Optimization of Tire Production Planning Using The Goal Programming Method and Sensitivity Analysis

Vera Devani, Muhammad Isnaini Hadiyul Umam, Yulia Aiza and Sarbaini

***Abstract*—In Indonesia there are many companies that are engaged in tire retreading or reuse of unused used tires. One of the problems in the retread business in Indonesia is that the tire production target is often not fulfilled and the lack of available tires is used as the main raw material for retreading due to the long process of sending tires from consumers to companies. The purpose of this study is to determine the optimal needs of resources, determine the priority of achievement and determine the value of sensitivity to the optimum solution achieved. The method used in this study is the Goal Programming Method, because it is suitable for problems that have many goals because through its deviation, the method can automatically capture information about the relative achievement of the goals to be achieved. Based on the results of research that has been done, it can be concluded that the maximum income earned by the company is IDR 474,426,000 or an increase of 36% from the limit set by the company. In addition, it can also be concluded that the sensitivity range for the boundary quantity value is the distance at which the shadow price remains valid. If it increases above the upper limit of sensitivity (increases) or decreases below the lower limit (decreases), the value of the shadow price will change.**

***Index Terms*—sensitivity analysis, goal programming, method, optimization.**

I. Introduction

DEVELOPMENTS in the industrial world is something that often happened in recent times. This is evident from the many industries that have stood up, both large, medium and small industries. If growth in the industrial world increases, competition will be even tighter, so we need a careful production planning in order to create a better company future. [1] explained that production planning is aterm strategy medium that is supported by making appropriate decisions so as to optimize industrial activity. According [2], production planning is a form of operations management, which is a tool that companies can use to direct the production system with a comprehensive planning and control system.

The right decision making needs to be done by a company, one of which is to evaluate existing production results by reviewing the optimization of production planning. It aims to minimize costs by paying attention to the financial side incurred, so that the benefits obtained become greater (maximizing profits). With the production planning, the company will be able to know what product plans and how many products will be produced in the future. In addition, companies will also be able to know the estimated amount of raw materials and production costs that will be used in production activities.

Problems that occur in this study is often not meeting the target of tire production because employees work not according to the schedule set by the company. In addition, there are also problems other, namely the lack of availability of used tires which are used as the raw material main for retreading due to the long process of shipping tires from consumers to companies. This has an impact on tire production that should have been completed on time and can meet demand, but because of these problems consumer demand is often not met. The following is a graph of tire demand and production results in 2017 and 2018.

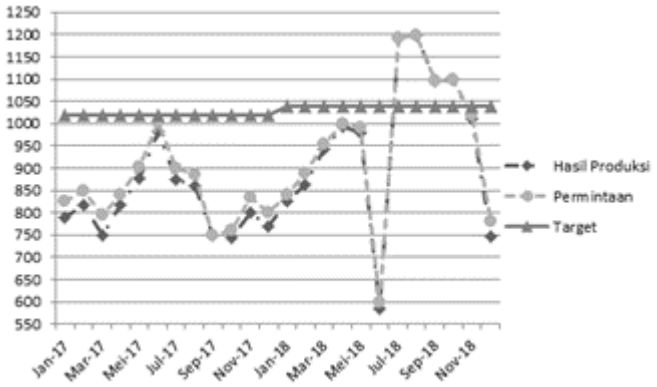


Fig. 1: Demand and Production Results of Tires

Based on Figure 1 can seen that the occurrence of fluctuations in demand and uncertain production results. In addition, in July-October 2018, consumer demand can be fulfilled while in other months consumer demand cannot be fulfilled, which if it often happens it will have an impact on the company.

Therefore, companies in their production activities require a good and correct production plan so that the optimal production results. To realize the good and right production planning, the use of resources and capital must be made as optimal as possible in order to produce quality products. Another problems that occur is a company that has several corporate goals that must be achieved, in fact the goals set are still

V. Devani is with the Industrial Engineering Study Program, Faculty of Science and Technology, UIN Sultan Syarif Kasim Riau, Pekanbaru, 28293, Indonesia, email: veradevani@gmail.com.

M. I. H. Umam is with the Industrial Engineering Study Program, Faculty of Science and Technology, UIN Sultan Syarif Kasim Riau, Pekanbaru, 28293, Indonesia, email: muhammad.isnaini@uin-suska.ac.id.

Y. Aiza is with the Industrial Engineering Study Program, Faculty of Science and Technology, UIN Sultan Syarif Kasim Riau, Pekanbaru, 28293, Indonesia, email: 11652203438@students.uin-suska.ac.id

Sarbaini is with the Mathematics Study Program, Faculty of Science and Technology, UIN Sultan Syarif Kasim Riau, Pekanbaru, 28293, Indonesia, email: sarbaini@uin-suska.ac.id

Manuscript received August 10, 2020; accepted July 4, 2022.

many that have not been achieved such as unfulfilled consumer demand, production results have not exceeded the target and so forth. Goal Programming Method can be used for production planning, because the Goal Programming Method is able to solve problems related to achieving many goals. One reason for choosing the Goal Programming Method is according to [3] which explains that, the Goal Programming Method is very suitable for problems that have many goals because through its deviation, the method can automatically capture information about the achievement relative of the goals to be achieved.

In addition, according [4] Goal Programming is a development method of linear programming that has three main components, namely decision variables, target constraints and objective functions, where the method can solve the problem of determining the optimal amount of production. Linear Programming is a planning of activities to obtain an optimum result or a result that achieves the best goal [5]. Torres and Ravindran (2019) cited by [6] explained that Goal Programming has deviational variables, namely variables that indicate the possibility of negative deviations (deviations below the target) and positive deviations (deviations above the target).

II. Research Method

Optimization is the achievement of the best condition, namely the achievement of a problem solution that is directed at the maximum and minimum limits [7]. Each company will try to achieve optimal conditions by maximizing profits or by minimizing costs incurred in the production process [8]. Meanwhile, according [9] explains that optimization is a normative approach to identify the best solution in making a decision on a problem.

Research related to production optimization has also been carried out by [10], [11], [12] and [13]. Mean while, research related to optimization of production using Goal Programming Method has been conducted by [14], [15], [16], [17] and [18]. However, in the research carried out, there has been no sensitivity analysis done to the optimum solution that has been achieved. For this reason, this research will analyze the solution optimum that has been achieved by using sensitivity analysis, so that changes can occur in the existing resources of the company.

The stages carried out in this study are as follows:

1) Preliminary research, consisting of preliminary surveys and literature studies conducted to determine the object of research and techniques used in solving problems.
2) Identification of the problem, is a stage to determine the problems that occur in the object of research.
3) Formulation of the problem, aims to find out what variables and constraints are used.
4) Research objectives, aim to formulate answers to problems encountered in research.
5) Data collection, data collected in this study are company profile, company organizational structure, tire production process, number of tire production in 2017-2019, total tire demand in 2017-2019, raw material costs, employee working hours and income.
6) Data processing, data processing using the Goal Programming Method with the help of software LINDO. Which previously had been done in advance forecasting the demand and results of tire production for 2020.
7) Analysis, the analysis used is a sensitivity analysis that can be known from the results of the software LINDO.
8) Conclusions, containing the results of research that has been done.

III. Results and Discussion

The steps taken in the calculation using the Goal Programming Method are:

A. Determination of Decision Variables

In this study, the decision variables are made:

X1 = Number of tire production ring 16 in January
X2 = Number of tire production ring 16 in February
X3 = Number of tire production ring 16 in March
X4 = Number of tire production ring 16 in April
X5 = Number of tire production ring 16 in May
X6 = Number of tire production ring 16 in June
X7 = Number of tire production ring 16 in July
X8 = Number of tire production ring 16 in August
X9 = Number of tire production ring 16 in September
X10 = Number of tire production ring 16 in October
X11 = Number of tire production ring 16 in November
X12 = Number of tire production ring 16 in December
X13 = Number of tire production ring 20 in January
X14 = Number of tire production ring 20 in February
X15 = Number of tire production ring 20 in March
X16 = Number of tire production ring 20 in April
X17 = Number of tire production ring 20 in month May
X18 = Number of tire production ring 20 in June
X19 = Number of tire production ring 20 in July
X20 = Number of tire production ring 20 in August
X21 = Number of tire production ring 20 in September
X22 = Number of tire production ring 20 in October
X23 = Number of tire production ring 20 in November
X24 = Number of tire production ring 20 in December
X25 = Number of tire requests ring 16 in January
X26 = Number of tire requests ring 16 in February
X27 = Number of tire requests ring 16 in March
X28 = Number of tire requests ring 16 in April
X29 = Number of tire requests ring 16 in May
X30 = Number of tire requests ring 16 in June
X31 = Number of tire requests ring 16 in July
X32 = Number of tire requests ring 16 in August
X33 = Number of tire requests ring 16 in September
X34 = Number of tire requests ring 16 in October
X35 = Number of tire requests ring 16 in November
X36 = Number of tire requests ring 16 in December
X37 = Number of tire requests ring 20 in January
X38 = Number of tire requests ring 20 in February
X39 = Number of tire requests ring 20 in March
X40 = Number of tire requests ring 20 in April
X41 = Number of tire requests ring 20 in May
X42 = Number of tire requests ring 20 in June
X43 = Number of tire requests ring 20 in July
X44 = Number of tire requests ring 20 in August

X45 = Number of tire requests ring 20 in September
X46 = Number of tire requests ring 20 in October
X47 = Number of tire requests ring 20 in November
X48 = Number of tire requests ring 20 in December

B. The Formulation of The Objective Function

In this study, there are five function objectives to be achieved, namely:

1) Revenue function to be maximized

$$\begin{aligned}\text{Max P} = {} & 208{,}200{,}000X_1 + 209{,}400{,}000X_2 + \\ & 210{,}600{,}000X_3 + 211{,}800{,}000X_4 + 213{,}000{,}000X_5 + \\ & 214{,}200{,}000X_6 + 216{,}000{,}000X_7 + 217{,}200{,}000X_8 + \\ & 218{,}400{,}000X_9 + 219{,}600{,}000X_{10} + 220{,}800{,}000X_{11} + \\ & 222{,}000{,}000X_{12} + 457{,}500{,}000X_{13} + 455{,}250{,}000X_{14} + \\ & 452{,}250{,}000X_{15} + 450{,}000{,}000X_{16} + 447{,}000{,}000X_{17} + \\ & 444{,}750{,}000X_{18} + 442{,}500{,}000X_{19} + 439{,}500{,}000X_{20} + \\ & 437{,}250{,}000X_{21} + 434{,}250{,}000X_{22} + 432{,}000{,}000X_{23} + \\ & 429{,}000{,}000X_{24} \quad (1)\end{aligned}$$

2) Functions of the amount of production to be maximized

$$\begin{aligned}\text{Max K} = {} & 347X_1 + 349X_2 + 351X_3 + 353X_4 + 355X_5 + \\ & 357X_6 + 360X_7 + 362X_8 + 364X_9 + 366X_{10} + 368X_{11} + \\ & 370X_{12} + 610X_{13} + 607X_{14} + 603X_{15} + 600X_{16} + 596X_{17} + \\ & 593X_{18} + 590X_{19} + 586X_{20} + 583X_{21} + 579X_{22} + 576X_{23} + \\ & 572X_{24} \quad (2)\end{aligned}$$

3) Function of the number of requests to be maximized

$$\begin{aligned}\text{Max T} = {} & 352X_{25} + 355X_{26} + 357X_{27} + 359X_{28} + 362X_{29} + \\ & 364X_{30} + 366X_{31} + 369X_{32} + 371X_{33} + 373X_{34} + 376X_{35} + \\ & 378X_{36} + 606X_{37} + 604X_{38} + 602X_{39} + 600X_{40} + 598X_{41} + \\ & 596X_{42} + 594X_{43} + 592X_{44} + 590X_{45} + 589X_{46} + 587X_{47} + \\ & 585X_{48} \quad (3)\end{aligned}$$

4) Function raw material costs to be minimized

$$\begin{aligned}\text{Min B} = {} & 5{,}455{,}000X_1 + 5{,}485{,}015X_2 + \\ & 5{,}515{,}000X_3 + 5{,}545{,}000X_4 + 5{,}575{,}013X_5 + \\ & 5{,}605{,}022X_6 + 5{,}650{,}011X_7 + 5{,}680{,}011X_8 + \\ & 5{,}710{,}000X_9 + 5{,}740{,}000X_{10} + 5{,}770{,}000X_{11} + \\ & 5{,}800{,}000X_{12} + 11{,}687{,}500X_{13} + 11{,}631{,}265X_{14} + \\ & 11{,}556{,}250X_{15} + 11{,}500{,}000X_{16} + 11{,}425{,}013X_{17} + \\ & 11{,}368{,}772X_{18} + 11{,}312{,}511X_{19} + 11{,}237{,}511X_{20} + \\ & 11{,}181{,}250X_{21} + 11{,}106{,}250X_{22} + 11{,}050{,}000X_{23} + \\ & 10{,}975{,}000X_{24} \quad (4)\end{aligned}$$

5) Function of employee working hours to be minimized

$$\begin{aligned}\text{Min J} = {} & 2{,}200X_1 + 2{,}112X_2 + 2{,}112X_3 + 2{,}024X_4 + \\ & 2{,}112X_5 + 2{,}024X_6 + 2{,}288X_7 + 2{,}288X_8 + 2{,}288X_9 + \\ & 2{,}288X_{10} + 2{,}200X_{11} + 2{,}200X_{12} + 2{,}200X_{13} + 2{,}112X_{14} + \\ & 2{,}112X_{15} + 2{,}024X_{16} + 2{,}112X_{17} + 2{,}024X_{18} + 2{,}288X_{19} + \\ & 2{,}288X_{20} + 2{,}288X_{21} + 2{,}288X_{22} + 2{,}200X_{23} + 2{,}200X_{24} \quad (5)\end{aligned}$$

C. Determination of The Constraints

The target constraints used in this study are revenue, total production, total demand, large tire raw material tire costs, small raw material costs, rubber raw material costs, gum raw material, glue costs raw material costs, tiner raw material costs, chord yarn raw material costs, plastic raw material costs and employee work hours.

D. Determine The Main Priorities

The Main Priority order in this study are:

1) P1 = Target maximizing income. The target to be minimized is the bottom deviation. Then that will be minimized is the value of $P_1(d_1^-)$. That is, the company wants the income earned is above the limits set by the company.
2) P2 = The target is to maximize the amount of production. The target to be minimized is the bottom deviation. Then that will be minimized is the value of $P_2(d_2^-)$. That is, the company wants the amount of production to be above the target and can meet consumer demand.
3) P3 = The goal is to maximize the number of requests. The target to be minimized is the bottom deviation. Then that will be minimized is the value of $P_3(d_3^-)$. That is, the company wants the number of requests above the target set by the company.
4) P4 = The goal of minimizing the cost of raw materials. The target to be minimized is a deviation above. Then what will be minimized is the value of $P_4(d_4^+, d_5^+, d_6^+, d_7^+, d_8^+, d_9^+, d_{10}^+, d_{11}^+)$. That is, the company does not want the cost of raw materials to exceed the budget specified.
5) P5 = The goal of minimizing employee work hours. The target to be minimized is a deviation above. Then what will be minimized is the value of $P_5(d_{12}^+)$. This means that the company wants work hours employees to faster so that the production process will be finished quickly, so the company can meet consumer demand.

E. Completion of The Software LINDO

Next step is the completion of Goal Programming using software LINDO. In LINDO the lower deviation is denoted by DB, whereas for the upper deviation is denoted by DA. The output of software LINDO is as follows:

Based on Figure 2 above, it can be seen that the variables that have values are the variables X6, X16 and X25. This value is substituted into the objective function equation 1, 2, 3, 4 and 5, so that the maximum income is IDR 474,426,000, the maximum production is 11.75 units, maximum requests is 1,038.4 units, the minimum raw material cost is IDR 12,128,150.66 and the minimum employee working hours is 2,165.68 hour / month.

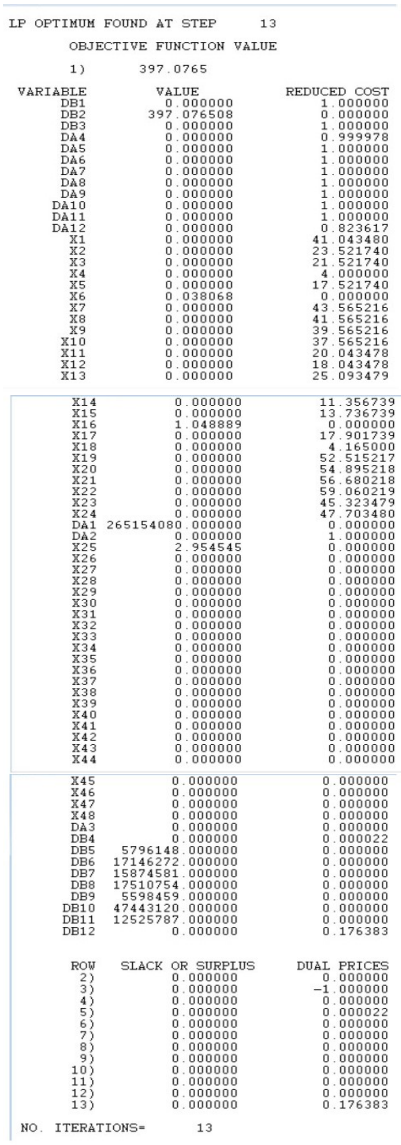
F. Sensitivity Analysis

This study uses sensitivity analysis in analyzing problems that will occur as follows:

1) Analysis of priority the achievement

To view the priority level of attainment of some objective function is achieved, it can be seen in the following table:

Based on TABLE I, it was found that the negative deviation value for ranking priority1 maximum revenue) and 3 (maximizing the number of requests) are fulfilled, because the negative deviation value is 0. While the priority ranking (priority) 2 (maximizing the amount of production) is not fulfilled, because the negative deviation value is not 0. Also, the positive deviation value in the ranking of priorities (priority) 4 (minimizing the cost of raw materials for large tires), 5 (minimizing the cost of materials raw for small tires), 6 (minimizing the cost of rubber raw materials), 7 (minimizing the cost ofraw materials gum), 8 (minimizing the cost of raw materials glue), 9 (minimizing the cost of raw materials for thinner), 10 (minimizing the



```
LP OPTIMUM FOUND AT STEP     13

        OBJECTIVE FUNCTION VALUE

        1)       397.0765

 VARIABLE        VALUE          REDUCED COST
       DB1         0.000000          1.000000
       DB2       397.076508          0.000000
       DB3         0.000000          1.000000
       DA4         0.000000          0.999978
       DA5         0.000000          1.000000
       DA6         0.000000          1.000000
       DA7         0.000000          1.000000
       DA8         0.000000          1.000000
       DA9         0.000000          1.000000
      DA10         0.000000          1.000000
      DA11         0.000000          1.000000
      DA12         0.000000          0.823617
        X1         0.000000         41.043480
        X2         0.000000         23.521740
        X3         0.000000         21.521740
        X4         0.000000          4.000000
        X5         0.000000         17.521740
        X6         0.038068          0.000000
        X7         0.000000         43.565216
        X8         0.000000         41.565216
        X9         0.000000         39.565216
       X10         0.000000         37.565216
       X11         0.000000         20.043478
       X12         0.000000         18.043478
       X13         0.000000         25.093479

       X14         0.000000         11.356739
       X15         0.000000         13.736739
       X16         1.048889          0.000000
       X17         0.000000         17.901739
       X18         0.000000          4.165000
       X19         0.000000         52.515217
       X20         0.000000         54.895218
       X21         0.000000         56.680218
       X22         0.000000         59.060219
       X23         0.000000         45.323479
       X24         0.000000         47.703480
       DA1 265154080.000000          0.000000
       DA2         0.000000          1.000000
       X25         2.954545          0.000000
       X26         0.000000          0.000000
       X27         0.000000          0.000000
       X28         0.000000          0.000000
       X29         0.000000          0.000000
       X30         0.000000          0.000000
       X31         0.000000          0.000000
       X32         0.000000          0.000000
       X33         0.000000          0.000000
       X34         0.000000          0.000000
       X35         0.000000          0.000000
       X36         0.000000          0.000000
       X37         0.000000          0.000000
       X38         0.000000          0.000000
       X39         0.000000          0.000000
       X40         0.000000          0.000000
       X41         0.000000          0.000000
       X42         0.000000          0.000000
       X43         0.000000          0.000000
       X44         0.000000          0.000000

       X45         0.000000          0.000000
       X46         0.000000          0.000000
       X47         0.000000          0.000000
       X48         0.000000          0.000000
       DA3         0.000000          0.000000
       DB4         0.000000          0.000022
       DB5   5796148.000000          0.000000
       DB6  17146272.000000          0.000000
       DB7  15874581.000000          0.000000
       DB8  17510754.000000          0.000000
       DB9   5598459.000000          0.000000
      DB10  47443120.000000          0.000000
      DB11  12525787.000000          0.000000
      DB12         0.000000          0.176383

       ROW   SLACK OR SURPLUS      DUAL PRICES
         2)         0.000000          0.000000
         3)         0.000000         -1.000000
         4)         0.000000          0.000000
         5)         0.000000          0.000022
         6)         0.000000          0.000000
         7)         0.000000          0.000000
         8)         0.000000          0.000000
         9)         0.000000          0.000000
        10)         0.000000          0.000000
        11)         0.000000          0.000000
        12)         0.000000          0.000000
        13)         0.000000          0.176383

NO. ITERATIONS=      13
```

Fig. 2: LINDO Software Output Results

TABLE I

Variable Deviation Positive and Negative Priority Achievement

Achievement Priority	Constraint	Variable Deviation Positive	Variable Deviation Negative	Exp
1	1	265.154.080	0,00	Fulfilled
2	2	0,00	397,08	Unfulfilled
3	3	0,00	0,00	Fulfilled
4	4	0,00	0,00	Fulfilled
4	5	0,00	5.796.148	Fulfilled
4	6	0,00	17.146.272	Fulfilled
4	7	0,00	15.874.581	Fulfilled
4	8	0,00	17.510.754	Fulfilled
4	9	0,00	5.598.459	Fulfilled
4	10	0,00	47.443.120	Fulfilled
4	11	0,00	12.525.787	Fulfilled
5	12	0,00	0,00	Fulfilled

cost of raw materials for yarn chord), 11 (minimizing the cost of plastic raw materials) and 12 (minimizing employee work hours) are met, because the positive deviation value is 0. mathematical approach through the Method is Goal Programming very suitable to use.

2) Sensitivity analysis of goal function coefficient

Based on the results of sensitivity analysis using software LINDO, it can be seen that the change in the value of the objective function coefficient X1 to X12 (the number of tire production ring 16 from January to December 2020) experienced an unlimited increase except at value X6.(June) which increased by 4 units. It also experienced a decrease that varies each month or can be seen in the section allowable decrease. For the value of the objective function coefficient X13 to X24 (the number of tire production ring 20 January - December 2020) experienced an unlimited increase except in X16 which increased by 4.21 units and decreased indefinitely. For the value of the objective function coefficient X25 to X36 (the number of tire requests ring from January to December 2020) has an unlimited increase except for the value of X25 which has increased by 0 units and decreased by 0 units. For the value of the objective function coefficient X37 to X48 (the number of tire requests ring 20 January - December 2020) has an unlimited increase, while for the decrease (allowable decrease) down by 0 units or does not decrease. Although there is an increase and decrease in the value of the right segment, it will not affect the objective function because the value of the current coefficient is 0.

3) Sensitivity analysis right section

Based on the results of sensitivity analysis using software LINDO, it can be seen that the value of a right segment can be has increased and decreased in value. Where in row 2 (total production), 3 (total demand), 5 (small tire raw material costs), 6 (rubber raw material costs), 7 (raw material costs gum), 8 (glue raw material costs), 9 (tiner raw material costs), 10 (yarn raw material costs chord) and 11 (plastic raw material costs) experienced an unlimited increase, while for row 1 (revenue) an increase of Rp 265,154,080, row 4 (raw material costs large tires) increased by Rp. 18,373,460 and row 12 (employee working hours) increased by 2,190.74 hours/month. As for the impairment in row 1 (income) which is experiencing an unlimited decrease, while for rows 2-12 has decreased varying or can be seen in the allowable decrease.

4) Sensitivity analysis shadow price

Based on the results of sensitivity analysis using software LINDO, it can be seen that the value of slack or surplus is zero, then the constraints are active. If the value of slack or surplus is zero and the value of dual prices is also zero, then the condition indicates that the addition of each unit of the value of the right segment to these constraints will cause the value of the objective function to decrease by zero. Like wise with the value of dual prices which are not zero, the value of the objective function will be reduced by the value of the dual prices . The sensitivity range for the boundary quantity value is the distance at which the shadow price remains valid. If it increases above the upper

limit of sensitivity (increases) or decreases below the lower limit (decreases), the value of the shadow price will change.

IV. Conclusion

Based on the results of research conducted using the Goal Programming Method, it can be seen that the company's maximum income is IDR 474,426,000, the maximum production amount is 11.75 units, the maximum number of requests is 1,038.4 units, the minimum raw material cost is IDR 12,128. 150.66 and minimum employee work hours are 2,165.68 hours/month. Based on the analysis that has been done, it can be concluded that the changes that occur will not affect the optimal solution.

References

[1] A. Chirzun, N. Nurhasanah, and T. A. Utami, "Rancangan perencanaan produksi jenis produk make to order dengan pendekatan simulasi sistem dinamik," *Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi*, vol. 3, no. 3, pp. 113–119, 2017.

[2] M. B. Soeltanong and C. Sasongko, "Perencanaan produksi dan pengendalian persediaan pada perusahaan manufaktur," *Jurnal Riset Akuntansi & Perpajakan (JRAP)*, vol. 8, no. 01, pp. 14–27, 2021.

[3] P. C. Paath, J. Tjakra, and A. Dundu, "Analisis pengendalian bahan proyek pembangunan dengan metode goal programming prioritas (studi kasus: Proyek pembangunan gedung sekolah eben haezar)," *Jurnal Sipil Statik*, vol. 3, no. 5, 2015.

[4] M. Y. Kabosu and K. Kartiko, "Analisis goal programming (gp) pada optimalisasi perencanaan produksi mebel ud. latanza," *Jurnal Statistika Industri dan Komputasi*, vol. 5, no. 01, pp. 22–40, 2020.

[5] I. Nuryana, "Optimasi jumlah produksi pada umkm raina kersen dengan metode linear programming," 2019.

[6] D. M. N. Faisal, H. Bagus, and S. Sunarya, "Perhitungaan metode goal programming untuk optimasi perencanaan produk keripik singkong pada pt. cassava chips," *Bulletin of Applied Industrial Engineering Theory*, vol. 2, no. 1, 2021.

[7] D. R. Indah and P. Sari, "Penerapan model linear programming untuk mengoptimalkan jumlah produksi dalam memperoleh keuntungan maksimal (studi kasus pada usaha angga perabot)," *Jurnal Manajemen Inovasi*, vol. 10, no. 2, 2020.

[8] Y. R. Akbar *et al.*, "Optimasi produksi pada industri kecil dan menengah karya unisi dengan penerapan model linear programming," *Jurnal Inovasi Penelitian*, vol. 2, no. 8, pp. 2883–2892, 2022.

[9] S. Suryanto, E. S. Nugroho, and R. A. K. Putra, "Analisis optimasi keuntungan dalam produksi keripik daun singkong dengan linier programming melalui metode simpleks," *Jurnal Manajemen*, vol. 11, no. 2, pp. 226–236, 2019.

[10] A. Akram, A. Sahari, and A. I. Jaya, "Optimalisasi produksi roti dengan menggunakan metode branch and bound (studi kasus pada pabrik roti syariah bakery, jl. maleo, lrg. viii no. 68 palu)," *Jurnal Ilmiah Matematika dan Terapan*, vol. 13, no. 2, 2016.

[11] M. Martini *et al.*, "Optimasi produksi hijab dengan fuzzy linear programming," *JITK (Jurnal Ilmu Pengetahuan dan Teknologi Komputer)*, vol. 3, no. 1, pp. 65–72, 2017.

[12] P. N. P. Krisnadewi and P. Y. Setiawan, "Optimalisasi produksi pada usaha kecil kripik terry di desa nyanglan kaja, kecamatan tembuku kabupaten bangli," *E-Jurnal Manaj. Unud*, vol. 7, no. 11, pp. 6011–6040, 2018.

[13] R. Rachman, "Optimalisasi produksi di industri garment dengan menggunakan metode simpleks," *Jurnal Informatika*, vol. 4, no. 1, 2017.

[14] W. Anggraeni, R. A. Vinarti, R. Tyasnurita, and J. Permatasari, "Production planning optimization using goal programming method in habibah busana," *Journal of Advanced Management Science Vol*, vol. 3, no. 4, 2015.

[15] E. E. Ajayi-Daniels, "Resource optimization in a fashion firm: a goal programming approach," *International Journal of management and fuzzy systems*, vol. 5, no. 1, pp. 14–20, 2019.

[16] F. Fauziyah, "Penerapan metode goal programming untuk mengoptimalkan beberapa tujuan pada perusahaan dengan kendala jam kerja, permintaan dan bahan baku," *Jurnal Matematika MANTIK*, vol. 2, no. 1, pp. 52–59, 2016.

[17] Y. Titilias, L. Linawati, and H. Parhusip, "Optimasi perencanaan produksi kayu lapis pt. xxx menggunakan metode goal programming," *Indonesian Journal of Mathematics and Natural Sciences*, vol. 41, no. 1, pp. 13–19, 2018.

[18] W. Widyaningsih and S. Andayani, "Optimasi perencanaan produksi bahan bakar minyak dengan fungsi kendala fuzzy menggunakan metode goal programming," *Pythagoras*, vol. 13, no. 1, 2018.