Study on the Influence of Industrial Infrastructure Construction on Regional Quality Productive Forces-taking New Energy Automobile Industry as an Example

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Abstract. Driven by the new quality productivity, the new energy automobile industry shows a broad development prospect. However, the current ratio of vehicles to piles cannot effectively support the sustainable development of this industry, and the imperfection of infrastructure construction has become an important bottleneck restricting the development of the new energy automobile industry in China, which may further affect the overall improvement of new quality productivity. Based on the panel data of 31 provinces (autonomous regions and municipalities) in China from 2016 to 2022, combined with the existing evaluation index system of new quality productivity, this paper deeply analyzes the influence of new energy vehicle infrastructure construction on regional new quality productive forces by constructing a panel random effect model. The results show that the infrastructure construction of new energy vehicles can promote the improvement of new quality productivity, and it has passed the data robustness test, showing regional heterogeneity. Based on this, it is suggested that according to the development level and demand for new quality productive forces in different regions, infrastructure construction should be moderately strengthened to provide effective policy reference for the development of regional new quality productivity.

Keywords: new energy vehicles; new quality productivity; infrastructure construction; number of public charging piles.

1. Introduction

New-quality productivity has been formed in practice and has shown a strong driving force and support for high-quality development [1]. The development of new quality productive forces not only promoted the innovation and upgrading of traditional industries but also pointed out the direction for China's scientific and technological innovation, industrial transformation, and economic development, further promoting the high-quality development of the economy [2].

The development of the new energy automobile industry is also inseparable from solid industrial infrastructure construction. Although the infrastructure of new energy vehicles is gradually improving and the development trend is promising, there is still a huge gap between domestic new energy vehicles and charging piles, especially public charging piles, and the ratio of vehicles to piles obviously cannot effectively support the development of new energy vehicles in China [7]. Imperfect infrastructure construction has become a bottleneck restricting the development of the new energy automobile industry in China, which may further affect the overall improvement of new quality productivity.

Thus, imperfect infrastructure construction is an important problem that hinders the development of the new energy automobile industry in China [11]. Vertically, it affects consumer demand and investment, and restricts technological progress and industrial upgrading; Horizontally, it leads to uneven development among regions and then affects the coordinated development of new quality productive forces across the country. Therefore, it is of great theoretical and practical significance to analyze the influence of infrastructure construction of the new energy automobile industry on regional new quality productivity.

The aim of this study is to reveal the driving mechanism of infrastructure construction to the development of the new energy automobile industry, deeply analyze the interaction mechanism between infrastructure construction and new quality productivity, and explore how to optimize the path of industrial infrastructure construction under the background of new quality productivity. This

study may provide a new perspective and methodological support for the development of a new energy automobile industry and the transformation and upgrading of the regional economy driven by new quality productivity.

To sum up, this study focuses on the emerging field of the new energy automobile industry. By introducing the concept of new quality productivity, it breaks through the traditional perspective of productivity, expands the depth and breadth of research, and discusses the impact of industrial infrastructure construction on regional new quality productivity. This research topic is not only cutting-edge but also combined with the actual needs of economic transformation and upgrading in contemporary China, filling the gaps in the systematic research on infrastructure construction of specific high-tech industries and regional economic development in the existing literature.

2. Theoretical Analysis and Research Hypothesis

2.1 The direct impact of new energy vehicle infrastructure on the development of regional new quality productive forces

As an important support of modern economic development, the completeness of infrastructure construction directly affects the promotion of regional new quality productivity. New quality productive forces represent a new form of productivity with innovation as the core, which needs a solid infrastructure as a guarantee. Previous research shows that perfect infrastructure is the premise of China's economic development [21]. The improvement of infrastructure can promote economic growth [22] and enhance economic development [23]. In this paper, the layout of public charging piles for new energy vehicles is the main basis for the infrastructure construction of the new energy vehicle industry, and the layout of public charging piles is reflected in the number of public charging piles in various regions.

Therefore, hypothesis 1 is proposed:

H1 The increase of new energy vehicle infrastructure can promote the development of regional new quality productivity.

2.2 Analysis of the regional heterogeneity characteristics of new energy vehicle infrastructure construction on the development of new quality productivity

The imbalance of regional economic development in China is remarkable, and there are great differences in the level of infrastructure construction and economic development among different regions. Relevant research shows that the regional differences in infrastructure development mainly come from regional differences, and the development speed of infrastructure in high-level areas is accelerated, while that in low-level areas is slowed down. In areas with developed economies, dense populations, and high education, the adoption rate of new energy vehicles is significantly higher [24]. This paper speculates that developed areas can transform traditional productivity into new quality productive forces more efficiently because of their relatively perfect infrastructure. Underdeveloped areas are relatively insufficient in infrastructure and supporting resources, so their conversion efficiency may be low, and this phenomenon may also appear in the new energy automobile industry. Based on the median division of per capita GDP of provinces (autonomous regions and municipalities) from 2016 to 2022, this paper regards areas with per capita GDP greater than or equal to the median level as developed areas, and areas with per capita GDP less than the median level as underdeveloped areas [25, 26].

Therefore, the hypothesis 2 is proposed:

H2: There are differences between developed areas and underdeveloped areas in the impact of new energy vehicle infrastructure construction on new quality productivity.

3. Description of research methods and variables

3.1 Sample selection and data sources

In this study, 31 provinces (autonomous regions and municipalities) in China (excluding Hong Kong, Macao and Taiwan) from 2016 to 2022 are selected as samples, and the auxiliary data used are from China Charging Alliance, Chinese Research Data Services Platform (CNRDS), "PPMAN Data" database, websites of authoritative institutions such as the number of compulsory insurance, Energy Statistics Bureau, China People's Bank and various authoritative statistical yearbooks, including national and provincial statistical yearbooks, environmental status bulletins and so on. For example, the *China Science and Technology Statistics Yearbook*, *China Energy Statistics Yearbook*, *China Financial Yearbook*, *China Agricultural Statistics Yearbook*, *China Industrial Statistics Yearbook*, *China Tertiary Industry Statistics Yearbook*, *and China Environmental Statistics Yearbook*.

Considering the blank of relevant data, this paper deletes some data before 2016 and after 2022, and finally, the time interval selected in this study is 2016-2022 (7 years).

3.2 Description of variables

3.2.1 Explained variables

The main explained variable in this paper is the new quality productivity, which is used to measure the development level of new quality productive forces in various places:

newqualityforces=new_quality_forces*100000

The measurement data of the new_quality_forces index comes from the "PPMAN Data" database, which refers to the practices of Ren Yuxin, Wu Yan et al. [30]. The evaluation system of the development level of new quality productive forcesis constructed as shown in Table 1:

Table 1 Evaluation index system of new quality productive force development

Target layer	Criterion layer	Primary index	Secondary index	Three-level index	Measurement mode	Attribute
New quality productive forces	The subject of labour	Labor productivity	Economic output	Per capita GDP	GDP/ total population	Positive
			Economic income	Per capita wage	The average wage of on-the-job workers	Positive
			Employment structure	Proportion of employment in tertiary industry	Number of employees in tertiary industry/total employment	Positive
		The educational level of laborers	Degree of education	Proportion of higher education population	Average years of education per capita	Positive
			Cultivation funds	Intensity of educational funds	Education expenditure/total fiscal expenditure	Positive
			Knowledge accumulation potential	Structure of students in school	Number of students/population in school	Positive
		Laborer spirit	Initiative spirit	Innovative manpower input	Full-time equivalent of R&D personnel	Positive
			Enterprising spirit	Entrepreneurship activity	Number of new businesses per 100 people	Positive
		Industrial development level	Informatization level	Enterprise informatization level	Number of enterprises engaged in e-commerce transactions/total number of enterprises	Positive
			Proportion of strategic industries	Proportion of emerging strategic industries	Added value of emerging strategic industries /GDP	Positive
		Ecological environment	Future industry	Robot installation density	Number of industrial robots installed in the region × (number of industrial employees in the region/total number of employees in the country)	Positive
			Green ecology	Green resources	Forest coverage rate	Positive
			Green production	Environmental protection efforts		Negative
	The means of labor	Material labor data	Infrastructure			Positive
			Energy utilization level			Positive

	Intangible labor data	Energy utilization potential	Pollution prevention quality	Environmental protection Expenditure/government public Finance expenditure
		Scientific and technological innovation level	Green invention achievement	Chemical oxygen demand discharge /GDP
		Digitalization level	Traditional infrastructure	Sulfur dioxide emissions /GDP
			Digital infrastructure	Number of green patent applications/number of patent applications
			Energy intensity	Highway mileage
			Green energy consumption level	Railway mileage
			Pollution prevention potential	Fiber length
			Number of patents per capita	Number of Internet broadband access ports per capita
			Economic input of new products	Energy consumption /GDP
			Digital economy	Low carbonization index of energy consumption structure
			Enterprise digitalization	Treatment capacity of waste gas treatment facilities
				Number of patents granted/total population
				New product development funds /GDP
				Digital economy index
				Digital level of enterprises

Reference: Ren Yuxin, Wu Yan, Wu Zhe. Financial Agglomeration, Industry-University-Research Cooperation and New quality productive forces[J/OL]. *Financial Theory and Practice*: 1-8 [2024-03-26].

Data source: data team PPMAN Data. New quality productive force level calculation (version 3, 2010-2023) database [EB/OL]. [September 23, 2024]. http://www.ppmandata.cn/.

Based on the relevant data and documents confirmed in academia and practice, the evaluation index system of new quality productive force development takes the qualitative change of laborers, the means of labor, the subject of labour, and their optimized combinations as the basic criteria, and uses entropy method to determine the index weights at all levels to calculate the development index of new quality productive force in various provinces (autonomous regions and municipalities).

3.2.2 Explanatory variables

The explanatory variable in this paper is the number of public charging piles (units). Under the guidance of the goals of "carbon peaking and carbon neutrality", China's new energy vehicle market is booming, and charging facilities, as an indispensable supporting service, has become a key force to support the new energy vehicle industry. A public charging pile is a charging pile that is built and operated to provide charging service for all or some vehicles in society. The number of public charging piles for new energy vehicles reflects the market demand for public charging piles for new energy vehicles in China to some extent. By collecting the data released by China's charging alliance, this paper collates the data on the number of public charging piles for new energy vehicles in various provinces (autonomous regions and municipalities) from 2016 to 2022.

3.2.3 Control variables

This paper mainly draws on the indicators of the evaluation system of the development level of new quality productive forces built by Ren Yuxin, Wu Yan et al. [30] and Wang Jue and Wang Rongji [31], and selects the factors that have a great influence on the new quality productive forces as the control variables. The control variables are as follows: forest coverage [32], sulfur dioxide emission /GDP [33, 34], railway mileage [35, 36], average years of education per capita [37, 38], employment proportion of tertiary industry [39, 40, 41], industrial wastewater treatment facilities (sets) [42] and

industrial waste gas treatment. The definitions and descriptions of variables in this paper are shown in Table 2:

3.3 Research model

3.3.1 Benchmark master model

In order to verify H1 and test the heterogeneity, this paper uses the panel random effect model as the benchmark main model, as shown below:

$$new\_quality\_forces_{it} = \alpha + \beta\, charge_{it} + g\, Controlit + \mu it$$

Among them, i and t represent provinces (autonomous regions and municipalities) and time respectively. new_quality_forces stands for new quality productivity; charge represents the number of public charging piles (units); Control stands for control variable; μ stands for residual.

4. The Empirical Results and Analysis

4.1 Principal model regression

Firstly, the regression results of the main model are analyzed. The regression results of the number of public charging piles of new energy vehicles in various provinces (autonomous regions and municipalities) to the development level of new quality productive forces are shown in Table 4.

Table 4 Regression Results of the Principal Model

	The whole country	
Variables	(1) newqualityforces	(2) newqualityforces
charge	0.043***(3.923)	0.046***(4.267)
forest		23.898(0.838)
emission		2.5e+07(0.523)
railway		-0.764***(-3.648)
education		-284.807(-0.637)
service		3.2e+04***(5.302)
water		4.410***(10.359)
gas		0.066(0.842)
N	217	210

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

Column (1) and column (2) are the regression results of the development level of new quality productive forces for the whole sample of 31 provinces (autonomous regions and municipalities) in China.

Table 4 shows that column (1) is the regression result of the development level of new quality productive forces without adding control variables, and the regression coefficient of the number of public charging piles for new energy vehicles to the development level of new quality productive forces is 0.043, which is significant at the level of 1%. This shows that there is a direct and significant positive correlation between the number of public charging piles and the level of regional new quality productive forces without considering other factors. This result shows that the number of public charging piles of new energy vehicles directly promotes the development of new quality productivity, which is an effective way to enhance the development of regional new quality productivity. The expansion of new energy vehicle infrastructure has a positive impact on promoting the development of new quality productivity.

Column (2) is the regression result after adding control variables on the basis of column (1), and the regression coefficient of the number of public charging piles for new energy vehicles has increased to 0.046, which is still at a 1% significance level. This change shows that the number of charging piles for new energy vehicles still has a significant impact on the productivity level of new

quality when the control variables such as forest coverage, sulfur dioxide emission /GDP, railway mileage, per capita education years, employment proportion of the tertiary industry, industrial wastewater and waste gas treatment facilities are taken into account, and each additional number of local public charging piles will increase the local new quality productive forces index by 0.046.

The results of benchmark regression emphasize the continuous positive effect of public charging pile infrastructure of new energy vehicles on the improvement of regional productivity level and show that even after controlling various potential influencing factors, the infrastructure construction of new energy vehicles is still an important factor to promote the development of new quality productivity.

Therefore, this result proves that hypothesis H1 is true: the increase of new energy vehicle infrastructure can promote the development of regional new quality productive forces to a certain extent.

4.2 Regional heterogeneity test

Based on the median per capita GDP of provinces (autonomous regions and municipalities) from 2016 to 2022, 31 provinces (autonomous regions and municipalities) in China are divided into developed regions and underdeveloped regions. The differences in the influence of the number of public charging piles for new energy vehicles in different regions on the development level of regional new quality productive forces are explored. The regression results are shown in Table 5.

Table 5 Regression Results of Heterogeneity Test

	Developed region	Less developed areas
Variables	(3) newqualityforces	(4) newqualityforces
charge	0.034***(2.727)	0.093(1.187)
forest	36.035(0.914)	3.108(0.065)
emission	2.3e+08(1.298)	-2.8e+07(-0.537)
railway	-0.666**(-2.331)	-0.315(-0.869)
education	-21.576(-0.041)	1164.798(0.860)
service	5.3e+04***(6.016)	-1.6e+04(-1.398)
water	4.279***(7.887)	2.991***(3.073)
gas	0.176*(1.724)	-0.011(-0.069)
N	106	104

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

Column (3) is the regression result of the development level of new quality productive forces in developed areas, and column (4) is the regression result of the development level of new quality productive forces in underdeveloped areas.

Table 5 shows that in developed areas, the regression coefficient of the influence of the number of public charging piles of new energy vehicles on the development level of new quality productive forces is 0.034, and it is significant at the level of 1%. This result shows that the infrastructure construction of new energy vehicles in developed areas has significantly promoted the improvement of regional new quality productivity. Developed regions usually have a relatively perfect economic foundation and innovative environment, which enables the infrastructure investment of the new energy automobile industry to be effectively transformed into the promotion of productivity, thus significantly promoting the growth of new quality productivity.

In contrast, the regression coefficient of underdeveloped areas is 0.093, but it has not reached the level of statistical significance. This means that although the number of public charging piles for new energy vehicles in underdeveloped areas has a positive impact on new quality productivity, this impact may not be significant. This phenomenon may be due to the weak economic foundation in underdeveloped areas, and the overall level of technological innovation and infrastructure construction is low, which makes the investment in infrastructure of new energy vehicles fail to effectively translate into significant productivity improvement. In these areas, although the increase

of charging piles may have a positive impact on the popularization and use of new energy vehicles, the overall impact has not yet shown significant productivity benefits due to other constraints such as insufficient technology research and development capabilities and lack of green investment.

Therefore, this result proves that hypothesis H2 is true: there are differences in the impact of new energy vehicle infrastructure construction on new quality productive forces between developed and underdeveloped areas. Developed regions, with their strong economic foundation and innovative ability, can effectively transform infrastructure investment into significant improvement of new quality productivity; In underdeveloped areas, although the number of charging piles has increased, due to the constraints of overall economic and technical conditions, its role in promoting new quality productive forces has not yet reached a significant level. Therefore, when making infrastructure investment strategies, policymakers need to consider the level of regional economic development and actual demand in order to achieve more effective productivity improvement.

5. Conclusions and Policy Suggestions

5.1 Research conclusions

Based on the panel data of 31 provinces (autonomous regions and municipalities) in China from 2016 to 2022, this paper constructs a panel random effect model with reference to the evaluation system of the development level of new quality productive forces recognized by academia. The aim of this paper is to discuss the influence of infrastructure construction of the new energy automobile industry on the regional new quality productive forces level, and draw the following conclusions:

First of all, the benchmark regression analysis shows that the regression coefficient of the number of public charging piles for new energy vehicles to the development level of regional new quality productive forces is significant at 1% regardless of whether the control variables are added, which indicates that the construction of public charging piles for new energy vehicles in the region has significantly improved the regional new quality productive forces level and passed the data robustness test.

Secondly, in the heterogeneity test, it is found that there are significant differences between the number of public charging piles of new energy vehicles in developed and underdeveloped areas on the new quality productivity. Although the construction of charging piles has a positive effect on the improvement of new quality productive forces in all regions, the less developed regions benefit more significantly. The possible reason is that the infrastructure in underdeveloped areas is relatively weak, and the marginal utility brought by the construction of charging piles is greater.

5.2 Policy suggestions

Based on this, the following policy suggestions are obtained:

It is important to moderately increase the intensity of infrastructure construction and narrow the regional development gap. The research shows that the number of public charging piles in new energy vehicles has significantly improved the level of new quality productivity, especially in underdeveloped areas. Therefore, the state needs to appropriately increase financial support and policy inclination for infrastructure construction of the new energy automobile industry in underdeveloped areas, provide necessary subsidies and preferential policies, and encourage enterprises and local governments to jointly participate in the construction of public charging infrastructure. By increasing the popularization rate of charging facilities, the use of new energy vehicles will be improved, thus promoting the development of a green economy and narrowing the regional economic development gap.

The development of a new energy automobile industry is of great significance in promoting a green economy, reducing environmental pollution, and reducing energy consumption. The construction of public charging piles is one of the important infrastructures for the development of the new energy automobile industry. In underdeveloped areas, due to the limitations of economic conditions and technical level, the development of the new energy automobile industry may face

some difficulties and challenges. Therefore, the state and local governments should increase their support to these areas to help them overcome difficulties and promote the development of the new energy automobile industry.

The government can formulate more favorable policies, such as tax relief and loan support, to attract more enterprises and investors to participate in the new energy automobile industry. Meanwhile, the government can also strengthen supervision to ensure fair competition in the market and prevent monopoly and unfair competition. The government can increase its support for the technological research and development of new energy vehicles and encourage enterprises to carry out technological innovation and upgrading. At the same time, the government can also strengthen cooperation with universities and scientific research institutions, train more professionals, and provide a talent guarantee for the development of the new energy automobile industry. The government can promote the application of new energy vehicles in various ways, such as holding exhibitions and carrying out test drive activities, so that consumers can better understand the advantages and usage of new energy vehicles. In addition, the government can also build charging facilities in some public places to facilitate consumers to use new energy vehicles.

5.3 Research limitations and future prospects

Although this study systematically discusses the influence of the number of public charging piles of new energy vehicles on the regional new quality productive forces level through rigorous data analysis, there are still some limitations.

The data of this study only covers the period from 2016 to 2022. Although the new energy automobile industry and infrastructure have developed rapidly in this time range, it still cannot fully reflect the changing trend and potential impact in a longer time span. Therefore, future research can extend the time span, so as to capture the comprehensive impact trajectory of more comprehensive industrial infrastructure construction on the economy, society, and environment, and further explore the long-term impact of the number of public charging piles for new energy vehicles on new quality productivity. Secondly, the data of 31 provinces (autonomous regions and municipalities) are used in this study. Although the sample size is large, there are significant differences in economic, social, and environmental aspects between different regions, which may affect the external validity of the research conclusions. In the future, we can study the development level of new quality productive forces at a more detailed regional level, and divide regions with different economic development levels into more sub-regions to provide more accurate policy suggestions. Thirdly, this paper mainly takes the number of public charging piles in the new energy automobile industry in various regions as the main basis for the infrastructure of the new energy automobile industry. More infrastructure for new energy vehicles can be considered in future research, such as private charging piles, charging stations, power exchange stations, maintenance stations, and so on.

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