Indonesia e-Bike Consumer Preference Trough Market Potential Research: A Choice-Based Conjoint Analysis

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Abstract.
E-bike is gaining popularity and accelerating the bike industry to speed up new product development. This study aims to identify e-bike preferences desired by consumers through market research. The choice-based conjoint method analyzes consumer preferences, forecasts potential e-bike market share, and classifies e-bike customer profiles. Each consumer preference profile is mapped regarding technical requirements through the availability of components on the market. The e-Bike battery type dominates 20% among other e-bikes feature preferences. It has also identified three e-bike profiles: city, mountain bike, and all-urban, with a market share receptively of 46%, 32%, and 22%. The research also concluded that there are two clusters of e-bike customers. The first cluster is the neutral consumer to e-bikes or conventional bike preferences. The second cluster is consumers who prefer e-bikes and are willing to pay more for technological and eco-friendly vehicles.

Keywords: e-bikes preference, choice-based conjoint, product development

1 Introduction

According to data published by the National Energy Council in the National Energy Outlook 2021 report, the transportation sector accounted for 43.1% of total national energy demand. Consequently, the Indonesian government has endeavored to reduce the number through various means, including adopting electric vehicles [1]. According to data from the National Energy Council, only 9,000 electric vehicles will be in operation by the middle of 2021, limited to cars, motorcycles, and buses in major cities such as Jakarta [2]. Currently, electric vehicles are predominantly automobiles, motorcycles, and buses. However, some electric vehicles, such as electric bicycles (e-bikes), are currently in high demand among consumers around the globe [3]. E-bikes contribute significantly to daily transportation in a variety of urban areas. They are desirable since they are faster, require less physical exertion than conventional bicycles, and offer more

M. Hartono et al. (eds.), *Proceedings of the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023)*, Atlantis Highlights in Engineering 21,
https://doi.org/10.2991/978-94-6463-288-0_32

significant health benefits than driving cars or operating motorcycles. A further advantage of e-bikes is their low operational costs, user-friendliness, and agility, which reduce travel time for their users, especially in congested areas [4] [5].

The increasing prevalence of e-bikes is followed by user demand for additional features. Rapidly altering consumer wants and needs results in a shorter product life cycle and a faster rate of product introduction [6]. The bike manufacturer must continue to innovate to satisfy their customers' needs while ensuring that the entire production process can be performed using the company's existing facilities at the lowest possible cost [7].

This study aimed to determine e-bike feature preferences desired by Indonesian consumers. This study was conducted following the concept of product development, beginning with market research to identify user preferences. The market research phase employed the Choice-Based Conjoint (CBC) methodology to determine consumer e-bike attribute preferences. Consumer preferences were input for subsequent analyses, focusing on the manufacturability of the bike industry refers to design for manufacturing method, but is not discussed further in this research. The following section will briefly discuss the research methodology and the market survey design in the third section. The fourth section highlights the survey result and discussion. This paper concludes with research findings and remarks on suggested e-bike product development.

2 Methodology

The methodology of the product development process is conducted by examining customer preferences through market research. A product-selection questionnaire determines customers' e-bike attribute preferences via CBC. The hierarchical Bayes approach evaluates each respondent's preferences for an e-bike attribute's utility based on the questionnaire. The CBC results indicate customer preferences, predict e-bikes market share, and classify Indonesian e-bikes consumers. They subsequently determined the manufacturability analysis through Design For Manufacturing (DFM) analysis based on consumer preferences.

2.1 Attribute Identification

Table 1. Literature Study for Electric Vehicle Attributes

Research	Object			Attributes							Methodology						Objective
	e-Bike	Electric Car	Electric Motor	Distance Travelled	Speed	Refuel Station	Emission Level	Purchase Price	Safety	Others	Choice Model	Qualitative	SEM	Conjoint Analysis	Cluster Analysis	Other Method	
[4]				✓		✓	✓	✓		✓	✓			✓		CBC, HB, MNL	Market potentials for PEV and HEV in Flanders
[5]	✓			✓	✓	✓	✓	✓	✓	✓		✓					Qualitative research through interviews about e-Bike user experience
[8]			✓	✓	✓	✓		✓		✓	✓					ML	Factors influencing consumer decision on electric vehicle adaption in Solo
[9]			✓							✓			✓				Consumer purchase intention in Taiwan
[10]		✓		✓	✓	✓		✓	✓	✓	✓			✓	✓	CBC, HB, MNL	Market Potentials for electric cars in Indonesia
[11]			✓	✓	✓	✓	✓	✓						✓	✓	CBC, HB, MNL	Market potentials for an electric motor in Indonesia
[12]	✓					✓	✓	✓								ANOVA	Factors influencing the e-Bike buying decision
This Research	✓		✓	✓	✓	✓	✓	✓		✓						CBC, HB, MNL, DFM	Consumer preference for e-Bike specifications and market potentials for electric bikes in Indonesia

CBC: Choice-based conjoint
MNL : Multinomial logit
DFM: Design for manufacturing
HB: Hierarchical bayes
ANOVA: Analysis of variance

Table 2. Definition of e-bikes Attributes

Attribute	Definition
Battery Type	Type of battery used in the e-bikes
Purchase Price	The amount of money spent to purchase an e-bike
Safety Features	Safety devices embedded in the e-bikes
Battery Capacity	The battery capacity of the e-bikes indicates the total amount of electricity generated.
Component's Brand	Brand of the components used on the e-bikes, such as brakes, motor, battery, etc
Motor Positions	Position of the motor on the e-bikes
Charger Type	Type of charger provided by the e-bikes manufacturer
Maximum Speed	The maximum speed that the e-bikes can reach (kilometres per hour)

2.2 Attribute Level

Attribute level refers to the distinct values that a specific attribute can be realized in a product or service. The attribute level is set to be easily communicable and serves as a point of reference for respondents to differentiate between options. **Table 3** shows the level options available for each attribute of e-bikes. The attribute level reduction was performed by reviewing relevant literature, consulting with experts, and responding to requests from a prominent bicycle manufacturer in Indonesia. An experienced manager of the manufacturing company validated the findings.

Table 3. Attribute Levels

	Attributes								
	Battery Type	Purchase Price	Safety Features	Battery Capacity	Motor Positions	Component's Brand	Charger Type	Maxim um Speed	Bike Type
	Integrated frames	<Rp 12,000,000	Without any safety features	<410	Mid Motor	A	Charger 2A	25	City Bike/Folding
Attribute Level	Semi-Integrated	Rp. 12,000,000 - Rp 25,000,0000	Mechanical Lock	410-600	Hub Motor	B	Charger 3A	32	All Urban
	Internal Tubes Battery	>Rp 25,000,000	Electronic Lock with Integrated App	>600		C	Fast Charging (4A)	45	Mountain Bike

2.3 Choice-Based Conjoint Design

The study employed a multinomial choice-based conjoint analysis with the hierarchical Bayes method and using multinomial logit model for the market simulation. The experimental design was selected to gather consumer preferences for various e-bike options available in the market. The experimental design incorporated a "not choosing" option [13] . This is analogous to the market scenario in which consumers can opt for or against products that align with their preferences. This research employs nine attributes, comprising a total of 25 levels, to construct a set of profiles. The full fractional design method resulted in a total of 8,748 profiles, which encompassed all possible combinations of attribute levels. Inefficient methods were avoided, and the fractional factorial design approach was employed instead. A minimum of 18 pair profiles had to be computed.

According to Hair, the maximum number of profiles that can be effectively used in each choice set is four [14]. The study consisted of choice sets that included three alternative profiles and a single option of "not choosing." The d-optimal design method was employed through statistical software to create the choice set. The method yielded 20 choice sets, comprising an estimation set and two holdout sets. The holdout set was reserved for the validation phase of the experimental outcomes.

2.4 Survey Process and Sample Characteristics

The scope of this study was limited to individuals who are 15 years of age or older. Data-gathering was performed by an internet-based survey platform involving 153 participants. Numbers of minimum respondent calculated using formula from prior research [15] for CBC conjoint with large population size. The study criteria specified that participants must have experience operating bikes or motorcycles. Having prior experience riding a bike and motorcycle is crucial in this research, as the e-bike is a hybrid mode of transportation that combines both. Therefore, to obtain insights about e-bike preferences, it is imperative to have participants who possess experience in both modes of transportation. The employed sampling methodology entailed non-probability sampling techniques, specifically judgmental sampling, and snowball sampling method [8].

2.5 Attitude and Preference of Respondents

Table 4 provides a summary of the demographic distribution of respondents. Questions about respondents' gender, age group, residence, level of education, occupation, monthly income, number of bicycles and number of motorcycles owned, bike and motorcycle riding experience (in years), distance travelled by bicycle per week, frequency of bicycle riding per week, and preferred type of e-bike were included in the demographic questions. For each series of questions, the distribution of respondents' demographic information is represented as a percentage. **Table 5** contains questions regarding the cycling activity of participants, as well as their understanding and evaluation of e-bikes. Respondents are interested in e-Bikes and the environmentally beneficial technology used by e-Bikes, as indicated by their responses. Additionally, respondents concur that it is necessary to take action to save the environment, including using environmentally beneficial vehicles.

Table 4. Summary of Respondent Demographics

Variables	Category	Percentage
Gender	Male	59%
	Female	41%
Age	15-24	16%
	17-24	1%
	25-34	21%
	35-44	32%
	45-54	22%
	>55	8%
Location	Bali	3%
	Bangka Belitung	1%
	Banten	3%
	Bengkulu	1%
	D.I. Yogyakarta	1%
	DKI Jakarta	19%
	Gorontalo	1%
	West Java	46%
	Central Java	3%
	East Java	10%
	West Kalimantan	1%
	East Kalimantan	1%
	North Kalimantan	1%
	Kepulauan Riau	1%
	Lampung	1%
	West Nusa Tenggara	1%
	East Nusa Tenggara	1%
	Papua	1%
	Riau	3%
	South Sulawesi	3%
	North Sulawesi	1%
	North Sumatera	3%

Variables	Category	Percentage
Education Level	Diploma (D1/D2/D3/D4)	12%
	Master (S2) or Doctoral (S3)	18%
	Bachelor (S1)	50%
	Senior High School	18%
	Junior High School	2%
Occupation	Athlete	1%
	Photographer	1%
	Freelance	1%
	Housewife	7%
	Consultant	1%
	Student	12%
	Government Employee	10%
	Private Officer	27%
	Coaches	1%
	Entrepreneur	20%
	Retired	3%
	Proffesional Officer (Doctor, Lawyer, etc)	16%
	Unemployed	1%
	Army	1%
Monthly Income in Rupiah	<6 mil/month	29%
	>20 mil/month	17%
	10-20 mil/month	27%
	6-10 mil/month	27%
Number of Motorcycle Owned	1 motor	37%
	2 motor	37%
	3 or more motor	13%
	Zero	13%
Number of Bicycle Owned	1bicycle	27%
	2 bicycle	31%
	3 or more bicycle	41%
Years of Experince Riding Bicycle	Less than 2 years	14%
	More than 2 years	86%

Variables	Category	Percentage
Frequency of riding bicycle in a week	2 times per week	33%
	1 times per week	23%
	5-7 times per week	8%
	3-4 times per week	27%
	Never	9%
Distance travelled with bike in a week	>80 km	14%
	0-20 km	20%
	21 km - 40 km	32%
	41 km - 60 km	20%
	61-80 km	13%
Frequency of long distance (>80km) ride with bicycle	more than 5 times a year	23%
	1 time per year	17%
	2-3 times per year	27%
	4-5 times per year	10%
	0 time per year	23%
Type of e-Bike that known/liked the most (prior of this study)	All urban bike	35%
	City bike/folding bike	33%
	Mountain bike	25%
	None	7%

Table 5. Descriptive Statistics of Attitude Indicators

Questions	Percentage of Response					Mean Score
	Strongly Disagree	Disagree	Netral	Agree	Strongly Agree	
Find the urge to do action that save the environment	7%	2%	24%	46%	22%	3,74
Interested on newest e-Bike technology	5%	6%	27%	42%	20%	3,66
Excited with vehichle that use newest technology features	5%	7%	27%	41%	21%	3,66
Willingness to pay more on product/service that environmentally friendly	4%	7%	29%	43%	16%	3,61
Planning on buying e-Bikes in 5-10 years	7%	14%	35%	29%	15%	3,31

Notes : variables codes (Strongly disagree = 1 and Strongly agree= 5)

3 Results and Discussion

Fig. 1 depicts the aggregate utilities for each attribute level. The scale of zero-centered diffs used aggregates all utility-level values for a specific attribute to zero. It should also be noted that a negative utility value at a particular attribute level does not imply that the level is unattractive to the respondent; instead, a negative utility value indicates that another attribute level is superior in the respondents' eyes. The attribute level with the highest share value is 45 kilometers per hour, while the attribute level with the lowest is 25 kilometers per hour. When summed, the attribute with the highest and lowest part values will have the highest importance and presentation value. This can be seen in Figure 2, which depicts the relevance of battery type with 20% importance.

Fig. 1. Aggregated Utilities for Each Attribute Level

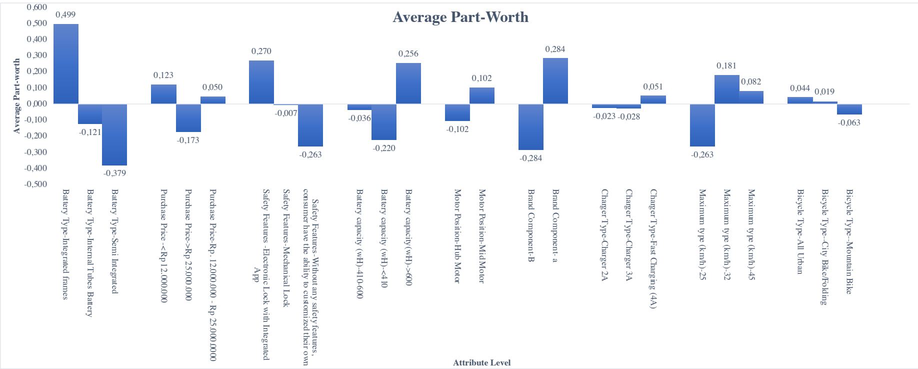
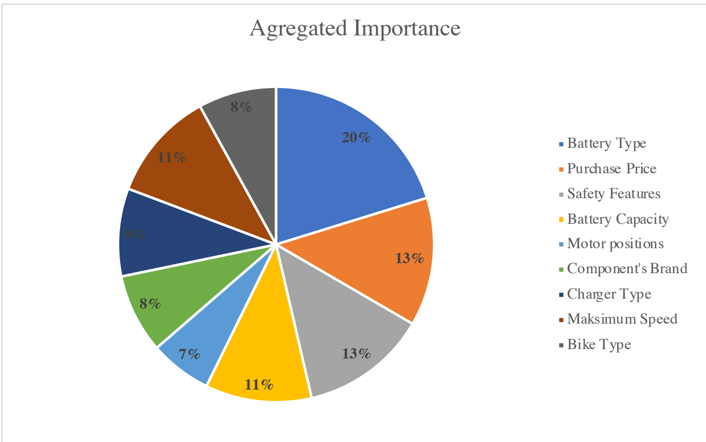


Fig. 2. Aggregated Importance of Each Attribute



To determine the most favored e-bike profile among participants, the cumulative utility score of the e-bike profile was computed. The e-bike profile's total utility value is calculated by aggregating the utility value of every attribute level of each e-bike's product profile. This computation determined the e-bike profile with the highest aggregate utility value. **Table 6** displays the top three e-bike profiles ranked by their total utility.

Table 6. CBC e-bikes Profile's Total Utility Rank

Product ID	Battery Type	Purchase Price	Safety Features	Battery Capacity (kWh)	Motor Positions	Component's Brand	Charger Type	Maximum Speed (kph)	Bike Type	Total Utility
City Bike/Folding Opt	Integrated frames	Rp. 12.000.000 - Rp 25.000.0000	Mechanical Lock	>600	Mid Motor	A	Fast Charging (4A)	45 km	City Bike/Folding	1,285
Mountain Bike Opt	Integrated frames	Rp. 12.000.000 - Rp 25.000.0000	Electronic Lock with Integrated App	>600	Mid Motor	B	Charger 3A	32 km	Mountain Bike	0,983
All urban Opt	Integrated frames	Rp. 12.000.000 - Rp 25.000.0000	Electronic Lock with Integrated App	<410	Hub Motor	A	Fast Charging (4A)	25 km	All Urban	0,563

The market share value of the e-bikes is predicted using its anticipated attribute level utility value. The conjoint simulation method is used to predict market share value. The simulation relied on the premise that consumers' selection of a new e-bike depends on its attributes. Three e-bike profiles with the best utility for each category were simulated together. Consumer preferences for e-bike attributes are used to create the composite simulation. E-bikes market share value projections were made twice. First, the market share value of the top three e-bike profiles with the highest total usefulness, as shown in Fig. 3a. Conjoin simulation will be conducted for three e-Bike profiles with the highest utility for each type of e-bike. The e-Bike profiles (from the CBC experiment results) with the highest utility can be seen in **Fig.** 3a.The city bike profile dominated the market share with 46%.

Fig. 3a. e-Bike market share (CBC profile)

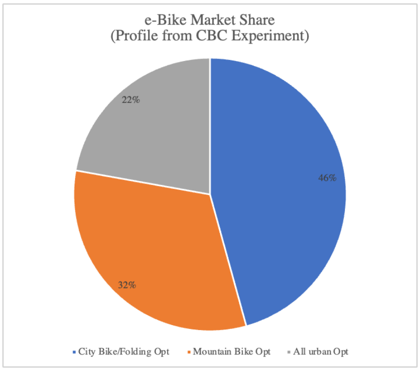
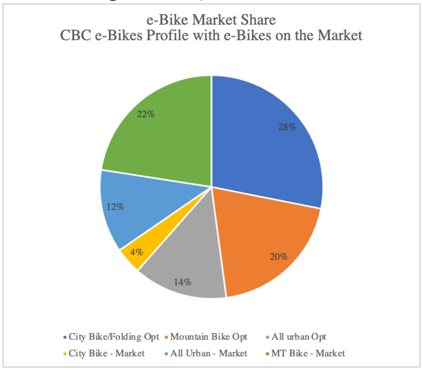


Fig. 3b. b. e-Bike market share (CBC profile and Existing Product)



The second e-bike market share value prediction is for the top three e-bike profiles and currently available e-bikes. It seeks to determine the market share of product profiles developed based on CBC experiments with previously marketed e-bike products. Figure 3b depicts the existing e-bike profile on the market, while **Table 7** displays the e-bike profile with the results of the CBC experiment. It can be seen that when compared to existing products on the market, the CBC experimental e-Bike profile's market share is reduced, but it still holds a 28% market share. The market share of extant city bikes on the market is only 4%, which is significantly different from the market share of the CBC experiment's city bikes.

Table 7. Profiles of E-bikes on the Market

	Product ID	Battery Type	Purchase Price	Safety Features	Battery Capacity (kWh)	Motor Positions	Component's Brand	Charger Type	Maximum Speed (kph)	Bike Type
Existing Product in Indonesia e-Bike Market	City Bike - Market	Internal Tubes Battery	Rp. 12.000.000 - Rp 25.000.0000	Without any safety features	<410	Hub Motor	A	Charger 2A	25 km	City Bike/Folding
	All Urban - Market	Semi Integrated	Rp. 12.000.000 - Rp 25.000.0000	Electronic Lock with Integrated App	410-600	Mid Motor	A	Charger 3A	32 km	All Urban
	MT Bike - Market	Integrated frames	>Rp 25.000.000	Electronic Lock with Integrated App	410-600	Mid Motor	A	Fast Charging (4A)	32 km	Mountain Bike

This study utilized agglomerative hierarchical clustering (AHC) to identify respondent segments by their characteristics. Agglomerative hierarchical clustering starts with each object as separate cluster, then clusters are formed by grouping objects into bigger and bigger clusters. The clustering variables are the individual part-worth [13], using Euclidean distance and ward's method as agglomeration method. The data suggest two groupings: Cluster 1 with 100 respondents and Cluster 2 with 53 respondents. Cluster 1, predominantly males aged 25-54, is shown via cluster cross-tabulation. Respondents in this cluster earn under 6 million Rupiah monthly. This cluster has up to two motorbikes or up to three bicycles and rides 21-40 km/week; Cluster 1 responded "neutral" or "agree" to e-bikes questions. Cluster 2 is gender balanced and has a smaller sample size with members aged 35–44. This cluster makes 10–20 million Rupiah each month. In contrast to Cluster 1, Cluster 2 has only one motorcycle and up to two bicycles. Cluster 2 travels 40-60 km/week. Due to their higher level of wealth, this cluster prefers e-bikes. It is willing to pay more for technologically advanced and eco-friendly vehicles, as shown by its responses to interest and riding habit questions. **Table 8** shows the details for each cluster.

Table 8. Cluster Characteristics

Difference Category	Cluster 1	Cluster 2
Gender	Dominated with male respondents	Varied between male and female respondents
Age	Varied in range 25-54 years old	Majority aged 35-44 years old
Salary range	Less than 6 million ru-piah per month and 6-10 million per month	6-20 million rupiah per month
Number of bike owned	3 bikes	2 bikes
Distance travelled by bike per week	21-40 km per week	41-60 km per week
Interested on newest e-Bike tech-nology	Neutral-Agree	Strongly Agree
Willingness to pay more on prod-uct/service that environmentally friendly	Neutral-Agree	Strongly Agree
Find the urge to do action that save the environment	Agree	Strongly Agree
Proffered purchase price attribute level	Under 12 million rupiah	12-25 million rupiah
Attribute's Importance Order	1. Battery Type 2. Safety Features 3. Purchase Price 4. Battery Capacity 5. Maximum Speed 6. Charger Type 7. Component's Brand 8. Motor Position	1. Battery Type 2.Purhcase Price 3. Safety Features 4. Maximum Speed 5. Battery Capacity 6. Charger Type 7. Component's Brand 8. Motor Position
Cluster Name	The Safe Performance	The Speed Practicality

4 Conclusion

The research findings indicate a significant level of interest in e-bikes among the Indonesian population. The attribute with the most importance is the maximum velocity, with a significance of 29%, whereas other attributes have importance ranging from 3% to 10%. The most preferred e-bike profile is the city bike with an integrated frame battery. It has a mechanical lock, a battery capacity exceeding 600 kWh, and a mid-motor with an A-brand component. The bike is priced between 12 and 25 million Rupiah, has a fast-charging charger, and can reach a maximum speed of 45 km/h. The market share of the city bike e-bike optimum profile is 46%, while the mountain bike profile holds 32%, and the all-urban profile is 22%. Upon integration with three different e-bike products catering to each bicycle type (city bike, mountain bike, all urban) currently available, the market share of the city bike declined to 28%. Meanwhile, the existing mountain bike products retained a market share of 22%. The mountain bike optimum, developed through the CBC experiment, achieved a 20% market share. The study revealed the existence of two distinct clusters of e-bike customers in Indonesia, with Cluster 1 having a significantly higher number of members than Cluster 2. Cluster 2 positively correlates with higher income levels and weekly bicycle mileage. Additionally, this group is willing to pay a premium for environmentally conscious products featuring advanced technology.

From the results of the market share analysis, it is expected that bicycle manufacturing companies will in the short term focus on producing e-bike-type city bikes because of the market share for city bikes. E-Bike manufacturing companies should also adjust marketing strategies based on consumer segments formed from the results of cluster formation. Members of the safe performance segment are very concerned with attributes related to the e-Bike battery. In conducting promotions, the thing that should be highlighted is that the e-Bike produced has an affordable price and a high battery capacity. The next segment is speed and practicality. Segment members are very interested in e-Bike technology and are willing to pay more for products with more environmentally friendly technology. In conducting promotions, we must highlight the advanced features possessed by e-Bikes to support the practicality and safety of their use. Bicycle manufacturing companies must also consider aspects of *design for manufacturing* when developing e-Bike products. The design for the manufacturing stage starts with considering sourcing strategies, estimating manufacturing costs, reducing component costs, reducing assembly costs, reducing production process support costs, and reducing logistics costs. In considering sourcing strategies, manufacturing companies should first reduce customer preferences into e-Bike components to ensure that all consumer desires can be facilitated.

Future research is expected to reach more respondents from different regions in Indonesia so that all regions can be represented. In conducting conjoint analysis for market share prediction, it should be done using the nested multinomial logit model method, where the addition of alternatives is a superset of the previous model. This is done to overcome the assumption of independence of irrelevant alternatives. The formation of clusters should be done in two stages. The first stage is to determine the optimal number of clusters with the *hierarchical* method. The next stage is to use the number of clusters and cluster centroid values as a reference for non-hierarchical *clusters* with the optimizing portioning method.

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