Disruptive Technology Selection for Automotive Industry: A Case Study from Indonesia

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Abstract

Automotive is one of the competitive industries supported by its significant technological advancement, but it is susceptible to disruption trends. In Indonesia, the automotive industry has many vehicle segments. One of them is the Medium Sport Utility Vehicle (MSUV) segment. The disruption phenomenon occurred in the Medium Sport Utility Vehicle segment due to the emergence of the X brand in 2019, enabled by disruptive technologies to challenge and gain the Y brand's market share as the incumbents. Therefore, there is an urgency to determine disruptive technology used in the automotive industry. This research utilizes Multi-Criteria Decision Making (MCDM) method combining Analytical Hierarchy Process (AHP) and Technique for Others Reference by Similarity to Ideal Solution (TOPSIS). The main results showed that Government Regulation was the most important criterion, while Electric Vehicles became the most preferred alternative for disruptive technology selection in the automotive industry. This research arguably has theoretical and practical contributions. Theoretically, this research was the first attempt to determine disruptive technology used in the automotive industry, while practically, this research could guide the automotive manufacturer to select the most disruptive technology while considering some critical criteria during the research and development process.

Keywords
Disruptive Innovation, Disruptive Technology, Automotive Industry, Electric Car, Autonomous Driving

1. Introduction

In this modern era, car ownership has been a primary need. Car as one of the transportation types is preferred due to its convenience compared to a motorcycle. Despite its convenience, the car price is relatively higher than a motorcycle. Customers tend to purchase a low-cost car of good quality. This becomes a strategic concern for automotive manufacturers requiring them to deliver good products and services to customers while also tightening their budget at the same time.

The automotive industry comprises design, supply, manufacture, sales, and after-sales service to customers (Fathi and Ahmadian 2016). Automotive is one of the competitive industries supported by its significant technological advancement (Cinicioglu et al. 2012). Its industry is susceptible to new technology and disruption trend. Disruption is a process whereby a smaller firm with fewer resources could challenge the incumbent's businesses (Christensen et al. 2015). Disruptive innovation originates in two types, the first is a low-end market, and the other is a new market (Christensen et al. 2015). A low-end market exists because the incumbents pay less attention to less-demanding customers. In contrast, a new market emerges because the new entrant creates a new market that non exists before (Christensen et al. 2015).

In Indonesia, the automotive industry plays a vital role in manufacturing, while the manufacturing sector contributes significantly to Indonesia's economic growth (Nurcahyo and Wibowo 2015). There are many vehicle segments in the Indonesian automotive industry, such as Large Sport Utility Vehicle (LSUV), Medium Sport Utility Vehicle (MSUV), Low Multi-Purpose Vehicle (LMPV), Medium Multi-Purpose Vehicle (MMPV), and many others.

Medium Sport Utility Vehicle (MSUV) segment in Indonesia faces a disruption threat due to the arrival of a new entrant from a Chinese car manufacturer challenging the X brand as the incumbent. The Chinese car manufacturer sells the Y brand with good enough quality and technology and lower price. Before the emergence of the Y brand, the X brand dominated the Medium SUV market share with around 81% in 2017 and 82% in 2018, while other brands controlled the rest. The emergence of the Y brand in 2019 stripped the incumbent's market share from 82% in the previous year to 43%. (See Table 1).

Even though there is an increasing market share for the X brand in 2020, this happened due to the covid-19 pandemic causing other brands and the Y brand to stop their production. As a result, other brands only produced 1,173 units while the Y brand produced 1,947 units. This caused a decrease in market share for those brands. In 2021, the X brand market share was still 43%, while the Y brand market share increased from 40% in 2019 to 48% in 2021. (See Table 1)

Moreover, table 1 shows the disruption that occurred in 2019 for the Medium SUV Segment was due to the new market created by the Y brand. Medium SUV Sales increased from 17,736 units to 24,488 units in 2019, while the X brand sales decreased from 14,565 to 10,432 units. On the other hand, other brands' sales increased from 3,171 units to 4,313 units in 2019, while the Y brand emerged into the market and sold 9,743 units. Other brands' sales increase which amounts to 1,142 units may come from the sales increase of Medium SUV. Furthermore, the rest of the sales increase of Medium SUV became the sales volume of the Y brand, proving this is the new market created by the Y brand. The rest of Y brand sales came from seizing X brand market share.

Table 1. Medium SUV Sales in Indonesia

Year	Total Medium SUV Sales (Unit)	The X Brand Sales (Unit)	The X Brand Market Share (%)	The Y Brand Sales (Unit)	The Y Brand Market Share (%)	Other Brands Sales (Unit)	Other Brands Market Share (%)
2017	16,564	13,342	81%	N/A	N/A	3,222	19%
2018	17,736	14,565	82%	N/A	N/A	3,171	118%
2019	24,488	10,432	43%	9,743	40%	4,313	17%
2020	8,099	4,979	61%	1,947	24%	1,173	15%
2021	20,780	8,972	43%	10,027	48%	1,181	9%

This phenomenon occurred because the Y brand used disruptive innovation enabled by disruptive technologies to challenge the incumbents and slowly gain the incumbent's market share. As a result, the X brand, as the incumbent, gradually lost its market share. Hence, disruptive innovation enabled by disruptive technologies is essential for firms to implement because it creates a new market (Sainio 2004). A new market is essential for automotive manufacturers to survive fierce market competition. Iyer (2018) stated that if automotive manufacturers do not implement a disruptive innovation strategy, the firms will compete in a zero-sum way to compete in market and lose a chance to increase market share through a new market.

Much research has been conducted to observe disruptive technologies implementation across many industries. Dyerson and Pilkington (2004) explored disruptive technology's role in the US automobile sector. Callaway and Hamilton (2008) studied the effect of disruptive technologies on the bank industry. Ganguly et al. (2011) also researched disruptive technologies by identifying and assessing the disruptive technologies' risks. Krishnan et al. (2020) reviewed disruptive technologies such as the Internet of Things, Autonomous Vehicles, 5G networks, and Artificial General Intelligence for smart cities.

Even though much research has been done to understand the disruptive technologies phenomenon, only a few studies discussed disruptive technologies in the automotive industry. Hence, this research aims to understand and determine disruptive technologies used in the automotive industry. Moreover, this paper could guide the automotive industry since it is crucial for them to know and exploit the business potentials of disruptive technologies to stay competitive and gain a larger market share.

This research aims to determine disruptive technology used in the automotive industry using the Multi-Criteria Decision Making (MCDM) method. Moreover, the paper is organized into six sections. Section 1 describes the introduction; Section 2 describes the literature review used in the research; section 3 explains the research methodology; Section 4 provides findings from the study; Section 5 presents the ranking of criteria and alternative analysis, and section 6 finally concludes the research paper by recommending future research.

2. Literature Review

2.1 Automotive Industry

Automotive is one of the most complex industries in the world. Many countries produce automotive products; one of them is Indonesia. The automotive industry plays a vital role in the growth of the manufacturing sector in Indonesia and significantly impacts the national economy (Nurcahyo and Wibowo 2015). Indonesia has a broad market segment for the automotive industry. Those markets are Hatchback Car, City Car, Multi-Purpose Vehicle, Sport Utility Vehicle, Sedan, and Low-Cost Green Car. The difference in the segment is based on the dimension.

2.2 Disruptive Technology

Over the years, the concept of disruptive technologies has gained widespread attention both from practitioners and academia (Ganguly et al. 2011). The term disruptive technologies originated from the work of Clayton Christensen. Christensen (1997) developed two terms for technology those are sustaining and disruptive technology. Sustaining technology can be incremental, discontinuous, or radical (Christensen 1997). Christensen stated that sustaining technology improves the performance of the established products that mainstream customers value (Christensen 1997).

On the other hand, disruptive technology is the innovation resulting in worse product performance in the near term, which this technology could cause the incumbent's failure (Christensen 1997). Products based on disruptive technologies are frequently more convenient and typically smaller, simpler and cheaper (Christensen 1997). Disruptive technologies are rising technologies that might cause displacement of the incumbent's technology (Christensen 1997). Disruptive technologies refer to technologies having a far-reaching effect on the business structure of firms and value creation (Amshoff et al. 2015). Another definition of disruptive technologies is the technology that could alter human life and industrial trends (Rahman et al. 2017).

Mckinsey Global Institute (2013) listed 12 disruptive technologies across industries, one of them being in the automotive industry, autonomous, and Near Autonomous vehicles. Wittman (2016) stated that core technological trends such as electrification and digitalization have a disruptive impact on the automotive industry. The disruptive technologies based on digitalization are the Internet of Things, Connected Car, and Autonomous Driving, while electrification-based is an electric car (Wittmann 2016). These disruptive technologies were believed will become the core of the automotive industry in the future.

2.3 Disruptive Innovation

Christensen divided innovation into two types, the first is sustaining, and the other is disruptive (Christensen 1997). Most product and service innovations are sustaining in which this sustaining innovation provides additional functionality or better quality to the most demanding customers (Christensen 1997). Unlike sustaining innovation, disruptive innovation originates in two types, the first one is a low-end market, and the other is a new market (Christensen et al. 2015). Disruptive innovation enables new entrants to sweep away leading firms by alarming regularity, often before the incumbents realize their mistakes (Hwang and Christensen 2008). Disruptive innovation has the potential to fundamentally change the way industries operate and could turn industries upside down (Rasool et al. 2018).

One of the disruptive innovation examples in the automotive industry is Honda Super Cub 50 cc, which is highly successful due to its new market in the United States market Christensen (1997) and Septiadhi (2019) stated that Toyota Avanza and Daihatsu Xenia are two disruptive cars in Indonesia because they targeted existing Low Multi-Purpose Vehicles, provided more exciting designs, and lower prices compared to other brands. Another example of disruptive innovation in the automotive industry is Toyota Corona. Toyota Corona was launched in 1965. Instead of building cars with powerful engines, Toyota focused on serving the lower tier of the United States car market by offering fuel-efficient, reliable, and compact cars at an affordable price (Iyer 2018).

2.4 Delphi Method

The Delphi method is a process to gather opinions from experts, which is designed to obtain convergence of views on a specific issue (Nordin et al. 2012). The Delphi method utilizes multiple iterations to develop a consensus of expert opinions during the process. Delphi method is designed to get open feedback from experts through a series of controlled questionnaires (Dachyar and Dewi 2015). Dalkey and Helmer developed the Delphi method of structured group communication (Hazza et al. 2022). The goal of the Delphi method is to converge expert opinions about a specific issue (Hsu and Sandford 2007). Delphi method is preferable to Focus Group Discussion as Delphi could prevent any bias during the feedback process from experts. The bias could happen if the expert in Focus Group Discussion is distracted and influenced by other experts' opinions.

2.5 Multi-Criteria Decision Making

Decision-making is a process pursued by organizations to obtain the most suitable actions to reach the desired objectives. Multi-Criteria Decision Making (MCDM) is a well-structured process to handle decision-making problems and determine the most attractive alternative considering all relevant criteria (Eltarabishi et al. 2020). Shukor et al. (2018) stated that Multi-Criteria Decision Making is a framework of decision aid that can evaluate multiple conflicting criteria. Multi-Criteria Decision Making (MCDM) methods have various implementations in many fields.

Two main MDCM methods are Analytical Hierarchy Process (AHP) and Technique for Others Reference by Similarity to Ideal Solution (TOPSIS). Analytical Hierarchy Process (AHP) is a Multi-Criteria Decision Making (MCDM) method used for the selection and prioritization of criteria and alternatives based on a pairwise comparison (Wind and Saaty 1980). Analytical Hierarchy Process (AHP) is a measurement method using pairwise comparisons, and it relies on the expert's judgments to derive priority scales (Russo and Camanho 2015). Researchers widely used the analytical Hierarchy Process (AHP) because it is a powerful tool with simplicity.

Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) is Multi-Criteria Decision Making (MCDM) method developed by Yoon and Hwang in 1981 (Chen et al. 2014). This method is based on the concept that the optimal alternative should be the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution (Chen et al. 2014). Table 2 shows the previous research covering the AHP or TOPSIS method for autonomous driving and electric vehicle as a disruptive technology in the automotive industry:

Table 2. Previous research on disruptive technologies in Automotive Industry

Research Theme	Author	MCDM Method	Year
Electric vehicle selection	Sonar and Kulkarni	AHP and MABAC	2021
Location selection for electric vehicle	Guler and Yomralioglu	AHP and Fuzzy AHP	2020
Risk prioritization for autonomous vehicle	Bakioglu and Atahan	AHP, TOPSIS and VIKOR	2020
Corridor selection for locating an autonomous vehicle	Dogan et al	Fuzzy AHP and TOPSIS	2019
Selection of commercially available electric vehicle	Biswas and Das	Fuzzy AHP and MABAC	2018

3. Methods

This research employs Multi-Criteria Decision Making (MCDM) combined with Delphi Method to select the disruptive technology considering relevant criteria. Chen et al. (2014) used both Analytical Hierarchy Process (AHP) and Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) for their research on autonomous vehicles in Urban Environments. Dogan et al. (2019) also used AHP and TOPSIS methods for corridor selection in locating autonomous vehicles.

Hence, this research utilized two MCDM methods for disruptive technology selection. Those methods were Analytical Hierarchy Process (AHP) and Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) method. The first method, AHP, was used for the criteria weighting. On the other hand, TOPSIS was used for the ranking of alternatives. This research used the Delphi method to gather expert opinions on disruptive technology selection. Dachyar and Dewi (2015) stated that recommended number of respondents for the Delphi method ranges from 5 to 14. Hence, the respondents of this research consist of 5 experts, ranging from General managers to managers with experience of over 20 years in the automotive industry. The experts in this research were from one of the automotive manufacturers in Indonesia.

Figure 1 describes the process of disruptive technology selection using the Analytical Hierarchy Process (AHP)-Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) method:

1. Literature review: A literature review approach was used to identify the criteria used in the research.
2. Criteria and Alternative Construction: After reviewing the literature, the next step is to construct the criteria and alternatives used in the research.
3. Criteria Validation: Criteria validation was needed to decide whether the criteria could be used or not. The criteria validation was obtained using the questionnaire addressed to the automotive experts. The automotive experts consist of 4 persons, ranging from General managers and Managers of Automotive manufacturers with more than 20 years of experience.
4. Pairwise Comparison Matrix Construction: This stage used Analytical Hierarchy Process (AHP) method. The pairwise comparison was used to know how important one criterion was compared to other criteria.
5. Questionnaire: The pairwise comparison data was obtained using a questionnaire addressed to automotive experts the same as stage 3. The questionnaire contained questions regarding the importance level of each criterion; then, the experts were asked to give a score from 1 to 9 for each criteria comparison, as shown in Table 3.
6. Criteria weighting: After obtaining the questionnaire, the data was inputted and calculated into the AHP model.
7. Decision Matrix Construction: In this stage, a decision matrix was created, which consists of alternatives and criteria. This stage used Technique for Others Reference by Similarity to Ideal Solution (TOPSIS) to rank the alternatives.
8. Questionnaire: To obtain the data for the decision matrix, a questionnaire was addressed to automotive experts the same as stage 5. The experts were asked to give a 1 to 5 for each alternative.
9. Ranking Alternatives: This stage was used to rank the selected alternatives evaluated according to the criteria performance discussed above.

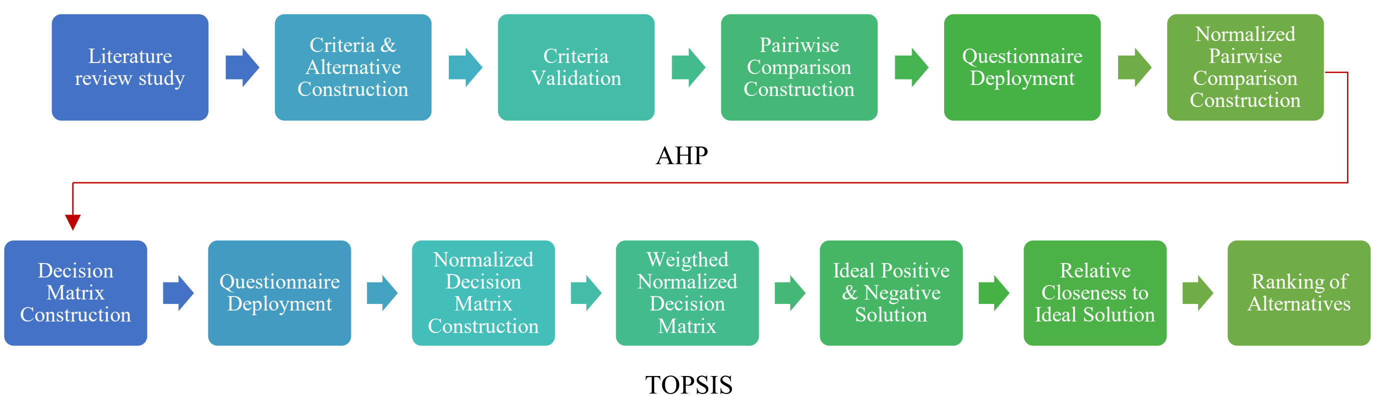

Figure 1. Disruptive Technology Selection Using AHP-TOPSIS Method

Table 3. Analytical Hierarchy Process Scale (Saaty 2008)

Importance Scale	Scale Description
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

4. Data Collection

4.1 Criteria and Alternative Construction

Criteria and alternatives in this research are obtained from the literature study. Mozaffari et al. (2012) listed 25 indicators used in technology selection. The author then sorted the criteria based on their suitability for the automotive industry. As a result, experts will validate seven criteria: Cost, Government Regulation, User Friendly, Technology Classification, Value Proposition, and Infrastructure. For the alternatives, Wittmann (2017) stated that disruptive technologies in the automotive industry are Electric Vehicles, Connected Cars, the Internet of Things, and Autonomous Driving. However, due to the slight difference between Connected Car and the Internet of Things, the author then combined the Internet of Things into Connected Car. Figure 2 shows the final criteria and alternatives for disruptive technologies.

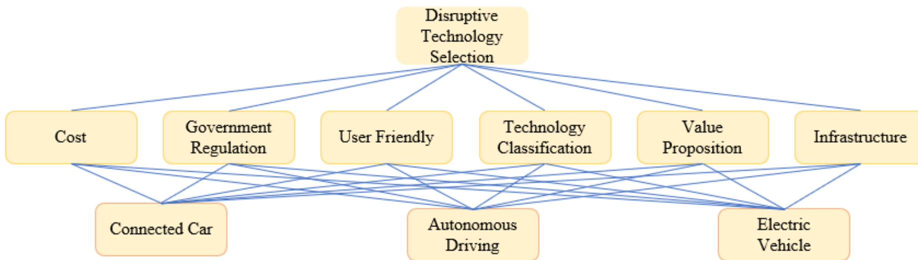

Figure 2. Criteria and Alternatives of Disruptive Technologies

4.2 Criteria Validation

Criteria validation was performed to filter whether the criteria were necessary for the research. If the criteria are considered not important, then the criteria will not be included in the pairwise comparison. A questionnaire containing several questions was deployed to automotive experts to validate the criteria. This questionnaire will measure the importance level of each criterion based on expert judgments. This research utilized five scales ranging from very unimportant, unimportant, average, important, and very important. The result obtained from the questionnaire will be calculated using Geomean values. If the value is less than 3.5, the criteria are considered unimportant and not included in the research (Dachyar and Pratama 2014). Table 4 shows the result of criteria validation using geometric mean.

Table 4. Criteria Validation Result

Criteria	Likert Scale Score by Respondent					Geometric Mean	Result
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5		
Cost	4	5	3	4	5	4.13	Accepted
Government Regulation	5	5	5	3	5	4.51	Accepted
User Friendly	4	5	3	4	4	3.95	Accepted
Technology Classification	4	5	4	4	4	4.18	Accepted
Value Proposition	4	4	4	3	4	3.78	Accepted
Infrastructure	4	5	4	3	5	4.13	Accepted
Maintainability	3	4	4	4	2	3.1	Rejected

4.3 Normalized Pairwise Comparison Matrix

After performing criteria validation then followed by pairwise comparison and normalized pairwise comparison matrix construction. This stage used the Analytical Hierarchy Process (AHP) method to know how important one criterion is compared to other criteria. Table 5 shows the normalized pairwise comparison matrix used in the research.

Table 5. Normalized Pairwise Comparison Matrix

Criteria	Cost	Government Regulation	User Friendly	Technology Classification	Value Proposition	Infrastructure
Cost	0.26	0.3	0.21	0.18	0.22	0.16
Government Regulation	0.36	0.4	0.65	0.34	0.26	0.42
User Friendly	0.09	0.04	0.07	0.33	0.30	0.13
Technology Classification	0.1	0.08	0.02	0.07	0.11	0.12
Value Proposition	0.08	0.11	0.02	0.05	0.07	0.1
Infrastructure	0.11	0.06	0.04	0.04	0.04	0.07

4.4 Final Criteria Weight

Table 6 shows the final result for each criteria's weight. It can be inferred from table 6, that Government Regulation became the most important criteria for disruptive technology selection in the automotive industry.

Table 6. Final Criteria Weight

Criteria	Weight
Government Regulation	0.41
Cost	0.22
User-Friendly	0.16
Technology Classification	0.08
Value Proposition	0.07
Infrastructure	0.06

4.5 Decision Matrix Construction

After performing criteria weighting, then followed by constructing a decision matrix for alternative ranking. After constructing the decision matrix, then the questionnaire approach was used and deployed to automotive experts to give a scale from 1 to 5. Table 7 shows the decision matrix created using the TOPSIS method.

After that, it needs to classify the criteria based on the cost-benefit attributes. The cost criteria were considered as the cost attribute, while the rest of the criteria were considered as the benefit attributes. Table 8 shows the result of the criteria attributes used in during the research. Table 9 shows the next step after cost-benefit attribute classification, which is constructing an ideal positive-negative solution. Furthermore, table 10 shows the result of the relative closeness of each alternative to the ideal solution. Table 11 shows the last stage of the TOPSIS method, which is constructing an alternative ranking based on the TOPSIS method.

Table 7. Decision Matrix

Alternatives	Criteria					
	Cost	Government Regulation	User Friendly	Technology Classification	Value Proposition	Infrastructure
Connected Car	0.22	0.27	0.06	0.04	0.04	0.06
Autonomous Driving	0.13	0.05	0.04	0.06	0.04	0.05
Electric Vehicle	0.04	0.22	0.06	0.07	0.06	0.07

Table 8. Criteria - Attributes

Attribute	Criteria					
	Cost	Government Regulation	User Friendly	Technology Classification	Value Proposition	Infrastructure
Cost	√					
Benefit		√	√	√	√	√

Table 9. Ideal Positive-Negative Solution

Ideal Solution	Cost	Government Regulation	User Friendly	Technology Classification	Value Proposition	Infrastructure
	Cost attribute	Benefit attribute	Benefit attribute	Benefit attribute	Benefit attribute	Benefit attribute
Positive	0.04	0.27	0.06	0.07	0.06	0.07
Negative	0.22	0.05	0.04	0.04	0.04	0.05

Table 10. Relative Closeness of Each Alternative to Ideal Solution

D+		D-	
Connected Car	0.18	Connected Car	0.22
Autonomous Driving	0.24	Autonomous Driving	0.09
Electric Vehicle	0.05	Electric Vehicle	0.25

Table 11. Ranking of Alternatives

Alternatives	Preference	Ranking
Connected Car	0.55	2
Autonomous Driving	0.274	3
Electric Vehicle	0.817	1

5. Results and Discussion

5.1 Analysis of Criteria Ranking

Figure 3 shows the ranking of criteria used to select disruptive technology. The criteria having the highest weight is Government Regulation. The automotive experts considered Government Regulation the most important criterion because it is mandatory to comply with the regulation when organizations want to implement disruptive technology in the automotive industry.

The second and third most important criteria were Cost and User Friendly. Automotive experts thought the cost is the second most important because the cost is the driving factor for organizations to stay competitive in the automotive market. Organizations need to create great disruptive technology with the lowest cost possible to sell the product at a lower price attracting customers to buy the product. On the other hand, User-Friendly criteria became the third most crucial factor because manufacturers need to create disruptive technology which is easy to use by the customers.

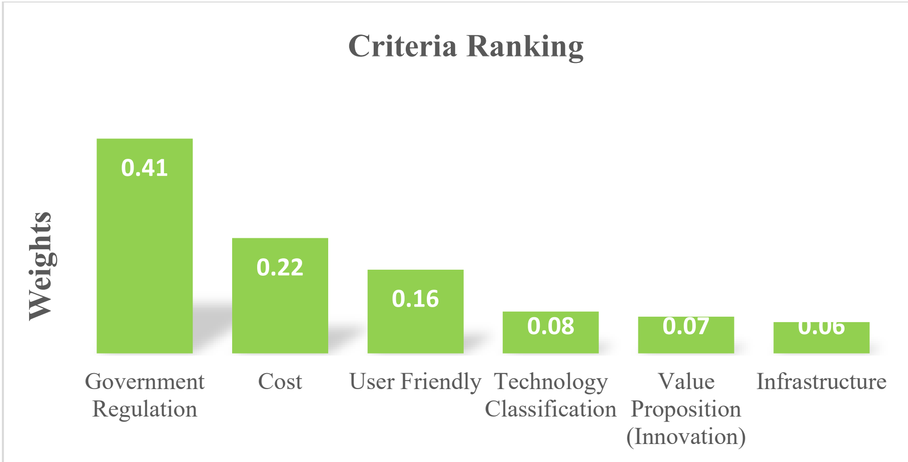

Figure 3. Criteria Ranking

5.2 Analysis of Alternatives Ranking

Figure 4 shows the ranking of alternatives used to select disruptive technology. The alternative having the highest preference is Electric Vehicles. Electric Vehicle is considered the most preferred alternative by automotive experts based on the criteria used for ranking. Electric Vehicles propose more disruptive characteristics than Connected Cars and Autonomous Driving.

Despite its inferiority in terms of Cost Criterion compared to other alternatives, Electric Vehicle possesses more advantages than the others. Electric Vehicles propose to customers with its User-Friendly technology, which customers do the plug and play during car usage. Furthermore, Electric Vehicles own more advanced technology and new customer value propositions.

Those new value propositions were the use of battery and no tailpipe emissions, which were considered the point of untapped value and superiority (Bohnsack and Pinkse 2017). Bohnsack and Pinkse (2017) explained that the point of untapped value as the disruptive technology's elements that could add value to customers, while the point of superiority is the point at which Electric Vehicle excels compared to the others. Moreover, Electric vehicles provide customers with a new user experience to drive clean transportation resulting in a new way of driving.

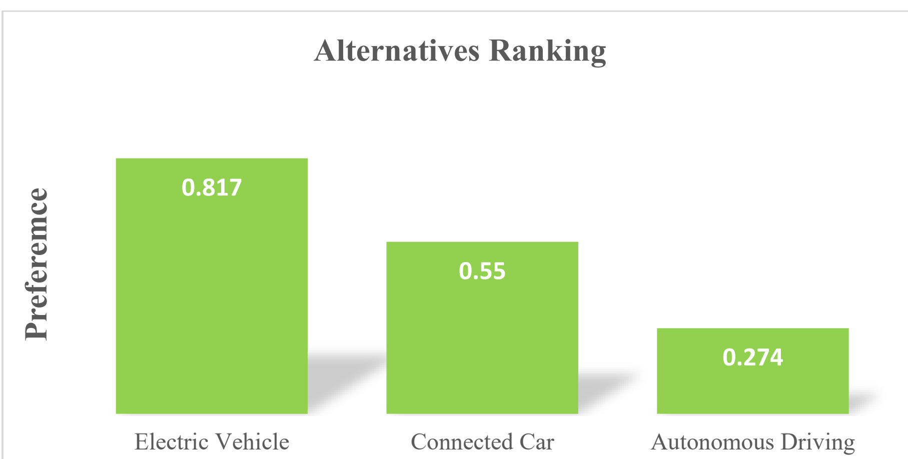

Figure 4. Alternatives Ranking

6. Conclusion

This research aimed to determine disruptive technology used in the automotive industry using the Multi-Criteria Decision Making (MCDM) method. The criteria used for disruptive technology selection were Government Regulation, Cost, User-Friendly, Technology Classification, Value Proposition, and Infrastructure. Furthermore, alternatives used were Electric Vehicles, Connected Cars, and Autonomous Driving. The research resulted in criteria ranking (weight) as follows: Government Regulation (0.41), Cost (0.22), User-Friendly (0.16), Technology Classification (0.08), Value Proposition (0.07), and Infrastructure (0.06). The findings showed the most important criteria during disruptive technology selection was Government Regulation. On the other hand, the research also resulted in alternatives ranking (preference) as follows: Electric Vehicle (0.82), Connected Car (0.55), and Autonomous Driving (0.27). The findings showed the most preferred alternative was Electric Vehicles.

This research arguably has theoretical and practical contributions. Theoretically, this research was the first attempt to determine disruptive technology used in the automotive industry. Practically, this research could guide the automotive manufacturer to select the most disruptive technology while considering some critical criteria during the research and development process. The limitations of this research are the lack of automotive manufacturers that have done using disruptive technologies. Hence, future research could gather more automotive manufacturers using disruptive technologies and consider other critical criteria during the disruptive technology selection.

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