RESEARCH ARTICLE | OCTOBER 09 2023

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AIP Conf. Proc. 2510, 030001 (2023)
https://doi.org/10.1063/5.0128324

The Selection Process for the Brand Rating of Convertible and Hybrid Laptop With MCDM-AHP Method Recommendations

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Abstract. Assessment of a technology product is seen from the performance criteria for its use over a period of one year. Especially for laptop products with the convertible and hybrid categories, it means that one laptop has two functions directly. The purpose of this study was to select the best Brand Rating of Convertible and Hybrid Laptop category in 2019. The method to be used to provide the best assessment is MCDM-AHP with a hierarchical model with four levels that are uniquely related to determine the optimal eigenvector value. The results obtained through a mathematically algebra matrices will be compared with the truth through the Expert Choice Application and provide identical values. The result is that the HP EliteBook x360 ranks first for Brand Rating of Convertible and hybrid laptops.

INTRODUCTION

At the end of 2019, the level of competition for laptops is very decisive. Many users want to know the clarity of the Brand Rating level, especially in the laptop field with Convertible and Hybrid criteria. From a number of Brand Ratings, laptops compete with each other to show the laptop performance of each Brand Rating. Competing with each other to become a product destination in the Convertible and Hybrid laptop class. It is indeed very difficult to evaluate [1] which laptop is selected as the leader of the product as the goal of selecting and evaluating Convertible and Hybrid laptops, because each product has its own advantages. The criteria for assessment are broken down into several sub-criteria [2], [3], [4].

The second level criteria used are five criteria, namely 1) Display and Audio, 2) Technical Support, 3) Value and Selection, 4) Media Input, and 5) Design, while the derivatives of the Display and Audio Sub-criteria are divided into four parts, namely Pixels, Sound, Shiney, and Graphics. The Technical Support sub-criteria are divided into five parts, namely Data transfer, Communication, Connector, Performance, and Memory. Value and selection sub-criteria are divided into three parts, namely Reliable, Object, and Part. Sub-criteria for Input Media are divided into four parts, namely Bearing, Process, Touchpad, and Size. The design sub-criteria are divided into four parts, namely Arrangement, Extrinsic value, Model, and Color.

At the alternative level, there are four product brands from Convertible and hybrid laptops, namely 1) HP Ellite Book x360 1030 G3, 2) DELL XP S 13, 3) ASUS Vivo Book Pro 17 and 4) Lenovo Yoga C 930.

The 3rd International Conference on Computer, Science, Engineering and Technology (ICComSET 2020)
AIP Conf. Proc. 2510, 030001-1–030001-8; https://doi.org/10.1063/5.0128324
Published by AIP Publishing. 978-0-7354-4677-9/$30.00

Based on the understanding of the number of criteria and their derivatives so that it is very complicated to use [5], [6], [7], the Multi-criteria concept becomes the basis for problem solving and is derived into a hierarchical concept using the Analytic Hierarchy Process (AHP) [8], [9], [10]. The distribution of the criteria derived becomes very complicated to determine decision making in determining the ranking [11] of Laptop Brand Rating on the positioning of Two in One Convertible and Hybrid Laptops at the end of 2019. With this complexity it is unique to be solved by the MCDM-AHP method [12], [13], [14].

The concept of the AHP method is built using iteration techniques for each level of solution [15], with the aim of finding the optimal eigenvector value [9] at each hierarchy level and unifying the values that have been obtained using mathematically algebra matrices based on optimal eigenvector [11], to become a unitary decision making, so that said to be The Unique AHP. The results of the calculations will be compared using the Expert Choice application software. The values obtained using mathematically algebra matrices provide similarities to those obtained using the Expert Choice application. This method is a very long way to prove, because the whole hierarchy will be tested one by one, starting from the criteria, sub-criteria, so that each alternative must be calculated using mathematically algebra matrices very carefully and patiently [2], even. should be compared again with the application of expert choice against the results obtained through mathematically algebra matrices.

METHODS

In this section, we will explain conceptually which is a brief description of understanding to build further development of the discussion. Some theoretical concepts that need to be conveyed are:

Multi-criteria Decision Making (MCDM).

The application of selection and evaluation using many criteria, more perfect can be done by using the multi-criteria decision making (MCDM) method [14] which is applied by decomposing into smaller parts so that it is easy to solve the problem [16]. For each level of criteria and sub-criteria is the result of a decomposition into a simpler hierarchy, this is done to make it easier to solve complex problems to become simpler [17], [18]. Many methods are based on MCDM such as SAW [19], TOPSIS [20], SMART, PROMETHEE [21], ELECTRE [7], VIKOR [22], and MOORA [23]. These methods are all applications of MCDM. The MCDM method is specifically used for unique problems which are simplified through a decomposition process into simple parts so that it is easy to solve problems [11].

Analytic Hierarchy Process(AHP).

Analytic Hierarchy Process (AHP) is a multi-criteria modeling outlined in the form of a hierarchy that provides a detailed and structured description of optimal and logical eigenvector value integration to provide a ranking of all aspects of the problem from complex to simple problems [24]. Problems with a hierarchical model can solve various problems [25], both quantitative, qualitative, or problems that are a combination of qualitative and quantitative. This modeling is known as AHP. Some of the stages in using AHP are: 1) building a modeling hierarchy, 2) arranging pairwise matrices, 3) testing the consistency according to the order on the random index, 4) Synthesis, and 5) determining the optimal decision [26]. The number of comparisons used can be measured by how many criteria and alternatives are used [2], this problem can be determined by the number of comparisons contained in (equation-1).

$$C = \frac{n*(n-1)}{2} \quad (1)$$

Number of comparisons C is an illustration of how many comparisons n must be arranged into two-dimensional pairwise matrices, if the expert choice application uses the upper triangle matrices as entry. This is an illustration for data element fields used using mathematical algebra matrices and expert choice applications. The pairwise matrices depicted can be seen in (Equation-2).

$$M = \begin{bmatrix} x_{(1,1)} & x_{(1,2)} & x_{(1,3)} & \cdots & x_{(1,q)} \\ x_{(2,1)} & x_{(2,2)} & x_{(2,3)} & \cdots & x_{(2,q)} \\ x_{(3.1)} & x_{(3,2)} & x_{(2,4)} & \cdots & x_{(3,q)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{(p,1)} & x_{(p,2)} & x_{(p,3)} & \cdots & x_{(p,q)} \end{bmatrix} \quad (2)$$

The calculation process is carried out by mathematically algebra matrices to get the optimal eigenvector value. In the process, to get the optimal eigenvector value, you have to do several iteration, this is the uniqueness of the MCDM-AHP method. The point is to determine the optimal decision, you must eliminate the value of the difference between the eigenvector and the iteration process that occurs between the last eigenvector and the previous eigenvector. this is what is called the iteration way, and if there is no difference found in the subsequent calculation of the eigenvector reduction, then the last eigenvector value is known as the optimal eigenvector.

The process of calculating the final eigenvector acquisition must be carried out thoroughly both at the criteria, sub-criteria, and alternative levels. Each eigenvector value that has been obtained at each level of the hierarchy will be unified through the addition process with the aim of determining the rank of each alternative that is the selection process for Convertible and hybrid and laptops. This stage of the process requires a formulation to be used, such as calculating the value of the λ max vector length obtained from the optimal eigenvector results with pairwise matrix formation for the first time, this is a depiction of the accumulative accumulation of eigenvectors. The next process is looking for the CI Consistency Index value by paying attention to (equation-3), to find the CI value, a Random Index (RI) table is needed (Table-1) and finally determines the Consistency Ratio CR which is used as a reference for each level. botch of criteria, sub-criteria, and alternative levels with attention (Equation-4). This is what is meant by the application of the AHP method to determine the ranking of a solution to a problem that is composed in advance in order to make it easier to solve problems from complex problems to simpler ones by giving the optimal eigenvector for each hierarchy level.

$$\mathrm{CI} = \frac{(\lambda\ \mathrm{max} - \mathrm{n})}{(\mathrm{n}-1)} \quad (3)$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{CR}} \quad (4)$$

The value of the random index RI is very decisive in determining the value of the Consistency Ratio (CR) which is adjusted to the number of orders contained in the matrices both in criteria and in alternatives, pay attention (Table-1).

TABLE 1. Random index

Ordo	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.48

The calculation process with AHP has its own uniqueness, where each calculation to determine the optimal eigenvector value must be repeated several times, this will continue to be done if the difference between the last eigenvector and the previous eigenvector values still has a difference. If the iteration process will be stop if the difference between the eigenvector is not found again or is zero.

IMPLEMENTATION AND RESULT

The AHP model hierarchy is an overall picture of the structuring of problems which are decomposed in an orderly manner according to each level. Convertible and hybrid laptop brand rating 2019 is a process of selecting laptop products with a modeling hierarchy consisting of four hierarchy levels, where the criteria are broken down into several sections of criteria, sub-criteria, and alternatives, pay attention (Figure-1) which is the problem to be raised in determining the ranking of Convertible and hybrid laptop brand rating and will be discussed in detail and the results obtained will be proven using the concept of mathematically algebra matrices with expert choices application.

Starting from the Criteria to prove whether the eigenvector Criteria value is optimal and can be said to be acceptable, it is necessary to test it by looking for the λ max, Consistency Index (CI), and Consistency Ratio (CR) to find the optimal eigenvector, pay attention (Table-2). Where this value can

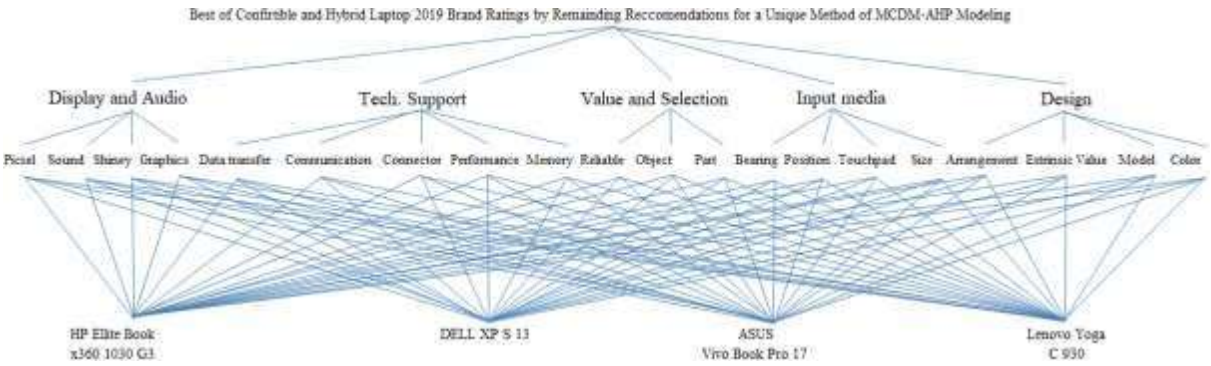


FIGURE 1. Hierarchy model of Convertible and hybrid laptop.

Starting from the Criteria to prove whether the eigenvector Criteria value is optimal and can be said to be acceptable, it is necessary to test it by looking for the λ max, Consistency Index (CI), and Consistency Ratio (CR) to find the optimal eigenvector, pay attention (Table-2). Where this value can be said to be acceptable if CR≤ 0.1; it is said to be feasible if the eigenvector criterion value gives a value in accordance with the expectation, all the calculation matrices by taking the three digits behind the comma. This is known as the level of accuracy in calculating the matrices. Selanjutnya dilanjutkan dengan lima Sub-criteria lainnya yaitu Display and Audio in (Tabel-3), Tech. Support in (Table-4), Value and Selection in (Table-5), Input Media (Table-6), dan Design in (Table-7).

TABLE 2. Pairwise matrices of Criteria and Consistency

Criteria	DA	TS	VS	IM	DS	Eigenvector
Display and Audio	1.000	2.896	2.126	2.579	1.993	0.370
Tech. Support	0.345	1.000	1.919	1.542	2.064	0.212
Value and Selection	0.470	0.521	1.000	1.600	1.259	0.158
Input Media	0.388	0.649	0.625	1.000	1.930	0.144
Design	0.502	0.485	0.794	0.518	1.000	0.116
	λ max =	5.198				
	Consistency Index =	0.050				
	Consistency Ratio =	0.044	CR<0.1 (Acceptable)			

TABLE 3. Pairwise matrices of Sub-criteria of "Display and Audio" and Consistency

SC-Display and Audio	PI	SO	SH	GR	Eigenvector
Picxel	1.000	1.659	2.075	2.240	0.384
Soud	0.603	1.000	1.870	2.388	0.294
Shiney	0.482	0.535	1.000	1.914	0.193
Graphics	0.446	0.419	0.523	1.000	0.129
	λ max =	4.061			
	Consistency Index =	0.020			
	Consistency Ratio =	0.023	CR<0.1 (Acceptable)		

TABLE 4. Pairwise matrices of Sub-criteria of Tech. Support and Consistency

SC-Tech. Support	DT	CM	CN	PE	ME	Eigenvector
Data Transfer	1.000	2.243	1.487	1.747	2.100	0.318
Communication	0.446	1.000	1.353	1.039	1.203	0.183
Connector	0.673	0.739	1.000	1.172	1.289	0.182
Performance	0.573	0.963	0.853	1.000	1.432	0.177
Memory	0.476	0.831	0.776	0.698	1.000	0.140
	λ max =	5.045				
	Consistency Index =	0.011				
	Consistency Ratio =	0.010	CR<0.1 (Acceptable)			

TABLE 5. Pairwise matrices of Sub-criteria of "Value and Selection" and Consistency

SC-Value and Selection	RE	OB	PA	Eigenvector
Reliable	1.000	1.889	1.104	0.419
Object	0.529	1.000	1.264	0.287
Part	0.906	0.791	1.000	0.294
	λ max =	3.066		
	Consistency Index =	0.033		
	Consistency Ratio =	0.057	CR<0.1 (Acceptable)	

TABLE 6. Pairwise matrices of Sub-criteria of Input Media and Consistency

K-Display and Audio	BE	PO	TO	SI	Eigenvector
Bearing	1.000	2.116	1.979	1.116	0.359
Position	0.473	1.000	1.015	1.023	0.201
Tauchpad	0.505	0.986	1.000	1.329	0.219
Size	0.896	0.977	0.753	1.000	0.222
	λ max =	4.080			
	Consistency Index =	0.027			
	Consistency Ratio =	0.029	CR<0.1 (Acceptable)		

TABLE 7. Pairwise matrices of Sub-criteria of Input Media and Consistency

K-Input Media	AR	EX	MO	CO	Eigenvector
Arrangement	1.000	1.996	1.304	1.289	0.335
Extrinsic Value	0.501	1.000	1.365	1.727	0.255
Model	0.767	0.733	1.000	1.490	0.229
Color	0.776	0.579	0.671	1.000	0.181
	λ max =	4.108			
	Consistency Index =	0.036			
	Consistency Ratio =	0.040			

For the continuation of the process it was implemented using the Expert Choice Application from the entire hierarchy which gave the same results to the Optimal Eigenvector, which is shown in (Figure-2).

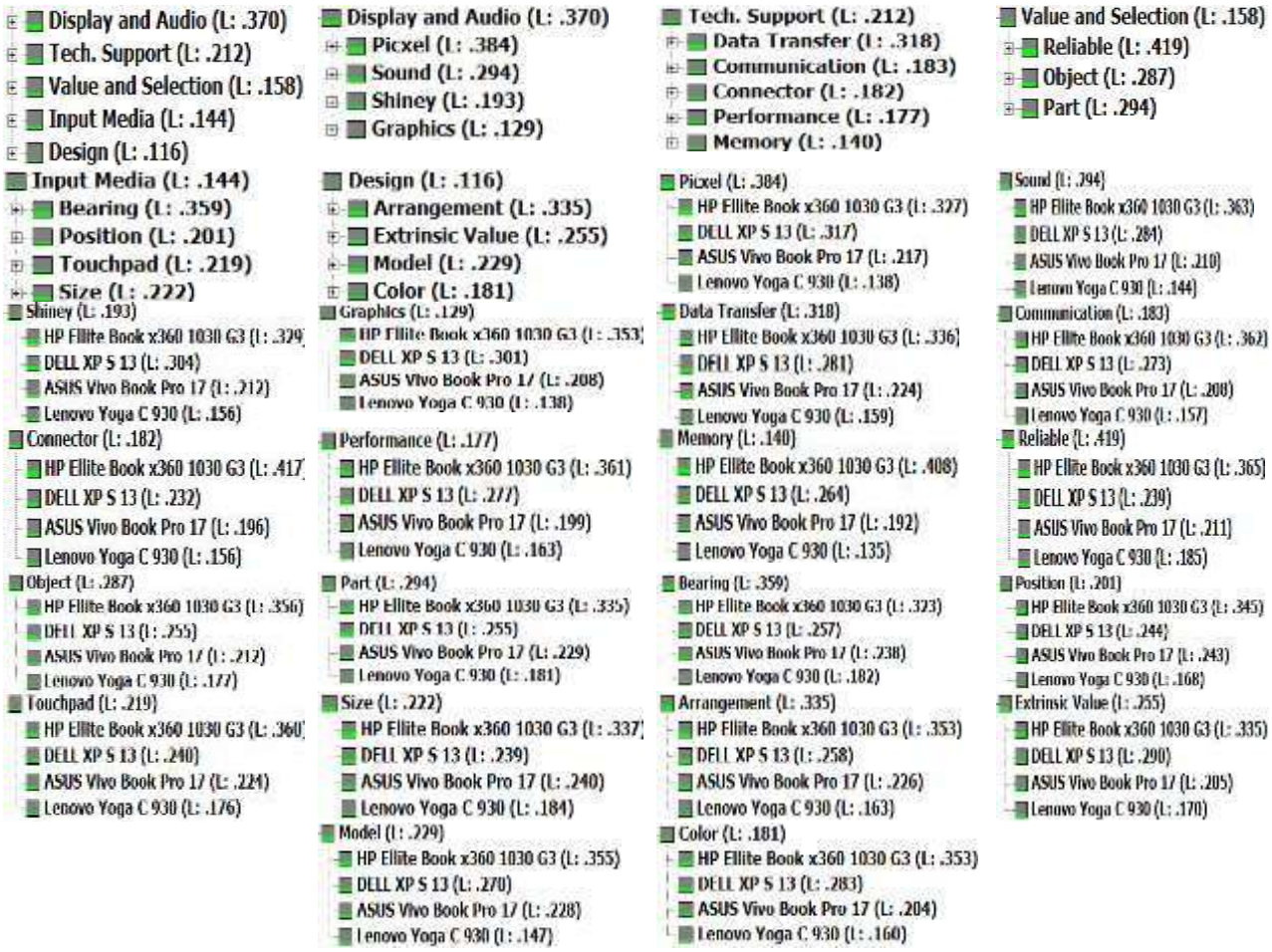
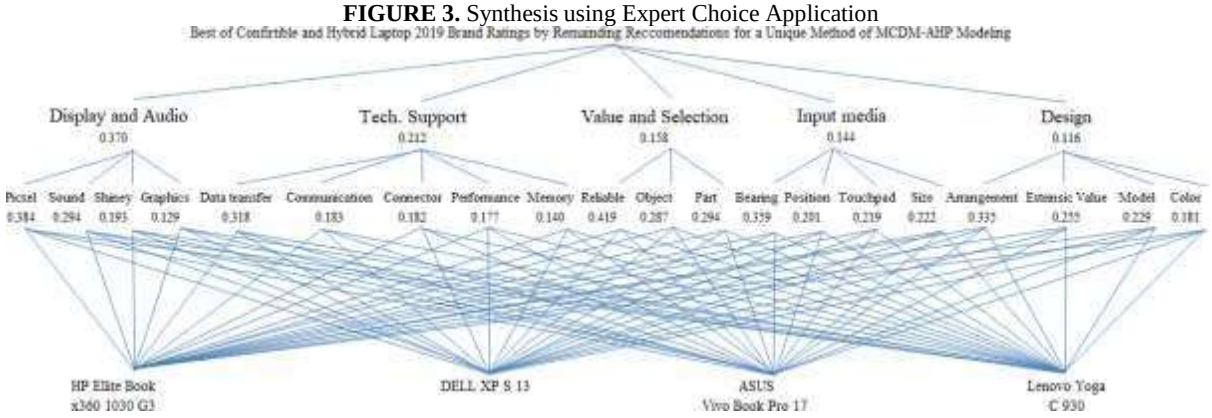


FIGURE 2. Optimal eigenvector throughout the hierarchy using Expert Choice Application

The results of calculations on the Brand Rating of Hybrid and Convertible Laptops through the Mathematically Algebra Matrices method and the Expert Choice Application from all Criteria, Sub-criteria, and Alternatives, as an acceptable decision basis. This is known based on the amount of Consistency Ratio (CR) <0.1; so that all the eigenvector values of the criteria, Sub-criteria, and alternatives can be accepted as the basis for the decision, the last stage is Synthesis to do a comprehensive calculation of the hierarchy model of the Brand Rating Hybrid and

Convertible Laptop giving a good contribution using Expert Choice Application can be seen in (Figure-3) while the results obtained by using the Mathematically Algebra Matrices can be seen in (Figure-4). The two methods that have been performed have yielded identical results.

FIGURE 3. Synthesis using Expert Choice Application



Synthesis of Convertible and Hybrid Laptop using Mathematically Algebra Matrices	
HP Ellite Book x360 1030 G3 =	0.349
DELL XP S 13 =	0.276
ASUS Vivo Book Pro 17 =	0.216
Lenovo Yoga C 930 =	0.159

FIGURE 4. Synthesis using Mathematically Algebra Matrices

CONCLUSION

The selection of the Brand Rating of Convertible and Hybrid Laptops optimally provides an overview for the best decision support. From the results of the unique calculation process with the MCDM-AHP method, it gives optimal results through the final stages of Synthesis. The results obtained are for the first rank with the highest optimal eigenvector value of 0.349 for the HP Ellite Book X 360 1030G3, then the second rank followed by DELL XP S13 with an optimal eigenvector value of 0.272, then the third rank is ASUS Vivo Book Pro 17 with an optimal eigenvector of 0.218, and The last ranking of the four alternatives is Lenovo Yoga C930 with an optimal eigenvector value of 0.160. Thus, it can be said that the best Brand Rating of Convertible and Hybrid Laptop in 2019 is the HP Ellite Book X 360 1030G3. Thus the MCDM-AHP method which is unique is able to provide optimal and best decision results for the selection of the Brand Rating of Convertible and Hybrid Laptops in 2019.

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