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The Impact of New Energy Vehicle Battery Service on Corporate Financial Performance

-- Research Perspective based on Charging Piles

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Abstract. In recent years, with the rapid development of technology and the "dual-carbon" goal, the new energy vehicle industry in emerging regions has been developing rapidly. However, as a core component of new energy vehicles, the battery has problems in safety, range and insurance services. Therefore, this paper explores the impact of new energy vehicle battery services on its financial performance from the perspective of charging piles. Taking China as an example, this paper uses the quarterly data of 530 listed new energy vehicle companies from March 2019 to June 2022 and the data of charging piles in each province. It establishes a panel model and a HLM multilayer linear regression model with the financial performance of new energy vehicle enterprises as the dependent variable and the number of charging piles as the independent variable to analyze the impact of new energy vehicle battery services on their financial performance. The empirical results show that (1) an increase in the number of charging piles significantly improves the financial performance of local new energy vehicle enterprises. (2) In terms of regional heterogeneity, the number of charging piles in coastal areas and economically underdeveloped areas has a greater impact on financial performance of local new energy vehicle enterprises. (3) The governmental governance capacity in the provinces, technological innovation capacity, and green development attention of local government have a significant moderating effect on the financial performance of local new energy vehicle enterprises.

Keywords: Charging Pile; Financial Performance; Panel Model; HLM Model.

1. Introduction

Battery is the core component of new energy vehicles, accounting for about 40% to 60% of the vehicle cost [1]. However, the current global services for new energy vehicle batteries are not perfect, facing such choke points as the lack of a perfect rate-setting system, and the difficulty of charging [2].

It can be seen that the development of new energy vehicle industry is unstoppable. But "will the layout of new energy vehicle battery infrastructure affect the financial performance of new energy vehicle enterprises?" This question has yet to be resolved. The new energy vehicle refers to the automobile category that contains advanced technology with water, wind, light and other multi-energy power as the power source [3]. Charging piles are charging devices that provide energy supplementation for electric vehicles [4]. The slow construction of charging piles triggered consumers' "mileage anxiety" [5].

At present, there is a relatively rich literature on the study of financial performance of new energy vehicles at home and abroad. Ling (2022)[6] used factor analysis to explore the factors affecting the performance of new energy automobile enterprises; Dong (2020)[7] and Rao (2022)[8] both started from the perspective of the "double integral" policy to study the financial performance of new energy automobile enterprises at different stages of the policy; Wu (2021)[9] used panel data of listed new energy automobile companies to test the performance.

There are also many scholars who carry out prospective research around the issue of charging piles. **First**, it is the site layout of charging piles, such as Yi et al. (2020)[10] used Monte Carlo simulation methods to solve the spatio-temporal distribution model of the vehicles.**Secondly**, in terms of

charging pile billing, for example, Su et al. (2018)[11] used blockchain technology to design a charging mechanism. **Finally**, in terms of charging pile operation and promotion, Zhu et al. (2017)[12] constructed a three-level Stackelberg game model for the interaction among electricity suppliers, charging pile operators and crowdfunding parties.

In summary, a large number of international scholars have invested in the research of new energy vehicles and battery services, but there are still three shortcomings. **First**, few studies have analyzed the financial performance of new energy vehicle enterprises from the perspective of charging pile infrastructure services. **Second**, the number of new energy vehicle enterprises should be updated in a timely manner. **Third**, few studies have focused on the impact of new energy batteries on the performance of vehicle enterprises from the intermediate Chinese province level.

Therefore, in order to fill the above academic gaps, this paper will synthesize some innovations from the following aspects. **First, content innovation:** based on the perspective of charging pile infrastructure services. **Second, method innovation:** this paper will build a panel fixed effect model and HLM linear multi-layer regression model for research. **Third, the innovation of data indicators:** this paper constructs the performance evaluation system of the new energy automobile industry from two types of qualitative and quantitative indicators.

The rest of the paper is organized as follows: chapter 2 presents the research hypotheses; chapter 3 presents research sample and analysis model; chapter 4 presents the empirical results; and finally, research conclusions and implication.

2. Theoretical Analysis and Research Hypotheses

2.1. Main Effect of the Number of Charging Piles on the Financial Performance of Local New Energy Vehicle Companies

The charging pile industry is rapidly rising with the development of new energy vehicles. (This study only considers public charging pile, not private charging pile) Charging piles are an important part of the new power system [13]. The performance of charging pile operators has shown an improving trend. First of all, the sufficiency of charging piles can directly promote the sales of new energy vehicles [14]. In addition, the increase of charging piles will help reduce the operating costs of new energy vehicles. **Based on this, hypothesis 1 is proposed. Hypothesis 1:** An increase in the number of charging piles will significantly improve the financial performance of local new energy vehicle enterprises.

2.2. The Regional Heterogeneity of the Number of Charging Piles on the Financial Performance of Local New Energy Vehicle Enterprises

The impact of the number of charging piles in inland and coastal areas on local new energy vehicle companies may vary due to factors such as geography, market and infrastructure [15]. The higher population density in coastal areas generate greater market demand. The increase in the number of charging piles can meet the charging needs of more consumers, thus stimulating the purchase willingness of new energy vehicles. **Therefore, the following hypothesis 2 is proposed. Hypothesis 2:** Compared with inland areas, the number of charging piles in coastal areas has a greater impact on the financial performance of local new energy vehicle enterprises.

Regional economy will affect the financial performance of local new energy vehicle enterprises. High levels of education and health, a stable Labour market and abundant job opportunities [16].Since the economic benefits of infrastructure have the law of diminishing returns to scale [17], each additional unit of charging pile in economically underdeveloped areas may have a greater marginal effect on the increase of financial performance. **Based on the above reasons, hypothesis 3 is proposed. Hypothesis 3:** Compared with developed areas, the number of charging piles in less developed areas has a greater impact on the financial performance of local new energy vehicle enterprises.

2.3. Moderating Effect of the Number of Charging Piles on the Financial Performance of Local New Energy Vehicle Companies

The strength of governmental governance capacity has a significant impact on the financial performance of local new energy vehicle enterprises [18]. In regions with strong governance capacity, the government can provide appropriate infrastructure support, thereby increasing market share. **Considering these facts, hypothesis 4 is proposed. Hypothesis 4:** Stronger governmental governance capacity will significantly improve the impact of charging piles on the financial performance of local new energy vehicle enterprises.

The improvement of technological innovation capacity has an important spillover effect [1]. It means an increase in innovative thinking, which will have a positive impact on the new energy vehicle industry [19]. First of all, the improvement of technological innovation capacity may lead to the improvement of charging pile technology [20]. Secondly, according to the "market-driven innovation theory" [21], the upgrading of scientific and technological innovation level may promote the development and innovation of new energy vehicles.**Therefore, hypothesis 5 is proposed. Hypothesis 5:** Technological innovation capacity and its spillover effect can promote the impact of charging piles on the market performance evaluation of local new energy vehicle enterprises.

Based on the "Attention-based view" [22] and the "green development theory" [23], local government's green development attention refers to the degree of government's attention to environmental protection. Local governments' attention to green development is reflected in policy support and incentive measures. In addition, local governments' focus on green development may have improved consumer awareness and attitudes toward new energy vehicles. **Based on the above theories, hypothesis 6 is proposed. Hypothesis 6:** Strong green development attention of local government can promote the evaluation of charging piles on the financial performance of local new energy vehicle enterprises.

3. Research Sample and Analysis Model

3.1. Sample Selection and Data Source

(1) Sample selection and grouping. In this paper, keywords such as "new energy vehicle" and "electric vehicle" are used to search samples on "Wancai" (Website link http://www.iwencai.com). In order to obtain reliable and comprehensive data, the following data processing is carried out on the samples: 1) Companies belonging to ST, *ST or PT (ST---- company operating losses for two consecutive years, special treatment; *ST-- The company suffered losses for three consecutive years and was warned of delisting; PT----Particular Transfer) during the sample period are excluded; 2) Eliminate enterprises with little relevance to the new energy automobile industry chain; 3) Eliminate enterprises whose main business is not the new energy automobile industry chain; 4) Eliminate enterprises with incomplete data. Finally, the observed values of 530 new energy vehicle enterprises listed in Shanghai and Shenzhen A-shares from March 2019 to June 2022 were obtained.

(2) Data window and source. In the data used for empirical analysis in this paper, independent variables -- the number of charging piles and the new incremental data of charging piles are from the National Big Data Alliance of New Energy Vehicles(NDANEV); The dependent variables are that the relevant data of financial performance of new energy vehicle enterprises are from CSMAR Database; Moderator Variables -- Patent data came from CNRDS Platform, and green development attention of local government data were collected from local government work reports and obtained from Wingo financial database platform; The rest of the data comes from the Wind Data Service.

3.2. Description of Variables

(1) Independent variables. The number of charging piles (NCP) and the new increment (ICP) of charging piles. Independent variables were represented by NCP and ICP in 31 provinces (except Hong Kong, Macao and Taiwan). NCP refers to the total number of charging piles that have been

built in a certain region over a period of time. ICP refers to the number of charging piles that are newly built.

(2) Dependent variable. Equity free cash flow (FCFE). FCFE flow is used to represent the financial performance of new energy vehicle enterprises. FCFE refers to the free cash flow generated by each share in a certain period of time. The data is from CSMAR. Referring to relevant research results [6]---[9], this paper also selects the gross profit margin (GOM) and the current ratio (CUR) to represent the operating efficiency and profitability of the enterprise, as well as the short-term debt paying ability and liquidity ability.

(3)Moderator Variable:

1) Government Governance Capacity (GOV). Based on the practice of Wu (2022)[24], a comprehensive evaluation of local government governance ability is carried out, and Bonina (2020)[25] is referred to select appropriate indicators to represent government governance ability. The final use of the number of medical and health institutions, education funding, R&D expenditure is expressed. All data are from the Wind Data Service.

2) Technological Innovation Capability (TEC). According to the research of Fang (2021)[26] and Yang (2019)[27], "the number of inventions obtained independently in the current year" is selected as the representation index. It refers to the number of independent inventions obtained by an entity in a given year.

3) Green Development Attention of Local Government (AGD). Referring to the practices of Tien (2023)[28] and Zhang (2024)[29], this paper mainly calculates the attention of local governments to green development based on word frequency analysis of the social responsibility reports in the work reports of local governments. According to the "basic view of attention" [30], people believe that attention is reflected in the vocabulary language used by individuals, and commonly used vocabulary information can reflect the focus of individual attention. Therefore, based on the Wingo financial database platform, the steps to measure the "green development attention of local government" mainly **include 3 steps:**

Step 1: The first step is to make reference to the research on keywords related to government texts and literatures, and to select five aspects according to Wen (2015)[31] and Qin (2020)[32] to make statistics on keyword word frequency indicators. Keywords and vocabulary are shown in Table 1:

Table 1. Keyword summary

First-level keyword	Second-level keyword
Development concept	Low-carbon economy, circular economy, green economy, ecological civilization demonstration zone, ecological city
Green production	High energy consumption, energy saving and emission reduction, water-saving irrigation, industrial water-saving, green manufacturing, consumption reduction
Green life	Domestic waste, green consumption, green travel
green ecology	Forest restoration, afforestation, water conservation
System construction	Joint prevention and control, local legislation, public participation, environmental supervision mechanism

Step 2: In the second step, based on the sample enterprises' social responsibility reports from 2019 to 2022, the frequency of local governments' green development attention keywords was calculated.

Step 3: The third step is to use Wingo database to count the total word frequency of social responsibility report.

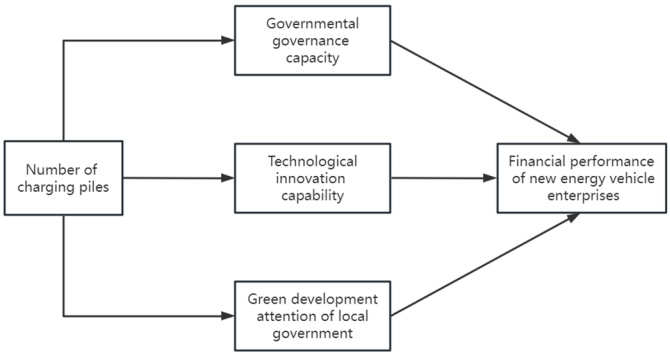

Figure 1. Theoretical framework of empirical research

Table 2. Measurement of variables and data sources

variable	Variable declaration	Data source
Dependent variable --- corporate financial performance		
Free cash flow to equity (FCFE)	Net cash flow from operating activities.	CSMAR Database
Gross operating margin (GOM)	Gross margin = Gross profit/sales revenue ×100%.	
Current ratio (CUR)	Current assets/current liabilities.	
Independent variables		
Number of charging piles (NCP)	Measure charging infrastructure for rechargeable vehicles	NDANEV
New Increment of Charging Pile (ICP)	Reflects the expansion of electric vehicle charging facilities	
Moderator Variables		
Government Governance Capacity (GOV)	Combining the number of health institutions, education funds and R&D expenditure	Wind
Technological Innovation Capability (TEC)	The "number of inventions obtained independently during the year"	CNRDS
Green Development Attention of Local Government (AGD)	Demonstrate the importance local governments attach to green development.	Wingo
Control Variables		
Return on Investment (ROI)	(Investment income - investment cost) /investment cost ×100%	CSMAR Database
R&d expense ratio (RDE)	R&d expenses/revenue ×100%	
Financial Leverage (FIN)	Total debt/shareholders' equity	
cash ratio(CAS)	Available cash/current liabilities ×100%	
asset-liability ratio(ALR)	Total liabilities/total assets ×100%	
equity ratio(EQU)	Shareholders' equity/total assets ×100%	
working capital(WOR)	Current assets - current liabilities	
Dummy Variables		
Region dummy variable	1 in coastal areas and 0 in inland areas	Manual sorting according to Wind Data Service
Level of development dummy variable	The average of the cumulative GDP of each province. The value is 1 for economically developed regions and 0 for economically underdeveloped regions	

(4) Dummy variables of regional and development level heterogeneity. Heterogeneity was tested by 0-1 assignment method. Coastal and inland cities are directly judged by the geographical location of the map of China, and the coastal area is assigned a value of 1, and the inland area is assigned a value of 0; The level of regional economic development is distinguished by the "cumulative GDP value of provinces" [33]. When the cumulative GDP value of a province is greater than the average of the cumulative GDP value of all provinces, a value of 1 is assigned; otherwise, it is 0.

(5) Control variables. In order to enhance the reliability of the research, this paper selects seven control variables, namely return on investment (ROI), R&D expense ratio (RDE), financial leverage (FIN), cash ratio (CAS), asset-liability ratio (ALR), equity ratio (EQU) and working capital (WOR), with reference to the research of Owoo (2017)[34].

The definition of main variables, specific measurement methods and data sources are shown in Table 2.

3.3. Model Selection

In this paper, the Winsor tail of 1% and 99% is used to process the sample data to avoid the influence of extreme values. The bidirectional panel fixed effect model is constructed in this paper. At the same time, this paper further uses the panel random effect model as a robustness test to measure whether the robustness of the panel data results is valid. Therefore, in order to verify the above hypothesis, this paper constructs the following bi-directional panel fixed effect model:

$$FCFE_{it} = \alpha_0 + \alpha_1 NCP_{it} + \alpha_2 Mechanism_{it} + \alpha_3 Control_{it} + Year_t + Individual_i + \varepsilon_{it} \quad (1)$$

Where, i represents different regions, t represents different time, $FCFE_{it}$ represents equity free cash flow, NCP_{it} represents the amount of charging pile, $Mechanism_{it}$ represents mechanism variable, $Control_{it}$ represents the control variable, $Year_t$ represents the time effect, $Individual_i$ represents the individual effect, ε_{it} represents the residual.

4. Analysis of Empirical Results

Based on the quarterly data of 530 listed Chinese new energy vehicle companies and the data of charging piles in various provinces, this paper uses STATA 17 statistical software to conduct empirical tests, and the results are as follows.

4.1. Main Effect Test

Table 3 shows the results of the regression between charging pile ownership and equity free cash flow:

Table 3. Main effect results

DV	FCFE	
Variable	(1)FE	(2)RE
NCP	3952.217***(3.961)	4069.189***(4.175)
Covariates	Y	Y
Time effect	Y	Y
Individual effect	Y	Y
N	7909	7909

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$s

As can be seen from Table 3, the ownership of charging piles in panel fixed effect model (1) and panel random effect model (2) are significant at the 1% level, and the coefficient is 3952.217 to 4069.189, indicating that the adequacy of charging piles has a significant positive impact on the financial performance of local new energy vehicle enterprises. It shows that every 10,000 increase in the number of charging piles in the region will increase the value of equity free cash flow of new energy vehicle enterprises in the region by 3952.217 to 4069.189 yuan. This proves that it is reasonable for H1: the increase in the number of charging piles will significantly improve the financial performance of local new energy vehicle enterprises.

4.2. Heterogeneity Test

Table 4. Results of regional heterogeneity test (fixed effect)

DV	FCFE	
Variable	Coastal areas	Inland areas
NCP	8923.251***(5.300)	6875.843***(4.162)
Covariates	Y	Y
Time effect	Y	Y
Individual effect	Y	Y
N	4816	3093

As can be seen from Table 3, in both coastal and inland areas, the panel fixed effect model is significant at the 1% level, and the coefficient of 8923.251 in coastal areas is larger than the coefficient of 6875.843 in inland areas. It indicates that the increase in the number of charging piles in coastal areas has a more significant positive impact on the financial performance of local new energy vehicle enterprises. This proves H2.

Table 5. Heterogeneity test results of development level (fixed effect)

DV	FCFE	
Variable	Economically underdeveloped areas	Economically developed areas
NCP	7905.943***(5.713)	2762.302(1.012)
Covariates	Y	Y
Time effect	Y	Y
Individual effect	Y	Y
N	5011	2898

As can be seen from Table 5, the panel fixed effect model in economically undeveloped areas is significant at the 1% level. This justifies H3.

4.3. Moderator Variable Test

Table 6 below shows the regression results of pile ownership and equity free cash flow when there are different moderator variables. Among them, GOV is calculated by the number of medical and health institutions, education funding and R&D expenditure using the equal weight method multiplied by 1/3 weight.

As can be seen from the table above, it indicates that GOV, TEC and AGD have a significant moderating effect on the relationship between charging pile ownership and equity free cash flow, and all of them are positive. Technological innovation can reduce the cost of enterprises, increase profits,

and highlight the positive externality of knowledge spillover. Among them, the regulating effect of provincial government governance ability is more important. This justifies H4, H5, and H6.

Table 6. Test results of moderator variables

DV Variable	FCFE		
GOV	2733.381***(7.392)		
TEC		1025.291***(10.097)	
AGD			1282.038***(7.850)
Covariates	Y	Y	Y
Time effect	Y	Y	Y
Individual effect	Y	Y	Y
N	7909	7909	7909

4.4. Robustness Test

In order to ensure the robustness, repeatability and reliability of the above research conclusions, the following robustness tests are conducted in this paper. First, the model is replaced. The random effects model assumes that the independent variable has no relation to other control variables and residuals.

Second, change the independent variables. The aim is to rule out the possibility of selection bias in the independent variables, explore more comprehensive explanations, and enhance the confidence of the results.

Finally, change the dependent variable. The robustness test of alternate variables is to verify the stability and robustness of empirical analysis results when different dependent variables are used.

Table 7 shows the regression results of robustness test after the independent variable is changed from NCP to ICP:

Table 7. Main effect results after changing independent variables

DV	FCFE	
Variable	(1)FE	(2)RE
ICP	4700.537*(1.583)	4795.721*(1.688)
Covariates	Y	Y
Time effect	Y	Y
Individual effect	Y	Y
N	5011	7909

As shown in Table 7, after the independent variable is changed from NCP to ICP, the new increment of charging piles under model (1) and model (2) are significant at the 10% level. The regression and test results in this paper are robust.

Based on the practice of Rao (2022)[8], the dependent variable is changed to gross operating margin (GOM). Similarly, according to the practice of Wu (2021)[9], the dependent variable is changed to the current ratio (CUR). Table 8 shows the regression results of robustness test after changing the dependent variable:

As shown in Table 8, after changing the dependent variable, the results of model (1) and (2) are significant at 1% level. Consistent with the conclusions above, the regression and test results in this paper are robust.

Table 8. Main effect results of changing dependent variables

DV	GOM		CUR	
Variable	(1)FE	(2)RE	(1)FE	(2)RE
NCP	1.91e+07***(4.528)	1.99e+07***(4.909)	1.40e-06***(10.858)	1.28e-06***(10.348)
Covariates	Y	Y	Y	Y
Time effect	Y	Y	Y	Y
Individual effect	Y	Y	Y	Y
N	7909	7909	7909	7909

The HLM model (Hierarchical linear model) is suitable for analyzing data with multiple layers. In this paper, the independent variable "the number of charging piles" is the provincial-level data, and the control variable contains the micro-company-level data, so the HLM model can be used for robustness test. Table 9 shows the robustness test results of HLM model when the independent variable is provincial macro data and the dependent variable is enterprise micro data:

Table 9. HLM model results

DV	FCFE
Variable	HLM model
NCP	2015.831* (1.956)
Covariates	Y
Time effect	Y
Individual effect	Y
N	7909

The results are shown in Table 9. The robustness test using HLM model shows that the number of charging piles is significant at the 1% level. The regression and test results in this paper are robust.

5. Research Conclusion and Implication

5.1. Research Conclusion

This paper makes an innovative contribution to the impact of the number of charging piles on the financial performance of new energy vehicle enterprises. Finally, the following conclusions are drawn: (1) The increase in the number of charging piles will significantly improve the financial performance of local new energy vehicle enterprises. From the point of view of the number of charging piles and the new increment, the profitability, solvency and operating capacity of local new energy vehicle enterprises have been significantly improved; (2) Regional heterogeneity has different impacts on new energy vehicle enterprises. The number of charging piles in coastal areas and economically underdeveloped areas has a greater impact on the financial performance of local new energy vehicle companies; (3) The government governance capacity, technological innovation capacity and the green development attention of local government have significant regulatory effect on the municipal financial performance of local new energy vehicle enterprises.

5.2. Policy Suggestions and Implication

(1) Increase the number and coverage of charging piles. This can cooperate with the comprehensive business model of new energy vehicles proposed by Wu (2021)[9] to jointly improve the financial performance of new energy vehicle enterprises. New energy vehicle companies should actively participate in the construction and investment of charging piles, and cooperate with the government to ensure that the number and coverage of charging piles can meet the needs of users. This will greatly improve the financial performance of the enterprise itself.

(2) Formulate regional differentiated subsidy policies for new energy vehicles. This paper's research on battery infrastructure services for new energy vehicles is innovative, which reminds people of Yu et al. (2020)[35] who suggested the government to provide financial subsidies and tax incentives to encourage enterprises in terms of policy implementation. The heterogeneity test in this paper highlights the policy designation of regional differentiation. Therefore, the government can increase the capital investment in the construction of charging piles in coastal areas to promote balanced regional development.

(3) Strengthen the collaboration between the government and new energy vehicle enterprises. The increased focus on green development by local governments means that policy makers recognize the urgency of environmental issues. Therefore, the government may introduce various policies, such as tax relief, car purchase subsidies, charging facilities construction, etc. to encourage the use and promotion of new energy vehicles.

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