Influencing Factors of Electric Bicycle Development Scale in Large Cities

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Abstract. The scale and influencing factors of the development of urban electric bicycles is vital to urban development. A model link is established between urban development and the development of electric bicycle scale. It is predicted that electric bicycles in Shenzhen will reach to 5,628,506 in the near future (2025) and to 7,342,929 in the medium term (2030), which is consistent with the expected development situation. Finally, it is pointed out that electric bicycles in large cities have advantages in terms of economy, land, population, and environment. As urban development continues to advance, electric bicycles will also continue to play an important role in the development green transportation in large cities.

Keywords: Electric bicycles · development scale · regression analysis · low-carbon transportation

1 Introduction

According to the China Bicycle Association, the number of electric bicycles in circulation has grown from 160 million in 2012 to 350 million in 2022, with a natural replacement cycle of approximately 3–5 years. The upward trend is expected to stabilize at over 60 million units, reflecting the holding/vehicle replacement cycle of the industry.

Furthermore, several cities across the country have attempted to regulate electric bicycles in response to the increasing volume of riders [1]. For instance, the new safety technical specification for electric bicycles, GB 17761–2018, has been implemented at the national level. Fuzhou City has issued a notice on strengthening the management of electric bicycles. After extensive deliberation, the "Shenzhen Electric Bicycle Management Regulations (Trial)" have also been reviewed and issued. However, several past regulations were human factors-neutral, such as the "power restriction" policy implemented in Shenzhen, which adopted a "one size fits all" approach that mismatches the travel needs of many electric bicycle riders.

2 Literature Review

Research on electric bicycles mainly focuses on analyzing the travel behavior of cyclists. Weinert J, Ma C, Yang X conducted a systematic analysis of the usage of electric bicycles in Shijiazhuang [2]. Cherry, Christopher, and Robert Cervero found that in China,

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cyclists who use electric bicycles travel more frequently than those who use traditional bicycles [3]. Weinert J, Ma C, and Cherry C pointed out that the rapid development of China's electric bicycle industry can be attributed to economic and technological factors, and support from green transportation policies, which have enabled electric bicycles to become widely used in households [4]. Campbell and Andrew Archibald studied the factors that influence people's choice between shared bicycles and shared electric bicycles in Beijing and found that the use of shared electric bicycles is most influenced by socioeconomic status, education level, and gender. Shared electric bicycles are less sensitive to distance, making them an attractive alternative to shared bicycles [5]. Sheng J in discussed the estimation of traffic capacity and bicycle equivalent units (BEUs) for electric bicycles. They proposed eight basic traffic flow diagrams for estimating the one-way traffic capacity and a novel BEU estimation model. These two parameters are essential for planning, designing, operating, and managing bicycle facilities. By optimizing bicycle lane design, formulating reasonable management policies, and strengthening bicycle lane planning and construction, it is expected to improve the capacity and safety of bicycle lanes and better meet the cycling needs of urban residents [6]. Aslak Fyhri and Hanne Beate studied the impact of purchasing electric bicycles on people's riding distances. People who purchased electric bicycles had an average daily riding distance increase from 2.1 to 9.2 km, and the proportion of cycling as the preferred mode of transportation increased from 17% to 49%. The results indicate that people who purchase electric bicycles do ride more, demonstrating its potential to improve cycling activity levels and have a positive impact on urban travel and the environment [7].

3 Data and Methodology

To ensure the authenticity and reliability of the study, authentic statistical data on per capita GDP, permanent population, annual average transportation expenditure per resident, and population density were collected from the Shenzhen Statistical Bureau's published yearbooks. However, data on electric bicycle ownership and non-motorized road network density were not available in official statistical reports. Breakpoint data table was obtained through online and survey collection [8].

To facilitate the construction of regression models, it is crucial to fit the breakpoint data of electric bicycle ownership, transportation expenditure, and the length of non-motorized lanes to produce continuous data for the years 2012 to 2021. Statistics of electric bicycle volume and influential factors from 2012 to 2021 is shown in Table 1.

4 Results

In summary, by conducting data validation on the number of electric bicycles from 2012 to 2021, the predicted range covers the actual number of electric bicycles, indicating that the model conforms to the expected scale of development. The fitting results of predicted and actual volume of the electric bicycle is shown in Table 2.

In order to better explore the relationship between the scale of electric bicycles and urban development, this article selects the near future (2025) shown in Table 3 and

Table 1. Statistics of electric bicycle volume and influential factors from 2012 to 2021

Year	Volume	Per capita GDP	Annual average transportation expenditure per resident	Permanent population	Population density	Road network density
2012	250000	116407	2890.39	1195.85	5282	0.274
2013	723881	124208	2846.56	1257.17	5323	0.324
2014	1152985	130448	2825.81	1317.86	5398	0.384
2015	1582090	135271	3050.88	1408.05	5697	0.454
2016	2011194	142494	3700.85	1495.35	5962	0.538
2017	2440299	150739	3589.57	1587.31	6234	0.637
2018	2869403	155320	4368.18	1666.12	6484	0.721
2019	3500000	159883	5089.54	1710.4	6484	0.893
2020	3727612	159820	4127.29	1764.38	6484	1.106
2021	4000000	173663	4866.58	1768.16	6484	1.253

Table 2. Fitting results of predicted and actual volume of the electric bicycle

Year	Predicted volume	95%	105%	Prediction range	Actual volume
2012	247207	234846	259567	234846 ~ 259567	250000
2013	724642	688410	760874	688410 ~ 760874	723881
2014	1154054	1096351	1211757	1096351 ~ 1211757	1152985
2015	1529583	1453104	1606062	1453104 ~ 1606062	1582090
2016	2094121	1989415	2198827	1989415 ~ 2198827	2011194
2017	2437166	2315308	2559025	2315308 ~ 2559025	2440299
2018	2882046	2737943	3026148	2737943 ~ 3026148	2869403
2019	3433389	3261720	3605059	3261720 ~ 3605059	3500000
2020	3746185	3558876	3933494	3558876 ~ 3933494	3727612
2021	4008777	3808338	4209216	3808338 ~ 4209216	4000000

medium to long term (2030) shown in Table 4 as the prediction years, and uses the model to predict the future scale of electric bicycles in Shenzhen.

In summary, the model predicts that the number of electric bicycles in Shenzhen will be 5,628,506 by 2025 and 7,342,929 by 2030. These predictions are consistent with actual development trends.

Table 3. Predicted volume of electric bicycles in 2025

Per capita GDP	Annual average transportation expenditure per resident	Permanent population	Population density	Length of non-motorized lanes	Predicted volume
185000	5894.563	2111.047	7374.523	2.279	5628506

Table 4. Predicted values for factors in 2030

Per capita GDP	Annual average transportation expenditure per resident	Permanent population	Population density	Length of non-motorized lanes	Predicted volume
200000	7164.563	2460.447	8192.948	3.944	7342929

5 Conclusion and Discussion

As resources become increasingly scarce and the environment continues to be damaged, urban development is rapidly changing, and the role of electric bicycles in urban passenger transportation is becoming increasingly significant.

This paper studies the development of electric bicycles in large cities. Investigations of micro-level individual travel behavior and characteristics of electric bicycle users were conducted in order to create profiles of personal information and travel behavior. Subsequently, macro-level urban development research was conducted using Shenzhen as a representative of large cities, establishing a model connecting urban development with the development of electric bicycles. Finally, predictions were made for the growth of electric bicycles in Shenzhen, presenting a typical urban model for the development of large cities.

Based on the conclusions of this study, we propose the following policy recommendations. First, it is vital to strengthen the construction of electric bicycle infrastructure. Considering the increasingly important role of electric bicycles in urban passenger transportation, it is suggested that cities should increase the construction and improvement of non-motorized lanes, enhance their connectivity and safety, and meet the growing demand for electric bicycles. Second, it is necessary to promote electric bicycles as an environmentally friendly and energy-saving mode of transportation, strengthen public outreach, increase public awareness and acceptance of electric bicycles, and alleviate urban traffic congestion and environmental pollution issues. Third, it is essential to improve electric bicycle regulatory policies. In line with the actual development needs of cities, formulate reasonable and feasible electric bicycle management regulations, avoid one-size-fits-all policies, and fully consider residents' travel needs and the development of the electric bicycle industry.

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