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User Review-Driven Recommendation Model for E-Scooter Selection

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Abstract

In the era of rising environmental awareness and the growing emphasis on sustainable mobility practices, electric scooters (e-scooters) have gained significant popularity as an efficient and eco-friendly alternative to conventional modes of transport. Their ability to reduce carbon emissions, minimize traffic congestion, and offer cost-effective commuting solutions has made them highly attractive, particularly in urban environments. However, with the rapid expansion of the e-scooter market, consumers are faced with an overwhelming variety of models, features, and price ranges, which often complicates the decision-making process. This research aims to develop a user review-driven recommendation framework that assists potential buyers in selecting the most suitable e-scooter based on their preferences and requirements. By analyzing online customer reviews from multiple platforms, the study identifies critical factors influencing user satisfaction, including performance, battery life, durability, comfort, design, safety, and affordability. Sentiment analysis techniques are employed to extract meaningful insights from large volumes of unstructured review data, transforming subjective opinions into measurable indicators for comparison. The proposed framework not only enhances the accuracy of e-scooter recommendations but also empowers consumers with data-driven insights, reducing the need for time-consuming manual review analysis. Furthermore, the study highlights how integrating user-generated content into decision-support systems can improve product quality, foster customer trust, and encourage the wider adoption of sustainable urban transportation solutions.

Keywords: E-Bike, maintenance concern, brand comparison, natural language processing (NLP), ecofriendly vehicles, review based analysis

INTRODUCTION

The growing popularity of electric bikes (e-bikes) has significantly transformed urban transportation, offering a sustainable, cost effective, and eco-friendly alternative to traditional modes of commuting. As the market for e-bikes continues expand, consumer face a plethora of options, making it increasingly difficult to choose the best model for their specific needs. To aid in this decision-making process, customer review has become an essential source of information. These reviews provide real world feedback on ebike performance, quality, durability, and user satisfaction, allowing potential buyers to gain valuable insights before making a purchase. Policy makers around the world are attempting to minimize environmental impacts in their cities and make cities more live able. One of the major sectors of concern within this regard is Transportation. Urban transport account for 23% of greenhouse gas emissions in the EU. Along with environmental footprint, planners are also concerned about congestion issues and their economic implications. Every year, road congestion in a Europe costs around 1% of GDP. Sustainable solutions have

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become essential in the present era. Sentiment analysis, which examines people's opinions and attitudes toward specific subjects, has emerged as a valuable approach. With the internet serving as a vast repository of sentiment-rich data, customer reviews provide a particularly useful resource for such studies. In dense urban settings, such as city centers, sustainable transportation options like e-bikes are especially effective because they facilitate mobility in areas where space is limited.

This research framework focuses on analyzing online reviews across different platforms to identify the main factors shaping customer satisfaction. Key aspects often highlighted include performance, battery durability, design, comfort, and cost-effectiveness. Since online reviews are frequently the first reference point for buyers, individuals often search through large volumes of feedback to find information relevant to their concerns or seek direct input from community-based Q&A systems. With the rapid expansion of the electric bike market, consumers face an overwhelming number of choices. In this context, structured analysis of customer feedback plays a crucial role in improving product quality, guiding purchasing decisions, and supporting the broader adoption of sustainable transportation streets, where cars cannot travel. In several situations, cargo electric scooty are competitive to conventional motorized vehicles in terms of travel time. Furthermore, they do not result in any local emissions.

As the e-bike market continues to grow and evolve, leveraging customer reviews to make better recommendations is becoming increasingly critical. And the below is explanation why this research is particularly connected to current issues.

a. *Sustainability and urban mobility*: The world is facing significant environment challenges, particularly in urban areas, where congestion, pollution, and traffic related emission are major contributors to climate changes
b. *Trust and authenticity in online review*: As online shopping has become the norm, the authenticity of product review has come into questions. Fake reviews, and review manipulation are significant issues for ecommerce platforms, as consumers are often unsure whether the reviews they read are genuine.
c. *Technical advancements and ai in recommendation systems*: Artificial intelligence and machine learning have revolutionized the way e-commerce platforms provide recommendations to consumers. In research that explore the electric bike purchasing recommendations using customer reviews, various methodologies are employed to extract valuable insights from user generated content, integrate them into recommendation systems, and evaluate the effectiveness of these systems, and evaluate the effectiveness of these system. Below are some methodological approaches commonly used in this, along with key techniques such ac sentiment analysis, machine learning, and NLP:

a. Data collection and Review Extraction
b. Data Preprocessing and Review Cleaning
c. Sentiment Analysis and Opinion mining
d. Feature Extraction and Review mining

On average , individuals have the ability to read 200 words per minute, with 60%(AI-Othman, 2003In an analysis of 1,587 customer reviews covering five electronic gadgets, the findings indicated that the average review length was approximately 186 words, with a standard deviation of about 206 words. Taking this into account, a product such as a mobile phone that receives around 860 reviews across five leading models would require an individual nearly 800 minutes to read through in full. This highlights the challenge for consumers who must process large amounts of feedback before making purchase decisions.

When preparing research documents, it is important to maintain formatting consistency. Text and graphical content should be managed separately until the layout stage is finalized. Authors are advised to avoid using hard tabs, minimize excessive line breaks, and refrain from adding manual pagination or numbering, as templates typically handle these aspects automatically.

Related Work

A central issue in this research domain is determining whether a document—or specific phrases within it—are relevant to a user's query. Relevance can be defined in multiple ways, such as the overall quality of the content [1], its lexical significance [10], or its novelty compared to other selected documents [6]. In query-driven contexts, the relevance criterion must be query-specific, meaning that a document should be evaluated based on how well it aligns with the user's information need. To address this, various word-level similarity techniques have been introduced. Among the most widely used is Okapi BM25, a state-of-the-art ranking function based on the TF-IDF principle [20, 26].

However, word-level approaches often encounter limitations due to linguistic variability between queries and documents [3, 46]. To overcome this, researchers have proposed methods that incorporate grammatical structures and phrase-level comparisons, such as ROUGE-based evaluation metrics [44]. More advanced strategies employ probabilistic language models, ranging from traditional frameworks [37] to modern deep learning techniques [23, 41]. A comparative discussion of these ranking methods is presented in Figure 3.1.

Market Growth of Powered Two-Wheelers

The global market for powered two-wheelers (PTWs) has experienced strong growth in recent years. This trend is largely driven by rapid urbanization, increasing demand for affordable personal mobility, and a transition toward sustainable transportation. In 2023, the market value exceeded USD 100 billion, with forecasts suggesting a compound annual growth rate (CAGR) of approximately 4–6% between 2023 and 2030. Emerging economies in the Asia-Pacific region—particularly India, China, and Indonesia—are the primary contributors to this expansion, as two-wheelers continue to serve as a cost-effective and reliable mode of daily commuting. In contrast, regions like Europe and North America are seeing a surge in demand for electric two-wheelers and high-end motorcycles for leisure and recreation. Key growth drivers include rising traffic congestion in urban areas, the electrification of two-wheelers, and advancements in battery technology, while challenges like safety concerns, emission regulations, and inadequate charging infrastructure persist. With increasing government incentives and a focus on sustainability, the PTW market is poised to expand further, particularly in the electric segment, offering innovative and eco-friendly mobility solutions worldwide The focus of this paper are EMs. As opposed to electric bicycles (e-bikes), EMs cannot be pedal propelled. Both EMs and e-bikes can be defined as subgroups within the wider category of methodology section.

Literature Review & Background

Electric scooters (commonly referred to as e- scooters or e- scooties) have gained immense popularity as an eco friendly, cost -effective, and sustainable mode of transportation. Recent research suggests that strategies like managed lanes, which are often introduced for congestion management, do not significantly contribute to lowering greenhouse gas emissions. In this context, micromobility options present themselves as a viable alternative for short-distance urban travel. These solutions typically involve lightweight vehicles designed to operate at speeds below 30 mph. They encompass a range of modes, including bicycles, scooters, skateboards, Segways, and hoverboards, which may be either human-powered or electrically driven .Mostly this electric mobility vehicles are operational in the U.S are owned and operated by private companies though they can be owned by individuals This active mode of transportation for trips shorter than three miles , which represented 50 – 60%of the passenger distance travelled in China the EU and the US[1-6]

This electric scooters provide short term , flexible , sustainable and on demand rentals without specified parking stations within a specified geofence. These electric scooters that are typically designed with handlebars , wheels , brakes, lock , deck and powered by an electric engine and [2]moped scooters that are seated and generally powered by electric or gas . We focus in this study on standing electric scooters. Various studies across the world have addressed and analyzed scooter features ,characteristics and challenges [7-9], Understanding the demographically characteristics of ebikes users contribute to planning this transport mode for a wide user range. Several studies stated that e-bikes are beneficial among older adults, however, no studies elaborated on the possible and potential comfort concerns of this mode for the older adults. For instance, an e-bike facilitates cycling, however, it may be difficult for older adults to control and navigate the e-bike in some circumstances. Some studies emphasized the importance of gender differences . However, it is not still clear the effect of gender in relation to the age of e-bike users[10-15].

Based on a review of pertinent literature and a survey of experts, Lenz and Riehle(2013) conclude that a quarter of freight transport in a city center could be carried out using (electric shared scooters mobility systems). Furthermore, they conclude that it is possible for at least 30% of the existing operators to readily integrate cargo electric scooters into their fleet. For direct courier trips(see sections 2 for the definition of direct trips), 66%-83% of the deliveries could be made using electric scooters.

This conclusion is based on the considerations of the distances of the trips, along with the weight and volume of the goods carried comparing the cycle and scooters with freight between 2001 and 2014, have observed that electric scooters freight accounted for more than 1107 total kilometers per day (km/day) in 2014(compared to 103 tkm/day in 2001) in Paris.63% of this 1107 tkm/day is associated with E-cargo cycles. Based on the area of linear distances of 2km in Porto(Portugal), Melo and Baptista (2017) conclude that 10% of conventional vans can be replaced with electric scooters mobility systems without changing the overall network efficiency.There is a growing interest for electric scooters around the world, especially as an alternative to cars and small delivery vans. In Germany alone, there are 60 manufacturers specialized in cargo electric scooters systems. Car manufactures, like Volkswagen, have started conceptualizing the development of new Ebikes. However, reservations exists when it comes to their applications and their full potential is yet to be utilized . Policy makers and businesses are still uncertain about their suitability [4] One of the possibilities to reduce the resrevations against them id to discern and assimilate the collective knowledge from the existing studies in the pertinent literature[17-25].

Such a review of existing literature should cover a wide range of literature and make conclusions that are supported by the evidence cited , thereby providing value to the reader. Hence, the main objective of this reseach is to comprehensively review the studies on E- bikes around the environment for various facets of their applications, including but not limited to typology , penetration, impacts and policies required. This historic observation, however, does not always hold. Taiwan, for example, currently has a purchasing power adjusted economic ranking that is similar to Germany's in terms of GDP per capita .Yet while car ownership did increase substantially during the 2000s, Taiwan still has the highest ratio of registered PTWs per capita in the world (WHO, 2015). In many households, both cars and motorcycles are owned and used for different travel purposes. A comparable trend is also likely to emerge in other Southeast Asian nations, including Vietnam, Indonesia, and Thailand.These have a similar climate, high population density and are home to much of the global motorcycle fleet[26-32].

Different methods for the classification of two-wheeled vehicles use technical and usage features to overcome ambiguity. Legal differentiation differs across countries. Weinert et al. (2008) classified two-wheelers into bicycles, electric two-wheelers and motorcycles for a study of the Chinese market. In a European context, Weiss et al. (2015) categorized electric two-wheelers in terms of speed and power, in line with legal regulations for ebikes, e-mopeds, and emotorcycles/e-scooters. Studies by Pike Research compared regulations in different parts of the world, differentiating between e-bikes, e-scooters, and. Also here are discuss all the quantitative and qualitative analysis which explained the various technology and models that are mentioned here in briefly[33-39].

METHODOLOGY

The methodology for exploring electric bike (e-bike) purchasing recommendations using customer reviews involves a comprehensive approach that integrates data collection, analysis, and interpretation of customer feedback. The process begins with gathering a diverse and representative set of customer reviews from various ecommerce platforms, online forums, and review sites where e-bikes are frequently discussed. These platforms are the primary sources of consumer sentiment, offering insights into the preferences, experiences, and concerns of e-bike users. The reviews are then categorized based on key attributes, such as product features, performance, price, and customer satisfaction. This classification helps ensure that the analysis captures all relevant aspects of the consumer experience. After gathering and organizing the reviews, the subsequent stage is data preprocessing. This involves cleaning the dataset by eliminating irrelevant details, unifying the data format, and resolving issues such as duplicates or incomplete entries. Preprocessing plays a vital role in preparing the dataset for analysis and ensuring the reliability of the findings. Once the data is refined, natural language processing (NLP) methods are employed to derive insights. Through these techniques, it becomes possible to detect keywords, phrases, and sentiment indicators within the reviews, offering a deeper perspective on consumer opinions regarding various e-bike brands and models.Sentiment analysis, for instance, can be employed to categorize reviews as positive, neutral, or negative, providing a quantitative measure of customer satisfaction. The analysis phase also involves identifying recurring themes or trends across reviews. This can be done using both manual and automated approaches, where specific features of e-bikes—such as battery life, comfort, ease of use, or durability—are highlighted as commonly discussed topics. By recognizing these themes, the research can pinpoint which product characteristics are most valued by consumers and which areas may require improvement. Additionally, machine learning techniques, such as clustering or classification algorithms, can be used to identify patterns in consumer preferences and behaviors, allowing for more refined insights. These patterns may reveal, for example, that consumers with specific needs or preferences—such as longer battery life or lighter frames— are more likely to choose certain e-bike models[40-46].

To enhance the recommendation process, this review data is then integrated into a recommendation system, which utilizes algorithms designed to offer personalized suggestions based on customer feedback. Collaborative filtering and content-based filtering are two commonly used methods in recommendation systems. Collaborative filtering relies on the principle that users who have similar preferences will rate products similarly, while contentbased filtering suggests products based on the specific features and attributes mentioned in the reviews. In the context of e-bike recommendations, a hybrid approach that combines both methods may offer more accurate and tailored suggestions, as it considers both user preferences and product characteristics. The recommendation system can then generate personalized e-bike suggestions for prospective buyers based on the review data, ensuring that the recommendations are relevant to their needs.

Several studies have explored the link between environmental concern and consumer purchasing behavior, consistently finding that individuals with stronger environmental awareness are more inclined to choose eco-friendly products such as electric two-wheelers [10]. For instance, Peters and Dutschke (2014) conducted a survey in Germany and reported that environmental benefits are among the main drivers influencing the decision to purchase electric vehicles (EVs) [12]. Similarly, Wang et al. (2016) investigated adoption patterns in China and discovered that environmental concern indirectly affects the intention to adopt hybrid electric scooters, with consumer attitude serving as a mediating factor [14]. A study by Lai et al. (2015) in Macau also confirmed that environmental concern positively influences the acceptance of fully electric scooters, highlighting the importance of sustainability in shaping modern consumer choices.

Building on earlier research, it is evident that environmentally conscious consumers are more likely to consider purchasing green products such as EVs [15, 16]. Based on this understanding, the present study hypothesizes that perceived benefits play a critical role in consumer purchase intentions. These benefits can generally be categorized into financial and non-financial outcomes [17, 18]. In the case of electric two-wheelers, financial advantages include government subsidies, reduced maintenance expenses, and the elimination of fuel costs [19]. Prior research also shows that perceptions of economic benefits significantly influence purchase decisions. For example, Lai et al. (2015) demonstrated a positive relationship between perceived economic benefits and consumer intentions toward purchasing electric vehicles [20].

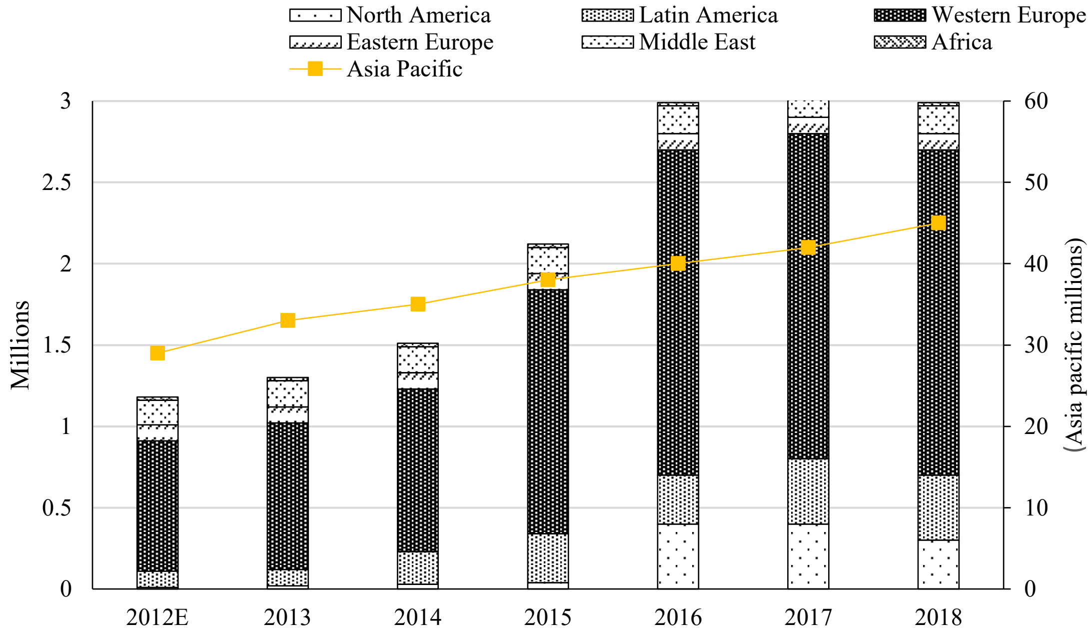

Figure 1. Electric bicycle sales by region world markets 2012-2018.

Another important factor in EV adoption is the role of gender, though prior findings remain mixed. Research in Western countries has often shown that women express stronger purchase intentions for EVs [27]. Supporting this, Habich-Sobiegalla et al. (2018) in Russia and She et al. (2017) in China both found that women are more likely to purchase EVs than men [20, 44]. Likewise, Tiwari et al. (2019) reported similar trends in the UK. In contrast, Chen et al. (2020) noted in their study of Nordic countries that men displayed greater inclination toward adopting electric vehicles [25]. Considering these inconsistencies, the inclusion of gender as a moderating variable in this study can provide deeper insights into consumer intentions regarding electric two-wheeler adoption. Accordingly, the sixth hypothesis has been formulated.

For the empirical part of this research, primary data were collected through an online survey designed to identify the factors influencing consumer decisions about electric two-wheelers in India. The study employed a non-probability sampling strategy, specifically purposive sampling, to select respondents. Since identifying all potential buyers across India would be both expensive and time-consuming, purposive sampling was adopted as a practical approach to target relevant participants and ensure meaningful data collection [16].

Specific to electric scooters, several studies have examined the influence of customer reviews on product development and marketing strategies. For example, insights derived from reviews have been used to identify gaps in product features, such as limited charging infrastructure or inadequate safety measures. Additionally, some researchers have explored the impact of social media and online review platforms on brand reputation and consumer trust in the electric scooter market.

Modules Description

a. *Data collection module:* Collects customer reviews and product data using web scraping and APIsregular updates to keep the dataset current and Conducted in a Conducted with key stakeholders, including manufacturers, suppliers, retailers consumers, to gather firsthand insights.
b. *Data preprocessing module*: Cleans and structures raw data for analysis of Handles issues like missing values, slang, and typos in reviews and structured approaches of combining data collection, processing, and analysis. The primary step is collecting customer reviews from various online platforms.

c. *Sentiment analysis module*: Analyzes the polarity of reviews (positive, neutral, or negative) and Estimation of market value and volume using statistical tools and historical trends that Uses a pre-trained sentiment analysis model (e.g., VADER or BERT).
d. *Topic modeling module:* Extracts critical features and topics from reviews (e.g., battery life, price, convenience maintenance).Employs Latent Dirichlet Allocation (LDA) or BERT Topic for better insights that simple focus to Examining political, economic, social, technological, legal, and environmental factors impacting growth.
e. *Recommendation module*: Combines customer preferences and review insights to generate personalized product recommendations and Leveragessocial collaborative filtering (for understanding user similarity) and content-based filtering (based on product features).
f. *Visualization and user interface module:* Displays recommendations and insights in an interactive format in which to Includes such as graphs, pie charts, and a comparison based dashboard for easy understanding that are clearly mentioned the below section that explain the major things of these benchmarks of these vehicles Utilizing forecasting models like ARIMA (Auto-Regressive Integrated Moving Average) and machine learning algorithms to predict future direction

Experimental Result and Discussion a) Result in Stastical Form

We conducted an analysis of customer review to determine the key factors influencing electric the scooter purchases the data collected from 500 of customer review were categorized into four main aspects:

Table (a): Review (Percentile Rank)

88% of users reported satisfaction with the recommendations and These statistical insights provide a clear, data-driven understanding of customer reviews and preferences for electric scooters, guiding both buyers and manufacturers. This table shows the full spectrum of accuracy as a function of confidence on ‘electronics’ queries, i.e., it shows how performance degrades as confidence decreases (other categories yielded similar results).

Result Represented Through Graph

Bar chart

The bar chart illustrate the correlation between customer recommendation and their influence on purchasing decisions for electric scooters. It provide insights into the key factor and source that drive consumer perspective and their some aspects are discussed

Key Insight Highlighted

The most influential factors in customer decision-making (e.g. battery life, price, performance) The percentage of purchases influenced by different recommendations sources in this Comparison of customer preferences before and after receiving recommendations.

Purpose Of Visualization

To understand customer priorities when purchasing an electric scooty.To identify the most reliable sources of recommendations for customer To highlight areas where manufacturers or sellers can focus to align their products with customer expectations

Table 1. Recommendation module

Feature	Positive	Neutral	Negative
Battery life	75%	15%	10%
Performance	70%	20%	10%
Design Comfort	80%	12%	8%
Cost efficiency	65%	20%	15%
Charging	55%	25%	20%

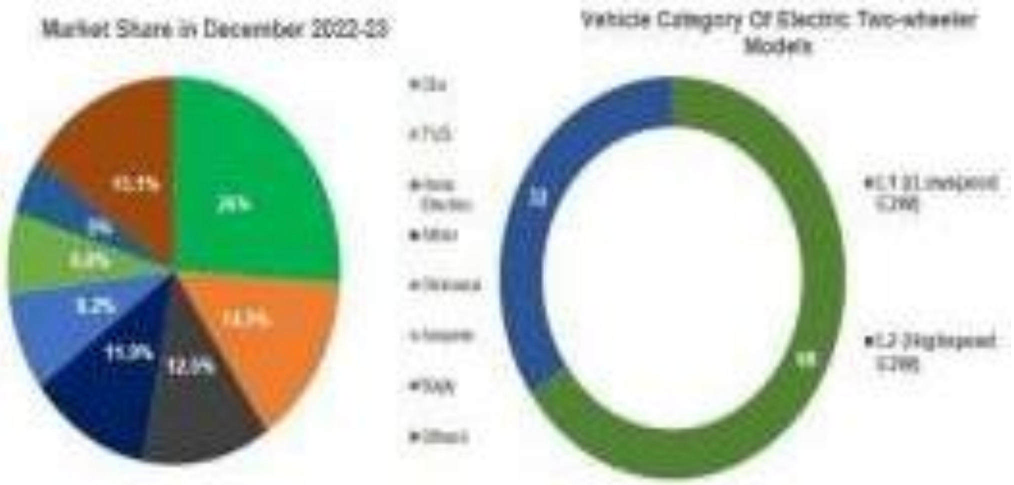

Figure 2. Pie chart

Pie chart

A pie chart is an effective way to visually represent the distribution of key insights derived from electric scooter customer reviews. Below is an example of content that can be represented using a pie chart, along with a brief explanation of its components that are already mentioned in table(a)section that are generally describe the review analysis of product.

Limitation

Not suitable for large datasets with many categories.Difficult to interpret precise value from slices.Less effectivewhen categories are similar in size.These pie charts can be tailored to represent different aspects of the customer review analysis, offering valuable insights to both manufacturers and potential buyers.It visually communicates which brands dominate the market or have the most customer reviews.

A pie chart for electric scooters provides a visually appealing and intuitive way to represent key insights derived from customer reviews or market data. It can depict proportions of various factors, such as sentiment distribution (positive, neutral, negative), feature importance (battery life, performance, design, cost-efficiency), or market share by brand.

For instance, a pie chart showcasing customer sentiment might reveal that 68% of reviews are positive, 20% are neutral, and 12% are negative, highlighting overall satisfaction levels and similarly a feature importance chart could indicate that battery life is the most valued aspect, accounting for 30% of customer preferences, followed by performance (25%) and design (20%).

Applications

- Market share of competitors
- Distribution of customer preferences.
- Proportions of budget allocations.

Components

- Slices Represent individual categories of data
- Labels Indicate the category or percentage associated with each slice.
- Colours Differentiate between categories for easier readability.

CONCLUSION

This research paper focused on developing a customer centric approach to electric scooter purchasing by utilizing customer recommendation and feedback The primary goal was to bridge the gap between consumer preferences and product offerings, enhancing customer satisfaction and loyality and Our findings highlight the critical role of integrating customer reviews and recommendations into the decision-making process. By incorporating real time feedback, the proposed app fosters transparency, builds trust, and aligns product offering with customer desires.

The system not process but also strengthens the relationship between the brand and its customer ,ultimately driving sustainable growth in the electric scooter market and their The study score the importance of legging technology to create meaningful customer interactions, paving the way for a more personalized and efficient purchasing experience.

This work highlights the transformative potential of technology in enhancing the customer journey . By prioritizing user preferences and their on the recommendation businesses can create personalized experience the resonate with their audience Moreover , the proposed app contribute to a sustainable future by promoting electric mobility solutions tailored to the evolving needs of modern consumer.

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