# Time and Cost Optimization using Fuzzy Goal Programming

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*Abstract*— **In an industry that is often faced with the problem of optimizing compound goals to be achieved such as maximizing sales, maximizing total production, and production costs. Multi objective linear programming method can be applied effectively in production planning because it has a great chance to solve every different aspect of production planning. In this research, we will apply fuzzy goal programming method to optimize time and cost in Port Container Handling. The experimental results have been conducted using three variants with different cases provide match results the desired by the decision maker. From the three variants, the second variant provides the most optimal results compared to other variants.**

***Keywords—time and cost optimization; multi objective linear programming; fuzzy goal programming; port container handling***

## I. INTRODUCTION

Planning is an important stage in the decision-making process. Good planning will determine the success rate in the industry. In an industry often faced with the problem of optimizing compound goals to be achieved such as maximizing sales value, maximizing total production, and minimizing production costs without necessarily reducing product quality. These goals contain different aspects that often do not coexist with one another [1].

Several methods are used to solve problems by providing optimal results such as through non-linear optimization approach and linear optimization [2]. The method that considers several objectives in a linear programming model is called multi-objective linear programming (MOLP) [3]. The MOLP method can be applied effectively in production planning, as it is likely to solve every different aspect of production planning [4].

Some of the methods used to solve the problem of compound destination model are goal programming (GP) and fuzzy goal programming (FGP). In GP each objective is weighted prior to analysis, whereas in FGP each goal is not given discrete weight, but it is enough to consider the decision maker's desire to determine the value constraints on each function of the existing goal [5].

Based on research that has been done by Tampinongkol [4] where in the research aims to design an application to solve the problem of fuzzy goal programming and determination of optimal solution result on company UD. Sinar Sakti Manado. The data used is the data of the company's production in 2014. In a study conducted by Effendi [6] where in this research aims to apply *non-linear* optimization method to *double timestamp event log*, the results of the study yielded an optimal solution of 71.83 hours and a cost of 2,853,415,853. Research conducted by Sutanto [7] where in the study aims to overcome obstacles when the shortage of goods at the retail level takes a long time in the distribution of goods from the warehouse to retailers. With the *physical internet* approach, the warehouse function and distribution center is replaced by a hub that serves to optimize transportation and availability. Research conducted by Sarno [8] aims to obtain minimum time duration and additional minimum cost of *single timestamp event log* using *linear programming*. Research conducted by Wiguna [9] aims to design a GIS application to map the location of a solar farm with a combination of methods between Fuzzy AHP and PROMETHEE.

In this research will be done cost optimization and dwelling time at Port Container Handling in Surabaya using Fuzzy Goal Programming. By using three different case variants, we will optimize the time and cost in each variant using the FGP method. The results from the FGP method in each variant will produce the most optimal variant.

## II. RESEARCH METHODOLOGY

### *A. FCFS*

First Come First Served (FCFS) is a scheduling algorithm where every ready-made process will be included in FIFO queue with first in first out principle, according to the time of arrival. The first process arrives to be executed.

FCFS formulated as follows:

$$TA = WT + LE \tag{1}$$

$$\overline{TA} = \sum TA / \sum J \tag{2}$$

$$WT = ME - WK \tag{3}$$

Where,

$TA$ : Turn around

$LE$ : Length of execution

$J$ : Job

$WT$ : Waiting time

$ME$ : Start the execution

$LS$ : Time of arrival

### *B. Fuzzy Goal Programming*

Fuzzy goal programming is a fuzzy programming approach to goal programming, where this method does not need to perform weighting calibration or do selection to the degree of importance of purpose function. This method only uses special preferences on the objectives that can be modeled by using the fuzzy membership function [10].

The FGP method is formulated as follows:

If $x = [x_1, x_2, \dots, x_n]T \in \mathcal{R}^n$ as a vector decision variables $f(x) = (f_1(x), \dots, f_m(x))$ is an objective function with constraint system form $G(x)$. Decision-makers want limits $f_i^*, (i = 1, 2, \dots, m)$ for each purpose function that meets the linear constraints $G(x)$. Using the concept of fuzzy sets, membership functions can be defined as follows:

*1)* State

$$\text{Max} f_i(x), i = 1, 2, \dots, m \quad (4)$$

With constraint $x \in G(x) \in R^n$

Suppose obtained $x_j^*$ $(j = 1, 2, \dots, n)$ is an optimal solution at objective function $f_i(x)$, get $f_i(x_j^*) = f_{i\,max}$

*2)* Find min $f_i(x_j^*) = f_{i\,min}$ for each $i$.

*3) Define membership function* $\mu_{fi}(x), (1, 2, \dots, m)$ in the form of*:*

$$\mu_{fi}(x) = \begin{cases} \dfrac{f_{i\,max} - f_i(x)}{f_{i\,max} - f_i^*} & f_i^* < f_i(x) \le f_{i\,max} \\ 1 & f_i(x) = f_i^* \\ \dfrac{f_i(x) - f_{i\,max}}{f_i^* - f_{i\,min}} & f_{i\,min} \le f_i(x) < f_i^* \end{cases}$$

*4) Next define* $\lambda - level F_i^\lambda(x)$ *or* $F(\lambda, x)$ so formed FGP model that is:

Define $x^*$, that meet:

$$\text{Max } \lambda \quad (5)$$

With constraint $x \in F(\lambda, x) \cap G(x)$

$$F(\lambda, x) = F^\lambda(x) = F_1^\lambda(x) \cap F_2^\lambda \cap \dots \cap F_i^\lambda(x) \dots \cap F_m^\lambda$$

With $F_i^\lambda(x) = \{x | \mu_{fi}(x) \ge \lambda; 0 \le \lambda \le 1, x \in F_i(x)\}$

Since the purpose function in the model to be discussed is the problem of maximization and minimization, according to Singh, FGP can be expressed:

Define $x$ (6)

Until,

$F_i(x) \le f_i$ or $F_i(x) \ge f_i (1, 2, \dots, m)$

With constraint,

$Ax \le b, x \ge 0$

Where $F_i(x)$ is a objective to *i*, $f_i$ is a level aspiration of purpose function $F_i(x)$, *A* is a matrix coefficient of use of each resource to produce a unit of decision variable value $x_j$, and ***b*** is a vector column on the right side of the constraint that states the availability of each resource.

The membership function $\mu_{fi}(x)$ for each objectives *fuzzy* can be expressed in form:

*1)* If $F_i(x) \le f_i$, so that

$$\mu_{fi}(x) = \begin{cases} 1 & F_i(x) \le f_i \\ \dfrac{U_i - F_i(x)}{U_i - f_i} & f_i \le F_i(x) \le U_i \\ 0 & F_i(x) \ge U_i \end{cases} \quad (7)$$

*2)* If $F_i(x) \ge f_i$, so that

$$\mu_{fi}(x) = \begin{cases} 1 & F_i(x) \ge f_i \\ \dfrac{F_i(x) - L_i}{f_i - L_i} & L_i \le F_i(x) \le f_i \\ 0 & F_i(x) \ge L_i \end{cases} \quad (8)$$

Where $U_i$ and $L_i$ is the upper and lower limits of the desired decision maker's preferences $f_i$ is an optimal limits (*max* or *min*) from the model.

Model FGP (2) and (3) can be expressed in form:

Define $x^*$ that meet,

$$Max\ \lambda \quad (9)$$

With constraint,

$$\mu_{fi}(x) \ge \lambda$$

$$Ax \le b, x \ge 0$$

Next the membership *fuzzy* function in purpose function is:

$$\mu_{fi}(x) = \begin{cases} 1 & F_i(x) \le f_{i\,min} \\ \dfrac{U_i - F_i(x)}{U_i - f_{i\,min}} & f_{i\,min} \le F_i(x) \le U_i \\ 0 & F_i(x) \ge U_i \end{cases} \quad (10)$$

$$\mu_{fi}(x) = \begin{cases} 1 & F_i(x) \ge f_{i\,max} \\ \dfrac{F_i(x) - L_i}{f_{i\,max} - L_i} & L_i \le F_i(x) \le f_{i\,max} \\ 0 & F_i(x) \ge L_i \end{cases} \quad (11)$$

The form about membership function (7) and (8) can showing in *Fig. 1*:

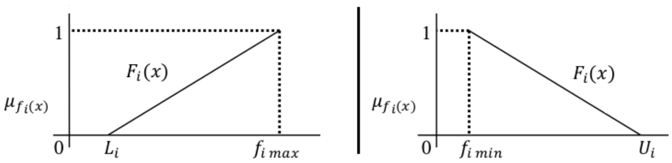


Fig. 1. The Form Membership *Fuzzy* Function

The greater the value $\lambda$ which is obtained, will result in the *fuzzy* membership value for each purpose function will be greater which means the solution obtained close to the optimal value (*max* or *min*).

## III. Result & Analysis

The results and discussion of the experiments that have been conducted, described as follows:

## *A. Data Testing*

The data used is dwelling time of log data at Port Container Handling in Surabaya (TPS). The data used are 3 variants, with different cases in each variants, data for all three variants are shown in Table 1, Table II, and Table III. Table I shows data variants 1 which will be used in this research, meanwhile data variants 2 and data variants 3 are explained in Table II and Table III respectively.

TABLE I. DATA VARIANTS 1

| *Activity* | *Cost* | *Time* |
|---|---|---|
| *DocumentEntryviaPDE* | 0 | 1 |
| *RequestBehandle* | 0 | 148 |
| *VesselBerthingProcess* | 53203.499 | 450 |
| *DischargeContainer* | 497.36707 | 22 |
| *BringContainertoYard* | 60.465331 | 2 |
| *StackContainerinYard* | 23.567584 | 855 |
| *ApproveBehandle* | 1.8458175 | 828 |
| *VerificationDocumentBehandle* | 6.7904388 | 413 |
| *CreatedocumentSPPB* | 2659.4633 | 0 |
| *SendSPPBInfo* | 0 | 464 |
| *CreateJobOrderDocumentDelivery* | 35.226131 | 2 |
| *SendJobOrderDeliveryInfo* | 0 | 1227 |
| *Truckin* | 11.701589 | 1 |
| *DispatchWQDeliverytoCHE* | 1.0388558 | 2 |
| *DetermineContainerType* | 2.3353664 | 2 |
| *DeterminingDry* | 18.383139 | 1 |
| *DecideTaskBeforeLiftContainer* | 2.3349725 | 2 |
| *LiftonContainerTruck* | 19.326058 | 39 |
| *TruckGoToGateOut* | 2.3282795 | 1 |
| *CheckContainerbeforeTruckout* | 2.3293147 | 1 |
| *TruckOut* | 11.696781 | 0 |

TABLE II. DATA VARIANTS 2

| *Activity* | *Cost* | *Time* |
|---|---|---|
| *DocumentEntryviaPDE* | 0 | 1 |
| *RequestBehandle* | 0 | 146 |
| *VesselBerthingProcess* | 64278.76 | 249 |
| *DischargeContainer* | 609.39495 | 27 |
| *BringContainertoYard* | 68.269487 | 2 |
| *StackContainerinYard* | 24.041282 | 749 |
| *ApproveBehandle* | 1.827298 | 726 |
| *VerificationDocumentBehandle* | 7.0275265 | 362 |
| *CreatedocumentSPPB* | 2668.252 | 0 |
| *SendSPPBInfo* | 0 | 407 |
| *CreateJobOrderDocumentDelivery* | 22.471991 | 2 |
| *SendJobOrderDeliveryInfo* | 0 | 526 |
| *Truckin* | 7.8268536 | 1 |
| *DispatchWQDeliverytoCHE* | 0.6447958 | 2 |
| *DetermineContainerType* | 1.4776138 | 2 |
| *DeterminingRefeer* | 18.97 | 1 |
| *DecideTaskBeforeLiftContainer* | 1.5330109 | 7 |
| *UnplugRefeerCable* | 7.3126053 | 2 |
| *LiftonContainerTruck* | 19.872564 | 51 |
| *TruckGoToGateOut* | 1.4389431 | 1 |
| *CheckContainerbeforeTruckout* | 1.4886588 | 1 |
| *TruckOut* | 7.4535667 | 0 |

TABLE III. DATA VARIANTS 3

| *Activity* | *Cost* | *Time* |
|---|---|---|
| *DocumentEntryviaPDE* | 0 | 1 |
| *RequestBehandle* | 0 | 144 |
| *VesselBerthingProcess* | 86387.533 | 525 |
| *DischargeContainer* | 752.0524 | 39 |
| *BringContainertoYard* | 219.36 | 2 |
| *StackContainerinYard* | 0 | 457 |
| *ApproveBehandle* | 1.667465 | 442 |
| *VerificationDocumentBehandle* | 6.3342884 | 220 |
| *CreatedocumentSPPB* | 2616.4689 | 0 |
| *SendSPPBInfo* | 0 | 248 |
| *CreateJobOrderDocumentDelivery* | 37.533098 | 2 |
| *SendJobOrderDeliveryInfo* | 0 | 274 |
| *Truckin* | 13.7574 | 1 |
| *DispatchWQDeliverytoCHE* | 1.1709138 | 2 |
| *DetermineContainerType* | 2.5295104 | 2 |
| *DeterminingUncontainer* | 14.79 | 1 |
| *DecideTaskBeforeLiftContainer* | 2.5724404 | 12 |
| *PrepareTools* | 77.828162 | 2 |
| *LiftonContainerTruck* | 47.94 | 64 |
| *TruckGoToGateOut* | 2.7060354 | 1 |
| *CheckContainerbeforeTruckout* | 3.0465592 | 1 |
| *TruckOut* | 13.555816 | 0 |

*B. Proposed Method*

Steps of research that will be done, showing in *Fig. 2*:

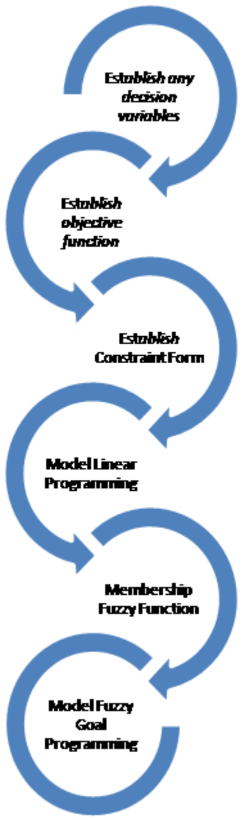


Fig. 2. The proposed method

*1) Establish any decision variables* is all activities undertaken at Port Container Handling in Surabaya for each variant:

*Variant* 1:

$x_1$ = *DocumentEntryviaPDE*
$x_2$ = *RequestBehandle*
$x_3$ = *VesselBerthingProcess*
$x_4$ = *DischargeContainer*
$x_5$ = *BringContainertoYard*
$x_6$ = *StackContainerinYard*
$x_7$ = *ApproveBehandle*
$x_8$ = *VerificationDocumentBehandle*
$x_9$ = *CreatedocumentSPPB*
$x_{10}$ = *SendSPPBInfo*
$x_{11}$ = *CreateJobOrderDocumentDelivery*
$x_{12}$ = *SendJobOrderDeliveryInfo*
$x_{13}$ = *Truckin*
$x_{14}$ = *DispatchWQDeliverytoCHE*
$x_{15}$ = *DetermineContainerType*
$x_{16}$ = *DeterminingDry*
$x_{17}$ = *DecideTaskBeforeLiftContainer*
$x_{18}$ = *LiftonContainerTruck*
$x_{19}$ = *TruckGoToGateOut*
$x_{20}$ = *CheckContainerbeforeTruckout*
$x_{21}$ = *TruckOut*

*Variant* 2:

$x_1$ = *DocumentEntryviaPDE*
$x_2$ = *RequestBehandle*
$x_3$ = *VesselBerthingProcess*
$x_4$ = *DischargeContainer*
$x_5$ = *BringContainertoYard*
$x_6$ = *StackContainerinYard*
$x_7$ = *ApproveBehandle*
$x_8$ = *VerificationDocumentBehandle*
$x_9$ = *CreatedocumentSPPB*
$x_{10}$ = *SendSPPBInfo*
$x_{11}$ = *CreateJobOrderDocumentDelivery*
$x_{12}$ = *SendJobOrderDeliveryInfo*
$x_{13}$ = *Truckin*
$x_{14}$ = *DispatchWQDeliverytoCHE*
$x_{15}$ = *DetermineContainerType*
$x_{16}$ = *DeterminingRefeer*
$x_{17}$ = *DecideTaskBeforeLiftContainer*
$x_{18}$ = *UnplugRefeerCable*
$x_{19}$ = *LiftonContainerTruck*
$x_{20}$ = *TruckGoToGateOut*
$x_{21}$ = *CheckContainerbeforeTruckout*
$x_{22}$ = *TruckOut*

*Variant* 3:

$x_1$ = *DocumentEntryviaPDE*
$x_2$ = *RequestBehandle*
$x_3$ = *VesselBerthingProcess*
$x_4$ = *DischargeContainer*
$x_5$ = *BringContainertoYard*
$x_6$ = *StackContainerinYard*
$x_7$ = *ApproveBehandle*
$x_8$ = *VerificationDocumentBehandle*
$x_9$ = *CreatedocumentSPPB*
$x_{10}$ = *SendSPPBInfo*
$x_{11}$ = *CreateJobOrderDocumentDelivery*
$x_{12}$ = *SendJobOrderDeliveryInfo*
$x_{13}$ = *Truckin*
$x_{14}$ = *DispatchWQDeliverytoCHE*
$x_{15}$ = *DetermineContainerType*
$x_{16}$ = *DeterminingUncontainer*
$x_{17}$ = *DecideTaskBeforeLiftContainer*
$x_{18}$ = *PrepareTools*
$x_{19}$ = *LiftonContainerTruck*
$x_{20}$ = *TruckGoToGateOut*
$x_{21}$ = *CheckContainerbeforeTruckout*
$x_{22}$ = *TruckOut*

*2)* The objective function to be achieved by the company is to minimize symbolic cost $Z(x)$.

for *variant* 1:

$$Min\ Z(x) = 0x_1 + 0x_2 + 53203{,}5x_3 + \cdots + 11{,}7x_{21}$$

for *variant* 2:

$$Min\ Z(x) = 0x_1 + 0x_2 + 64278{,}8x_3 + \cdots + 18{,}9x_{22}$$

for *variant* 3:

$$Min\ Z(x) = 0x_1 + 0x_2 + 86387{,}5x_3 + \cdots + 13{,}5x_{22}$$

*and for the second purpose is to minimize the time symbolized by* H(x).

for *variant* 1:

$$Min\ H(x) = 1x_1 + 148x_2 + 150x_3 + \cdots + 0x_{21}$$

for *variant* 2:

$$Min\ H(x) = 1x_1 + 146x_2 + 249x_3 + \cdots + 0x_{22}$$

for *variant* 3:

$$Min\ H(x) = 1x_1 + 144x_2 + 525x_3 + \cdots + 0x_{22}$$

*3)* Establish any form of constraint that is the company's desire to process dwelling time for three days with the most optimal cost.

for *variant* 1:

$$Dwelling\ Time = 1x_1 + 148x_2 + \cdots + 0x_{21} \le 7143$$

for *variant* 2:

$$Dwelling\ Time = 1x_1 + 146x_2 + \cdots + 0x_{22} \le 7143$$

for *variant* 3:

$$Dwelling\ Time = 1x_1 + 144x_2 + \cdots + 0x_{22} \le 7143$$

*4)* *Model linear programming* to minimize costs and time, can be expressed as follows*:*

The objective function:

for *variant* 1:

$$Min\ Z(x) = 0x_1 + 0x_2 + 53203{,}5x_3 + \cdots + 11{,}7x_{21}$$

$$Min\ H(x) = 1x_1 + 148x_2 + 150x_3 + \cdots + 0x_{21}$$

for *variant* 2:

$$Min\ Z(x) = 0x_1 + 0x_2 + 64278{,}8x_3 + \cdots + 18{,}9x_{22}$$

$$Min\ H(x) = 1x_1 + 146x_2 + 249x_3 + \cdots + 0x_{22}$$

for *variant* 3:

$$Min\ Z(x) = 0x_1 + 0x_2 + 86387{,}5x_3 + \cdots + 13{,}5x_{22}$$

$$Min\ H(x) = 1x_1 + 144x_2 + 525x_3 + \cdots + 0x_{22}$$

Forms constraints:

for *variant* 1:

$$Dwelling\ Time = 1x_1 + 148x_2 + \cdots + 0x_{21} \le 7143$$

for *variant* 2:

$$Dwelling\ Time = 1x_1 + 146x_2 + \cdots + 0x_{22} \le 7143$$

for *variant* 3:

$$Dwelling\ Time = 1x_1 + 144x_2 + \cdots + 0x_{22} \le 7143$$

*5)* The Fuzzy membership function is formed based on the optimal solution obtained from the calculation of linear programming and decision maker preference. The fuzzy membership function for the minimum cost purpose is*:*

$$\mu_{Z(x)} = \begin{Bmatrix} 1 & Z(x) \le Z^* \\ \dfrac{\bar{Z} - Z(x)}{\bar{Z} - Z^*} & Z^* \le Z(x) \le \bar{Z} \\ 0 & Z(x) \ge \bar{Z} \end{Bmatrix}$$

The function of fuzzy membership for the minimum purpose of time is:

$$\mu_{H(x)} = \begin{Bmatrix} 1 & H(x) \le H^* \\ \dfrac{\bar{H} - H(x)}{\bar{H} - H^*} & H^* \le H(x) \le \bar{H} \\ 0 & H(x) \ge \bar{H} \end{Bmatrix}$$

Where,

$Z^*$ : Minimum cost solution for linear programming.

$\bar{Z}$ : The maximum cost the decision owner wants.

$H^*$ : Minimum time solution for linear programming.

$\bar{H}$ : The maximum time the decision owner wants.

*6)* *Model fuzzy goal programming,* after the solution is determined from each destination which is expressed in the fuzzy membership function. This model will be modeled with one purpose that can be analyzed such as linear programming model. For $\mu_{Z(x)} \ge \lambda$ with $\mu_{Z(x)} = \frac{\bar{Z}-Z(x)}{\bar{Z}-Z^*}$ at $Z^* \le Z(x) \le \bar{Z}$, at $\bar{Z}$ and $Z^*$ the valuable *real,* apply $Z(x) + (\bar{Z} - Z^*)\lambda \le \bar{Z}$

$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n + (\bar{Z} - Z^*)\lambda \le \bar{Z}$

For $\mu_{H(x)} \ge \lambda$ with $\mu_{H(x)} = \frac{\bar{H}-H(x)}{\bar{H}-H^*}$ at $H^* \le H(x) \le \bar{H}$, where $\bar{H}$ and $H^*$ the valuable *real*, apply $H(x) + (\bar{H} - H^*)\lambda \le \bar{H}$

$b_{11}x_1 + b_{12}x_2 + \cdots + b_{1n}x_n + (\bar{H} - H^*)\lambda \le \bar{H}$

Then the fuzzy goal programming model obtained is:

$Max\ \lambda$

With constraints:

for *variant* 1:

$$0x_1 + 0x_2 + \cdots + 11{,}7x_{21} + (84624{,}84624)\lambda \le 84624$$

$$1x_1 + 148x_2 + 150x_3 + \cdots + 0x_{21} + (7143{,}2827)\lambda \le 7143$$

$$1x_1 + 148x_2 + \cdots + 0x_{21} \le 7143$$

for *variant* 2:

$$0x_1 + 0x_2 + \cdots + 18{,}9x_{22} + (84624{,}84624)\lambda \le 84624$$

$$1x_1 + 146x_2 + 249x_3 + \cdots + 0x_{22} + (7143{,}956)\lambda \le 7143$$

$$1x_1 + 146x_2 + \cdots + 0x_{22} \le 7143$$

for *variant* 3:

$$0x_1 + 0x_2 + \cdots + 13{,}5x_{22} + (84624{,}79048)\lambda \le 84624$$

$$1x_1 + 146x_2 + 525x_3 + \cdots + 0x_{22} + (7143{,}1555)\lambda \le 7143$$

$$1x_1 + 144x_2 + \cdots + 0x_{22} \le 7143$$

The results of experiments performed using fuzzy programming objectives gave results on Variant 1 at a cost of US$84624, time 2827 minutes. Variant 2 is US$84624 cost, 956 minutes time. Variant 3 is US$79048 for cost, while 1555 minutes time. The results of time optimization on each variant obtained with fuzzy goal programming are shown in Fig. 3. While the optimization cost is seen in Fig. 4.

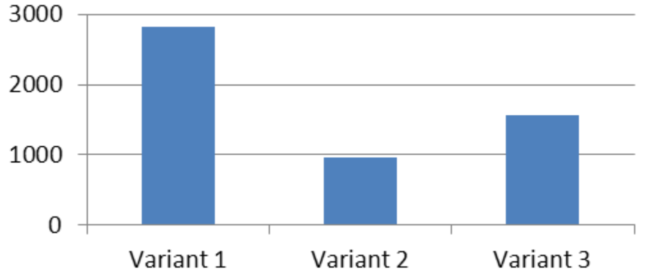


Fig. 3. Optimization Results in Time of Three Variants

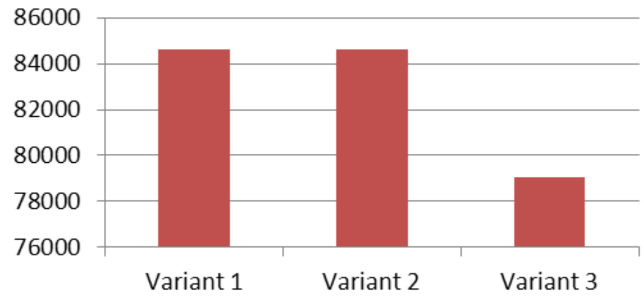


Fig. 4. Optimization Results in Cost of Three Variants

## IV. Conclusion

Cost and time optimization performed on fuzzy goal programming method give optimization result of cost for Variants 1 remain the same as US$84624 from the desire of the decision maker equal to US$84624. While the optimization time for Variants 1 of 2827 minutes from the decision of the owner of decision 7143 minutes, while for the optimization of cost for Variants 2 of US$84624 and time 956 minutes, and cost optimization results for Variants 3 of US$79048 and time 1555 minutes. From the results of tests conducted Variants 3 provides more optimal results compared with other variants. In the next research, the fuzzy goal programming method will be applied to data with higher complexity and sample by applying another variation of the fuzzy method.

## V. Acknowledgment

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## References

[1] Fauziyah, "Penerapan Metode Goal Programming untuk Mengoptimalkan Beberapa Tujuan pada Perusahaan dengan Kendala Jam Kerja, Permintaan, dan Bahan Baku," *Jurnal Matematika*, vol. 02, no. 01, Oktober 2016.

[2] Putra, I.,G.,A.,J., Asih, M.,N., Widana, I.,N, "Optimalisasi Penjualan Kain Endek Dengan Metode Karush-Kuhn-Tucker (KKT)," *E-Jurnal Matematika*, vol. 04, no. 04, pp. 158 - 162, Nopember 2015.

[3] Suriadi, A.S., "Perencanaan Produksi Agregat Dengan Model Fuzzy Goal Programming Pada Industri Alat Musik, " *Jurnal Teknologi dan Manajemen*, vol. 12, no. 01, Februari 2014.

[4] Tampinongkol, F.F., Rindengan, A.J., Latumakulita, L.A., "Aplikasi Fuzzy Goal Programming (Studi Kasus: UD. Sinar Sakti Manado)," *Jurnal de Cartesian*, vol. 04, no. 02, September 2015.

[5] Rindengan, A., J., Supriyo, P., T., Kustiyo, A., "Model Fuzzy Goal Programming yang Diselesaikan dengan Linear Programming pada Perencanaan Produksi," *Jurnal de Cartesian*, vol. 02, no. 02, September 2013.

[6] Y. A. Effendi and R. Sarno, "Non-Linear Optimization of Critical Path Method," *Accepted International Conference on Science in Information Technology (ICSITech)*, Oktober 2017. DOI: 10.1109/ICSITech.2017.8257091.

[7] Sutanto, Y., Sarno, R., "Inventory Management Optimization Model with Database Synchronization through Internet Network (A Simulation Study)," *International Conference on Electrical Engineering and Informatics (ICEEI)*, pp. 115 - 120, August 2015. DOI: 10.1109/ICEEI.2015.7352480.

[8] R. Sarno and Y. A. Effendi, "Hierarchy Process Mining from Multi-Source Logs," Telecommunication, Computing, Electronics and Control (TELKOMNIKA), Vol.15, No.4, 2017

DOI: http://dx.doi.org/10.12928/telkomnika.v15i4.6326

[9] Wiguna, K.,A., Sarno, R., Ariyani, N., F., "Optimization Solar Farm Site Selection Using Multi-Criteria Decision Making Fuzzy AHP and PROMETHEE: Case Study in Bali," *International Conference on Information, Communication Technology and System (ICTS)*, pp. 237 - 243, October 2016. DOI: 10.1109/ICTS.2016.7910305.

[10] Chen, Y., L., Chen, L., H., Huang, C., Y., "Fuzzy Goal Programming Approach to Solve Equipment Purchasing Problem of an FMC," *International Journal of Industrial Engineering*, vol. 16, no. 04, Juni 2008.