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A FRESH GRADUATES' GUIDE TO SELECTING THEIR FIRST CAR USING ZERO-ONE GOAL PROGRAMMING

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ABSTRACT

Being a fresh graduate and to decide the best car among variables of cars is a complex decision since there are various things need to be considered. In addition, owning a transport without proper money planning could lead to money burden. In response to this problem, this study aims to develop a systematic approach in identifying a suitable and affordable car for fresh graduates in Malaysia. Zero-One Goal Programming formulation is developed for choosing a car with optimal features within the determined constraints.

Keywords*: Car, Fresh Graduates, Selection, Zero-One Goal Programming.*

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1. Introduction

There are various brands of cars, such as Toyota, Honda, Proton, BMW and many more to choose from. Most of fresh graduates selection on car were based on the brand they recognize compared to an unfamiliar brand (Lee & Govindan, 2014). They are easily attracted to the advertisement and promotions. They tend to choose the car based on the external appearance, brands, and current trending rather than their financial capabilities. This has been one of the issues highlighted by Malaysia government that lead these young adults toward bankruptcy (Mohamad, 2020).

Fresh graduates can compare the available car models within their required budget by considering the qualitative and quantitative criteria of selection before purchasing a car. As such, Patil et al. (2017) suggested that the car's appearance, interior of the car and the add-on features are used as the qualitative features for the alternatives selection. Following, the quantitative features that are considered for evaluation are the car price, mileage, power, displacement, torque, and service location. Also, Prabowol et al. (2019) had proposed a system that could actually recommend car selection based on any individual's choice, preferences and given information.

From the above, the process of determining the best practicable solution according to the established criteria and problems are common occurrences in our daily life. Multiple criteria decision-making (MCDM) is an approach available to support decision makers who are faced with various decision criteria and various decision options (Choudhuri, 2014). There are four key components contained in MCDM method which are available alternatives, criteria by which the alternatives are judged and compared, weights for the relative importance of the criteria, and decision-makers whose preferences are important (Juliet, 2021).

In this study, Zero-One Goal Programming (ZOGP) method is utilised for it is a suitable method in dealing problem arising from various conflicting resources which are called goals and multiple objectives or goals to be attained. ZOGP is an extension of Goal Programming. Just like Goal Programming, ZOGP attempts to combine the logic of optimization in mathematical programming with the decision maker's desire to satisfy several goals (Yilmaz & Dağdeviren, 2011). It also allows for an ordinal ranking of goal, where the low-priority goals are considered only after the higher-priority goals have been satisfied to the fullest extent possible and it is very useful in the situations where the multiple goals are conflicting and cannot all be fully achieved (Hughes & Grawoig, 1973).

ZOGP allocate the optimal values of a set of variables where there are multiple and conflicting goals in the problems, and measured in priority exist among the goals. It relies on the mutually exclusive yes (1) and no (0) decisions to find the optimal solution. Each variable only represented by 0 or 1 and could represent rejection or selecting of an option (Hayes, 2021).

2. Methodology and Implementation

There are 5 steps in the research process. Figure 1 shows the flowchart for this study.

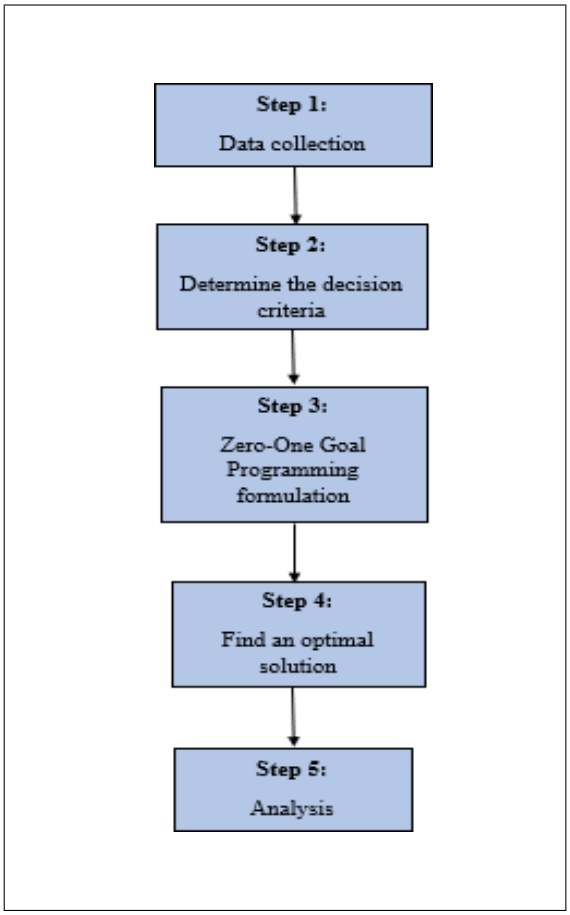


Figure 1. Flowchart of the study.

2.1 STEP 1 : Data Collection

Data regarding the cars and the decision criteria chosen were obtained from Proton and Perodua official website. Table 2 shows 6 types of car chosen for car selection and the decision criteria. The car selected

were Perodua Axia 10 AV, Perodua Myvi 1.3 L X (A.S.A 2.0), Proton Saga Standard 1.3 L, Proton Bezza 1.3 X, Proton Iriz 1.3 L Standard MT and Proton Persona 1.6 L Standard MT.

Table 1. Car Brands and the Criteria.

	Perodua Axia 1.0 AV	**Perodua Myvi 1.3L X (A.S.A 2.0)**	**Proton Saga Standard 1.3 L**	**Proton Bezza 1.3X**	**Proton Iriz 1.3 L Standard MT**	**Proton Persona 1.6L Standard MT**
Decision variable	X_1	X_2	X_3	X_4	X_5	X_6
Price of the car (RM)	41 427	46 959	32 800	42 551	36 700	42 600
Annual monthly payment (RM)	5 868.00	6 648.00	4 644.84	6 024.00	5 197.08	6 032.64
Annual maintenance fee (RM)	240.63	213.32	138.69	213.32	138.69	138.69
Annual fuel cost (RM)	1 138.98	1 166.04	1 225.08	1 180.80	1 215.24	1 335.78
Annual road tax payment (RM)	20	70	70	70	70	90
Annual car insurance payment (RM)	1 324.90	1 468.73	1 100.60	1 354.13	1 202.00	1 387.10
Total displacement (cc)	998	1 329	1 332	1 329	1 332	1 597

2.2 STEP 2 : Decision Criteria Determination

The decision criteria for the car selection were price of the car, annual monthly payment, annual maintenance fee, annual fuel cost, annual road tax payment, annual insurance payment and total displacement (cc) as illustrated in the Table 1. The monthly payment for each car is assumed to have an interest rate of 3.05% with zero deposit for 9 years agreement. It is also to note that, the choice of cars selected for this study is based on average salary of the fresh graduates which is RM 2378 per month (Cho, 2020). Using the information mentioned,

i. only cars with monthly installment less than RM 600 or the annual monthly payment of RM 7200 or less are selected.
ii. the annual maintenance fees for each car are estimated by using maintenance calculator that can be found online and are based on mileage of 20000 km in 12 month.
iii. it is assumed that RON95 will be used and the fuel cost is RM2.05 as of July 2021.
iv. the road tax annual fees for each car determined by their total displacement. For a car that have engine displacement below 1000cc, engine displacement between 1201cc and 1400cc and engine displacement between 1401cc until 1600cc, the road tax fees is RM 20, RM 70 and RM 90 respectively.
v. and, it is assumed that the annual car insurance coverage type is comprehensive.

2.3 STEP 3 : Zero-One Goal Programming (ZOGP) Formulation

Based on proposed method by Rashid et al. (2019), this problem can be formulated as follows:

2.3.1 ZOGP formulation in general

$$\text{Minimise } \sum_{i=1}^{n} P_k\left(d_i^+ + d_i^-\right) \tag{1}$$

Subject to:

$$\text{Hard constraints } \sum_{j=1}^{n} a_j x_j = b_i \tag{2}$$

$$\text{Soft constraints } \sum_{j=1}^{n} a_j x_j + d^+ - d_i^+ = b_i \tag{3}$$

such as

$$x_j = 0 \text{ or } 1 \text{ and } x_j, d_i^-, d_i^+ \geq 0 \text{ for } i = 1, 2, \ldots, m; j = 1, 2, \ldots, n$$

where

x_j	=	0 ;do not select the car or $x_j = 1$; select the car
a_j	=	The input criteria of the car.
x_j	=	The decision variable, j for car that will be selected.
P_k	=	The priority and the goal of the constraints.
d_i^-	=	The amount by which the goal is underachieved.
d_i^+	=	The amount by which goal is overachieved.
b_i	=	The target or aspiration level that was assigned.

2.3.2 Decision and deviation variables

As in Table 1, there are six decision points representing the six cars. The deviation variables on the other hand, are as follows:

d_1^- : underachievement of the annual spending on the car

d_1^+ : overachievement of the annual spending on the car

d_2^- : underachievement of the car price

d_2^+: overachievement of the car price

d_3^- : underachievement of the annual monthly payment

d_3^+ : overachievement of the annual monthly payment

d_4^- : underachievement of the annual maintenance fee

d_4^+ : overachievement of the annual maintenance fee

d_5^- : underachievement of the annual fuel cost

d_5^+: overachievement of the annual fuel cost

d_6^- : underachievement of the annual road tax payment

d_6^+: overachievement of the annual road tax payment

d_7^- : underachievement of the annual car insurance payment

d_7^+: overachievement of the annual car insurance payment

d_8^- : underachievement of the annual total displacement (cc)

d_8^+: overachievement of the annual total displacement (cc)

2.3.3 Goal and priority

Following are the eight goals of the car selection that have been arranged according to the importance and priority of each goal.

First Priority	(P1)	: Minimize the annual spending on the car
Second Priority	(P2)	: Minimize the car price
Third Priority	(P3)	: Minimize the annual monthly payment
Fourth Priority	(P4)	: Minimize the annual maintenance fee
Fifth Priority	(P5)	: Minimize the annual fuel cost
Sixth Priority	(P6)	: Minimize the annual road tax payment
Seventh Priority	(P7)	: Minimize the annual car insurance payment
Eighth Priority	(P8)	: Maximize the total displacement (cc)

2.3.4 Modeling constraints

There are two (2) types of constraints; namely hard constraint and soft constraint. The hard constraints are the constraints that must be fulfilled in this study. Soft constraints are the set of

constraints consisting positive deviation of overachievement, d^+ and negative deviations of underachievement, d^- . Thus, for this problem,

i. Hard Constraints

a) Annual spending on the car.

The annual spending should not exceed RM 8560.80, which is 30% from fresh graduates annual salary.

$$5868\,X_1 + 6648\,X_2 + 4644.84\,X_3 + 6024\,X_4 + 5197.08\,X_5 + 6032.64\,X_6 + 240.63\,X_1 + 213.32\,X_2 + 138.69\,X_3 + 213.32\,X_4 + 138.69\,X_5 + 138.69\,X_6 + 1138.98\,X_1 + 1166.04\,X_2 + 1225.08\,X_3 + 1180.80X_4 + 1215.24\,X_5 + 1335.78\,X_6 + 20.00\,X_1 + 70X_2 + 70X_3 + 70\,X_4 + 70\,X_5 + 90\,X_6 + 1{,}324.90\,X_1 + 1{,}468.73X_2 + 1100.60\,X_3 + 1354.13X_4 + 1202.00\,X_5 + 1387.10\,X_6 + d_1^- - d_1^+ = 8560.80$$

ii. Soft Constraints

a) The car price.

The car price should not exceed RM 40 506.17. This is an average price that is calculated based on the price of the six cars listed above.

$$41427\,X_1 + 46959\,X_2 + 32800\,X_3 + 42551\,X_4 + 36700\,X_5 + 42600\,X_6 + d_2^- - d_2^+ = 40506.17$$

b) The annual monthly payment.

The annual monthly payment must not exceed RM 5 136.48 which is 60% from the annual spending on the car.

$$5868\,X_1 + 6648\,X_2 + 4644.84\,X_3 + 6024\,X_4 + 5197.08\,X_5 + 6032.64\,X_6 + d_3^- - d_3^+ = 5136.48$$

c) The annual maintenance fee.

There is no fixed cost for a car maintenance fee. The car that has driven 20000 km were assumed to cost RM 300.

$$240.63\,X_1 + 213.32\,X_2 + 138.69\,X_3 + 213.32\,X_4 + 138.69\,X_5 + 138.69\,X_6 + d_4^- - d_4^+ = 300.00$$

d) The annual fuel cost.

The annual fuel cost should not exceed RM 1 284.12 which is 15% from the annual spending on the car,

$$1138.98\,X_1 + 1166.04\,X_2 + 1225.08\,X_3 + 1180.80\,X_4 + 1215.24\,X_5 + 1335.78\,X_6 + d_5^- - d_5^+ = 1284.12$$

e) The annual road tax payment.

The annual road tax price is quite affordable for all car users. A car with an estimated 1300cc costs RM 70 a year in Peninsular Malaysia based on a reliable website (wapcar).

$$20\,X_1 + 70\,X_2 + 70\,X_3 + 70\,X_4 + 70\,X_5 + 90\,X_6 + d_6^- - d_6^+ = 70$$

f) The annual car insurance payment.

The annual car insurance should not exceed RM 1284.12 which is 15% from the annual spending on the car.

$$1324.90\,X_1 + 1468.73\,X_2 + 1100.60\,X_3 + 1354.13\,X_4 + 1202.00\,X_5 + 1387.10\,X_6 + d_7^- - d_7^+ = 1284.12$$

g) The total displacement (cc).

The total displacement (cc) were related with the fuel mileage. Cars with total displacement of 1000cc to 1500cc will have better fuel mileage. Typically, cars with best fuel mileage had total displacement up to 1000cc.

$$998\,X_1 + 1329\,X_2 + 1332\,X_3 + 1329\,X_4 + 1332\,X_5 + 1597\,X_6 + d_8^- - d_8^+ = 1000$$

2.3.5 Objective function

The goal-programming problem is to minimize the value of the objective function subject to goal constraints.

$$\text{Minimise} \sum_{i=1}^{n} P_k \left(d_i^+ + d_i^- \right)$$

2.4 STEP 4 : Finding an optimal solution

LINGO software is used to solve the optimisation problem. The constraints are entered as shown in Figure 2.

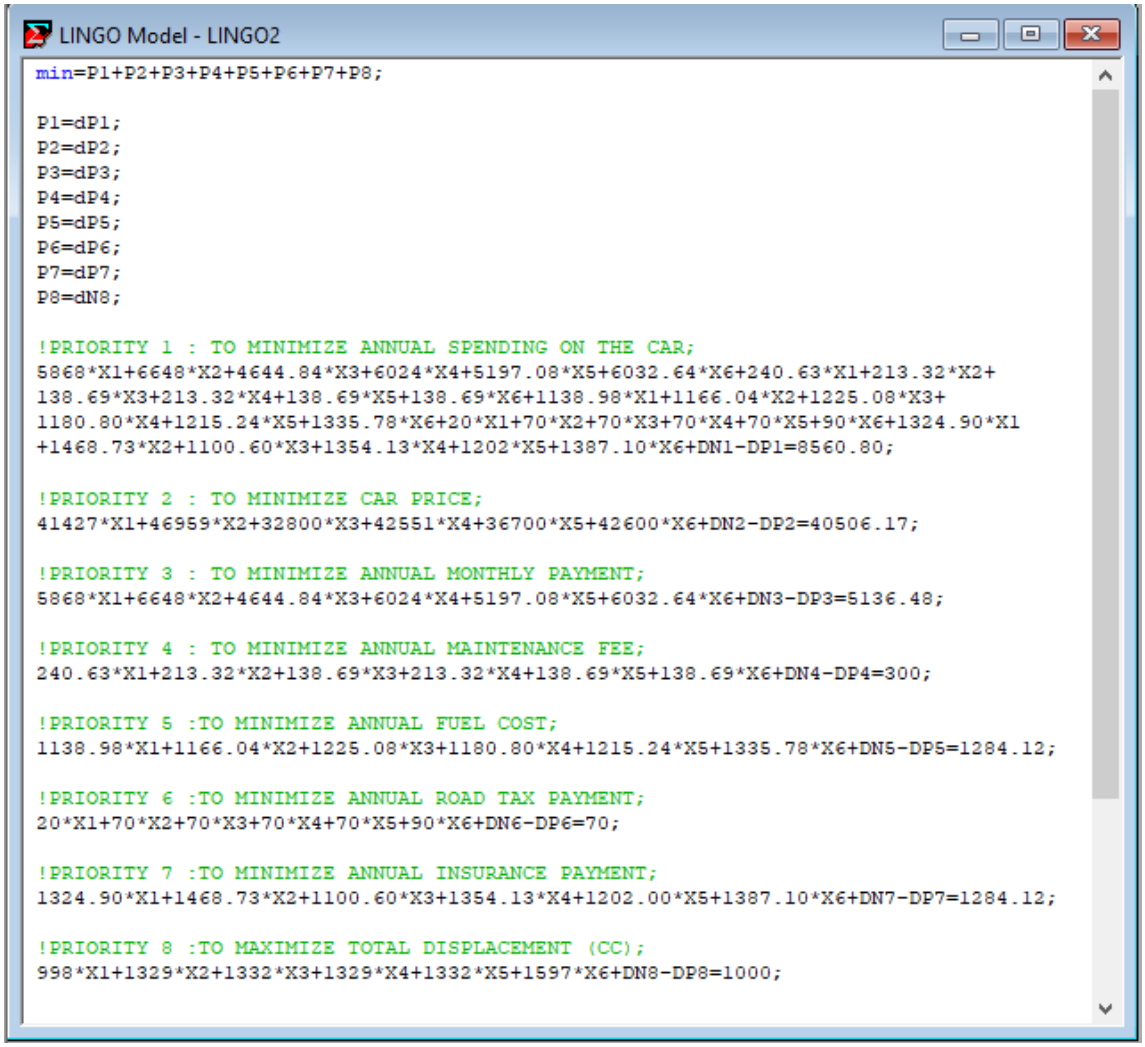
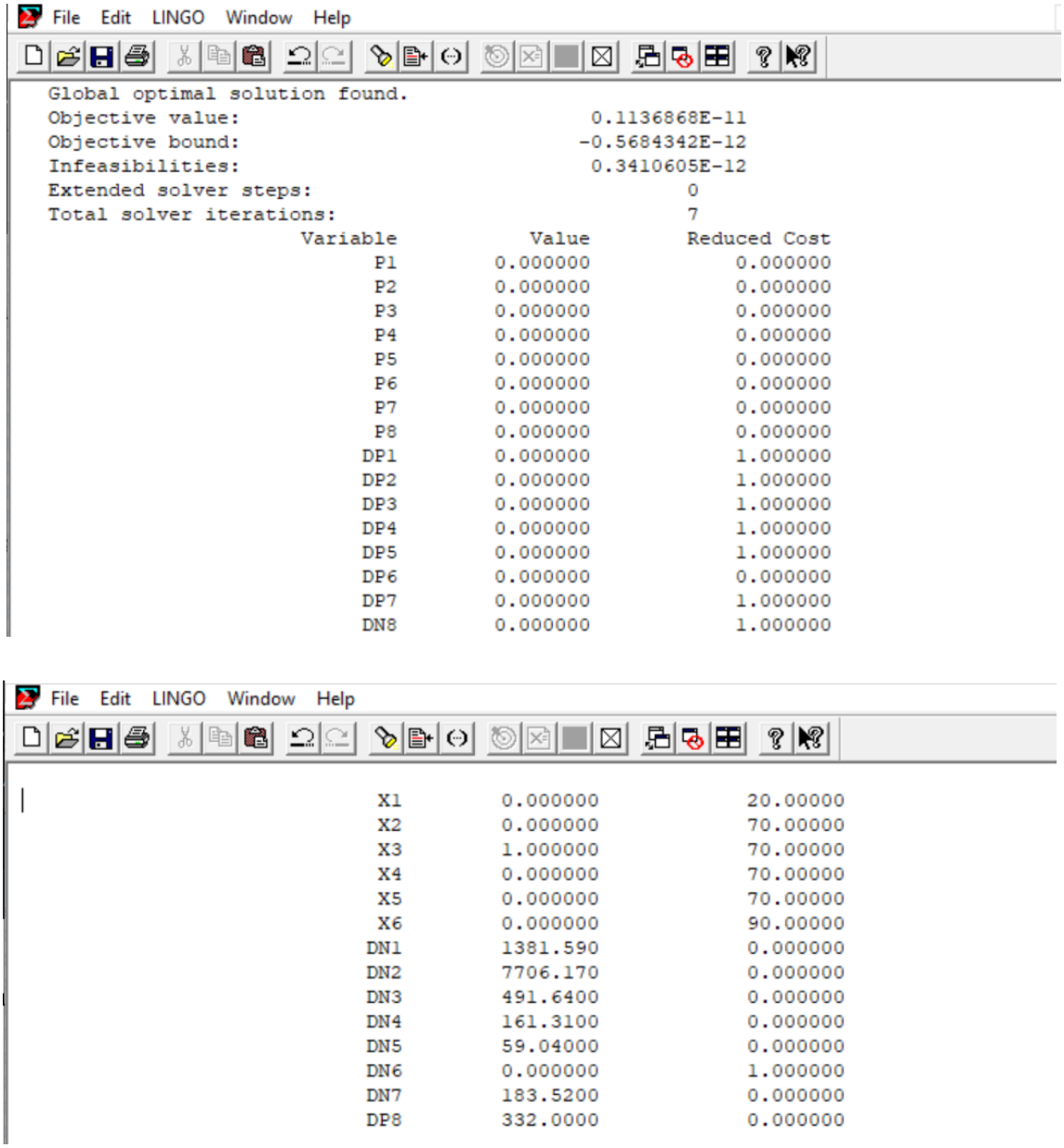


Figure 2. Objective function,Constraints and Comments.

2.5 STEP 5 : Analysis

The solutions obtained (see Figure 3) are then analysed and discussed in this phase.



File Edit LINGO Window Help

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  Global optimal solution found.
  Objective value:                              0.1136868E-11
  Objective bound:                             -0.5684342E-12
  Infeasibilities:                              0.3410605E-12
  Extended solver steps:                                    0
  Total solver iterations:                                  7
                       Variable           Value        Reduced Cost
                             P1        0.000000            0.000000
                             P2        0.000000            0.000000
                             P3        0.000000            0.000000
                             P4        0.000000            0.000000
                             P5        0.000000            0.000000
                             P6        0.000000            0.000000
                             P7        0.000000            0.000000
                             P8        0.000000            0.000000
                            DP1        0.000000            1.000000
                            DP2        0.000000            1.000000
                            DP3        0.000000            1.000000
                            DP4        0.000000            1.000000
                            DP5        0.000000            1.000000
                            DP6        0.000000            0.000000
                            DP7        0.000000            1.000000
                            DN8        0.000000            1.000000
```


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```
                             X1        0.000000            20.00000
                             X2        0.000000            70.00000
                             X3        1.000000            70.00000
                             X4        0.000000            70.00000
                             X5        0.000000            70.00000
                             X6        0.000000            90.00000
                            DN1        1381.590            0.000000
                            DN2        7706.170            0.000000
                            DN3        491.6400            0.000000
                            DN4        161.3100            0.000000
                            DN5        59.04000            0.000000
                            DN6        0.000000            1.000000
                            DN7        183.5200            0.000000
                            DP8        332.0000            0.000000
```

Figure 3. Solution Report using LINGO Software

3. Results and Discussions

Table 2 shows the value obtained for each deviational variable according to priorities that has been set up.

Table 2. Deviational Variables according to Priorities.

Priority	d_i^+	d_i^-	Goal Achievement
1	0	1381.59	Achieved
2	0	7706.17	Achieved
3	0	491.64	Achieved
4	0	163.31	Achieved
5	0	59.04	Achieved
6	0	0	Achieved
7	0	183.52	Achieved
8	332	0	Achieved

From the table above :

i. For Priority 1, the budget chosen for the annual spending was RM 8560.80, which is 30% from fresh graduates annual salary. The result shows the value for negative deviational variable is 1381.59 and the positive deviational variable is 0. Thus, the annual spending on the car selected is RM 7179.21. Even though it did not get total value of RM 8560.80, but it is achieved since it fulfills the target to not exceed RM 8560.80 for annual spending on the car.

ii. Priority 2 is to minimize the car price. The value for positive deviational variable is 0 while the value for negative deviational variable is 7706.17. Therefore, the car price was reduced to RM 32 800. Priority 2 is achieved since the car price obtained is RM 32800 and it is less than RM 40506.17.

iii. Priority 3 is to minimize the annual monthly payment. The value obtained shows that the positive deviational variable is 0 while the negative deviational variable is 491.64. The value obtained shows that RM 491.64 is reduced from the annual monthly payment. This indicates that the annual monthly payment is RM 4644.84. Thus, Priority 3 is achieved since it is preferred that the monthly payment does not exceed RM 5136.48.

iv. Priority 4 is to minimize the annual maintenance fees. The value of the positive deviational variable is 0 while the negative deviational variable is 163.31. Thus the annual maintenance fees have been reduced to RM 136.63 from RM 300. The fourth priority is achieved and the annual maintenance fee decreases to RM 161.31.

v. Priority 5 is to minimize the annual fuel cost. The annual fuel cost decrease to RM 59.04 since the negative deviational variable obtained was 59.04. Hence, the annual fuel cost is RM 1225.08. The fifth priority has been achieved since the annual fuel cost does not exceed RM 1284.12.

vi. Priority 6 is to minimize the annual road tax payment. For this priority, the value for negative deviational is 0 and the value for positive deviational is also 0. Thus, the

total annual road tax obtained is fixed at RM 70. Hence, Priority 6 is achieved since the annual road tax payment is optimum.

vii. Priority 7 is to minimize the annual car insurance payment. The annual car insurance payment is reduced to RM 183.52 since the negative deviational variable obtained is 183.52. Hence, the annual insurance payment is RM 1100.60 from RM 1284.12.The seventh priority has been achieved since the annual insurance payment does not exceed RM1284.12.

viii. Priority 8 is to maximize the total displacement. For this priority, the value for negative deviational is 0 while the value for positive deviational is 332. Hence, the total displacement increases up to 332cc. The total displacement is greater than 1000cc and this shows that Priority 8 is also achieved.

In conclusion, all priorities are achieved. Table 3 shows the aggregation result obtained from the LINGO software, which indicates the car selected is Proton Saga Standard 1.3 L.

Table 3. The Aggregation Result.

Decision Variable	**Cars**	**Value**
X_1	Axia 10 AV	0
X_2	Myvi 1.3L X (A.S.A 2.0)	0
X_3	Proton Saga Standard 1.3 L	1
X_4	Bezza 1.3 X	0
X_5	Proton Iriz 1.3 L Standard MT	0
X_6	Proton Persona 1.6 L Standard MT	0

The annual expenses of Proton Saga Standard 1.3 L, which include the annual monthly payment, the annual maintenance fees, the annual fuel cost, the annual road tax, and the annual car insurance of the car is shown in Table 4. Hence from the result obtained, the objective is achieved since the annual spending for Proton Saga Standard 1.3 L is RM 7179.21, which is less than RM 8560.80.

Table 4. Estimated Annual Expenses for Proton Saga Standard 1.3 L.

Expenses	**Price annually (RM)**
Monthly payment	4 644.84
Maintenance fee	138.69
Fuel cost	1 225.08
Road tax payment	70
Insurance payment	1 100.60
Total	7 179.21

4. Conclusions and Recommendations

4.1 Conclusions

Deciding the best car among variables of cars is a complex decision. Fresh graduates usually choose the car based on desires rather than their financial capability. Hence, this study highlighted several criteria (car features) to be considered for the car selection. Six brands of car has been chosen as the alternatives in this study. The criteria for the car selection were price of the car, annual monthly payment, annual maintenance fee, annual fuel cost, annual road tax payment, annual car insurance payment and total displacement (cc). Next, Zero-One Goal Programming (ZOGP) formulation is developed to find the best car with the optimal features by using LINGO software. The objective function consists of eight goals, which represent by eight priorities. The eight determined priorities are to minimize the annual spending on the car, the car price, the annual monthly payment, the annual maintenance fee, the annual fuel cost, the annual road tax payment, the annual car insurance payment and to maximize the total displacement. This problem is solved using LINGO. From the results obtained, the car that is most suitable for fresh graduates according to the preference criteria is Proton Saga Standard 1.3 L. ZOGP is therefore is a recommendable method to be applied for any problem involving selection.

4.2 Recommendations

In future, to make the selection process more convenience to society, it is suggested to increase the priority by considering both quantitative and qualitative criteria such as the safety and security, interior and exterior of the car. Next, the decision variables should also be increased for fair comparison. Furthermore, the software should also be developed in accordance with the state-of-the-art-technology.

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