



AN EMPIRICAL STUDY ON THE PREFERENCE OF LAPTOP IN MALAYSIA WITH ANALYTIC HIERARCHY PROCESS MODEL

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Abstract

The existing of laptop is to make human life easier as it is light and portable. However, there are varieties of laptop brands in the market nowadays. The consumers need to consider multiple factors or decision criteria before they select a suitable laptop. Analytic Hierarchy Process (AHP) model is a technique that deals with multiple criteria decision making (MCDM) problem. AHP model can help to select the best alternative based on the preference of the decision makers. The objective of this study is to determine the priority of decision criteria in the selection of laptops among the students in Malaysia with AHP model. The decision criteria identified in this study are price, speed, weight, colour, design, warranty period and technical service. In addition, this paper aims to determine the most preferred laptop among Acer, Asus, Lenovo, Toshiba, Dell and MacBook with AHP model. The results of this study show that Acer is the most preferred laptop followed by

Asus, Lenovo, Toshiba, Dell and MacBook among the students. Price, speed and warranty period are ranked as top three influential decision criteria in this study. The significance of this study is to determine the most preferred laptop as well as the most influential decision criteria in the selection of laptop among the students in Malaysia with AHP model.

Keywords: Laptop, Multi-Criteria Decision Making, Analytic Hierarchy Process, Priority, Students

1. Introduction

The existing of laptop is to make human life easier as it is light and portable [1]. The mobility of laptop enhances its wide usage [2]. Laptops have become the fundamental needs for most of the people especially officers and students because it is very useful in business as well as personal use [3]. There are varieties of laptop brands in the market nowadays. Therefore, the customers' expectation on the laptops have increased gradually [4]. Laptop is one of the electronic devices for the students because of educational purpose. They utilize it to obtain notes, books, internet access, communication, entertainment and other purposes. They need to consider multiple factors or decision criteria before selecting the most suitable laptop [5, 6]. Analytic Hierarchy Process (AHP) model is a technique that deals with multiple criteria decision making (MCDM) problem. AHP model can help to select the most appropriate alternative based on the preference of the decision makers [7].

Yeriko et al. [1] conducted a study on the preference of laptop in Manado City by using AHP model. The researchers intended to identify the most preferable laptop among the users. In their study, physical appearance, price and speed were chosen as the decision criteria in the selection of laptop. The results showed that speed was the ranked as the most important factor in the selection of laptop in Manado City. Srichetta et al. [2] applied AHP model in evaluating and selecting notebook computers. The objective of their study was to determine the significant factor in choosing the best product. The researchers found out that CPU speed was ranked as the first criteria in the selection of notebook computer. Sharma [4] performed a research on the management and engineering students to identify their favorable laptop brand. Lakshmi et al. [6] implemented one of the MCDM method which is Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) in

determining the best laptop. McMullen [8] applied Data Envelopment Analysis (DEA) in determining the efficient notebook out of 146 notebook. Mustakerov et al. [9] and Dashore et al. [10] also considered price and weight as part of the decision criteria in the selection of laptop.

AHP has been widely used in other fields such as supplier selection [11], insurance [12], pharmaceutical supply chain risk assessment [13], telehealth system [14], biomass energy [15], mobile network operators [16], fast food restaurant [17], job selection [18] and so on. The objective of this study is to determine the priority of decision criteria in the selection of laptops among the students in Malaysia with AHP model. The decision criteria identified in this study are price, speed, weight, colour, design, warranty period and technical service. In addition, this paper aims to determine the most preferred laptop among Acer, Asus, Lenovo, Toshiba, Dell and MacBook with AHP model. The next section discusses about the data and methodology used in this study. Section 3 presents the empirical results of this study and section 4 concludes the paper.

2. Material and Methods

In this study, Acer, Asus, Lenovo, Toshiba, Dell and MacBook are selected as decision alternatives. The decision criteria are price, speed, weight, colour, design, warranty period and technical service.

AHP model is widely used in determining the ranking or priority of decision alternatives and decision criteria. Basically, AHP model consists of three hierarchy levels. The top level is the main objective of the problem, which is the selection of the laptop. The second level is the decision criteria whereas the third level is the decision alternatives. Figure 1 presents AHP hierarchy structure whereas Table 1 shows the hierarchy level in this study.

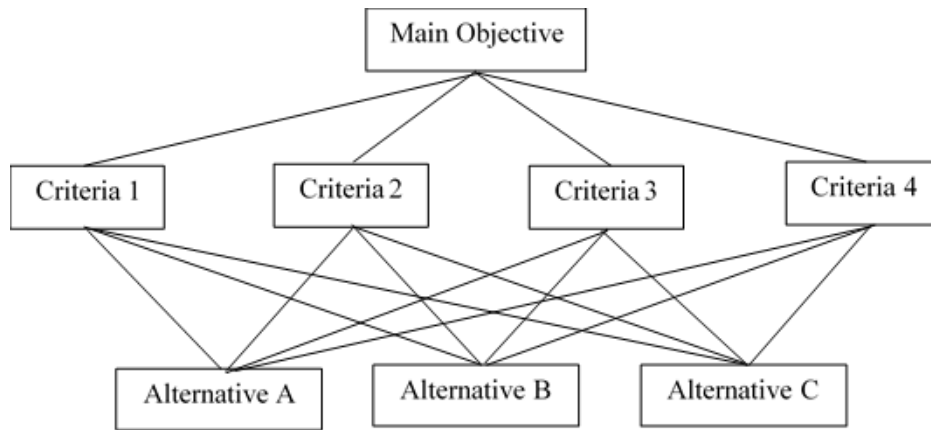


Figure 1: AHP Hierarchy Structure

Table 1: Hierarchy Level of Laptop Selection

Top Level: Main Objective	Laptop Selection
Second Level: Decision Criteria	C1: Price C2: Speed (RAM, dimension, etc) C3: Weight C4: Color C5: Design C6: Warranty Period C7: Technical Service
Third Level: Decision Alternatives	A1: Acer A2: Asus A3: Lenovo A4: Toshiba A5: Dell A6: MacBook

Data analysis for AHP model is performed in five steps as follows [18].

Step 1: Determine the main objective, decision criteria and decision alternatives for the study.

Step 2: Perform pairwise comparison for second and third level based on ratio scale introduced by Saaty [19]. Table 2 indicates the meaning for the scale of 1-9.

Table 2: Ratio Scale used for Pairwise Comparison

Scale	Definition
1	A and B are equal importance
3	A is slightly more importance than B
5	A is strongly more importance than B
7	A is very strong more importance than B
9	A is absolute more importance than B
2, 4, 6, 8	Intermediate values

Collected data will be converted into pairwise comparison matrices. There are seven decision criteria and six decision alternatives in this study. Matrix below shows the pairwise comparison matrix for the decision criteria.

$$C = \begin{bmatrix} 1.0000 & 3.1997 & 5.0098 & 5.0098 & 4.4398 & 2.7408 & 3.0202 \\ 0.3125 & 1.0000 & 4.4804 & 5.2059 & 4.2892 & 2.9912 & 3.2912 \\ 0.1996 & 0.2232 & 1.0000 & 3.1760 & 1.1123 & 0.3242 & 1.1092 \\ 0.1996 & 0.1921 & 0.3149 & 1.0000 & 0.7397 & 0.2188 & 0.4674 \\ 0.2252 & 0.2331 & 0.8991 & 1.3519 & 1.0000 & 1.3702 & 0.8697 \\ 0.3649 & 0.3343 & 3.0849 & 4.5711 & 0.7298 & 1.0000 & 1.8407 \\ 0.3311 & 0.3038 & 0.9016 & 2.1396 & 1.1498 & 0.5433 & 1.0000 \end{bmatrix} \quad (1)$$

The pairwise comparison matrices for the decision alternatives with respect to each decision criterion is shown as follows.

Price (C_1):

$$A_{C_1} = \begin{bmatrix} 1.0000 & 1.8020 & 1.5804 & 2.0698 & 2.0123 & 3.4485 \\ 0.5549 & 1.0000 & 3.0490 & 2.3977 & 2.1270 & 3.3255 \\ 0.6328 & 0.3280 & 1.0000 & 2.3007 & 1.9578 & 3.5951 \\ 0.4831 & 0.4171 & 0.4347 & 1.0000 & 2.8667 & 3.3206 \\ 0.4970 & 0.4701 & 0.5108 & 0.3488 & 1.0000 & 3.0490 \\ 0.2900 & 0.3007 & 0.2782 & 0.3012 & 0.3280 & 1.0000 \end{bmatrix} \quad (2)$$

Speed (C_2):

$$AC_2 = \begin{bmatrix} 1.0000 & 2.2486 & 2.1294 & 1.9480 & 1.3422 & 0.7906 \\ 0.4447 & 1.0000 & 3.4235 & 2.8961 & 1.8726 & 1.7929 \\ 0.4696 & 0.2921 & 1.0000 & 1.6412 & 1.5393 & 1.4568 \\ 0.5133 & 0.3453 & 0.6093 & 1.0000 & 1.6452 & 1.6571 \\ 0.7451 & 0.5340 & 0.6497 & 0.6078 & 1.0000 & 1.2891 \\ 1.2649 & 0.5578 & 0.6864 & 0.6035 & 0.7757 & 1.0000 \end{bmatrix} \quad (3)$$

Weight (C_3):

$$AC_3 = \begin{bmatrix} 1.0000 & 2.3059 & 1.7255 & 2.4515 & 1.7892 & 1.7721 \\ 0.4337 & 1.0000 & 2.1196 & 2.5245 & 1.7294 & 1.0165 \\ 0.5795 & 0.4718 & 1.0000 & 2.7745 & 1.7162 & 1.2429 \\ 0.4079 & 0.3961 & 0.3604 & 1.0000 & 1.6329 & 1.2697 \\ 0.5589 & 0.5782 & 0.5827 & 0.6124 & 1.0000 & 0.9222 \\ 0.5643 & 0.9838 & 0.8046 & 0.7876 & 1.0843 & 1.0000 \end{bmatrix} \quad (4)$$

Colour (C_4):

$$AC_4 = \begin{bmatrix} 1.0000 & 1.2584 & 2.0515 & 2.0419 & 1.1319 & 0.6464 \\ 0.7947 & 1.0000 & 3.6261 & 3.3824 & 2.3162 & 2.1378 \\ 0.4875 & 0.2758 & 1.0000 & 1.3520 & 1.0794 & 0.9100 \\ 0.4897 & 0.2957 & 0.7397 & 1.0000 & 1.4324 & 1.1566 \\ 0.8834 & 0.4317 & 0.9264 & 0.6982 & 1.0000 & 1.3276 \\ 1.5470 & 0.4678 & 1.0989 & 0.8646 & 0.7532 & 1.0000 \end{bmatrix} \quad (5)$$

Design (C_5):

$$AC_5 = \begin{bmatrix} 1.0000 & 1.2280 & 1.5206 & 1.3653 & 1.5207 & 0.3892 \\ 0.8143 & 1.0000 & 2.5711 & 3.0245 & 1.6300 & 0.5268 \\ 0.6576 & 0.3889 & 1.0000 & 1.8604 & 1.3966 & 1.0697 \\ 0.7325 & 0.3306 & 0.5375 & 1.0000 & 1.3147 & 0.9425 \\ 0.6576 & 0.6135 & 0.7160 & 0.7606 & 1.0000 & 0.8882 \\ 2.5696 & 1.8984 & 0.9349 & 1.0611 & 1.1259 & 1.0000 \end{bmatrix} \quad (6)$$

Warranty period (C_6):

$$AC_6 = \begin{bmatrix} 1.0000 & 1.9892 & 2.2961 & 1.3843 & 0.9763 & 0.6912 \\ 0.5027 & 1.0000 & 2.0853 & 1.5725 & 1.2496 & 1.0503 \\ 0.4355 & 0.4795 & 1.0000 & 1.0624 & 1.2261 & 0.8420 \\ 0.7224 & 0.6359 & 0.9412 & 1.0000 & 1.5044 & 1.1278 \\ 1.0243 & 0.8003 & 0.8156 & 0.6647 & 1.0000 & 1.1874 \\ 1.4467 & 0.9521 & 1.1876 & 0.8867 & 0.8422 & 1.0000 \end{bmatrix} \quad (7)$$

Technical service (C_7):

$$A_{C_7} = \begin{bmatrix} 1.0000 & 1.8843 & 2.2388 & 1.4843 & 0.6057 & 0.4720 \\ 0.5307 & 1.0000 & 2.1863 & 1.9054 & 1.0018 & 0.6863 \\ 0.4467 & 0.4574 & 1.0000 & 0.9485 & 0.9935 & 0.5439 \\ 0.6737 & 0.5248 & 1.0543 & 1.0000 & 0.8522 & 0.8267 \\ 1.6510 & 0.9982 & 1.0065 & 1.1734 & 1.0000 & 1.4383 \\ 2.1185 & 1.4570 & 1.8387 & 1.2097 & 0.6953 & 1.0000 \end{bmatrix} \quad (8)$$

Step 3: All pairwise comparison matrices above will be converted into normalized matrices through normalization method to calculate the weights and ranking for the decision criteria and decision alternatives. Each element in the column will be divided by column's sum to form the normalized matrix. Average of the row in the normalized matrix will represent the weights of the decision criteria or decision alternatives. w^T indicates weight score for decision criteria whereas Q indicates the combination matrix of weight score of decision alternatives with respect to each decision criterion.

Step 4: The overall weights for the decision alternatives in matrix \mathbf{F} is computed as follows.

$$\mathbf{F} = \mathbf{Q} \times \mathbf{w}^T \quad (9)$$

Highest weights in matrix \mathbf{F} indicates that the particular decision alternative gives the highest ranking.

Step 5: Consistency ratio (CR) is used to check for consistency in pairwise comparison matrix [20]. The formula for CR is shown as follows.

$$CR = \frac{CI}{RI} \quad (10)$$

where Consistency Index (CI) is

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (11)$$

and

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{i=n} \frac{i^{\text{th}} \text{ entry in } A \mathbf{w}^T}{i^{\text{th}} \text{ entry in } \mathbf{w}^T} \quad (12)$$

Table 3 shows the Random Index (RI) with respect to the number of decision criteria [21].

Table 3: Random Index

n	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If $CR \leq 0.10$, the result is consistent and acceptable.

3. Results and Discussions

Figure 2 shows the weights or priority of all decision criteria in the selection of laptop among the students.

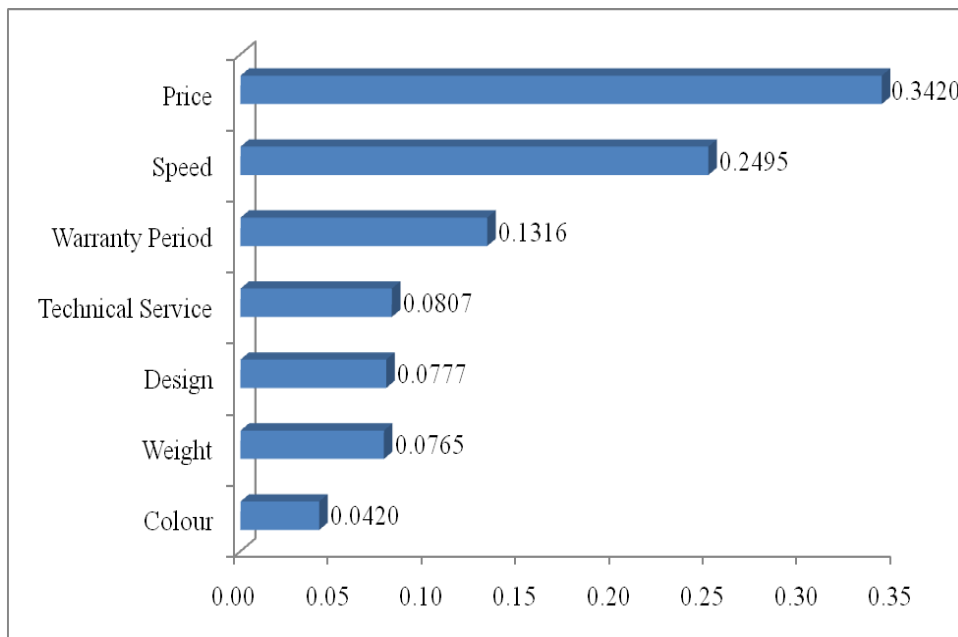


Figure 2: Weights for Decision Criteria in the Selection of Laptop

As shown in Figure 2, price (0.3420) is the most considerable factor or decision criteria for the students in the selection of laptop. Speed (0.2495) is ranked as the second most important factor followed by warranty period (0.1316), technical service (0.0807), design (0.0777), weight (0.0765) and lastly color (0.0420). The results show that price, speed and warranty period are the top three most influential criteria in the selection of laptop among the students. Figure 3 to Figure 9 illustrate the priority of decision alternatives with respect to each decision criterion. Higher weight score denotes higher priority.

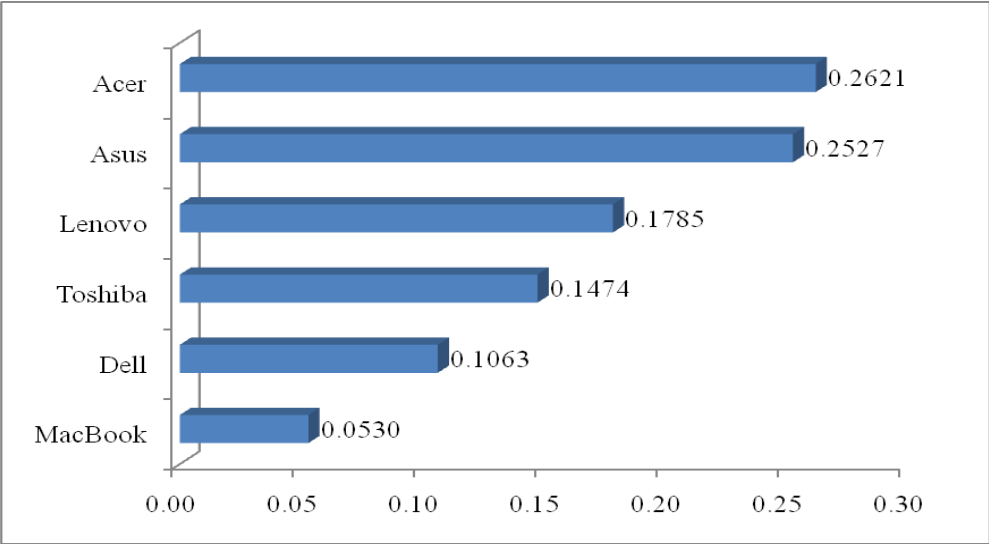


Figure 3: Priority of Laptop based on Price

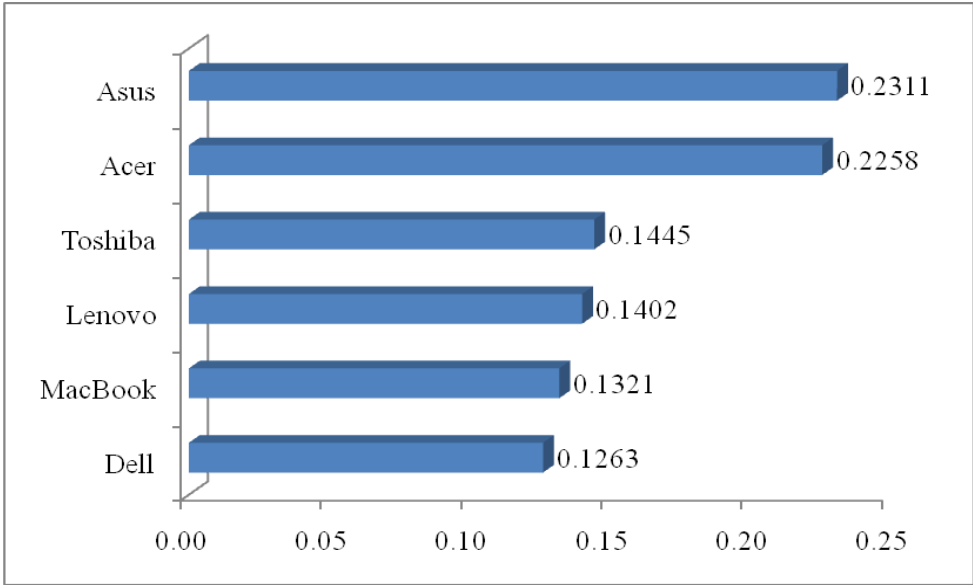


Figure 4: Priority of Laptop based on Speed

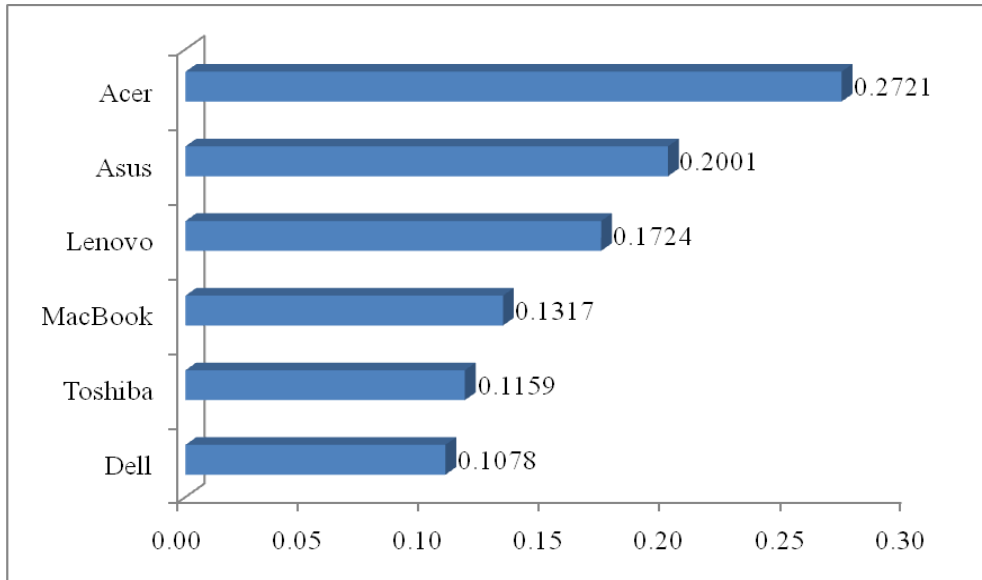


Figure 5: Priority of Laptop based on Weight

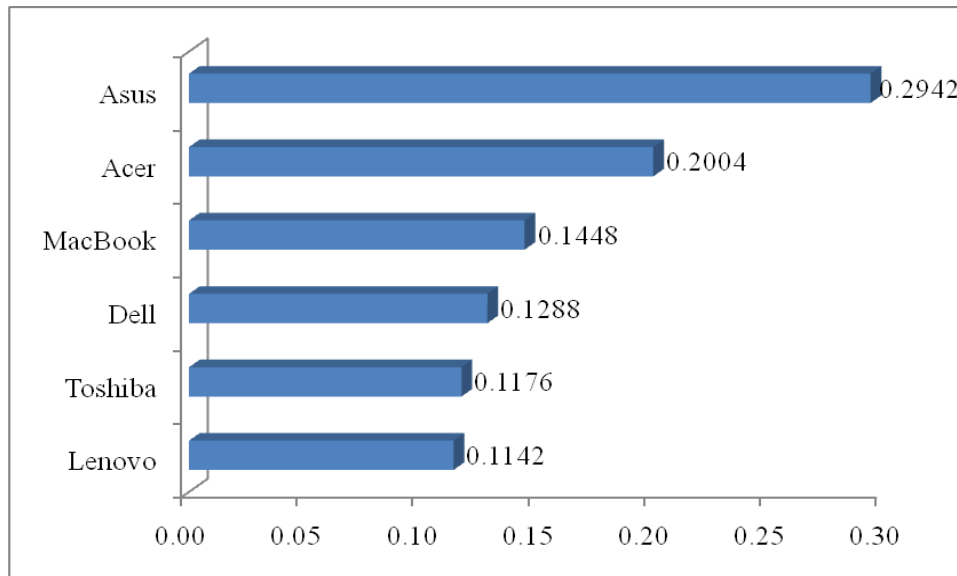


Figure 6: Priority of Laptop based on Colour

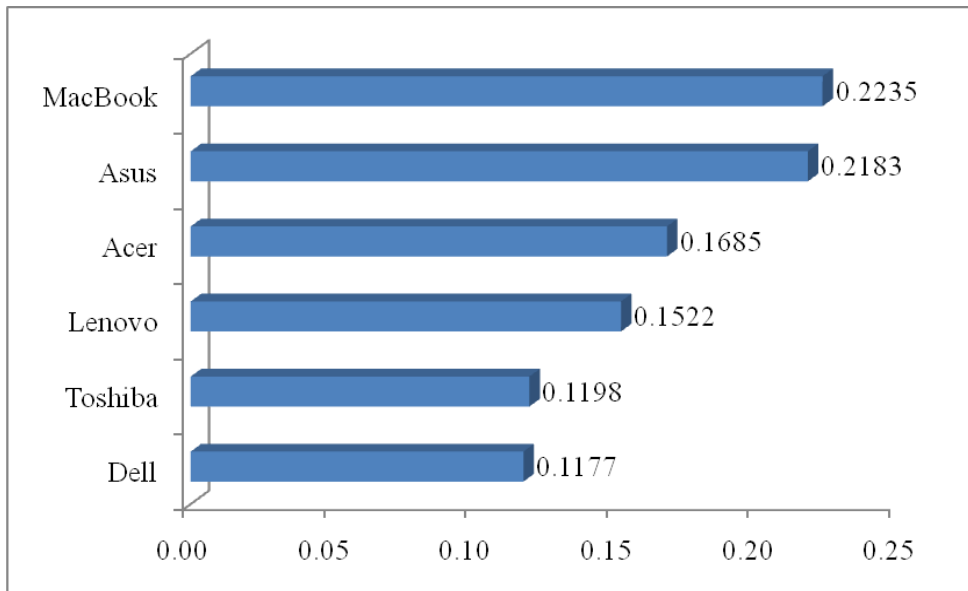


Figure 7: Priority of Laptop based on Design

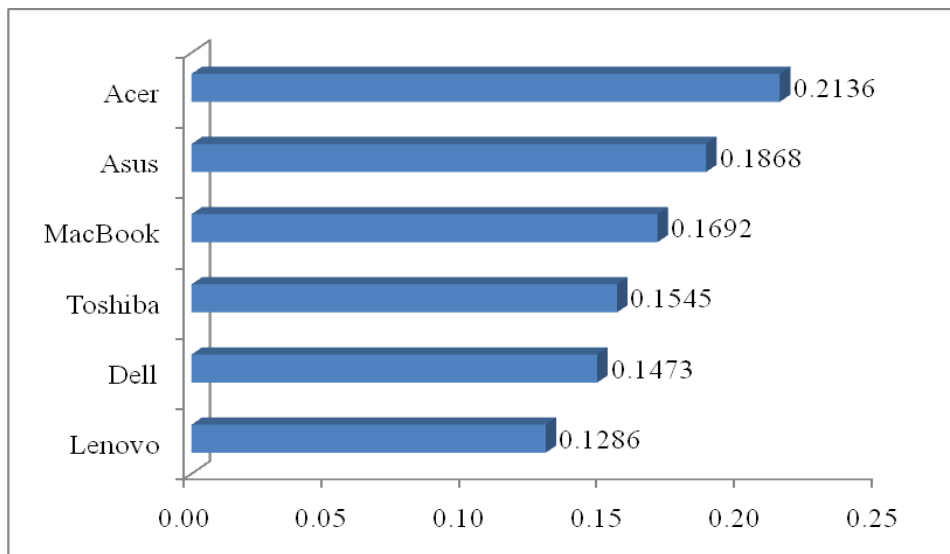


Figure 8: Priority of Laptop based on Warranty Period

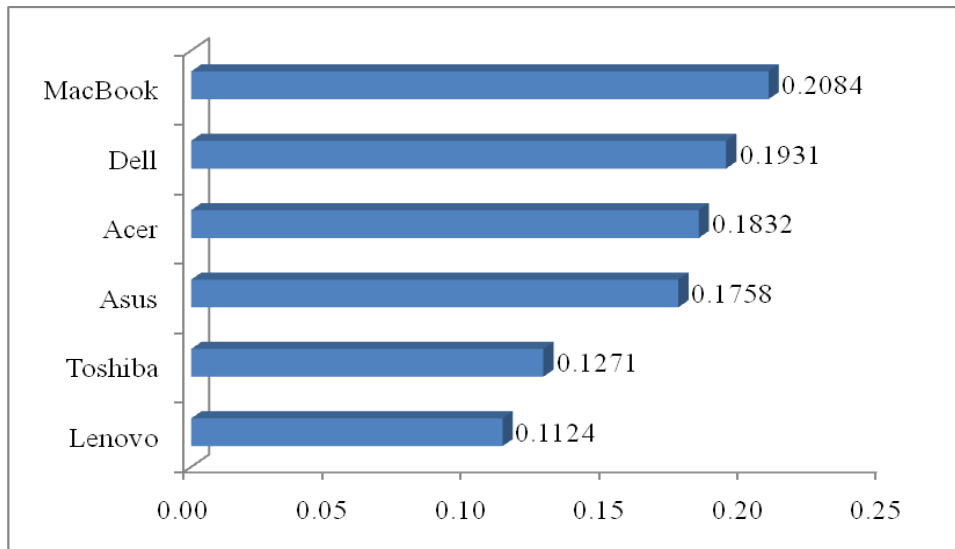


Figure 9: Priority of Laptop based on Technical Service

As shown from Figure 3 to Figure 9, Acer is ranked as the highest priority in terms of price, weight and warranty period. Asus obtains the first ranking among the laptops in terms of speed and color. For MacBook, it is ranked as the first priority under design and technical service. However, MacBook is ranked at the lowest in terms of price. On the other hand, Dell and Lenovo obtain the lowest ranking for few criteria. Dell is ranked as the lowest in terms of speed, weight and design. For Lenovo, it gives the lowest ranking in terms of color, warranty period and technical service.

Figure 10 presents the overall weights or priority in the selection of laptop among the students in this study.

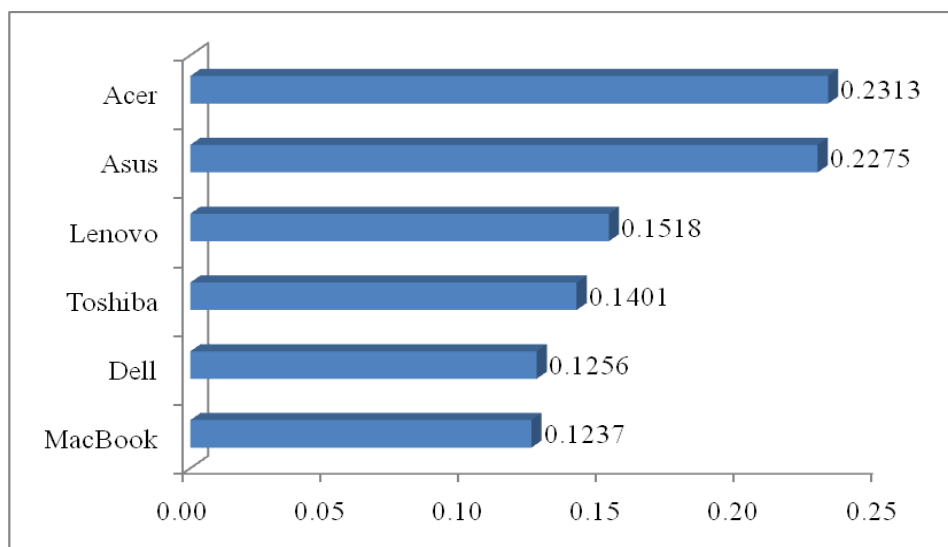


Figure 10: Overall Weights in the Selection of Laptop

Based on Figure 10, the results show that Acer (0.2313) is the most preferred laptop among the students with respect to all decision criteria which are price, speed, weight, colour, design, warranty period and technical service. The preference of laptop is followed by Asus (0.2275), Lenovo (0.1518), Toshiba (0.1401), Dell (0.1256) and finally MacBook (0.1237). In this study, the overall consistency ratio is 0.0594 which is below 0.10. This implies that the pairwise comparison matrix does not show inconsistency problem. Therefore, the results obtained in this study with AHP model are acceptable and reliable.

4. Conclusions

This paper aims to determine the priority of decision criteria in the selection of laptop among the students in Malaysia with AHP model. The decision criteria identified in this study are price, speed, weight, colour, design, warranty period and technical service. Besides that, this paper aims to determine the most preferred laptop among Acer, Asus, Lenovo, Toshiba, Dell and MacBook with AHP model. The results of this study show that Acer is the most preferred laptop followed by Asus, Lenovo, Toshiba, Dell and finally MacBook. Price, speed and warranty period are ranked as the top three influential decision criteria by the students in this study. The significance of this paper is to determine the most preferred laptop as well as the most influential decision criteria in the selection of laptop by the students with AHP model. Moreover, this study also helps other less favourable laptops such as Dell and MacBook to identify the potential improvements based on the most influential decision criteria.

References

- [1] Tampi, Y.A.N., Pangemanan, S.S. and Tumewu, F.J., 2016. Consumer decision making in selecting laptop using Analytical Hierarchy Process (AHP) method. *Jurnal EMBA*, 4(1): 316-322.
- [2] Srichetta, P. and Thurachon, W., 2012. Applying fuzzy analytic hierarchy process to evaluate and select product of notebook computers. *International Journal of Modeling and Optimization*, 2(2): 168-173.
- [3] Kecek, G. and Demirağ, 2016. A comparative analysis of TOPSIS and MOORA in laptop selection. *Research on Humanities and Social Sciences*, 6(14): 1-9.

- [4] Sharma, P., 2012. A study of brand choice of laptops by management and engineering students. *International Refereed Research Journal*, 3(4): 50-57.
- [5] Rayhan, D.S.A., 2016. Selection of best laptop for educational purpose by using ANP. *World Journal of Social Sciences*, 6(2): 167-181.
- [6] Lakshmi, T.M., Venkatesan, V.P. and Martin, A., 2015. Identification of a better laptop with conflicting criteria using TOPSIS. *I.J. Information Engineering and Electronic Business*, 6: 28-36.
- [7] Saaty, T. L., 1980. *The Analytic Hierarchy Process*. New York, McGraw-Hill.
- [8] McMullen, P.R., 2000. Selection of notebook personal computers using Data Envelopment Analysis. *The Southern Business and Economic Journal*, 23(3): 200-214.
- [9] Mustakerov, I., Borissova, D. and Bantutov, E., 2012. Multiple-choice decision making by multicriteria combinatorial optimization. *Advanced Modeling and Optimization*, 14(3): 729-737.
- [10] Dashore, K., Pawar, S.S., Sohani, N. and Verma, D.S., 2013. Product evaluation using entropy and multi criteria decision making methods. *International Journal of Engineering Trends and Technology*, 4(5): 2183-2187.
- [11] Akarte, M. M., et al., 2001. Web based casting supplier evaluation using analytic hierarchy process. *Journal of the Operational Research Society*, 52(5): 511-522.
- [12] Khan, M., Bharathi, S.V. and Londhe, B.R., 2015. Ranking the critical buying factors of private health insurance using analytic hierarchy process. *Indian Journal of Science and Technology*, 8(S6): 35-42.
- [13] Jaberidoost, M., Olfat, L., Hosseini, A., Kebriaeezadeh, A., Abdollahi, M., Alaeddini, M. and Dinarvand, R., 2015. Pharmaceutical supply chain risk assessment in Iran using Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods. *Journal of Pharmaceutical Policy and Practice*, 8(1), p.9.
- [14] Cancela, J., Fico, G. and Waldmeyer, M.T.A., 2015. Using the Analytic Hierarchy Process (AHP) to understand the most important factors to design and evaluate a telehealth system for parkinson's disease. *BMC Med Inform Decis Mak*, 15(Suppl 3), p.S7.
- [15] Yadav, S., Srivatava, A.K. and Singh, R.S., 2015. Selection and ranking of multifaceted criteria for the prioritization of most appropriate biomass energy sources for the production of renewable energy in Indian perspective using Analytic Hierarchy Process. *International Journal of Engineering Technology Science and Research*, 2: 89-98.

- [16] Lam, W.S., Leong, W.B. and Lam, W.H., 2015. Selection of mobile network operator based on multi-criteria decision making model using Analytic Hierarchy Process. *Mathematics and Statistics Journal*, 1(1): 12-18.
- [17] Lam, W. S., Chen, J. W. and Lam, W. H., 2016. An empirical study on the selection of fast food restaurants among the undergraduates with AHP model. *American Journal of Information Science and Computer Engineering*, 2(3): 15-21.
- [18] Lam, W. S., Lee, W. K. and Lam, W. H., 2015. Multi-criteria decision making in job selection problem using Analytic Hierarchy Process model. *Mathematics and Statistics Journal*, 1(2): 3-7.
- [19] Winston, W. L., 2004. *Operations research and algorithms*. Belmont, Brooks/Cole.
- [20] Saaty, T.L., 2008. Decision making with the Analytic Hierarchy Process. *Int. J. Services Sciences*, 1(1): 83-98.
- [21] Saaty, T. L., 1980. *The Analytic Hierarchy Process*. New York, McGraw-Hill.