"Assessment of the betterness of a battery electric vehicle: A multi-criteria decision-making approach"

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ASSESSMENT OF THE BETTERNESS OF A BATTERY ELECTRIC VEHICLE: A MULTI-CRITERIA DECISION-MAKING APPROACH

Abstract

Despite the advantages and benefits of a battery electric vehicle, its adoption rate remains low. Previous studies have explored factors that influence the adoption of electric vehicles. However, studies investigating whether an electric car outperforms a gasoline car are still limited. Therefore, this study aims to assess the betterness of an electric vehicle compared with a gasoline vehicle in helping customers perform their jobs to be done. A multi-criteria decision-making approach using the analytic hierarchy process is built on two main criteria, namely, customer pains and customer gains, where customer pains are divided into cost pains and non-cost pains, and customer gains are divided into functional gains and emotional gains. Using the most affordable battery electric vehicle in the Indonesian market, interviewees who live in the greater Jakarta and drive to work were invited to perform the pairwise comparison processes. The finding of this study shows that with respect to helping customers perform their jobs to be done, a battery electric vehicle is equally to moderately worse than a gasoline vehicle with a worse score of 0.5946 compared with a better score of 0.4054. This finding comes from interviewees who prioritize customer gains with a priority score of 0.6993 over customer pains with a priority score of 0.3007. Considering that the analytic hierarchy process allows a small number of interviewees, the result obtained should be limited as an early prediction about the betterness of an electric car compared with a gasoline car from a certain group of persons.

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INTRODUCTION

The presence of electric vehicles (EV) is inevitable. EV in various forms has been introduced in many countries. In Indonesia, the government has implemented financial and non-financial incentives to accelerate EV adoption. Well-known manufacturers have introduced battery electric vehicles (BEV). However, early introduced BEVs are still not affordable for most people (Gaikindo, 2022). Besides the high price of EVs, the availability of public charging stations is still very limited (Dong et al., 2020; Tarei et al., 2021).

Consumers' purchase decisions toward electric vehicles have been studied. Factors influencing the adoption of electric vehicles have been explored at the macro level. In general, the factors that influence the adoption of electric vehicles are grouped into three groups, namely consumer, car attributes, and environmental settings (Buhmann & Criado, 2023). In practice, at the micro level, consumers adopt a new product by comparing it with existing products via examining the benefit to cost ratio (Meyer & Garg, 2005).

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Numerous studies on EV adoption use an assumption that consumers evaluate products based on absolute value (Jang & Choi, 2021). However, in the context of consumers deciding to adopt a new product, there is a propensity to choose based on products that have been and are currently being used (Kim et al., 2016). Consumers also use past experience as a reference point as a criterion in deciding the gain or loss from a new choice (Tversky & Kahneman, 1991). In fact, consumers have a tendency to maintain the status quo preference, which prefers old products over new products (Hess et al., 2012).

Therefore, the explanation for the adoption of an electric vehicle as a new solution must be based on the betterness of an electric vehicle compared with an existing gasoline vehicle in helping customers perform their jobs to be done (Christensen et al., 2016). Using the value proposition design framework (Osterwalder et al., 2014), betterness here is explained by how capable an electric vehicle reduces customer pains and fulfills customer gains experienced by customers driving their gasoline vehicles.

1. LITERATURE REVIEW

Assessing the betterness of an electric vehicle compared with a gasoline vehicle is approached as a multi-criteria decision-making problem. In efforts to develop a multi-criteria decision-making model consisting of criteria and sub-criteria, a literature review related to exploring the factors that influence consumers' decision to adopt an electric vehicle has been conducted. Factors influencing EV adoption from previous studies are then grouped in two main criteria used in this study: customer pains and customer gains.

1.1. Factors influencing EV adoption

Previous studies explain EV adoption by referring to the Theory of Planned Behavior (TPB) (Ajzen, 1991), which further explains the existence of intention as a good predictor of behavior. Following this theory, existing research explores the factors that influence consumers' purchase intention towards EVs. Several studies show that fulfilling psychosocial aspects with an emotional dimension is more important than instrumental aspects with a functional dimension in influencing EV adoption decisions (Steg, 2005; Zhu et al., 2012; Kato, 2021).

As with other new products, EVs will be accepted by the market if they can increase the benefit-over-price ratio (Meyer & Garg, 2005). This consideration of benefits and costs is in line with the Theory of Planned Behavior (Ajzen, 1991; Sun, 2020). Huang et al. (2021) and Jaiswal et al. (2022) show that consumer knowledge about technology has a positive impact on perceived usefulness, perceived ease of use and intention to adopt EVs.

Digalwar and Rastogi (2023) show that infrastructure and financial factors have a positive impact on EV adoption, while vehicle performance has a negative impact on EV adoption. Clinton and Steinberg (2019) show that providing incentives in the form of purchase rebates to reduce EV prices can increase EV sales. Apart from financial incentives, the availability of battery charging infrastructure also influences the adoption of electric vehicles (Mpoi et al., 2023). Meanwhile, other studies show that financial incentives have more of an indirect effect on adoption and directly affect attitude and perceived behavioral control (Ansab & Kumar, 2022). Aungkulanon et al. (2023), for example, show that current conditions related to infrastructure policy, technology and markets hinder factors for EV adoption. Liu et al. (2021) show that battery charging infrastructure and non-purchase limitations affect the increasing EV adoption, while financial incentives have little influence.

The quick win that EV users can obtain is energy costs, which drop significantly, thus reducing the total cost of ownership by around 10% to 12% for the retail segment and 35% to 42% for the fleet segment (Sankaran & Venkatesan, 2022). Even though the total cost of ownership (TCO) of an EV is smaller than ICEs and is a long-term advantage of EVs, the resale value factor is also a determinant factor of EV adoption (Tiwari et al., 2020). Resale value is determined by depreciation costs. Schloter (2022) shows that EV depreciation of 13.9%, which is higher than ICE cars of 10.4% per year.

Plananska et al. (2023) reveal cultural and symbolic barriers among certain groups of society to switching to EVs. Self-image motive also explains why people switch to EVs (Li et al. 2022).

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Gunawan et al. (2022) and Chaturvedi et al. (2022) explain that hedonic motivation is also one of the factors influencing EV adoption. Moreover, personal innovativeness and environmental concern also significantly influence purchase intention of EV (He et al., 2018) and environmental concern (Dash, 2021; Shalender & Sharma, 2021). Other studies show that intention to adopt EVs is influenced by private meaning, i.e. reinforced identity (Herziger & Sintov, 2023). Snelders and Schoorman (2004) show that consumers evaluate products not only from instrumental benefits such as performance and range in the case of EVs, but also based on perceptions of the products' symbolic meaning. Another study shows reputation-driven consumers only prefer an EV because its price is higher than gasoline vehicles (Buhmann & Criado, 2023).

Indonesia is one of the largest automotive markets in the Asia-Pacific region. In 2022, the market size of passenger cars in Indonesia remained in fifth place with a total of 783,563 vehicles, below China in first place with a total of 23,563,287 vehicles, followed by India with 3,792,356 vehicles, Japan with 3,448,297, and South Korea with 1,420,486 vehicles (Statista, 2022). Meanwhile, in terms of EV adoption, until 2021, the level of EV adoption remained low. In most countries, EV sales are still below 5% of total vehicle sales. Only China and South Korea have EV adoption rates above 5%. China tops the EV adoption rate with 16.1% followed by South Korea at 6.5%. Below that are Australia with 2.9%, Japan 1.2%, Thailand 0.7%, India 0.5%, Malaysia 0.3% and Indonesia 0.1% (Statista, 2021).

Even though the EV market prospect in Indonesia shows promise, there are still a limited number of studies on EV adoption in the Indonesian market. Veza et al. (2022) conveyed various opportunities and challenges related to EV adoption in Indonesia. Setiawan et al. (2022) using a system dynamics simulation shows that government policy in reducing EV taxes which burden consumers will increase EV adoption.

A study on the adoption of electric motor cycle vehicles in Indonesia shows that adequate perceptions about electric motorcycles, environmental benefits, and economics and incentive policies have a positive impact on the adoption of electric motorcycles (Murtiningrum et al., 2022). Another study on customer intention to use EVs in Indonesia shows that attitude toward factors such as performance expectancy, effort expectancy, hedonic motivation, price, and functional, financial and social risks have the most influence on EV adoption (Gunawan et al., 2022). Another study on purchase intention toward EVs shows that target customers who are well-educated and are in the senior management positions have a moderate preference towards purchasing high priced BEVs (Febransyah, 2021).

Previous studies show that when consumers make a new purchase, their purchasing decision is based on the performance of the product they are currently using (Kim et al., 2016). Tversky and Kahneman (1991) state that consumers use previous experience as a reference point to assess the gain or loss of a new choice. Therefore, this study aims to assess the betterness of an electric vehicle compared to a gasoline vehicle in helping customers perform their jobs to be done.

1.2. Model building

In this study, a multi-criteria decision-making model based on the analytic hierarchy process (AHP) is structured into five levels: goal; criteria, sub-criteria; sub-sub-criteria; and alternatives. Figure 1 shows the decision hierarchy of the AHP model used in this study. In Level 1, the goal is how a battery electric car helps customers perform their jobs to be done (JTBD), in this case, commuting to work, compared with an internal combustion engine (ICE) or gasoline-powered car. Level 2 contains customer pains and customer gains (Osterwalder et al, 2014) in performing their JTBD using existing ICE cars.

Level 3 contains sub-criteria for customer pains and customer gains. Customer pains are divided into two types of pains: cost pains and non-cost pains. Meanwhile, customer gains consist of functional gains and emotional gains. Further, at Level 4, cost pains include operating costs, which consist of vehicle price or installment costs (Lin & Wu, 2018; Degirmenci et al., 2017; Han et al., 2017; Krishnan & Koshy, 2021), maintenance costs, fuel costs (Heffner et al., 2007), insurance costs (de Sa et al., 2020), and annual taxes. Meanwhile, non-cost pains include queuing at gas stations, payment at gas stations, restricted road access, and driving

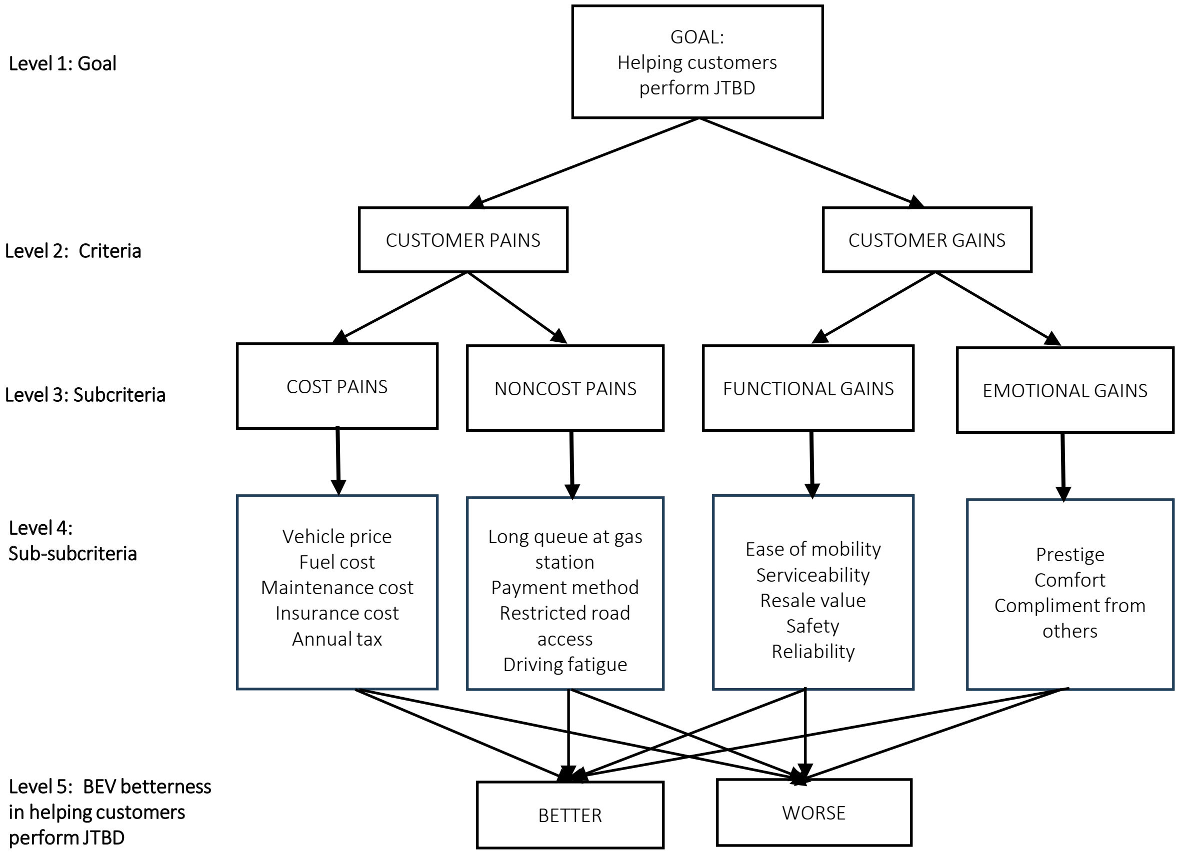

Figure 1. AHP model for assessing the betterness of a battery electric vehicle

fatigue (Paudel et al., 2023). Functional gains include ease of mobility, serviceability, safety, resale value (Lashari et al., 2021; Tiwari et al. 2020), and reliability. Emotional gains consist of prestige (Z. Zhao & J. Zhao, 2020), comfort (Previte et al., 2019; Singh et al., 2020) and compliment from others.

At Level 5, a BEV is assessed if it performs customers' JTBD better than an ICE car with respect to all sub-sub-criteria at Level 4. The assessment of EV betterness is performed by considering that consumers when making new purchases have the propensity to choose based on products that are being used now (Kim et. al, 2016). Tversky and Kahneman (1991) also show that consumers use previous experience as a reference point to assess the gain or loss of a new choice.

2. METHODOLOGY

The key process in the analytic hierarchy process (AHP) is pairwise comparison. The process compares two entities or objects at the lower level with

Table 1. Ratio scale in performing AHP's pairwise comparison

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment very strongly over another, its dominance demonstrated in practice
7	Very strong importance	An activity is favored very strongly over another, its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For a compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

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respect to (w.r.t.) one entity at the upper level. For example, as seen in Figure 1, two main criteria, i.e., customer pains and customer gains are compared to each other with respect to the entity at the upper level, which is goal: helping customers perform JTBD. In performing pairwise comparisons, decision-makers use a ratio scale, as shown in Table 1 (Saaty, 1980).

After completing pairwise comparison at each level, the following pairwise comparison matrix, *P* is obtained as follows:

$$P = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ . & . & & . \\ . & . & & . \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix}, \quad (1)$$

where $a_{ji} = 1/a_{ij}$, since the AHP uses a ratio scale in performing pairwise comparison and *n* indicates the number of entities being compared. When comparing *n* entities, there are n (*n*-1) / 2 pairwise comparisons to perform. After having the matrix *P*, the local priority, *W*, which shows the weight or degree of importance of entities at the lower level relative to one item at the upper level is obtained from the following Eigen equation (Saaty, 1980):

$$P[W] = \lambda_{\max}[W], \quad (2)$$

where $\lambda_{\max}$ is the largest Eigenvalue of *P*. When pairwise comparison is performed perfectly consistent, the $\lambda_{\max}$ value will be equal to the number of entities being compared. In practice, however, it is not always the case. There is a need to check the consistency ratio (CR) of the pairwise comparison matrix with the following equation:

$$CR = \frac{CI}{RI}, \quad (3)$$

where the consistency index, *CI* is obtained from the following equation

$$CI = \frac{\lambda_{\max} - n}{n - 1}, \quad (4)$$

and *RI* is random index whose values are given in Table 2 (Saaty, 1980).

Table 2. Random index for consistency ratio

No.	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	058	0.9	1.12	1.24	1.32	1.41	1.46	1.49

If $CR \le 0.1$, it means that pairwise comparison is performed satisfactorily. If not, pairwise comparison process needs to be revised until $CR \le 0.1$.

Furthermore, global priority, or ranking of alternatives, is calculated using the following equation (Saaty, 1980):

$$S_i = \sum_{j=1}^{N} a_{ij} W_j, \quad \text{for} \quad i = 1, 2, 3, \dots, M, \quad (5)$$

where S_i is the *weighted score* of alternative *i*, a_{ij} is the score of alternative *i* with respect to criteria *j*, W_j is the weight of criterion *j*, *M* is number of alternatives, *N* is number of criteria.

Back to Figure 1, the pairwise comparison process starts at Level 2 to determine the degree of importance of customer pains and customer gains. A typical question asked here is: "With respect to commuting to work with your own cars now, which do you prioritize, reducing customer pains or meeting customer gains? By how much on a 1-9 ratio scale?"

Pairwise comparison continues at Level 3. Here, interviewees are asked to assess the level of importance of the sub-criteria of customer pains and customer gains. Referring to customer pains, interviewees are asked: "Which one is more painful, cost pains or non-cost pains? By how much on a 1-9 ratio scale?" Next in terms of customer gains:"Which one is more beneficial, getting functional gains or emotional gains? By how much on a 1-9 ratio scale?"

At Level 4, the pairwise comparison is performed to rate the importance of sub-sub-criteria. With respect to cost pains, one of questions in performing pairwise comparison is: "Which one is more painful, vehicle cost or fuel cost? By how much on a 1-9 ratio scale?" With respect to Non-Cost Pains, interviewees are asked 'Which one is more painful, long queue at the gas station or driving fatigue?" With respect to functional gains, one of questions is: "Which one is more beneficial, ease of mobility or serviceability?" With respect to emotional gains: "Which one is more beneficial, prestige or comfort? By how much on a 1-9 ratio scale?"

Finally at Level 5, interviewees are asked to perform pairwise comparison on the betterness of BEV compared with an ICE vehicle in helping customer perform their JTBD.An example of pairwise comparison question is: «With respect to the current increase in fuel cost, does the BEV help customers perform better or worse than the ICE vehicle you are using now? By how much on a 1-9 ratio scale?"

In performing pairwise comparison, interviewees are allowed to use their subjectivity as long as consistency in pairwise comparison is maintained. However, differences in assessments in the pairwise comparison and the decision results of each interviewee cannot be avoided even though each of them is consistent in the pairwise comparison. When this happens, we can use the aggregation of individual priorities (AIP) procedure to aggregate the priorities generated from each source by geometrically averaging the priorities as follows (Ramanathan & Ganesh, 1994; Forman & Peniwati, 1998):

$$P_g\left(A_j\right)=\prod_{i=1}^{n} P_i\left(A_j\right), \qquad (6)$$

where $P_g(A_j)$ is the priority aggregation of alternative j, $P_i(A_j)$ is the priority of alternative j of intervieweei, and n is the number of interviewees.

This study uses the most affordable four-seater BEV currently introduced in Indonesian market with a price of around IDR 200-300 million (USD 15,385-19,230) and the following specifications: compact dimensions, the length of 2.9 m; width of 1.5 m and height of 1.6 m; the driving range of 200 to 300 km with battery charging 4 to 8.5 hours at home. Seven interviewees have the following persons: "Commuters come from professionals at senior management level and above who use their own gasoline cars to complete their mobility work and have the ability to pay for next vehicle at the price up to IDR 300 million or USD 19,230."

To implement the AHP model, several interviewees are invited to provide their judgment in pairwise comparison. Previous studies have shown that the AHP does not require many experts and is a subjective method that emphasizes the quality of the assessments of the experts used (Dias & Ioannou, 1996; Lam & Zhao, 1998; Tavares et al., 2008); further, the AHP does not require a certain number of experts to carry out pairwise comparison (Guillén-Mena et al., 2023).

Using the decision hierarchy, as shown in Figure 1, pairwise comparison is performed at Levels 2, 3, 4 and 5. Each assessment given by the interviewee is directly entered into the Superdecisions software. For each pairwise comparison, the consistency ratio of the interviewee is checked. If the consistency ratio is below 10%, pairwise comparison can be used, if it is above 10%, the interviewee is asked to perform pairwise comparison again.

3. RESULTS

The following tables show the pairwise comparison matrices of Interviewee #1. At Level 2, pairwise comparison is performed to obtain priority from two main criteria: customer pains and customer gains. Table 3 shows the pairwise comparison matrix of the main criteria with respect to (w.r.t.) the objective of performing JTBD.

Table 3. Pairwise comparison matrix of main criteria from Interviewee #1

w.r.t. OBJECTIVE	Customer pains	Customer gains
Customer pains	1	0.2
Customer gains	5	1

From Table 3, a 5reveals that Interviewee #1 considers customer gains to be five times more important or strongly preferred compared with customer pains. This can be inferred that Interviewee #1 is already satisfied with his ICE in JTBD performance. A 0.2 is the reciprocal of 5, meaning that customer pains are 1/5 or 0.2 more important than customer gains. Meanwhile, a 1 in the diagonal matrix describes the object compared to itself. For this pairwise comparison, there is no inconsistency problem because it only involves two objects being compared.

At Level 3, the main criteria for customer pains and customer gains are divided into subcriteria. Customer pains consist of cost pains and non-cost

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pains; customer gains are divided into functional gains and emotional gains. Pairwise comparison at Level 3 is performed to compare the subcriteria w.r.t. the main criteria. Tables 4 and 5show the pairwise comparison matrices between cost pains and non-cost pains w.r.t customer pains and functional gains and emotional gains w.r.t. customer gains.

Table 4. Pairwise comparison matrix of subcriteriaof customer pains from Interviewee #1

w.r.t. customer pains	Cost pains	Non-cost pains
Cost pains	1	5
Non-cost pains	0.2	1

Table 5. Pairwise comparison matrix of sub-criteria of customer gains from Interviewee #1

w.r.t. customer gains	Emotional gains	Functional gains
Emotional gains	1	3
Functional gains	0.33	1

From the pairwise comparison above, it is shown that Interviewee #1's cost pains are strongly more painful than non-cost pains, and emotional gains are moderately more important than functional gains. Because it only compares two objects, the pairwise comparison above is still perfectly consistent.

The next pairwise comparison is carried out between the sub-criteria of the cost pains sub-criteria, as shown in Table 6. The consistency ratio of this pairwise comparison is 6.74%, which is acceptable because it is still below 10%. From Table 5, it is shown that vehicle costs contribute the most to cost pains, followed by maintenance costs, fuel costs, and insurance costs as well as annual vehicle taxes.

For pairwise comparison between sub-criteria of non-cost pains, as shown in Table 7, the consistency ratio is 2.57%, so pairwise comparison is accepted. From Table 6, it is shown that the ordinality of non-cost pains starts from queue at the gas station, which is the most painful, followed by driving fatigue, restricted road access and ease of payment at the gas station.

The pairwise comparison matrix of sub-sub-criteria of functional gains is presented in Table 8. The consistency ratio of 4.64% is still below the upper limit of 10%; thus, pairwise comparison is accepted. It is obtained that Interviewee #1 ranked ease of mobility as the most enjoyed functional benefit from using an ICE vehicle, followed by reliability, safety, serviceability and resale value.

Table 9 shows the pairwise comparison matrix between the emotional gains sub-criteria. Here,

Table 6. Pairwise comparison matrix of sub-sub criteria of cost pains from Interviewee #1

w.r.t. cost pains	Vehicle cost	Maintenance cost	Fuel cost	Insurance cost	Annual tax
Vehicle cost	1	7	5	9	9
Maintenance cost	0.1429	1	0.33	5	3
Fuel cost	0.2	3	1	7	5
Insurance cost	0.11	0.2	0.1429	1	1
Annual tax	0.11	0.33	0.2	1	1

Table 7. Pairwise comparison matrix of sub-sub-criteria of non-cost pains from Interviewee #1

w.r.t . non-cost pains	Queue at gas station	Payment at gas station	Restricted road access	Driving fatigue
Queue at gas station	1	7	5	3
Payment at gas station	0.1429	1	0.5	0.2
Restricted road access	0.2	2	1	0.33
Driving fatigue	0.33	5	3	1

Table 8. Pairwise comparison matrix of the sub-sub-criteria of functional gains of Interviewee #1

w.r.t. functional gains	Ease of mobility	Serviceability	Resale value	Safety	Reliability
Ease of mobility	1	5	7	4	3
Serviceability	0.2	1	3	0.33	0.33
Resale value	0.1429	0.33	1	0.2	0.1667
Safety	0.25	3	5	1	0.5
Reliability	0.33	3	6	2	1

Table 9. Pairwise comparison matrix of the sub-sub-criteria of emotional gains of Interviewee #1

w.r.t. emotional gains	Prestige	Comfort	Compliment from others
Prestige	1	0.33	3
Comfort	3	1	5
Compliment from others	0.33	0.2	1

Interviewee #1 rated comfort as the biggest emotional benefit, followed by prestige and compliments from others. The pairwise comparison is also accepted with a consistency ratio of 3.73%.

The final pairwise comparison is at the alternative level. Here interviewees are asked to assess if the BEV can help customers perform their JTBD better or worse than the ICE car they use with respect to all sub-sub-criteria. The pairwise comparison matrices at the alternative level are shown in Tables 10, 11, 12, and 13.

Table 10. Pairwise comparison matrix of EV betterness w.r.t. sub-sub-criteria of cost pains

	Better	Worse
w.r.t. vehicle cost		
Better	1	0.33
Worse	3	1
w.r.t. maintenance cost		
Better	1	3
Worse	0.33	1
w.r.t. fuel cost		
Better	1	9
Worse	0.11	1
w.r.t. insurance cost		
Better	1	0.5
Worse	2	1
w.r.t. annual tax		
Better	1	9
Worse	0.11	1

Table 11. Pairwise comparison matrix of EV betterness w.r.t. sub-sub-criteria of non-cost pains

	Better	Worse
w.r.t. queue at gas station		
Better	1	7
Worse	0.1429	1
w.r.t. payment at gas station		
Better	1	2
Worse	0.5	1
w.r.t. restricted road access		
Better	1	5
Worse	0.2	1
w.r.t. driving fatigue		
Better	1	1
Worse	1	1

Table 12. Pairwise comparison matrix of EV betterness w.r.t. sub-sub-criteria of functional gains

	Better	Worse
w.r.t. ease of mobility		
Better	1	2
Worse	0.5	1
w.r.t. serviceability		
Better	1	0.33
Worse	3	1
w.r.t. resale value		
Better	1	0.33
Worse	3	1
w.r.t. safety		
Better	1	0.5
Worse	2	1
w.r.t. reliability		
Better	1	0.33
Worse	3	1

Table 13. Pairwise comparison matrix of EV betterness w.r.t. sub-sub-criteria of emotional gains

	Better	Worse
w.r.t. prestige		
Better	1	0.33
Worse	3	1
w.r.t. comfort		
Better	1	0.2
Worse	5	1
w.r.t. compliment from others		
Better	1	0.33
Worse	3	1

After completing the pairwise comparison with Interviewee #1, the pairwise comparison process is repeated with the other interviewees.

After Interviewee #1 performed pairwise comparison, the super decisions software reveals the results as shown in Table 14. It is obtained that the limiting scores of better and worse are 0.0881 and 0.1619, respectively. The normalized scores of better and worse become 0.3482 and 0.6518. This means that Interviewee #1 assesses that with respect to helping customers perform their JTBD, namely commuting to work, the BEV is slightly to moderately worse than an ICE car.

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Table 14. Results of Interviewee #1's pairwise comparison

Code	Name	Normalized by cluster	Limitation
1	Better	0.3484	0.0871
2	Worse	0.6516	0.1629
3	Customer gains	0.8333	0.2083
4	Customer pains	0.1667	0.0417
5	Emotional gains	0.7500	0.1563
6	Functional gains	0.2500	0.0521
7	Cost pains	0.8333	0.0347
8	Non-cost pains	0.1667	0.0069
9	Fuel cost	0.2020	0.0070
10	Insurance cost	0.0385	0.0013
11	Maintenance cost	0.1134	0.0039
12	Vehicle cost	0.5976	0.0208
13	Annual tax	0.0485	0.0017
14	Comfort	0.6370	0.0995
15	Compliment from others	0.1047	0.0164
16	Prestige	0.2583	0.0404
17	Ease of mobility	0.4838	0.0252
18	Reliability	0.2313	0.0120
19	Resale value	0.0399	0.0021
20	Safety	0.1625	0.0085
21	Serviceability	0.0826	0.0043
22	Driving fatigue	0.2643	0.0018
23	Payment at gas station	0.0609	0.0004
24	Queue at gas station	0.5693	0.0040
25	Restricted road access	0.1056	0.0007

It is also obtained that the main criterion for customer gains has a priority of 0.8333 compared with 0.1667 for customer pains. This explains that, with respect to performing JTBD, Interviewee #1 strongly prefers reducing customer gains than reducing customer pains. It can also be inferred that Interviewee #1 is relatively satisfied with the ICE vehicle used. Further, from the main criteria for customer gains, Interviewee #1 prioritizes emotional gains with a priority of 0.75 rather than functional gains of 0.25. Meanwhile, for the main criteria for customer pains, cost pains with a priority of 0.8333are strongly more painful than non-cost pains with a priority of 0.1667.

Table 15 shows EV betterness according to Interviewee #1 in with respect toJTBD, customer gains, customer pains, emotional gains, functional gains, cost pains and non-cost pains. Although the BEV has not been able to help customers perform their JTBD better than an ICE car, with respect to customer pains and its sub-criteria cost pains and non-cost pains, the BEV shows its superiority over an ICE car.

Having finished with Interviewee #1, the pairwise comparison process continues with the other interviewees. The results are shown in the following tables. Table 16 shows the EV betterness in performing JTBD from each interviewee.

Using Eq. (6) to aggregate interviewees' priority, it is obtained the overall EV betterness as follows:

$$\mathit{Overall\ EV\ betterness} = \begin{bmatrix} Better \\ Worse \end{bmatrix} = \begin{bmatrix} 0.4054 \\ 0.5946 \end{bmatrix}. \quad (7)$$

From all interviewees who provided assessments, it is revealed that the most affordable BEV in the Indonesian market performs worse than an ICE car in helping customers perform their JTBD with a worse score of 0.5946 compared to a better score of 0.4054. It should be noted that the assessments above come from interviewees who already have customer pains and customer gains based on their respective experiences using their ICE vehicles. Table 17 shows the degree of importance of customer gains and customer pains for each interviewee.

Table 15. EV betterness from Interviewee #1

EV betterness	Interviewee #1						
	JTBD	Customer gains	Customer pains	Emotional gains	Functional gains	Cost pains	Non-cost pains
BETTER	0.3484	0.2640	0.7951	0.197	0.4652	0.773	0.7588
WORSE	0.6516	0.7360	0.2049	0.803	0.5348	0.227	0.2412

Table 16. EV betterness in helping customers perform their JTBD compared to ICE car

Overall EV betterness	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.3484	0.5148	0.4389	0.2145	0.6875	0.4033	0.2757
Worse	0.6516	0.4852	0.5611	0.7855	0.3125	0.5967	0.7243

Table 17. Interviewees' priority on customer pains and customer gain in performing JTBD

Priority	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Customer gains	0.8333	0.875	0.125	0.9	0.1429	0.875	0.875
Customer pains	0.1667	0.125	0.875	0.1	0.8571	0.125	0.125

Aggregating interviewees' priorities result in the overall priority of customer pains and customer gains as follows:

$$\textit{Priority in performing JTBD} = \begin{bmatrix} \textit{Customer Gains} \\ \textit{Customer Pains} \end{bmatrix} = \begin{bmatrix} 0.6993 \\ 0.3007 \end{bmatrix}. \quad (8)$$

Overall, the interviewees invited to this research are more concerned with maintaining or increasing customer gains than reducing or eliminating customer pains with a preference level of 0.6993 for customer gains and 0.3007 for customer pains.

Next, based on the criteria of customer pains and customer gains, it is of great interest to assess EV betterness in fulfilling those two criteria. Table 18 shows the assessment of each interviewee regarding the ability of BEV compared to ICE in fulfilling customer gains.

After aggregating interviewees' priorities, it is revealed that EV betterness in fulfilling customer gains is as follows:

$$\textit{EV betterness in fulfilling Customer Gains} = \begin{bmatrix} \textit{Better} \\ \textit{Worse} \end{bmatrix} = \begin{bmatrix} 0.3124 \\ 0.6876 \end{bmatrix}. \quad (9)$$

It is revealed that, for interviewees who prioritize customer gains rather than customer pains, the most affordable BEV is still worse than an ICE car in meeting their customer gains. The BEV is rated worse with a priority score of 0.6876 and better with a priority score of 0.3124. Meanwhile, in terms of reducing customer pain, the results of all interviewees' assessments of BEV capabilities are as shown in Table 19.

After aggregating interviewees' priorities, the EV betterness is obtained in reducing customer pains as follows:

$$\textit{EV betterness in reducing Customer Pains} = \begin{bmatrix} \textit{Better} \\ \textit{Worse} \end{bmatrix} = \begin{bmatrix} 0.6538 \\ 0.3462 \end{bmatrix}. \quad (10)$$

It is shown that the most affordable BEV used in this study effectively performs better than an ICE car in reducing customer pains. The BEV is rated better with a priority score of 0.6538 and worse with a priority score of 0.3462. Next, in terms of fulfilling emotional gains, each interviewee assessed the ability of BEV compared with ICE. The results are as shown in Table 20.

The result of the aggregation of interviewees' priorities is as follows:

$$\textit{EV betterness in creating emotional gains} = \begin{bmatrix} \textit{Better} \\ \textit{Worse} \end{bmatrix} = \begin{bmatrix} 0.2284 \\ 0.7716 \end{bmatrix}. \quad (11)$$

For interviewees who prioritize emotional gains rather than functional gains, as shown in the pairwise comparison in Table 5, the most afford-

Table 18. EV betterness with respect to customer gains

EV betterness w.r.t. customer gains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.2640	0.5023	0.3152	0.1650	0.4093	0.3657	0.2328
Worse	0.7360	0.4977	0.6848	0.8350	0.5907	0.6343	0.7672

Table 19. EV betterness with respect to customer pains

EV betterness w.r.t. customer pains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.7951	0.6535	0.4565	0.6504	0.7349	0.6659	0.5758
Worse	0.2049	0.3465	0.5435	0.3496	0.2651	0.3341	0.4242

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Table 20. EV betterness with respect to emotional gains

EV betterness w.r.t. emotional gains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.197	0.25	0.1286	0.1802	0.3744	0.3214	0.2094
Worse	0.803	0.75	0.8714	0.8198	0.6256	0.6786	0.7906

Table 21. EV betterness with respect to functional gains

EV betterness w.r.t. functional gains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.4652	0.53	0.3386	0.163	0.651	0.3714	0.3968
Worse	0.5348	0.47	0.6614	0.837	0.349	0.6286	0.6032

able BEV is still considered worse than an ICE car in terms of meeting emotional gains. The BEV is worse with a priority score of 0.7716 compared to better with a priority score of 0.2284.

Furthermore, the interviewees' assessment of the most affordable BEV in terms of fulfilling functional gains is shown in Table 21. For functional gains which are not as important as emotional gains according to interviewees, this BEV is considered worse in fulfilling functional gains compared to an ICE car. The results of the aggregation of interviewees' priorities show that the most affordable BEV is still worse with a priority score of 0.5934 compared to better with a score of 0.4066.

Aggregated EV betterness w.r.t. functional gains:

$$EV\ betterness\ in\ creating\ functional\ gains = \begin{bmatrix} Better \\ Worse \end{bmatrix} = \begin{bmatrix} 0.4066 \\ 0.5934 \end{bmatrix}. \tag{12}$$

In terms of reducing cost pains, the results of the interviewees' assessment of BEV as the most affordable are as shown in Table 22. With regard to customer pains, as shown in Table 3, reducing cost pains is considered to be strongly more important than reducing non-cost pains. It turns out, in terms of reducing cost pains, the most affordable BEV is rated better with a priority score of 0.6847 compared to worse of 0.2498.

Aggregated EV betterness w.r.t. cost pains:

$$EV\ betterness\ in\ reducing\ cost\ pains = \begin{bmatrix} Better \\ Worse \end{bmatrix} = \begin{bmatrix} 0.6847 \\ 0.3153 \end{bmatrix}. \tag{13}$$

Finally, in terms of reducing non-cost pains, the results of the interviewees' assessment of the most affordable BEV are as shown in Table 23. Almost the same as the ability to overcome cost pains, the BEV is also better than ICE with a better score of 0.6769 and a worse of 0.3231.

Aggregated EV betterness w.r.t. non-cost pains:

$$EV\ betterness\ in\ reducing\ noncost\ pains = \begin{bmatrix} Better \\ Worse \end{bmatrix} = \begin{bmatrix} 0.6769 \\ 0.3231 \end{bmatrix}. \tag{14}$$

Table 22. EV betterness with respect to cost pains

EV betterness w.r.t. cost pains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
Better	0.773	0.6922	0.4062	0.627	0.764	0.727	0.7502
Worse	0.227	0.1539	0.5938	0.373	0.236	0.273	0.2498

Table 23. EV betterness with respect to non-cost pains

EV betterness w.r.t. non-cost pains	Interviewee						
	#1	#2	#3	#4	#5	#6	#7
BETTER	0.7588	0.5508	0.808	0.7904	0.5532	0.6558	0.5508
WORSE	0.2412	0.4492	0.192	0.2096	0.4468	0.3442	0.4492

4. DISCUSSION

While numerous studies show that the price of electric cars is still one of the main barriers against the adoption of electric vehicles, this study can enrich the explanation of the still low adoptionof electric vehicles. Using the most affordable electric vehicle in the Indonesian market, the BEV is still not able to help customers perform commuting to work better than an ICE car. Overall, the BEV is rated worse with a score of 0.5946 rather than better with a score of 0.4054. Because the AHP uses a ratio scale, these results explain that the BEV is 1.47 worse than an ICE vehicle in helping customers perform their JTBD.

It should be emphasized that the interviewees invited to this research prioritized customer gains with a weight of 0.6993 rather than reducing customer pains with a weight of 0.3007. It can be inferred that the invited interviewees have been satisfied with their ICE cars in helping them perform their JTBD.

In terms of customer pains, it is obtained that the BEV shows its superiority compared to an ICE car, which is shown by a better score of 0.6538 compared to worse of 0.3462. For customer pains in the form of cost pains, the BEV is considered capable of helping customer perform their JTBD better than an ICE car with a better score of 0.6847 compared to a worse score of 0.3153. This study supports previous studies that show a BEV is better than an ICE vehicle in term of total cost of ownership (Sankaran & Venkatesan, 2022), vehicle cost (Lin & Wu, 2018; Degirmenci et al., 2017; Han et al., 2017; Krishnan & Koshy, 2021) and fuel cost (Degirmeci et al., 207). Due to government financial incentives, the annual tax on electric vehicles is significantly lower than that of gasoline vehicles. Also, in terms of reducing non-cost pains, a BEV is equally to moderately better than an ICE vehicle with a wetter score of 0.6769 compared a worse score of 0.3231. One reason that explains this is the existence of a policy that waives the odd-even license plate rule on main roads for electric vehicle owners. Home charging solutions for filling batteries are also one of the reasons BEVs are chosen to overcome long queues at gas stations when using ICE vehicles.

However, with respect to meeting customer gains, the BEV is worse than an ICE car with a score of better 0.3124 and worse 0.6876. For emotional gains, the most affordable BEV is moderately worse than ICE. Meanwhile, for functional gains, BEV is equally to moderately worse than ICE. It should be noted here, in terms of customer gains criteria, both functional and emotional gains, the interviewee compared the ICE cars used today with the most affordable cars with all the limitations of the BEV to meet customer gains demands. With the dimensions of affordable BEV vehicles being much smaller than ICEs in general and fewer comfort features that have been enjoyed from ICE cars, interviewees prefer ICEs to these small and affordable BEVs. For today's car owners, as studies suggest, vehicles have a symbolic meaning (Snelders & Schoormans, 2004) which explains the reinforced identity (Herziger & Sintov, 2023) of the user.

The results above explain that making BEVs affordable does not automatically mean ICE users will move to BEVs. Indeed, in terms of its ability to reduce customer pain, both cost pains and non-cost pains, BEV is better than ICE. However, the advantage of this affordable BEV in reducing customer pain is not accompanied by an advantage in maintaining customer functional and emotional gains, which is actually more important to interviewees than reducing customer pains.

Thus, an increase in the benefit-over-cost ratio, which is a condition for innovation (Meyer & Garg, 2005), does not occur in the case of affordable battery electric vehicle. This is an important finding from the study that is not in line with the general recommendation that EV adoption will be high if the price of electric vehicles is made affordable. Lowering the price of electric vehicles at the expense of functional and emotional benefits does not increase the benefit-over-cost ratio.

Even though it is currently the cheapest on the Indonesian market, with regard to functional benefits, the BEV assessed in this study is still considered not as good as an ICE car in terms of in terms of safety, reliability and resale value. In terms of emotional benefits, the most affordable BEV being studied is still considered not prestigious, comfortable and attractive as an ICE car. The findings in this study are in line with those of Buhmann and Criado (2022), showing that consumers purchase a high-price electric vehicle due to self-image and reputation motives.

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CONCLUSION

The assessment of the betterness of an electric vehicle in performing JTBD using a multi criteria decision model has been presented. This study provides a solid foundation for developing a decision model to make an early prediction on whether a battery electric vehicle will be accepted by a certain customer segment. An assessment of the most affordable BEV in the Indonesian market shows that the BEV is equally to moderately worse than an ICE car in helping customers perform their JTBD, which is commuting to work.

The widely accepted proposition that the price of BEV must be made affordable to make its adoption high needs to be more justified. This study shows that making electric vehicles affordable does not automatically mean that ICE users will switch to a BEV. Based on operational cost factors including energy/electricity costs, maintenance costs, annual taxes, BEVs are significantly superior to ICE cars. However, having considered functional and emotional benefit factors, the most affordable BEV in the Indonesian market still cannot outperform an ICE car for a group of personas interviewed in this study.

This study provides a practical implication for EV makers. To reach the majority of customers with limited ability to pay, EV makers cannot simply rely on the cheapest price, but still must provide all the benefits that customers have obtained from ICE vehicles.

However, this study has several limitations. The invited interviewees are commuters who drive their ICE cars to perform their commuting work. The pains and gains used as the main criteria in this study come from their experience driving ICE cars. The assessment of EV betterness does not include new customer gains which could actually be an advantage of an EV compared with ICE vehicle. Future research needs to invite those who already drive BEVs to complement the customer pains and gains that come from ICE car users.

This study also uses interviewees who have been satisfied with their ICE cars in fulfilling customer gains. This is what makes the most affordable BEV unable to compete with ICEs in functional and emotional benefits. This study also limited interviewees to commuters who use ICE cars daily for mobility purposes and who have a garage at home. With the need for mobility within the city alone, the home charging solutions can easily overcome the long queues of ICE cars at gas stations and of course significantly reduce the cost of recharging batteries compared with oil fuel. This explains why the BEV used in this study is superior in reducing customer pains, i.e., cost and non-cost pains compared with ICE cars.

Last, this study only interviews a few personas who prioritize fulfilling customer gains more than reducing customer pains and are asked to evaluate the most affordable BEV on the market. In further research, a choice experiment involving larger sample of commuters, who can represent the whole commuters driving their gasoline cars, should be conducted in assessing the betterness of various battery electric vehicles compared with comparable gasoline vehicles.

AUTHOR CONTRIBUTIONS

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Formal analysis: Ade Febransyah.
Funding acquisition: Ade Febransyah.
Investigation: Ade Febransyah.
Methodology: Ade Febransyah.
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Software: Ade Febransyah.
Supervision: Ade Febransyah.
Validation: Ade Febransyah.
Visualization: Ade Febransyah.
Writing – original draft: Ade Febransyah.
Writing – review & editing: Ade Febransyah.

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