the LP problem. Generally, a company's primary objective is to maximize long-term profits (financial value). In scenarios such as truck or airline distribution systems, the objective shifts to minimizing shipping costs.
- The presence of constraints limits our ability to achieve our goals. For example, when deciding how many units of each product to manufacture in a company's lineup, factors such as labor and machinery availability can pose challenges. As a result, the goal is to maximize or minimize the objective function while considering these resource limitations.
- The existence of various alternative actions is crucial for effective decision-making. In cases where a company produces multiple products, management employs LP to allocate limited resources effectively. Without alternatives to consider, the application of LP becomes redundant.

According to Susdarwono (2020), the decision variables Z and X are employed in the objective function of linear programming. The variable X represents the quantity of products or outputs that need to be produced to achieve optimal results. The linear programming model utilizes various symbols to facilitate this process. Linear programming model, using some of the symbols below:

- **m**: Represents the types of limitations on the availability of resources or facilities.
- **n**: Denotes the types of activities that utilize the resources or facilities.

- **i**: Indicates the number of each type of resource or facility available (where i=1,2,…,m*i*=1,2,…,*m*).
- **j**: Refers to the number of each type of activity that employs the available resources or facilities (where j=1,2,…,n*j*=1,2,…,*n*).
- **xj**: Represents the level of the jth activity (where j=1,2,…,n*j*=1,2,…,*n*).
- **aij**: Indicates the quantity of resource i*i* required for each unit of output produced by activity j*j* (where i=1,2,…,m*i*=1,2,…,*m* and j=1,2,…,n*j*=1,2,…,*n*).
- **bi**: Signifies the amount of available resources (or facilities) i*i* allocated to each unit of activity (where i=1,2,…,n*i*=1,2,…,*n*).
- **Z**: Represents the optimized value (either maximum or minimum).
- **Cj**: Reflects the increase in the value of Z if there is an increase in the level of activity X*j* by one unit; it also represents the contribution of each unit of activity output j*j* to the value of Z.

  Based on the formulation of the symbols in question, a mathematical pattern used to express a linear programming problem is drawn up, namely:

  Purpose function:

  Maximize $Z = C_1X_1 + C_2X_2 + C_3X_3 + \ldots + C_nX_n$

  Some limitations:

  1) $a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots + a_{1n}X_n \leq b_1$

  2) $a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots + a_{2n}X_n \leq b_2$

  ….

  m) $a_{m1}X_1 + a_{m2}X_2 + a_{m3}X_3 + \ldots + a_{mn}X_n \leq b_m$ where: $X_1 \geq 0, X_2 \geq 0, \ldots, X_n \geq 0$

As previously mentioned, the objective of a linear programming problem is represented by the objective function. The first constraint indicates that the output from activity 1, which produces a certain quantity of goods or services, multiplied by the resource requirement per unit for that activity, is added to the output from activity 2 multiplied by its respective resource requirement per unit. This process continues for all activities up to the nth one. The total resource usage must not exceed the available capacity for resource 1, referred to as b1. Use some other constraint up to m, that also applies.

### Basic Assumptions of Linear Programming

Christian (2013) outlines several essential assumptions for linear programming, which include:

- **Certainty**: The coefficients in the objective function (cj*cj*) and the constraint functions (aij*aij*) are known with certainty and remain constant throughout the analysis.
- **Proportionality**: All coefficients in the model, cj*cj* and aij*aij*, are proportional to the magnitude of the decision variables, meaning that changes in output levels will lead to proportional changes in resource usage.
- **Additivity**: The total activity is equal to the sum of individual activities, indicating that there are no interactions among different activities.
- **Divisibility**: The solutions to linear programming problems (xj*xj* values) do not need to be whole numbers; they can take on fractional values.
- **Non-negativity**: Decision variables cannot assume negative values.

Furthermore, Jay (2019) states that linear programming is a mathematical technique that aids operational managers in planning and making decisions regarding resource allocation.

### QM for Windows or ExcelQM for Mac

It is crucial to utilize an appropriate method for optimizing outcomes in linear programming. One widely adopted technique for determining the optimal combination of three or more variables is the simplex method. In contemporary applications, with numerous decision variables involved, computers can efficiently solve many linear programming (LP) problems. The simplex method is particularly effective for problems with a manageable number of decision variables. However, when confronted with a larger set of variables and constraints, solutions typically necessitate computer applications such as LINDO. For more complex LP scenarios, software like QM for Windows or ExcelQM for Mac can be employed. The results obtained from identifying the optimal solution are expected to aid companies and decision-makers in effectively planning production and sales (Al Vonda et al., 2019).

QM stands for Quantitative Methods, a software package included with various textbooks on Quantitative Methods or Management Science. This user-friendly software requires minimal initial guidance, as users can easily access the "help" screen directly from the program (Taylor III, 2019). The software is also featured in the book "Quantitative Methods for Management" under the name POM QM (Production and Operations Management – Quantitative Methods).

While QM for Windows and ExcelQM for Mac offer certain functionalities, some features may not be present in POM for Windows or vice versa (Render et al., 2018).

According to Harsanto (2017), QM for Windows and ExcelQM for Mac are software tools designed for operations management, capable of effectively addressing various business challenges. Both applications offer a range of modules that support decision-making in business as well as in other fields. The available modules include: Assignment, Break-Even/Cost-Volume Analysis, Decision Analysis, Forecasting, Game Theory, Goal Programming, Inventory Management, Linear Programming, Markov Analysis, Material Requirements Planning, Network Analysis, Project Management (PERT/CPM), Quality Control, Simulations, Statistics, Transportation, and Waiting Lines. These features enable users to analyze data efficiently and make informed decisions.

### Production Optimization

According to Haslan et al. (2018), optimization is defined as achieving a balance by selecting the best alternative from a range of available criteria. This involves maximizing or minimizing the value of a function with multiple variables while adhering to various constraints, such as those related to labor, capital, and materials. Essentially, production optimization involves maximizing the efficient use of the constraints associated with various production factors. Key factors of production include capital, machinery, equipment, raw materials, auxiliary materials, and labor. By effectively managing these resources, organizations can enhance productivity and achieve better overall performance.

In this context, Aprilyanti (2019) highlights that a mathematical optimization solution method is applied to allocate limited resources among competing user types. This process involves both maximizing cost contributions and minimizing costs. The activity plan developed to achieve optimal results is designed to assist operational managers in effectively planning and making decisions regarding the allocation of an organization's or company's limited resources, as represented within a linear programming framework.

Jek (2011) notes that optimization and linear programming problems are addressed in the field of Operations Research, which focuses on finding optimal solutions by considering objectives and constraints. Optimization is described as the process of utilizing mathematical models, with various methods available for finding optimal solutions, including linear programming, non-linear programming, and multiple objective approaches.

## METHOD

The study was carried out from January to April 2024. It was conducted at CV. Meubel Jaya, South Jakarta The data or decision variables used in this study were: 3-door wardrobe

(X1), 2-door wardrobe (X2), 1-door wardrobe (X3), A 6-seats dining table (X4), dining table B 4 chairs (X5), guest chair set (X6), bed 180 x 200cm (X7), bed 160 x 200cm (X8), nightstand (X9), ordinary table (X10), ordinary chair (X11).
The data utilized in this study comprises both primary and secondary sources. Primary data was collected through direct interviews with reliable sources, specifically furniture owners from CV. Meubel Jaya. In contrast, secondary data was obtained from the company itself for clarification purposes. This secondary data also includes information sourced from various documents and reports related to CV. Meubel Jaya, as well as previous research journals, articles, internet data, and literature pertinent to optimizing production and sales profits.
The specific data required for this study includes: Processing time, Raw materials, Supporting materials, Production outputs, Product sales volume, Selling price per unit, Variable costs, Fixed costs, Total costs, and Sales profits. This comprehensive collection of data is essential for analyzing and optimizing the production and sales processes within the company.

**Methods of Data Analysis**
This analysis uses the Integer Programming method and objective function is formulated as follows:

Maks $Z = C1X1+C2X2+C3X3+C4X4+C5X5+C6X6+C7X7+C8X8+C9X9+C10X10+C11X11$

Remarks:
Z = Maximum profit
C1, ..., C11 = Product profit contribution … 1st, ..., 11th
X1, ..., X11 = Product group … 1st, ..., 11th
Constraint function or Subject to:

Teak Wood = $a12X1 + a13X2 + a14X3 + a15X4 + a16X5 + a17X6 + a18X7 + a19X8 + a20X8 + a21X9 + a22X10 + a23X11 \leq b1$
Triplex = $a24X1 + a25X2 + a26X3 + a27X6 \leq b2$ Nail = $a28X1 + a29X2 + a30X3 + a31X9 \leq b3$
Door hinges = $a32X1 + a33X2 + a34X3 \leq b4$ Door key = $a35X1 + a36X2 + a37X3 \leq b5$
Putty = $a38X1 + a39X2 + a40X3 + a41X4 + a42X5 + a43X6 + a44X7 + a45X8 + a46X8 + a47X9 + a48X10 + a49X11 \leq b6$
Wood glue = $a50X1 + a51X2 + a52X3 + a53X4 + a54X5 + a55X6 + a56X7 + a57X8 + a58X8 + a59X9 + a60X10 + a61X11 \leq b7$
Thinner = $a62X1 + a63X2 + a64X3 + a65X4 + a66X5 + a67X6 + a68X7 + a69X8 + a70X8 + a71X9 + a72X10 + a73X11 \leq b8$
1stVarnish = $a74X1 + a75X2 + a76X3 + a77X4 + a78X5 + a79X6 + a80X7 + a81X8 + a82X8 + a83X9 + a84X10 + a85X11 \leq b9$
2ndVarnish = $a86X1 + a87X2 + a88X3 + a89X4 + a90X5 + a91X6 + a92X7 + a93X8 + a94X8 + a95X9 + a96X10 + a97X11 \leq b10$
Sandpaper = $a98X1 + a99X2 + a100X3 + a101X4 + a102X5 + a103X6 + a104X7 + a105X8 + a106X8 + a107X9 + a108X10 + a109X11 \leq b11$
Rafters = $a110X7 + a111X8 \leq b12$
handyman working hours = $a112X1 + a113X2 + a114X3 + a115X4 + a116X5 +a117X6 + a118X7 + a119X8 + a120X8 + a121X9 + a122X10 + a123X11 \leq b13$

**Remarks:**

a: the number of sources i needed to obtain each unit of output (output)
X1, ..., X11 = Product group i …., to 11

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X1, ..., X11 = Product group i …., to 11

**Variable Operational Definition**

- Production: Production refers to the utilization of teak wood raw materials and other materials to manufacture eleven different types of furniture based on consumer custom orders. This process involves several key steps, including: 3-door wardrobe (X1), 2-door wardrobe (X2), 1-door wardrobe (X3 ), dining table A 6 chairs (X4), dining table B 4 chairs (X5), guest chair set (X6), bed 180 x 200 cm (X7), bed 160 x 200 cm (X8), nightstand (X9), regular table (X10), regular seat (X11).
- Raw Materials are the various materials required for the manufacture of a product. In furniture production, these materials can be categorized into three main types: Main Raw Material (Teak Wood), Additional Raw Materials (Plywood, Rafters), and Finishing Materials (they include: Varnish:, Polish.
- Production Cost refers to the average total cost incurred in processing raw materials into finished furniture that is ready for sale.
- Workers are individuals engaged in the furniture-making process within the company, participating in various stages from material preparation to finishing. These workers typically operate under the following conditions: First, work hours: they work an average of 8 hours per day. Second, work schedule: they are employed for approximately 24 days per month..
- Fixed Costs refer to all components of costs that are incurred over a specific period of time and remain constant regardless of the level of output produced by the company.
- Variable Costs are the costs that vary directly with the level of production. Unlike fixed costs, which remain constant regardless of output, variable costs change proportionally based on the volume of furniture produced..
- Profit is defined as the difference between the sales value of each furniture product and the total production cost associated with producing that furniture.
- Worker's Working Hours refers to the total amount of time that a handyman or worker spends on the job, expressed in hours. In this context, each worker typically works: 8 Working Hours per Day, this standard workday allows for a structured schedule, enabling workers to focus on their tasks effectively..

## RESULTS AND DISCUSSION

### Furniture Production Process of CV. Meubel Jaya

The production process at CV. Meubel Jaya involves several stages, starting from the preparation of raw materials and culminating in the sale and delivery of finished furniture. The specific stages of the production process are as follows: preparation of raw materials, cutting wood or boards, assembling or making furniture, elbow punching/drilling, first sanding, caulking, second sanding, coloring/polishing, varnish, drying and packaging. The next process is the sale and delivery to the buyer. This structured approach ensures that each piece of furniture meets quality standards while fulfilling customer custom orders effectively.

### Formulation of Linear Programming Model

The formulation of a linear programming model involves several key stages, which are essential for effectively solving optimization problems. These stages include: formulating several decision variables, formulating objective functions, and formulating limiting or constraint functions.

- **Formulation of Decision Variables and Objective Functions**

The objective function in the study aimed to maximize the optimal profit from the existing decision variables. Specifically, the decision variables mentioned include the number or quantity of furniture unit productions. Here is a detailed explanation of how you might formulate the objective function as shown in Table 1.

Tabel 1. Data on Prices, Costs, and Profit per month of production

| Variabel | Furniture Type | Price per unit (Rp) | Total Cost per unit (Rp) | Profit per unit (Rp) | Total Production (Rp) | Total Profit per month (Rp) |
|---|---|---|---|---|---|---|
| X1 | 3 door wardrobe | 8.000.000 | 5.600.000 | 2.400.000 | 2 | 4.800.000 |
| X2 | 2 door wardrobe | 6.200.000 | 4.340.000 | 1.860.000 | 2 | 3.720.000 |
| X3 | 1 door wardrobe | 5.000.000 | 3.500.000 | 1.500.000 | 3 | 4.500.000 |
| X4 | Dining Table A (6 chairs) | 4.000.000 | 2.800.000 | 1.200.000 | 2 | 2.400.000 |
| X5 | Dining Table B (4 chairs) | 3.500.000 | 2.450.000 | 1.050.000 | 2 | 2.100.000 |
| X6 | Guest chair set | 4.200.000 | 2.940.000 | 1.260.000 | 2 | 2.520.000 |
| X7 | Bed (180 x 200) | 3.000.000 | 2.100.000 | 900.000 | 2 | 1.800.000 |
| X8 | Bed 160 x 200) | 2.600.000 | 1.820.000 | 780.000 | 2 | 1.560.000 |
| X9 | Night stand | 750.000 | 525.000 | 225.000 | 5 | 1.125.000 |
| X10 | Ordinary Table | 600.000 | 420.000 | 180.000 | 5 | 900.000 |
| X11 | Ordinary Chair | 400.000 | 280.000 | 120.000 | 15 | 1.800.000 |
| Total | | | | | | 27.225.000 |

Source : Researcher secondary data processing, 2024

Based on the data in Table 1 above, the objective function in this study is formulated as follows:

$$Z\max = 4.800.000X_1 + 3.720.000X_2 + 4.500.000X_3 + 2.400.000X_4 + 2.100.000X_5 + 2.520.000X_6 + 1.800.000X_7 + 1.560.000X_8 + 1.125.000X_9 + 900.000X_{10} + 1.800.000X_{11}$$

Data on the use of materials for making each furniture and inventory per month are presented in Table 2.

**Table 2. Data on Material Usage and Inventory per Month**

Source: Researcher secondary data processing, 2024

| Uraian | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | Stock |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-1 Teak wood (plank block) | 8 | 7 | 6 | 4 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 400 |
| C-2 Triplex (sheets) | 4 | 3 | 3 | | | | | | 2,5 | | | 15 |
| C-3 Nail (pieces) | 240 | 188 | 162 | 30 | 30 | | | | 30 | | | 800 |
| C-4 Door hinges (pieces) | 24 | 16 | 12 | | | | | | | | | 60 |
| C-5 Door key (piecess) | 8 | 6 | 3 | | | | | | | | | 20 |
| C-6 Putty (kg) | 4 | 3 | 1,5 | 3 | 3 | 4 | 1 | 1 | 2,5 | 1,25 | 1,75 | 42 |
| C-7 Wood glue (bottle) | 5 | 3 | 1,5 | 2 | 2 | 2 | 1 | 1 | 2,5 | 2,5 | 3,75 | 30 |
| C-8 Thinner (liter) | 3 | 2 | 1,5 | 1 | 1 | 3 | 1 | 1 | 1,25 | 1,25 | 3,75 | 25 |
| C-9 Varnish-1 (liter) | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2,5 | 2,5 | 7,5 | 35 |
| C-10 Varnish-2 (liter) | 3 | 2 | 1,5 | 1 | 1 | 3 | 1 | 1 | 1,5 | 1,25 | 3,75 | 25 |
| C-11 Sand paper (sheets) | 8 | 7 | 9 | 6 | 5 | 8 | 5 | 5 | 7,5 | 5 | 7,5 | 100 |
| C-12 Rafters (beams) | | | | | | | 5 | 4 | | | | 60 |
| C-13 Handyman working time (hour) | 34 | 30 | 48 | 16 | 14 | 36 | 28 | 14 | 10 | 15 | 15 | 768 |

The formulation of the constraint functions based on the data in Table 2 is as follows:
Teak wood : 8X1 + 7X2 + 6X3 + 4X4 + 3X5 + 3X6 + 3X7 +3X8 + 2X9 + 3X10 + 3X11 ≤ 400 (plank block)
Triplex 5mm: 4X1 + 3X2 + 3X3 + 2,5X6 ≤ 15 (sheets)
Nail: 240X1 + 188X2 + 162X3 + 30X4 + 30X5 + 30X9 ≤ 800 (pieces)
Door hinges: 24X1 + 16X2 + 12X3 ≤ 60 (pieces) Door key: 8X1 + 6X2 + 3X3 ≤ 20 (pieces)
Putty: 4X1 + 3X2 + 1,5X3 + 3X4 + 3X5 + 4X6 + 1X7 + 1X8 + 2,5X9 + 1,25X10 + 1,75X11 ≤ 42 (kg)
Wood glue: 5X1 + 3X2 + 1,5X3 + 2X4 + 2X5 + 2X6 + 1X7 + 1X8 + 2,5X9 + 2,5X10 + 3,75X11 ≤ 30 (bottles)
Thinner: 3X1 + 2X2 + 1,5X3 + 1X4 + 1X5 + 3X6 + 1X7 + 1X8 + 1,25X9 + 1,25X10 + 3,75X11 ≤ 25 (liter)
Varnish-1: 3X1 + 2X2 + 3X3 + 2X4 + 2X5 + 2X6 + 2X7 + 2X8 + 2,5X9 + 2,5X10 + 7,5X11 ≤ 35 (liter)
Varnish-2: 3X1 + 2X2 + 1,5X3 + 1X4 + 1X5 + 3X6 + 1X7 + 1X8 + 1,5X9 + 1,25X10 + 3,75X11 ≤ 25 (ltr)
Sandpaper: 8X1 + 7X2 + 9X3 + 6X4 + 5X5 + 8X6 + 5X7 + 5X8 + 7,5X9 + 5X10 + 7,5X11 ≤ 100 (sheets)
Rafters: 5X7 + 4X8 ≤ (beams)
Handyman working hour: 34X1 + 30X2 + 48X3 + 16X4 + 14X5 + 36X6 + 28X7 + 14X8 + 10X9 + 15X10 + 15X11 ≤ 768 (hours)

**Optimization Results with QM for Windows**.

By using QM for Windows version 5.3 software, data processing results were obtained as in Table 3 below.

**Table 3. Integer Programming Solution in QM for Windows**

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | | RHS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximize | 4,8 | 3,72 | 4,5 | 2,4 | 2,1 | 2,52 | 1,8 | 1,56 | 1,13 | 0,9 | 1,8 | | |
| C-1 | 8 | 7 | 6 | 4 | 3 | 3 | 3 | 30 | 2 | 3 | 3 | <= | 400 |
| C-2 | 4 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 2,5 | 0 | 0 | <= | 15 |
| C-3 | 240 | 188 | 162 | 10 | 30 | 0 | 0 | 0 | 30 | 0 | 0 | <= | 800 |
| C-4 | 24 | 16 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <= | 60 |
| C-5 | 8 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <= | 20 |
| C-6 | 4 | 3 | 1,5 | 3 | 3 | 4 | 1 | 10 | 2,5 | 1,25 | 1,75 | <= | 42 |
| C-7 | 5 | 3 | 1,5 | 2 | 2 | 2 | 1 | 10 | 2,5 | 2,5 | 3,75 | <= | 30 |
| C-8 | 3 | 2 | 1,5 | 1 | 1 | 3 | 1 | 10 | 1,25 | 1,25 | 3,75 | <= | 25 |
| C-9 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 20 | 2,5 | 2,5 | 3,75 | <= | 35 |
| C-10 | 3 | 2 | 1,5 | 1 | 1 | 3 | 1 | 10 | 1,5 | 1,25 | 7,5 | <= | 25 |
| C-11 | 3 | 7 | 9 | 6 | 5 | 8 | 5 | 50 | 7,5 | 5 | 3,75 | <= | 100 |
| C-12 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 40 | 0 | 0 | 7,5 | <= | 60 |
| C-13 | 34 | 30 | 48 | 16 | 14 | 36 | 28 | 140 | 10 | 15 | 15 | <= | 768 |
| Variable type | Integer | Integer | Integer | Integer | Integer | Integer | Integer | Integer | Integer | Integer | Integer | | |
| Solution-> | 0 | 0 | 4 | 8 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | Optimal Z-> | 43,2 |
| Remarks: The value for each decision variable (Xi) is expressed in Million Rupiah | | | | | | | | | | | | | |

Based on the calculations presented in Table 3, it is evident that the optimal production plan for MSME furniture, specifically People's Teak Wood Furniture, includes only four types of products: 4 units of 1-door cupboards (X1), 8 units of 6-seat dining tables (X2), 8 units of dining tables (X3), and 1 unit of a bed measuring 180 x 200 cm (X4). Consequently, CV Meubel Jaya is projected to achieve a monthly profit of Rp. 43,200,000, which is 37.7% higher than if it were to produce all 11 types of furniture listed in Table 1. This aligns with the limited availability of teak wood raw materials in the market.

Given the restricted supply of wood for MSMEs like CV Meubel Jaya, which depends on People's Teak Wood, it is advisable to limit the range of furniture types produced and instead focus on meeting small-scale consumer demand. The data in Table 3 also indicates that further increases in production are not feasible, as the values for other furniture products are zero. This reinforces the need for strategic production planning that accommodates resource limitations while maximizing profitability.

The availability of raw materials, particularly teak wood, has been identified as limited and competitive among various sectors of the wood industry, including primary, secondary, and tertiary producers. To address these limitations, CV. Meubel Jaya sources teak wood boards and beams from community forest industries, primarily located in West Java. However, the supply from these community teak forests is often inconsistent due to inadequate management practices that do not adhere to the principles of maximum and sustainable yield. This observation aligns with previous findings by Hardjanto (2000) and Mile (2010).

Additionally, CV. Meubel Jaya employs only four full-time carpenters who work eight hours a day. These workers are tasked with producing 11 types of furniture based on current customer orders. While the available working hours are substantial, adding more workers would be constrained by the limited raw materials and marketing challenges. Given the scarcity of teak wood, it is advisable for CV. Meubel Jaya to focus on producing only four types of furniture that yield optimal profits. Should the availability of raw materials increase, there may be opportunities to hire additional labor and utilize machinery to enhance production efficiency.

## CONCLUSION

- Production and sales of UMKM furniture as CV. Meubel Jaya reaches the point of optimizing profits per month if it only concentrates on furniture, 4 sets of 6 chair dining tables, 8 sets of 4 chairs dining tables and 1 of wooden bad (180 x 200 cm).
- Optimal profits per month from the CV. Meubel Jaya, can reach IDR. Rp. 43,200,000.- or 37.7% greater if producing 11 types of furniture currently with a profit of only IDR. 27.225.000,- or with a difference of IDR.15.975.000,-

**Research Implications and Limitations**

- Due to the limited availability of teak wood in the market, this research indicates that production optimization can be achieved by utilizing alternative types of wood that are more abundantly available from suppliers.
- This research primarily relies on secondary company data and validation through interviews, which means that the optimization results generated using QM for Windows may differ if the actual volume of wood used for each piece of furniture produced, along with processing time, were directly measured.
- Another limitation of this research pertains to the use of artisan labor. Currently, the workforce consists of only four craftsmen, who are supported by various machines, including cutting machines, sanders, and compressors. It is essential to accurately measure both the time utilized for each piece of furniture produced and the efficiency of these machines. To address these limitations, further research is necessary to incorporate adequate raw material resources and to consider additional constraints such as machine usage time, drying processes in the sun, and other relevant activities involved in the production process..

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