Sales People Training Programme Scheduling Using Multiple Objective Linear Programming: Case Study of an Indonesian Motorcycle Distributor

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One of the problems that has to be overcome by a motorcycle distributor is how best to deliver an effective product knowledge training programme to a new salesman working in a motorcycle dealership. Scheduling such a training programme essentially means a trade-off between maximizing the number of salesmen that can be trained and minimizing the training costs. Based on the collected data, there are numerous motorcycle dealers citywide and it will not be possible for a motorcycle distributor company to conduct a training programme in each city exclusively, therefore, a coverage area policy is applied. In total, there are 5 coverage areas and a training activity will be delivered in each of these areas. One method that can be used to predict the number of new salesmen trained in these areas is the winter-holtz method, whereby multiple-objective linear programming (MOLP) is used to schedule the training programme in these coverage areas based on the forecasting result. The proposed optimization method

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(finding a trade-off between trained sales people maximization and training cost minimization) is best compared to the current optimization method applied by the company (only maximizing the number of trained sales people) or indeed linear programming to solely minimize the training cost. The application of MOLP provides 3% less trained sales people compared to the current optimization method applied by the company and reduces the training cost by up to 19.8%.

Keywords: Salespeople, Scheduling, Forecasting, Multiple Objective Linear Programming, Winter-Holtz.

1 Introduction

Recent awareness by researchers and practitioners of the importance of quality service at a company strategic level is increasing. One objective of a company is to able to provide a higher service level for customers, thus leading to a higher competitive advantage. Awareness of such an issue is critical due to the fact that customers and employees' satisfaction can be affected by such [3]. The service level offered by motorcycle dealers is determined by the quality of its salespeople. The salespeople are the primary asset of a motorcycle dealer to maintain operational continuity. Therefore, research shows that the sales/marketing department is crucial to the facilitation of salespeople training and improvement of sales productivity [14].

It has been stated that being a visionary owner is also important in order to manage a salespeople's competitive advantage and thus, ensure that their required competence level is acquired [12]. In this case, a salespeople's competitive advantage is a core indicator of a successful motorcycle dealership, therefore a training programme must be provided by the motorcycle supplier on their motorcycles product to be sold by the particular motorcycle dealer.

The company in this study is essentially required to schedule training for nearly two thousand salespeople in five different areas of geographical coverage, especially to new salespeople with limited product knowledge. This has to be done with a limited number of trainers and limited funding. Two methods are applied in order to calculate a balance between cost and achievement of a number of trained salespeople. Based on current requirements and policy, the aim of this research is to determine required training programmes in the year of 2017. The two applied methods are, firstly, the Holtz-Winter forecasting to forecast the number of new sales people that have to be trained and secondly, Multiple Objective Linear Programming (MOLP) to determine the training programmes schedule.

A forecasting method can be used to predict the new sales people that have to be trained. One chosen quantitative forecasting method is time series. Time series is performed based on the pattern of historical data [5]. Patterns that can be recognized are seasonal, exponential and trend. Based on possible pattern recognition, one time series forecasting method, which can recognize these three patterns is the aforementioned Winter-Holtz Method [10]. This forecasting procedure is commonly applied to data in order to recognise any of the three trends in question [2].

After acquiring the forecasting result, scheduling of training programmes can be performed by Multiple Objective Linear Programming (MOLP). The MOLP is performed by a series of steps and one of the steps is Goal Programming (GP). Goal Programming (GP) is an optimization technique that can be used to solve a problem, whereby a decision-maker can set an functions target objective with a certain desired result. GP will determine a solution which minimizes the penalty weight factor from each of prior specified objective functions [5].

Goal programming, which is a basic function of MOLP, can be applied in numerous challenging scheduling situations, such as scheduling of household electrical appliances [1], hospital nurse shift scheduling [7], medical personnel visitation scheduling [4], police officer scheduling based on a flexible and cyclic scheduling preference [16], and plantation observation [13]. It is, however best applied to multiple objective functions [13]. MOLP has a similarity to GP with the only difference being the determination of the target. In GP, the target value is directly specified, but in MOLP each of the objective functions is calculated one by one, then it is followed by the Goal Programming calculation.

This is performed by firstly calculating one of the objective functions and then is repetitively performed to each other objective function using a simple Linear Programming (LP) until all of the objective functions are calculated [11]. Kohoren and Syrjänen (2004) developed an interactive formal approach based on a Data Envelope Analysis (DEA) and MOLP to find a feasible solution to maximizing the value of a number of output variables simultaneously [8]. The MOLP basic solving algorithm is presented in Figure 1 [11].

1. Start
2. n = 1
3. There are "m" amount of objective functions
4. Calculating the "nth" objective function with a simple linear programming. Temporarily neglecting the other objective function.
5. Record the result of "nth" objective function. The result is target tn
6. If all objective functions have been recorded (n > m), then continue to step 8, if not then continue to step 7.
7. n = n + 1, repeat step 4.
8. Solving the Goal Programming equation with an overachieved (w_i^+) value dan underachieved (w_i^-) value equal to 1.
9. Reviewing by the decision-maker to adjust the overachieved (w_i^+) value dan underachieved (w_i^-)
10. Finish

Figure 1 MOLP Algorithm.

2 Research Approach

The context of this research is a case study (early 2017) of Indonesian motorcycle distribution company. Collected data is aligned with company policy related to confidentiality and within the scope of requirement. Data is collected to define the product knowledge training using Aim, Content, Method, Execution, and Evaluation [5]. Forecasting using the Winter-Holtz method is performed using historical data of newly registered salespeople throughout the year 2016. Company policy related to the scheduling of training is gathered to perform the optimization of the calculation using MOLP.

2.1 ACMEE Identification

Product knowledge training is defined through ACMEE identification. This activity is performed through observation of training. Presentation of ACMEE for product knowledge training is presented in Table 1.

2.2 Winter-Holtz Method

The new salespeople forecasting method is performed based on the calculation using 2016 annual data for every coverage area as presented in Table 2. Further data required is to be collected, however, the element that will not be used for the forecasting calculation is those sales people who have not been trained in 2016 as a consideration of the scheduling calculation (Table 3). After the data is collected, the new salespeople forecasting is performed using

Table 1 ACMEE identification for training product knowledge

No.	Function	Definition of Function
1	Aim	• To ensure sales people have knowledge of the motorcycle product that has to be sold as a basic competence in a motorcycle sales activity.
2	Content	• Basic information and components and specification of the motorcycle (Frame, Engine, Electrical). • Basic information, components, spare parts, and motorcycle specification (Frame, Engine, Electrical). • The competitive features of the motorcycles.
3	Method	• Training is delivered via presentation of the trainer in class. • There are 5 places/coverage areas of training programmes, coded as JMR, MAD, KED, MAL and SID. • The participant is chosen based on an invitation sent by the motorcycle distributor company to new sales people working in the motorcycle dealer.
4	Execution	• The participant who agrees to participate will come to the training based at a specified place and time. Any participant who refuses to accept the invitation will be replaced by another invited salesperson. • The participant will receive a training module and the trainer will give a presentation about the product knowledge in the class.
5	Evaluation	• After the training, the participant will complete a comprehensive test. • The participant will be given an opportunity to review the training after the activity has finished. A test related to product knowledge will also be given to the participant to measure understanding of the content. • The pass/fail system is not applied in the product knowledge training. What is required by the participant is attending the training.

the winter-Holtz method, followed by a management review for a forecasting parameter and result adjustment to ensure a more realistic result. This Method has three estimations of parameters presented in Equations 1 to 3 below [10]:

1. Exponential Level estimation

$$\mathrm{Lt} = \alpha\left(\frac{Y_t}{S_{t-s}}\right) + (1-\alpha)(\mathrm{Lt}-1+\mathrm{Tt}-1) \tag{1}$$

2. Trend estimation

$$\mathrm{Tt} = \beta(\mathrm{Lt}-\mathrm{Lt}-1) + (1-\beta)\mathrm{Tt}-1 \tag{2}$$

Table 2 2016 New sales people data

Month	Coverage Area				
	JMR	MAD	KED	MAL	SID
1	58	33	46	63	62
2	43	34	61	57	71
3	30	43	33	54	65
4	46	49	78	88	121
5	83	49	71	71	115
6	53	31	54	49	104
7	32	14	38	52	40
8	34	27	56	62	57
9	53	23	59	36	80
10	38	56	35	46	77
11	46	53	30	63	82
12	26	32	38	67	55

Table 3 2016 Untrained sales people

Coverage Area				
JMR	MAD	KED	MAL	SID
33	69	53	54	194

3. Seasonal estimation

$$\mathrm{St} = \gamma\left(\frac{T_t}{L_t}\right) + (1-\gamma)\mathrm{St} - \mathrm{s} \tag{3}$$

Based on the three parameters, the forecasting calculation is presented in equation Yt + 1 = (Lt + r + Tt) St − s (Equation 4 [10]).

$$\mathrm{Yt} + 1 = (\mathrm{Lt} + \mathrm{r} + \mathrm{Tt})\mathrm{St} - \mathrm{s} \tag{4}$$

- α = Level constants
- β = Trend constants
- γ = Seasonal constants
- Lt = Linearity estimation in period t
- Lt−1 = Linearity estimation in one period before t
- Tt = Trend estimation in period t
- Tt−1 = Trend estimation in one period before t

The forecasting result is given in Table 4. A graph to visualize the result is presented in Figures 2, 3 and 4.

Table 4 2017 New sales people forecasting result

	Coverage Area				
Month	JMR	MAD	KED	MAL	SID
1	45	21	54	39	64
2	30	10	73	43	57
3	44	24	40	53	103
4	55	25	57	49	52
5	40	33	77	48	51
6	27	39	42	80	45
7	39	40	60	66	81
8	48	26	80	46	40
9	35	12	44	50	57
10	23	29	63	62	51
11	33	31	84	58	92
12	41	40	46	56	46

Table 5 Forecasting quality measurement

No.	Area	MAD	RSFE	TS
1	SID	29	−24	−0,82
2	JMR	21	−50	−2,39
3	MAD	14,45	−20	−1,4
4	KED	29	−18	−0,61
5	MAL	8	10,14	0,81

MAD = *Mean Absolute Demand*
RSFE = *Running Sum Forecast Error*
TS = *Tracking Signal*

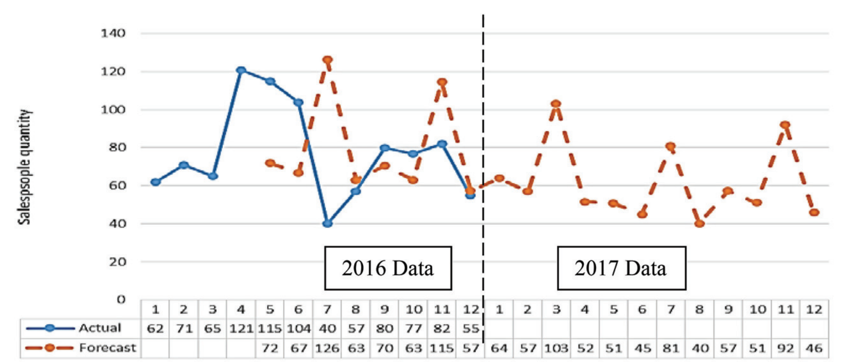

Figure 2 Comparison of historical and forecasted data for new sales people in area SID.

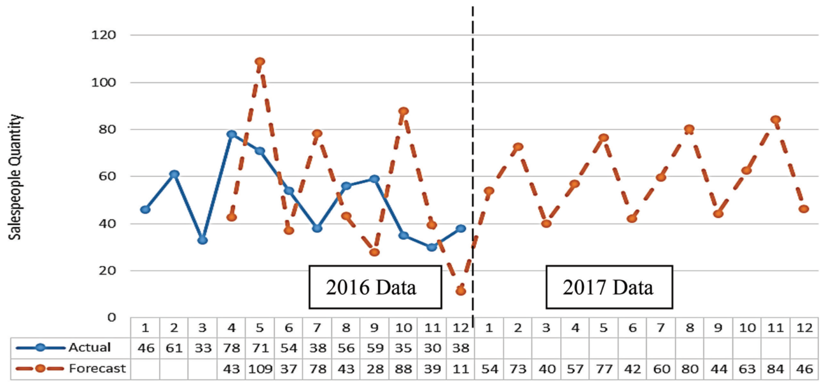

Figure 3 Comparison of historical and forecasted data for new sales people in area KED.

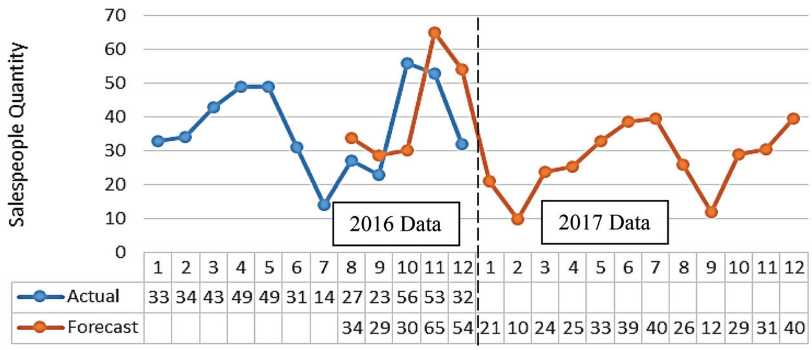

Figure 4 Comparison of historical and forecasted data for new sales people in area MAD.

2.3 Forecasting Quality Measurement

One of the parameters to determine the quality of a forecast result is tracking signal (TS) [15]. TS is a comparison between forecast errors with mean absolute demand. The tracking signal equation is presented in Equations 5 and 6. Based on a numerical value and visual representation, the tracking signal will be acceptable for a TS value near 0 with a range of ±3 to ±8.

$$\text{MAD} = \alpha\left(\frac{\sum |A_i - F_i|}{n}\right) \tag{5}$$

$$\text{TS} = \alpha\left(\frac{\sum A_i - F_i}{MAD}\right) \tag{6}$$

A_i = Actual value in period i
F_i = Forecast value in period i
n = Quantity of compared value

2.4 MOLP Calculation for Scheduling

Based on the forecasting, costing and company policy related to the training, the MOLP is performed from the start of mathematical modelling. The computation is followed by the LP to determine each objective function result separately. The calculation of the training programmes is performed through MOLP, followed by the weight determination of 'overachieve' and 'underachieve' value. Based on Figure 1, the MOLP calculation is started by calculating each objective function, the mathematical modelling for which is presented in Equations 7 to 12.

Decision variables:

X_{ij} = Training schedule conducted in coverage area i, month/period-j
t_1 = Trained sales people
t_2 = Training cost (in thousand Rupiah)

Constants:

U_{ij} = Untrained sales people in coverage area i, month/period-j
F_{ij} = New sales people forecasting result in coverage area-i, month/period-j
c_i = Training cost in coverage area-i
a = Participant for each training session
Cl_{max} = Maximum training programmes that can be conducted in a year.
X_{max_j} = Maximum training programmes that can be conducted in month/period-j
X_{min_j} = Minimum training programmes that can be conducted in month/period-j
X_{min_i} = Minimum training programmes that can be conducted in coverage area i

Objective functions:

1. Trained sales people maximization

$$\mathrm{t}_1 = a \sum_{i=1}^{5} \sum_{j=1}^{12} (\mathcal{X}_{ij}) \text{ Maximization} \tag{7}$$

2. Training cost minimization

$$\mathrm{t}_2 = \sum_{i=1}^{5}\sum_{j=1}^{12}(C_i \mathcal{X}_{ij}) \text{ Minimization} \tag{8}$$

Note: When determining the value of the 1st and 2nd objective function with *linear programming* (LP), both objective functions are calculated exclusively.

3. The training schedule per coverage area must be more than the minimum requirement.

$$\sum_{i=1}^{5}\sum_{j=1}^{12}(\mathcal{X}_{ij}) \geq \mathrm{X_{mini}} \tag{9}$$

4. The training schedule in a year must not exceed the maximum allowance.

$$\sum_{i=1}^{5}\sum_{j=1}^{12}(\mathcal{X}_{ij}) \leq \mathrm{Cl_{max}} \tag{10}$$

5. The equation to determine the number of untrained sales people for period-j.

$$U_{ij} = U_{ij-1} - a\,\mathcal{X}_{ij-1} + F_{ij} \tag{11}$$

Note: for the $\mathrm{U_{i1}}$ in every coverage area, the result is not computed from the specified equation, but presented in Table 3.

6. The number of untrained sales people must be more than 0. This constraint is specified to ensure that the participant is not below the requirement based on company policy.

$$U_{ij} \geq 0$$

Note: for the U_{i1} in every coverage area, the result is presented in Table 3.

$$\sum_{i=1}^{5}\sum_{j=1}^{12}(\mathcal{X}_{ij}) \geq 0 \text{ dan integer} \tag{12}$$

After the value of each objective function is obtained, the goal programming (GP) formulation can be performed. The GP calculation is performed repetitively to determine the trade-off between 2 objective functions based on the agreed weight factor. The weight factor is assigned to ensure that the final result can be mutually agreed because sometimes the weight consideration of each objective function is not equal [11]. The variables, constants, and formulation that will be used in GP are similar to the LP calculation with some addition as presented in Figures 13 to 15.

Decision Variables:

$\mathrm{Y}_{\min}$ = Addition of percentage weight factor for every 'under' and 'overachieve'
d_i^- = *Underachieve* for objective function i
d_i^+ = *Overachieve* for objective function i

Constant:

w_i^- = *underachieve* value for objective function i
w_i^+ = *overachieve* value for objective function i

Objective function:

$$\mathrm{Y}_{\min} = \sum_{i=1}^{2} \frac{1}{t_i}(w_i^- \ d_i^- + \ w_i^+ \ d_i^+) \tag{13}$$

Soft Constraint:

1. The sum of trained sales people and the over/underachieve value must be equal to t_1

$$\mathrm{t}_1 = \sum_{i=1}^{5} \sum_{j=1}^{12} (a \ \mathcal{X}_{ij}) + d_1^- - d_1^+ = \mathrm{t}_1 \tag{14}$$

2. The sum of training costs and the over/underachieve value must be equal to t_2

$$\mathrm{t}_2 = \sum_{i=1}^{5} \sum_{j=1}^{12} (c_i \mathcal{X}_{ij}) + d_2^- - \ d_2^+ = \mathrm{t}_2 \tag{15}$$

Hard Constraint:

The constraints used in prior linear programming are hard constraints and are re-used in the goal programming calculation.

The MOLP calculation is started by gathering data on the cost related to the conduct of the training. The fixed training cost for every coverage area is 750 IDR. The transport and trainer incentive for every coverage area is 400 IDR for area JMR, 400 IDR for area MAD, 250 IDR for KED, 200 IDR for MAL and 100 IDR for SID. The cost unit is expressed in thousands of Indonesian Rupiahs.

Besides the above, additional data required to determine the mathematical model in MOLP is a company policy related to the training procedure as follows:

- Not all of the new sales people must be trained.
- The maximum training programmes throughout 2017 is 35.
- The monthly training is a maximum of 4 and minimum of 2.
- The number of participants for every training session must be 30 people per shift or 60 people per schedule.
- No training can be conducted in June 2017.

3 Results and Discussion

The current training schedule is performed separately with costing activity. In the current implementation, the scheduling activity is performed with the objective function only to maximize the number of trained salespeople (t_2) by adopting the principles of classic LP. This policy leads to a higher cost because the cost acts as a result of the scheduling instead of a basic consideration. The result of the comparison between the current implemented LP and MOLP is presented in Table 6. Based on Table 6, there are 2 prior proposed computations, namely MOLP and cost minimization LP. The cost minimization LP can give an output of a greatly reduced cost, but the number of trained salespeople is also greatly reduced, which is not acceptable to the decision- maker. The computation of MOLP, as shown in the Appendix, shows the reduction of the number of trained salespeople compared to the current computational method by 3%, but with a reduction of the current cost of 19.8%. The acquired result shows that 34 training programmes can be conducted.

Based on the result of MOLP, the acquired result is a trade-off between 2 objective functions: cost minimization and trained salespeople maximization. The trained salespeople maximization is represented by the quantity of training programmes. The result of MOLP is acquired repetitively because the decision-maker has to constantly adjust the weight factor for each objective function until the result can be agreed [11]. The agreed weight factor is 3 for the underachieved trained salespeople (W_1^-). The basic consideration of this policy is the 'underachieved' value of trained salespeople compared to the target value, which is 3 times bigger compared to the other weight factor (W_1^+, W_2^-, and W_2^+) as presented in the Appendix. The computational result of the scheduling is presented in Table 7.

Table 6 Result of comparison between LP and MOLP

Result	LP		MOLP Based on 2 Objective Functions
	Trained Sales People Maximization	Training Cost Minimization	
Trained sales people	2100	1320	2040
Training cost (in Thousand IDR)	8050	3900	6450
Training programmes in 2017	35	22	34

Table 7 Training Programmes Scheduling in 2017

Month	Training Programmes in Each Area				
	JMR	MAD	KED	MAL	SID
1	1	1	0	0	0
2	0	0	0	2	0
3	0	1	3	0	0
4	0	1	1	0	0
5	0	0	1	0	2
7	0	0	0	0	2
8	0	4	0	0	0
9	0	0	0	0	4
10	0	3	0	0	1
11	1	1	0	0	1
12	0	0	0	0	4
Total	2	11	5	2	14
Total number of training programmes in 2017					34
Trained sales people					2040
Training costs (in thousands)					6450

4 Conclusion

The objective of this research was to perform a training programmes scheduling by using multiple objective optimizations, for an Indonesian motorcycle distribution company currently employing thousands of salesmen,. The scheduling had to fulfil two contradictory objectives, namely, training cost minimization and trained salesmen maximization. The decision maker took part in determining the weight factor for each objective. The training schedule is to be performed in 5 different geographical coverage areas for one year. New salesmen that have to be trained will be forecasted using the winter-Holtz method, thereafter the multiple-objective linear programming is performed.

Compared to the current optimization method applied by the company, the number of trained salesmen is reduced by 3% but the training cost is reduced significantly by 19.8%, which is more favourable. Based on an understanding of the result, a better result may still be acquired by considering the city determined to be the coverage area to further reduce the system cost.

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Appendix:

The Computation of Training Programmes Using MOLP

1. **Computing each objective function (t_1 and t_2) with linear programming:**

Decision variable:

- X_{ij} = The training schedule conducted in coverage area i, month/period-j
- t_1 = Trained sales people
- t_2 = The training cost (in thousand Rupiah)

Constants:

- U_{ij} = The constant is acquired through calculation, only for the U_{i1} in every coverage area, which is already presented in Table 3.
- F_{ij} = Presented in Table 6.
- c_i = Presented in the description of the costing
- $a = 60$
- Cl_{max} = 35
- X_{max_j} = 4 (Period 1 to 5 and 7 to 12)
  = 0 (Period 6)
- X_{min_j} = 2 (Period 1 to 5 and 7 to 12)
  = 0 (Period 6)
- X_{min_i} = 2

Objective functions:
The calculation is performed twice, the first one being the calculation of t_1 and the second one is the calculation of t_2

- Trained sales people maximization
  $t_1 = 60\,[\mathcal{X}_{11} + \mathcal{X}_{12} + \mathcal{X}_{13} + \mathcal{X}_{14} + \mathcal{X}_{15} + \mathcal{X}_{21} + \cdots + \mathcal{X}_{57} + \mathcal{X}_{58} + \mathcal{X}_{59} + \mathcal{X}_{5\ 10} + \mathcal{X}_{5\ 11} + \mathcal{X}_{5\ 12}]$ Maximization
- Training cost minimization
  $t_2 = 400_{\mathcal{X}_{11}} + 400_{\mathcal{X}_{12}} + ... + 200_{\mathcal{X}_{21}} + 200_{\mathcal{X}_{22}} + ... + 400_{\mathcal{X}_{41}} + 400_{\mathcal{X}_{42}} + ... + 100_{\mathcal{X}_{5\ 11}} + 100_{\mathcal{X}_{5\ 12}}$ Minimization

Constraint:

1. The training schedule per period must not exceed the maximum allowance.

$$\mathcal{X}_{11} + \mathcal{X}_{21} + \mathcal{X}_{31} + \mathcal{X}_{41} + \mathcal{X}_{51} \leq 4$$
$$\mathcal{X}_{12} + \mathcal{X}_{22} + \mathcal{X}_{32} + \mathcal{X}_{42} + \mathcal{X}_{52} \leq 4$$
$$\cdots$$
$$\mathcal{X}_{1\ 11} + \mathcal{X}_{2\ 11} + \mathcal{X}_{3\ 11} + \mathcal{X}_{4\ 11} + \mathcal{X}_{5\ 11} \leq 4$$
$$\mathcal{X}_{1\ 12} + \mathcal{X}_{2\ 12} + \mathcal{X}_{3\ 12} + \mathcal{X}_{4\ 12} + \mathcal{X}_{5\ 12} \leq 4$$

2. The training schedule per period must be more than the minimum requirement.

$$\mathcal{X}_{11} + \mathcal{X}_{21} + \mathcal{X}_{31} + \mathcal{X}_{41} + \mathcal{X}_{51} \geq 2$$
$$\mathcal{X}_{12} + \mathcal{X}_{22} + \mathcal{X}_{32} + \mathcal{X}_{42} + \mathcal{X}_{52} \geq 2$$
$$\cdots$$
$$\mathcal{X}_{1\ 11} + \mathcal{X}_{2\ 11} + \mathcal{X}_{3\ 11} + \mathcal{X}_{4\ 11} + \mathcal{X}_{5\ 11} \geq 2$$
$$\mathcal{X}_{1\ 12} + \mathcal{X}_{2\ 12} + \mathcal{X}_{3\ 12} + \mathcal{X}_{4\ 12} + \mathcal{X}_{5\ 12} \geq 2$$

3. The training schedule per coverage area must be more than the minimum requirement.

$$\mathcal{X}_{11} + \mathcal{X}_{12} + \mathcal{X}_{13} + \mathcal{X}_{14} + \mathcal{X}_{15} + \mathcal{X}_{16} + \mathcal{X}_{17} + \mathcal{X}_{18} + \mathcal{X}_{19} + \mathcal{X}_{1\ 10} + \mathcal{X}_{1\ 11} + \mathcal{X}_{1\ 12} \geq 2$$
$$\cdots$$
$$\mathcal{X}_{51} + \mathcal{X}_{52} + \mathcal{X}_{53} + \mathcal{X}_{54} + \mathcal{X}_{55} + \mathcal{X}_{56} + \mathcal{X}_{57} + \mathcal{X}_{58} + \mathcal{X}_{59} + \mathcal{X}_{5\ 10} + \mathcal{X}_{5\ 11} + \mathcal{X}_{5\ 12} \geq 2$$

4. The training schedule in a year must not exceed the maximum allowance.

$$\mathcal{X}_{11}+\mathcal{X}_{12}+\mathcal{X}_{13}+\mathcal{X}_{14}+\mathcal{X}_{15}+\mathcal{X}_{21}+\cdots+\mathcal{X}_{57}+\mathcal{X}_{58}+\mathcal{X}_{59}+\mathcal{X}_{5\,10}$$
$$+\mathcal{X}_{5\,11}+\mathcal{X}_{5\,12}\leq 35$$

5. The equation to determine the untrained sales people for period-j.

$$U_{12}=U_{11}-60\,\mathcal{X}_{11}+F_{12}\geq 0$$
$$U_{13}=U_{12}-60\,\mathcal{X}_{12}+F_{13}\geq 0$$
$$\ldots$$
$$U_{5\,11}=U_{5\,10}-60\,\mathcal{X}_{5\,10}+F_{5\,11}\geq 0$$
$$U_{5\,12}=U_{5\,11}-60\,\mathcal{X}_{5\,11}+F_{5\,12}\geq 0$$

Note: for the U_{i1} in every coverage area, the result is not computed from the specified equation, but presented in Table 3.

6. Nonegativity and integer
$\sum_{i=1}^{5}\sum_{j=1}^{12}(\mathcal{X}_{ij})\geq 0$ dan integer

1. **The mathematical computational result**

The computation is performed through spreadsheet modelling using Microsoft Excel 2013 and Solver Simplex LP. The computational result of t_1 and t_2 with linear programming is presented in Table 6. The t_1 (trained sales people) is 2100 and the t_2 (training cost in thousand of Indonesian Rupiahs) is 3900 IDR (in thousands). Both target values are calculated exclusively.

2. **Goal Programming calculation after the result of t_1 and t_2 is obtained using Linear Programming**

The variables and constant that will be used in Goal Programming are similar to the Linear Programming calculation. However, there are some additional variables and a constant that will be considered as follows:
Decision Variables:

- Y_{min} = Summation of percentage weight factor for every 'under' and 'overachieve'
- d_1^- = *underachieve* for objective function t_1
- d_1^+ = *overachieve* for objective function t_1
- d_2^- = *underachieve* for objective function t_2
- d_2^+ = *overachieve* for objective function t_2

Constants:
The determination of weight factor constants is performed through discussions and management review.

$w_1^- = 3 \quad w_2^- = 1$
$w_1^+ = 1 \quad w_2^+ = 1$

The determination of objective function is performed through linear programming.

$t_1 = 2100$
$t_2 = 3900$ (in thousands of rupiahs)

Objective Function:

Minimization of percentage weight factor for every 'under' and 'overachieve'

$$\begin{aligned} Y_{min} &= \frac{1}{t_1}(w_1^-\, d_1^- + \, w_1^+\, d_1^+) + \frac{1}{t_2}(w_2^-\, d_2^- + \, w_2^+\, d_2^+) \text{ Minimization} \\ &= \frac{1}{2100}(3d_1^- + \, 1d_1^+) + \frac{1}{3900}(1d_2^- + \, 1d_2^+) \end{aligned}$$

Soft Constraint:

1. The sum of trained sales people and the over/underachieve must be equal to 2100 (t_1)

$$\begin{aligned} &60\, [\mathcal{X}_{11} + \mathcal{X}_{12} + \mathcal{X}_{13} + \mathcal{X}_{14} + \mathcal{X}_{15} + \mathcal{X}_{21} + \cdots + \mathcal{X}_{57} + \mathcal{X}_{58} + \mathcal{X}_{59} + \mathcal{X}_{5\ 10} \\ &\qquad + \mathcal{X}_{5\ 11} + \mathcal{X}_{5\ 12}] + d_1^- - d_1^+ = 2100 \end{aligned}$$

2. The sum of training costs and the over/underachieve value must be equal to 3900 (t_2)

$$\begin{aligned} &400\mathcal{X}_{11} + 400\mathcal{X}_{12} + \ldots + 200\mathcal{X}_{21} + 200\mathcal{X}_{22} + \ldots + 100\mathcal{X}_{5\ 11} + 100\mathcal{X}_{5\ 12} \\ &\qquad + d_2^- - d_2^+ = 3900 \end{aligned}$$

Hard Constraint:
The constraints used in the prior linear programming are hard constraints, which are re-used in the goal programming calculation.

1. Mathematical Modelling Computation Results

The computation is performed through spreadsheet modelling using Microsoft Excel 2013 and Solver Simplex LP. Based on the mathematical modelling computation, the number of trained sales people is 2040 with the total training cost of 6450 IDR (in thousand).

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Biographies

Weiz Shahzad Kalia was borned in Bojonegoro, Indonesia, 1994. He is an Industrial Engineering and Operation Management MSc student at The University of Nottingham, UK since 2017. He is an awardee of Nottingham University Business School Dean's Scholarship for Excellence and ASEAN Masters scholarship. He is an FSAE racing team C-BOM (Costed Bill of Material) coordinator of The University of Nottingham and an academic coordinator of Indonesian Student Association – Nottingham, UK. He also had an insight experience of motorcycle distributor and railway part manufacturing operational process. He is also a writer of a Visual Basic for Application and Optimization related book. Prior to his master study, he acquired a bachelor degree in Industrial Engineering from Brawijaya University Indonesia in 2016 and actively involved in industrial computer laboratory as a laboratory assistant.

Dewanto Harjunowibowo was borned in Yogyakarta, Indonesia. He graduated from Gadjah Mada University and completed his master degree from the same university in 2010. He is an Assistant Professor in Universitas Sebelas Maret, Indonesia. To support his carrier, he is taking PhD degree at the Department of Architecture and Built Environment Research Division Sustainable Energy Technology in the University of Nottingham, UK. His research interests are image processing, artificial intelligence, energy conversion, heat storage, and solar cooling. He is a member of professional societies such as Indonesian Physics Society, World Society of Sustainable Energy Technologies (WSSET), International Association of Computer Science and Information Technology (IACSIT), and member of South Asia Institute of Science and Engineering (SAISE).

Lenny is an MA student at University of Nottingham, UK since September 2017. She is a recipient of Indonesia Endowment Fund for Education in 2017/2018. She previously taught English language at one of the private high schools in Pontianak city in West Borneo, Indonesia. She was also in charge of school public affairs, organized education fairs in Pontianak and conducted a number of youth exchange projects at school.