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OPTIMIZATION OF PRODUCTION AND BENEFITS OF USING LINEAR PROGRAMMING IN THE LINGGARJATI FURNITURE BUSINESS

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Abstract: **Massive exploitation of natural forests and concentration in the plywood industry until the late 1980s caused Indonesia to currently experience a shortage of raw materials for the secondary (meuble) industry. Especially for teak, currently many furniture industries depend on the supply of sawn wood from the surrounding community forests. This study intends to determine the level of furniture production from PT. Linggarjati which relies on the sawn timber industry from the surrounding community forests in order to generate optimum profits. The secondary data used in this study were obtained from the company with interviews for data clarification which include, the production process, raw materials, supporting materials and implementation time related to each type of furniture produced. The analysis method uses Linear Programming with the help of ExcelQM software for Mac version 5.3. The constraint function used is teak wood raw material, various supporting materials for making furniture and labor hours.**

The results showed that only some types of furniture can be produced to provide optimal profit for Linggarjati furniture, among others; 3 three-door cabinets, 4 table sets with 6 chairs and 10 beds measuring 180 x 200 cm. From the combination of these products, it can produce an optimal profit of Rp. 33,518,275,- The results of this analysis show that the three types of furniture alone can provide a greater profit of 78.5% compared to producing and selling the 11 types of furniture that currently exist, the profit is only Rp. 18,776,693,- or with a difference of Rp. 14,741,582,-

Keywords: **Wood Furniture Industry, Optimization, Linear Programming, and ExcelQM**

I. INTRODUCTION

Companies that process wood, especially sawn wood, concentrate more on the size or sorting needed by consumers and provide them according to demand trends. Various sizes are produced and sold at sawn timber shops in order to meet consumer demand. Meanwhile, the wood furniture industry that uses sawn wood as its raw material is in short supply or has to compete with other primary wood industries such as sawn wood, plywood and pulp. The competition for wood entrepreneurs is more stringent in the effort to obtain raw materials that is increasingly limited by wood entrepreneurs due to the development and progress of the business world.

The existing conditions cause wood furniture entrepreneurs – especially small and medium enterprises (SMEs) – to work hard and make good plans so that they can continue to produce and sell their furniture products. To meet the demand for sawn timber, local sawmills are sought to obtain logs as raw material from the surrounding community gardens or forests (Hardjanto & Suhardjito, 2000); (Miles, 2010). In turn, production and sales are more tailored to consumer demand or orders only, competing competitively. This is because in general, sustainable yields cannot be provided by community forests due to uneven distribution and incomplete age classes in community forest areas (Mile, 2010). Thus, one way to cover the "gap" so that the need for raw materials is met is that the industry must bring in raw materials from outside its territory, through inter-island transportation in Indonesia. In line with that, JR, (2009) said that the efficiency and optimization of the industry is directed so that companies gain profits through suppressing operational costs and increasing the benefits of processing results.

Many studies have been carried out using the linear programming method for profit optimization and others, but many have been applied to large companies or specifically for teak wood furniture and other class I/II wood. Even then, it is not related to the actual condition of the resulting break even point or the existing conditions compared to the conditions when using an optimization approach with the application of a linear program. Furthermore, in relation to production planning in order to achieve the company's success in being able to gain profits and/or be able to survive in the midst of intense competition for sawn wood raw materials, production is below the capacity of the machines and equipment as well as the workforce owned or at least reaching the break even point (BEP). Thus, a special research is needed to calculate the optimal profit that can be achieved by SME furniture entrepreneurs by using linear programming analysis.

II. LITERATURE REVIEW

Micro, Small and Medium Enterprises (MSME) of Furniture Industries

In opening a business or creating jobs, the general public is very interested in various business sectors, such as trade, industry, and manufacturing, thus making them participate in the development of small, micro and medium enterprises (MSMEs) and cooperatives and have a stake in the Indonesian economy. Home furnishings that include all items, such as chairs, tables and cabinets are furniture. Movable is the origin of the word furniture, which means to move, while furniture comes from French. Furniture has the origin of the word founir which means furnish has a different meaning, but refers to the same thing, namely tables, chairs, cabinets, and so on. In other words, the utensils that are in the house and used by residents to sit, lie down or store small objects, such as clothes or cups are furniture. Furniture is made of wood, boards, leather, screws etc. (https://en.wikipedia.org/wiki/Furniture). Furniture is not only useful for comfort and home furnishings, but also social meanings that confirm social status are carried by furniture. Minimalist furniture can also be luxurious if the material is expensive, such as teak wood in diameter and large. Today, furniture has become a product of fashion, fashion, and lifestyle.

According to Darusman, (2018), the development of MSMEs in the timber sector has not been so advanced because they do not have a strong network to be able to compete with big entrepreneurs, including capturing the export market well. It is said that in fact this model of business by small, medium and multi-product entrepreneurs is not a new thing that can be redeveloped in Indonesia as has been studied by the Faculty of Forestry Team of IPB (1997). Then to reach a more economical scale (economies of scale) in order to build excellence in the production and marketing process, the many and small MSMEs need to unite and lead gradually to a more downstream level. In this way they can become bigger companies at the regional and national level. Such market networks and chains are not new, since the early 1970s they have been successful in supplying 80% of the volume of the international rattan market.

Linear Programming and Optimization Calculations

According to Taylor III (2018), the main purpose of management science is to solve problems related to decision making that face and confuse managers, both companies engaged in the public and private sectors, and to solve these problems a mathematical model is made. Traditionally, these models have been solved by various mathematical techniques, all of which are only suitable for certain types of problems. As a branch of science, management science is always mathematical so it often seems complex and complicated.

Furthermore, it is said that linear programming is the decision of a company represented by a model consisting of various linear relationships with objectives and resource constraints. So, linear programming is a problem-solving approach developed for decision making by using mathematical symbols or algebraic symbols in which it relates to the allocation of economic resources such as machinery, labor, raw materials, capital, and others in large quantities. or the quantity is limited to achieve the optimum goal or maximize profit, maximize sales, maximize welfare, minimize costs, minimize losses, minimize time, and so on. The characteristics of linear programming (LP) are as follows:

• The variables involved in the problem are not negative ($\geq$ 0).

• With a linear function of the variables can determine the criteria for selecting the best value of the decision variable. The objective or objective function is the function of this criterion. The objectives to be achieved are related to maximizing revenue, maximizing profit, or minimizing costs.

• As a set of linear equations or linear inequalities can describe the operating rules governing the process (ie source step). The term for this set of linear equations is a constraint or constraint. The limitations of the resources (raw materials, workers, capital, and machines) that are owned to achieve the desired goals are indicated by the constraints/constraints.

Jay et al., (2019) stated that many management decisions are very effective on organizational resources which usually include machines, (for example in the case of airlines it is airplanes), workers (for example pilots), money, time, and materials (for example: aviation fuel). To produce products (eg, machinery, furniture, food or clothing) or services (eg, airline schedules, advertising policies or investment decisions) can use these resources. A widely used mathematical technique to help operational managers plan and make the decisions needed to allocate resources is linear programming (LP).

According to Susdarwono (2020), said that Z and X as decision variables are used in the objective function. The number of products or outputs that must be produced in order to obtain optimal results is represented by the decision

variable (X). Linear programming model, using some of the symbols below:
m : kinds of limitations on the availability of resources or facilities.
n : kinds of activities that use the resource or facility.
i : number of each type of resource or facility availability (i = 1, 2, . . ., m).
j : the number of each type of activity that uses the availability of resources or facilities (j = 1, 2, . . ., n).
Xj : jth activity level (j = 1, 2, . . ., n).
aij : the number of sources i needed for each unit of output produced by activity j (i = 1, 2, . . ., m, and j = 1, 2, . . ., n).
bi : the number of available resources (facilities) i to be allocated to each unit of activity (i = 1, 2, . . ., n).
Z : optimized value (maximum or minimum).
Cj: increase in the value of Z if there is an increase in the level of activity (Xj) by one unit (unit); or is the contribution of each unit of activity output 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 = C1X1 + C2X2 + C3X3 + . . . + CnXn
Some limitations:
1) a11X1 + a12X2 + a13X3 + . . . + a1nXn ≤ b1
2) a21X1 + a22X2 + a23X3 + . . . + a2nXn ≤ b2
….
m) am1X1 + am2X2 + am3X3 + . . . + amnXn ≤ bm
where: X1 ≥ 0, X2 ≥ 0, . . ., Xn ≥ 0
As already explained, the goal to be achieved in a linear programming problem is reflected or illustrated by the objective function in linear programming. The meaning of the first constraint is that activity 1 that produces the number of goods or services 1 multiplied by the need for resources 1/unit (meaning for activity 1 the total allocation of 1) is added to the acquisition of activity 2 multiplied by the need for each unit of output 2 for source 1 (then next up to the nth activity) will not exceed the amount (capacity) available for source 1 (which is called b1). Use some other constraint up to m, that also applies.

Basic Assumptions of Linear Programming

Christian (2013) suggests several assumptions needed in linear programming as follows; Certainty → The coefficients in the objective function (cj) and the constraint function (aji) can be known with certainty and do not change. In the objective and constraint functions, proportionality → All the coefficients in the formulation, cj and aji, are coefficients that are variable to the magnitude of the decision variable. Additivity → The total activity is equal to the sum (additivity) of each individual activity. Divisibility → The solution to a linear programming problem (xj value) does not have to be an integer. Non negative (non negativity) → Decision variables cannot be negative in value.
Furthermore, according to Jay (2019) a mathematical technique designed to facilitate operational managers in planning and making decisions needed in resource allocation is linear programming.

QM for Windows dan ExcelQM For Mac

It is necessary to have an appropriate method in finding the optimization of the results of linear programming. In determining the optimal combination of three or more variables, a commonly used method is the simplex method. Today, the many decision variables involved in solving some LP problems with the help of computers can be quickly solved. An algorithm that is generally known as the simplex method can solve the decision variables that contain not too many problems. However, if there are more variables and constraints / limiting factors, it must be solved by a computer with various applications such as LINDO, etc. For complex LP implementations, QM For Windows or ExcelQM for Mac software can be used. The results of determining the optimal solution are expected by the company to be helped or decision makers in the right production and sales planning (Al Vonda et al., 2019)
QM stands for quantitative methods which is a computer package that is included in companion sites in various Quantitative Methods or Management Science textbooks. The software is very user friendly and requires almost no preliminary instructions except for the “help” screen which can be accessed directly from the program (Taylor III, 2019). This linear programming problem processing software is also provided in the book Quantitative Methods for Management under the name POM QM (Production and Operation Management – Quantitative Methods) where there are things that are contained in QM for Windows and EcelQM for Mac, not in POM for Windows or vice versa (Render et al, 2018)
According to Harsanto (2017) QM for Windows and ExcelQM for Mac are software provided for operations management. In order to find solutions to various business problems appropriately, you can use QM for Windows or ExcelQM for Mac. Various modules in the business decision-making area as well as in various other fields are also available in QM for windows or ExcelQM for Mac. Assingment, Break Even/Cost-Volume Analysis, Decision Analysis, Forecasting, Game Theory, Goal Programming, Inventory, Linear Programming, Markov Analysis, Material Requirements Planning, Networks, Project Management (PERT/CPM), Quality Control, Simulations, Statistics, Transportation, Waiting Lines is a module available in QM for windows or ExcelQM for Mac.

Production Optimization

According to Haslan, et al (2018), a balance that is achieved because the best alternative is selected from a variety of certain criteria available is optimization. How the value of a function of various variables is made to be maximum or minimum by observing several available constraints, including constraints in the form of labor, capital, and materials is basically a matter of optimization. So, production optimization is the most efficient use of the limitations of various factors of production. Capital, machinery, equipment, raw materials, auxiliary materials, and labor are some of the factors of production. In line with that, Aprilyanti (2019) stated that through the allocation of limited resources among competing user types, a mathematical optimization solution method was applied. The maximization of cost contribution and cost minimization are optimization. An activity plan to obtain optimal results, which is designed to facilitate operational managers in planning and making decisions needed to allocate the limited resources of an organization or company contained in a linear program.

Jek (2011) states that optimization and linear programming problems are also discussed in the Operations Research book which is also to find optimal problem solving by looking at the objectives and limitations or constraints. It is said further that optimization is the process of using mathematical models and the solution can use several methods such as linear programming, non-linear programming, multiple objectives, and others to find the optimal solution of a problem.

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III. RESEARCH METHODS

The research was conducted at the Linggar Jati Furniture production site, Kebayoran Lama, South Jakarta. The study was carried out from January to March 2020. The data or decision variables used in this study were: 3-door wardrobe (X_1), 2-door wardrobe (X_2), 1-door wardrobe (X_3), A 6-seater dining table (X_4), dining table B 4 chairs (X_5), guest chair set (X_6), bed 180x200cm (X_7), bed 160x200cm (X_8), nightstand (X_9), ordinary table (X_{10}), ordinary chair (X_{11}).

The data in the following study consists of primary and secondary data. The results of interviews conducted directly with trusted sources who are furniture owners of Linggar Jati Furniture are primary data, for clarification of secondary data quoted from the company in question. While the data quoted from various documents and reports from the furniture company Linggar Jati Furniture, as well as from various other sources such as previous research journals, articles/data from the internet, and literature related to optimizing production and sales profits are secondary data. Regarding the data needed in the following study, they are: processing time, raw materials, supporting materials and production results, product sales volume, selling price per unit product, variable costs, fixed costs, total costs, and sales profits.

Methods of Data Analysis

This analysis uses the Linear Programming method as follows:

Objective function is formulated as follows:

Maks $Z = C_1X_1+C_2X_2+C_3X_3+C_4X_4+C_5X_5+C_6X_6+C_7X_7+C_8X_8+C_9X_9+C_{10}X_{10}+C_{11}X_{11}$

Remarks:

Z = Maximum profit

$C_1, ..., C_{11}$ = Product profit contribution … 1^{st}, ..., 11^{th}

$X_1, ..., X_{11}$ = Product group … $1^{s}t$, ..., 11^{th}

Constraint function or Subject to:

Teak Wood = $a_{12}X_1 + a_{13}X_2 + a_{14}X_3 + a_{15}X_4 + a_{16}X_5 + a_{17}X_6 + a_{18}X_7 + a_{19}X_8 + a_{20}X_8 + a_{21}X_9 + a_{22}X_{10} + a_{23}X_{11} \le b_1$

Triplex = $a_{24}X_1 + a_{25}X_2 + a_{26}X_3 + a_{27}X_6 \le b_2$

Nail = $a_{28}X_1 + a_{29}X_2 + a_{30}X_3 + a_{31}X_9 \le b_3$

Door hinges = $a_{32}X_1 + a_{33}X_2 + a_{34}X_3 \le b_4$

Door key = $a_{35}X_1 + a_{36}X_2 + a_{37}X_3 \le b_5$

Putty = $a_{38}X_1 + a_{39}X_2 + a_{40}X_3 + a_{41}X_4 + a_{42}X_5 + a_{43}X_6 + a_{44}X_7 + a_{45}X_8 + a_{46}X_8 + a_{47}X_9 + a_{48}X_{10} + a_{49}X_{11} \le b_6$

Wood glue = $a_{50}X_1 + a_{51}X_2 + a_{52}X_3 + a_{53}X_4 + a_{54}X_5 + a_{55}X_6 + a_{56}X_7 + a_{57}X_8 + a_{58}X_8 + a_{59}X_9 + a_{60}X_{10} + a_{61}X_{11} \le b_7$

Thinner = $a_{62}X_1 + a_{63}X_2 + a_{64}X_3 + a_{65}X_4 + a_{66}X_5 + a_{67}X_6 + a_{68}X_7 + a_{69}X_8 + a_{70}X_8 + a_{71}X_9 + a_{72}X_{10} + a_{73}X_{11} \le b_8$

1^{st}Varnish = $a_{74}X_1 + a_{75}X_2 + a_{76}X_3 + a_{77}X_4 + a_{78}X_5 + a_{79}X_6 + a_{80}X_7 + a_{81}X_8 + a_{82}X_8 + a_{83}X_9 + a_{84}X_{10} + a_{85}X_{11} \le b_9$

2^{nd}Varnish = $a_{86}X_1 + a_{87}X_2 + a_{88}X_3 + a_{89}X_4 + a_{90}X_5 + a_{91}X_6 + a_{92}X_7 + a_{93}X_8 + a_{94}X_8 + a_{95}X_9 + a_{96}X_{10} + a_{97}X_{11} \le b_{10}$

Sandpaper = $a_{98}X_1 + a_{99}X_2 + a_{100}X_3 + a_{101}X_4 + a_{102}X_5 + a_{103}X_6 + a_{104}X_7 + a_{105}X_8 + a_{106}X_8 + a_{107}X_9 + a_{108}X_{10} + a_{109}X_{11} \le b_{11}$

Rafters = $a_{110}X_7 + a_{111}X_8 \le b_{12}$

handyman working hours = $a_{112}X_1 + a_{113}X_2 + a_{114}X_3 + a_{115}X_4 + a_{116}X_5 + a_{117}X_6 + a_{118}X_7 + a_{119}X_8 + a_{120}X_8 + a_{121}X_9 + a_{122}X_{10} + a_{123}X_{11} \le b_{13}$

Remarks:

a: the number of sources i needed to obtain each unit of output (output) (output)

$X_1, ..., X_{11}$ = Product group i …., to 11

Variable Operational Definition

- Production: Production is the use or utilization of teak wood raw materials and other materials to produce 11 (eleven) kinds of furniture according to consumer custom orders consisting of: 3-door wardrobe (X_1), 2-

door wardrobe (X_2), 1-door wardrobe (X_3), dining table A 6 chairs (X_4), dining table B 4 chairs (X_5), guest chair set (X_6), bed 180x200 cm (X_7), bed 160x200 cm (X_8), nightstand (X_9), regular table (X_{10}), regular seat (X_{11}).

- Raw Materials are various materials needed for the manufacture of a product. There are three categories of raw materials in furniture production, namely the main raw material (teak wood), additional raw materials (plywood, rafters, etc.), and finishing materials (varnish, polish, etc.).
- Production cost is the average total cost used for processing raw materials into furniture that is ready for sale.
- Workers are individuals who work or are involved in the process of making furniture in the company from material preparation to finishing who work an average of 8 hours per day or 24 days / month.
- Fixed costs are all components of costs incurred per unit time, and the amount is fixed regardless of the output produced by the company.
- Variable costs are the average costs that are fixed per unit of furniture produced but change proportionally with the volume of production produced.
- Profit is the difference between the sales value per furniture product minus the total production cost of each furniture.
- Worker's Working Hours is the entire working time of a handyman expressed in hours, which is 8 working hours per person per day.

IV. RESEARCH RESULTS AND DISCUSSION

Linggar Jati Furniture Production Process

The production process carried out by Linggar Jati Furniture follows stages starting from the 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.

Formulation of Linear Programming Model

There are several stages in the formulation of the linear programming model that must be carried out, namely 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 following study is to maximize optimal profit from the existing decision variables. Some of the decision variables in the following study are the number or quantity of furniture unit production and monthly profit as shown in Table 1.

Table 1. Data on Prices, Costs and Profits per month of production

Variable	Furniture Type	Price per unit (Rp)	Total Cost per unit (Rp)	Profit per unit (Rp)	Total Production (Unit)	Total Profit per month (Rp)
X1	3 door wardrobe	7.000.000	5.497.456	1.502.544	2	3.005.088
X2	2 door wardrobe	5.200.000	4.309.039	890.961	2	1.781.922
X3	1 door wardrobe	4.000.000	3.373.000	627.000	3	1.881.000
X4	Dining Table A (6 Chairs)	3.000.000	2.040.750	959.250	2	1.918.500
X5	Dining Table B (4 chairs)	2.500.000	1.554.396	945.604	2	1.891.208
X6	Guest Chair Set	3.200.000	2.396.914	803.086	2	1.606.172
X7	Bed (180x200)	2.000.000	1.059.441	940.559	2	1.881.118
X8	Bed (160x200)	1.600.000	845.865	754.135	2	1.508.270
X9	Nightstand	650.000	415.617	234.383	5	1.171.915
X10	Ordinary Table	400.000	263.875	136.125	5	680.625
X11	Ordinary Chair	250.000	153.275	96.725	15	1.450.875
Total						18.776.693

Source: Researcher secondary data processing, 2021

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

$Z\ max = 3.005.088X_1 + 1.781.922X_2 + 1.881.000X_3 + 1.918.500X_4 + 1.891.208X_5 + 1.606.172X_6 + 1.881.118X_7 + 1.508.270X_8 + 1.171.915X_9 + 680.625X_{10} + 1.450.875X_{11}$

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

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

Source: Researcher secondary data processing, 2021

The formulation of the constraint functions based on the data in Table 2 is as follows:
Teak wood : $8X_1 + 7X_2 + 6X_3 + 4X_4 + 3X_5 + 3X_6 + 3X_7 + 3X_8 + 2X_9 + 3X_{10} + 3X_{11} \leq 400$ (plank block)
Triplex 5mm: $4X_1 + 3X_2 + 3X_3 + 2{,}5X_6 \leq 15$ (sheets)
Nail: $240X_1 + 188X_2 + 162X_3 + 30X_4 + 30X_5 + 30X_9 \leq 800$ (pieces)
Door hinges: $24X_1 + 16X_2 + 12X_3 \leq 60$ (pieces)
Door key: $8X_1 + 6X_2 + 3X_3 \leq 20$ (pieces)
Putty: $4X_1 + 3X_2 + 1{,}5X_3 + 3X_4 + 3X_5 + 4X_6 + 1X_7 + 1X_8 + 2{,}5X_9 + 1{,}25X_{10} + 1{,}75X_{11} \leq 42$ (kg)
Wood glue: $5X_1 + 3X_2 + 1{,}5X_3 + 2X_4 + 2X_5 + 2X_6 + 1X_7 + 1X_8 + 2{,}5X_9 + 2{,}5X_{10} + 3{,}75X_{11} \leq 30$ (bottles)
Thinner: $3X_1 + 2X_2 + 1{,}5X_3 + 1X_4 + 1X_5 + 3X_6 + 1X_7 + 1X_8 + 1{,}25X_9 + 1{,}25X_{10} + 3{,}75X_{11} \leq 25$ (ltr)
Varnish-1: $3X_1 + 2X_2 + 3X_3 + 2X_4 + 2X_5 + 2X_6 + 2X_7 + 2X_8 + 2{,}5X_9 + 2{,}5X_{10} + 7{,}5X_{11} \leq 35$ (liter)
Varnish-2: $3X_1 + 2X_2 + 1{,}5X_3 + 1X_4 + 1X_5 + 3X_6 + 1X_7 + 1X_8 + 1{,}5X_9 + 1{,}25X_{10} + 3{,}75X_{11} \leq 25$ (ltr)
Sandpaper: $8X_1 + 7X_2 + 9X_3 + 6X_4 + 5X_5 + 8X_6 + 5X_7 + 5X_8 + 7{,}5X_9 + 5X_{10} + 7{,}5X_{11} \leq 100$ (sheets)
Rafters: $5X_7 + 4X_8 \leq$ (beams)
Handyman working hour: $34X_1 + 30X_2 + 48X_3 + 16X_4 + 14X_5 + 36X_6 + 28X_7 + 14X_8 + 10X_9 + 15X_{10} + 15X_{11} \leq 768$ (hours)

Optimization Results with ExcelQM.
By using ExcelQM software for Mac version 5.3, the results of data processing are obtained as shown in Table 3.

Table 3. Linear Programming Solution in ExcelQM

Description	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	SIGN	RHS
Maximize	3.005.088	1.781.922	1.881.000	1.918.500	1.891.208	1.606.172	1.881.118	1.508.270	1.171.915	680.625	1.450.875	sign	RHS
C-1	8	7	6	4	3	3	3	3	2	3	3	<	400
C-2	4	3	3						2,5			<	15
C-3	240	188	162	30	30				30			<	800
C-4	24	16	12									<	60
C-5	8	6	3									<	20
C-6	4	3	1,5	3	3	4	1	1	2,5	1,25	1,75	<	42
C-7	5	3	1,5	2	2	2	1	1	2,5	2,5	3,75	<	30
C-8	3	2	1,5	1	1	3	1	1	1,25	1,25	3,75	<	25
C-9	3	2	3	2	2	2	2	2	2,5	2,5	7,5	<	35
C-10	3	2	1,5	1	1	3	1	1	1,5	1,25	3,75	<	25
C-11	8	7	9	6	5	8	5	5	7,5	5	7,5	<	100
C-12							5	4				<	60
C-13	34	30	48	16	14	36	28	14	10	15	15	<	768
Results													
Variables	2,5	0	0	3,75	0	0	10	0	0	0	0		
Objective													33.518.275

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Cell	Name	Original Value	Final Value	Integer
$B$29	3 door wardrobe	2,5	2,5	Contin
$C$29	2 door wardrobe	0	0	Contin
$D$29	1 door wardrobe	0	0	Contin
$E$29	Dining Table A (6 Chairs)	3,75	3,75	Contin
$F$29	Dining Table B (4 chairs)	0	0	Contin
$G$29	Guest Chair Set	0	0	Contin
$H$29	Bed (180x200)	10	10	Contin
$I$29	Bed (160x200)	0	0	Contin
$J$29	Nightstand	0	0	Contin
$K$29	Ordinary Table	0	0	Contin
$L$29	Ordinary Chair	0	0	Contin

Source: Researcher secondary data processing, 2021

Based on the results of the calculations in Table 3, it can be seen that the products that should be produced by Linggar Jati Furniture only consist of 3 (three kinds), namely 2.5 units of 3-door wardrobe (X_1), a dining table set of 6 chairs 3.75 units and a dining room table. bed size 180 x 200 cm as many as 10 units. To facilitate the calculation and analysis, it is rounded up to 3 units of X_1, 4 units of X_4 and 10 units of X_7. Thus, Linggar Jati Furniture will get a profit per month of Rp. 33,518,275.- or almost twice (78.5% greater) than producing 11 kinds of furniture as listed in Table 1. This is also in line with the limited number of teak wood raw materials on the market. With the limited supply of wood for an SME such as Linggar Jati Furniture, it is also advisable to limit the desire to produce various types of furniture, even though market demand is quite adequate. From Table 1, the final value also shows that based on these data, it can no longer increase its production because the value is zero for other furniture products.

The availability of raw materials, especially teak, has been described from the start as limited and contested between various types of primary, secondary and tertiary wood industries. In connection with these limitations, Linggar Jati Furniture seeks to meet the needs of raw materials in the form of boards and teak wood blocks from the community forest industry, which generally come from around West Java. The supply from community teak forest sources is often discontinuous because the silvicultural system of community teak forests has not or is not managed professionally with the principle of maximum and sustained yield. This is in line with what has been previously stated by Hardjanto & Suhardjito, (2000) and Mile, (2010).

In addition, Linggar Jati Furniture also only employs 4 workers who work full time (8 hours per day) but concurrently for 11 kinds of products to be produced as listed in Table 1. However, the availability of working hours based on Table 2 is quite large. however, if more manpower is added, it will be constrained by raw materials and in turn also marketing. Based on the limited raw material constraints, it is appropriate if Linggar Jati Furniture only concentrates on 3 (three) types of output that provide optimal benefits. Conditions may change if wood raw materials are available in sufficient quantities. and the use of machines that help with manual work can be done.

Table 4. Status of resources used in ExcelQM solution

Cell	Name	Cell Value	Formula	Status	Slack
$S$14	C-1 Teak wood (plank block)	65	$S$14<=$T$14	Not Binding	335
$S$15	C-2 Triplex (sheets)	10	$S$15<=$T$15	Not Binding	5
$S$16	C-3 Nail (pieces)	712,5	$S$16<=$T$16	Not Binding	87,5
$S$17	C-4 Door hinges (pieces)	60	$S$17<=$T$17	Binding	0
$S$18	C-5 Door key (piecess)	20	$S$18<=$T$18	Binding	0
$S$19	C-6 Putty (kg)	31,25	$S$19<=$T$19	Not Binding	10,75
$S$20	C-7 Wood glue (bottle)	30	$S$20<=$T$20	Binding	0
$S$21	C-8 Thinner (liter)	21,25	$S$21<=$T$21	Not Binding	3,75
$S$22	C-9 Varnish-1 (liter)	35	$S$22<=$T$22	Binding	0
$S$23	C-10 Varnish-2 (liter)	21,25	$S$23<=$T$23	Not Binding	3,75
$S$24	C-11 Sand paper (sheets)	92,5	$S$24<=$T$24	Not Binding	7,5
$S$25	C-12 Rafters (beams)	50	$S$25<=$T$25	Not Binding	10
$S$26	C-13 Handyman working time (hour)	425	$S$26<=$T$26	Not Binding	343

Source: Data processed by researchers, 2021

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The results of data processing in Table 4 show optimal conditions with the use of raw materials and resources that have advantages (surplus/slack) namely teak, triplex, nails, putty, thinner, varnish, sandpaper, rafters and labor hours. Furthermore, resources such as hinges, locks, wood glue and polish, have no advantages (bindings).

Shadow Price and Sensitivity Analysis

Shadow price in sensitivity analysis can be used to identify opportunities or alternative resource enhancements that can increase profits for Linggar Jaya Furniture. The data in Table 5 presents the value of the largest shadow price is Plitur, which is 921,868, which means that if there is an increase in the use of varnish by 1 unit, it will increase sales or profits by Rp. 921,868.

Table 5. Output sensitivity analysis from ExcelQM

Constraints (Sensitivity Report)

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$S$14	C-1 Teak wood (plank block)	65	0	400	1E+30	335
$S$15	C-2 Triplex (sheets)	10	0	15	1E+30	5
$S$16	C-3 Nail (pieces)	712,5	0	800	1E+30	87,5
$S$17	C-4 Door hinges (pieces)	60	2190,583333	60	3,33067E-16	57,33333333
$S$18	C-5 Door key (piecess)	20	0	20	1E+30	1,11022E-16
$S$19	C-6 Putty (kg)	31,25	0	42	1E+30	10,75
$S$20	C-7 Wood glue (bottle)	30	37382	30	2,916666667	2
$S$21	C-8 Thinner (liter)	21,25	0	25	1E+30	3,75
$S$22	C-9 Varnish-1 (liter)	35	921868	35	2	5,833333333
$S$23	C-10 Varnish-2 (liter)	21,25	0	25	1E+30	3,75
$S$24	C-11 Sand paper (sheets)	92,5	0	100	1E+30	7,5
$S$25	C-12 Rafters (beams)	50	0	60	1E+30	10
$S$26	C-13 Handyman working time (hour)	425	0	768	1E+30	343

Source: Data processed by researchers, 2021

However, it must be remembered that from Table 5 it can also be seen that Plitur as a production resource only increased by 2 liters but decreased by 5.83 liters. The alternative of adding resources is in Table 5, where the sensitivity solution is through the available shadow price and has the largest value. However, in this case it still cannot be done because the shadow price value above 0 (zero) actually occurs not in the main raw material (teak wood which is limited in the market) or the working hours of the artisans but instead on additional materials or resources such as Plitur, Wood Glue and Hinge.

The effect of changes in the results of the analysis in Table 5, which can be observed from the interval/degree of sensitivity/sensitivity which consists of an allowable increase or an allowable decrease in sensitivity intervals and an allowable decrease. Both increase and decrease, this kind of limitation also applies to the objective function, which in this case is the profit from selling furniture at Linggar Jati Furniture.

V. CONCLUSIONS AND IMPLICATIONS OF THE RESEARCH

Conclusions

- Production and sales of Linggar Jati Furniture furniture reaches the point of profit optimization per month if you only concentrate on 3 door wardrobe furniture, 4 dining tables with 6 chairs and 10 beds measuring 180 x 200 cm.
- Optimal profit per month from Linggar Jati Furniture's furniture business can reach Rp. 33,518,275,- or 78.5% greater than producing and selling 11 kinds of furniture at this time, the profit is only Rp. 18,776,693,- or with a difference of Rp. 14,741,582,-

Research Implications and Limitations

- Due to the limited raw material for teak in the market, this kind of research will result in the optimization of production value on the use of other types of wood which are available in sufficient quantities from suppliers.
- This research is based more on secondary company data and confirmation of data through interviews so that the results of optimization with ExcelQM will be different

if the cubication of wood used for each furniture is directly measured, including the processing time.

- Another limitation of this research is related to the use of handyman labor. The craftsmen used are limited to 4 people, but they are assisted by cutting machines, sandpaper, compressors and others whose time usage must also be measured for each furniture produced. For this reason, further research is needed with sufficient raw material resources and other constraints such as the time of using the machine, drying in the sun and other activities.

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