

# Text Analysis of Policy Coherence between the Central Government and the Provincial Governments in the New Energy Vehicle Charging Infrastructure

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# Abstract

In the context of China's burgeoning new energy vehicle industry, the development of charging infrastructure plays a pivotal role. This study examines 648 new energy vehicle charging infrastructure policies enacted by central and provincial governments between 2012 and 2022, investigating the alignment between central and local policies in terms of thematic focus and policy synergies. Concerning policy themes, the coherence between central and local policies is evaluated through the analysis of high-frequency words and the construction of co-word networks. The analysis of policy coherence involves a two-dimensional framework that considers Policy tools and objectives, employing fuzzy mathematics to measure the degree of coherence. This research sheds light on the current status and challenges in the formulation of policies related to new energy vehicle charging infrastructure. Notable findings include the congruence of core principles between central and regional policies, albeit variations in the distribution of thematic content and high-frequency terms. Regarding policy coherence, supply-based policies in each region exhibit alignment with central policies, while disparities emerge in the coherence of environmental and demand-based tools. The central and eastern regions display strong coherence with central policy objectives, whereas the northeastern and western regions require improved alignment, particularly in aspects like technological quality, operational efficiency, and planning. The policy analysis underscores future pathways: provincial governments can take action through environment and demand-oriented policies, enhancing collaboration with the central government. Adapting policies to local nuances and

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flexibly aligning them with regional characteristics ensures the effective implementation of policies on the ground.

### **Keywords**

New Energy Vehicles, Charging Infrastructure, Policy Themes, Central and Local Policies

# **1. Introduction**

## Context and Significance of the Study

The rapid growth in global energy demand and environmental pollution pressure has led to increasing international attention to issues such as energy transition and environmental protection. In this context, the low-carbon, environmentally friendly sustainable development strategy is the inevitable choice of countries around the world. Therefore, electric vehicles have become an effective solution to implement energy strategies, air pollution prevention and control programs and energy saving and emission reduction policies in countries around the world with the advantage of energy saving and environmental protection, and have been developed rapidly. Charging facilities, as the supporting infrastructure for electric vehicles, affect and constrain the promotion and application of electric vehicles, and therefore have also received attention from the government. Central and provincial governments have successively launched a variety of new energy vehicle charging infrastructure policy systems, including strategic planning, regulations and standards, as well as subsidies and incentives.

However, at present, China's charging infrastructure is still facing problems such as insufficient construction quantity, poor operation and weak profitability, which is one of the short boards in the electric vehicle industry and restricts the development of electric vehicles. The charging infrastructure industry is in a critical period of development, and it is crucial to clarify the mechanism of the influence of government policies on the charging infrastructure industry for the development of the industry. The research perspectives of domestic and foreign scholars on charging infrastructure include market development, profit model, usage efficiency and practical application, etc. The research content covers the industrial development, operation mode, planning layout and optimization method of charging infrastructure as well as case studies in a broader way. However, in terms of policy research, scholars have conducted more policy research on the new energy vehicle industry, and less research specifically on charging infrastructure policy.

This study will sort out and mine China's new energy vehicle industrial policies at the central and local levels from the perspectives of central and local new energy vehicle charging infrastructure policy co-word networks as well as synergies. By comparing the high-frequency word co-occurrence network of central and local policies and constructing three dimensional indicators of Policy tools, policy objectives, and policy themes to evaluate the consistency of central and local policies from 2015-2022, it will provide suggestions for the government's subsequent promulgation of new energy vehicle industry policies. One of the main challenges facing the development of new energy vehicles (NEVs) in China is the lack of adequate charging infrastructure. According to the China Electric Vehicle Charging Infrastructure Promotion Alliance, China had about 810,000 public charging piles by the end of 2021, but over 70 percent of them were concentrated in regions such as Guangdong and Shanghai, while many counties and villages were still short of charging facilities. The ratio of NEVs to public charging piles was about 5.6:1, far exceeding the international standard of 3:12. Moreover, the uneven distribution of charging infrastructure across regions and sectors has resulted in low utilization rates and high operating costs for some charging stations (source:

# https://www.gizmochina.com/2022/06/12/china-87000-new-ev-charging-station s-may-2022/).

The organizational structure of this paper is as follows: Chapter 1 provides a literature review and presents the innovation points. This section will introduce the current research status and explain the innovative aspects and research value of this paper. Chapter 2 outlines the theoretical foundation and analytical framework. It will elaborate on the theories and research methods involved in policy analysis. Chapter 3 focuses on empirical analysis, presenting an analysis of policy collection, policy issuance, policy co-word networks, and coherence. Chapter 4 consists of conclusions and recommendations. This section summarizes the research findings and provides suggestions for government policy formulation.

## Literature review

So far, the policy objectives of new energy vehicles have been released in a wide range of areas, including technological innovation, industrial upgrading, economic growth, energy saving and emission reduction, and so on. China's new energy vehicle industry has initially entered a new era of highly marketized and differentiated development. Jia & Ly (2014) compared and analyzed the management measures related to new energy vehicles at home and abroad, and found that China's policy system and development route are more similar to that of the United central governments, which adopts the ways of encouraging subsidies and combining with the average fuel consumption of enterprises, however, the United central government has formed a set of perfect industrial evaluation system. Zuo et al. (2020) through the study and analysis of the new energy automobile industry policies of the United central governments, Japan, Germany, South Korea and Britain, combined with the actual situation of China's new energy automobile industry, proposed that the role of laws and regulations should play a guiding role in strengthening the supervision and management of vehicle safety, improve the innovation capacity of the key core technologies, enhance the efficiency of industrial synergistic development, and promote the internationalization of the new energy automobile industry. By analyzing the use of new energy vehicle Policy tools in demonstration cities at home and abroad, Zhang & Xu (2017) compared the gap between the incentive effects of Policy tools. Xu (2017) and others studied the development status of motor and battery technologies for new energy vehicles in China based on the co-word network, and looked forward to the future development direction of the technologies.

The coherence of new energy vehicles is mainly reflected in the joint coherence of policy subjects, i.e., central and local coherence; and the matching coherence of Policy tools, i.e., the comprehensive use of policy measures. Numerous scholars have already studied the coherence of new energy vehicle industry policies. Wang & Zhang (2017) construct a three-dimensional framework of structure, process and content, pointing out that the new energy automobile industry policy has gradually become a system but the problem of fragmentation has gradually come to the forefront, and policy coherence is the road to the development of new energy automobile industry. Zhang et al. (2020) combed the new energy automobile industrial policies at the national level in 2007-2017, and carried out research on policy coherence from the aspects of policy measures and strength, and put forward modification suggestions for policy and sectoral coherence. He et al. (2021) studied the coherence of new energy automobile industry policies at the central and local levels from the perspectives of "policy area" and "time dimension", and concluded that the lack of coherence between the central and local levels occurs when the central policy is changed or when there are large changes in the policy, and that the coherence of policies and measures in various policy areas of the value chain of the new energy automobile industry is uneven. It is concluded that when the central policy shift or policy change is large, there will be no coherence between the central and provincial governments, and the coherence of the policies and measures in the value chain of new energy vehicle industry will be uneven. Zhang (2021) studied and put forward opinions and suggestions on the synergistic development of new energy vehicle industry policies from various aspects, such as technological innovation, climate environment, energy and sustainable development, central policy and local policy analysis. Liu et al. (2019) used the covariance matrix analysis method and decoupling model to prospect the synergistic implementation of double integral policy for new energy vehicles. Bai & Meng (2018) analyzed the importance of the position of provincial governments between central and local enterprises in China's new energy vehicle industry, and elucidated the significant dual principal-agent relationship of provincial governments in the process of industrial policy formulation and implementation.

However, up to this point, few scholars have directed their focus towards policy research related to new energy vehicle infrastructure, let alone delving into the study of the central-local consistency of such policies in China. Therefore, this study aims to address this gap by undertaking a comprehensive examination of the coordination between central and local policies concerning new energy vehicle infrastructure. It seeks to explore the issuance and implementation effectiveness of policies related to new energy vehicle infrastructure and subsequently provide recommendations.

#### Contribution of this study

1) In terms of research content, previous studies have focused on new energy vehicle industrial policies at the national level, covering policy documents for the entire industry chain such as financial subsidies, tax incentives, laws and regulations, etc., with less policy content targeting the construction and promotion of charging infrastructure, and a lack of comparative analyses of synergies between central and local charging policies. The research of this project is dedicated to the new energy vehicle charging infrastructure industrial policies launched at the national and local (provincial zones) levels, and analyses the consistency between central and local (provincial zones) policies.

2) In terms of research methodology, it is mainly divided into policy text theme analysis and policy quantitative coherence analysis. This study is the first to analyze the themes of new energy vehicle charging infrastructure policies, extract high-frequency theme words, construct a common word network, and find the connections and differences between policy themes. Secondly, we establish a quantitative policy index system and construct a two-dimensional analysis framework of "policy tools - policy objectives" to analyze the coherence of central and local charging facilities industrial policies in the time dimension. This paper introduces the text analysis method, the co-word analysis method and the coherence index into the evaluation of charging infrastructure policy, so as to study the central and local new energy vehicle charging infrastructure policy in a more complete and scientific way.

Reasonable, targeted policy can play a great positive role in the development of charging facilities, in the face of the current new energy charging facilities appear short board, the government needs to central new energy charging infrastructure policy for systematic scientific analysis, so as to better promote and develop the new energy vehicle industry.

# 2. Rationale and Analytical Framework

#### 2.1. Co-Word Analysis

Co-word analysis was originated in the 1970s. Zhong & Li (2008) generally proposed the following steps: extracting high-frequency keywords, constructing co-occurrence matrices, and utilizing multivariate statistical methods to analyze information and interpret results. In the field of policy analysis, co-word analysis has found extensive application. Law et al. (1988) examined recent advancements in co-word analysis methods and concluded it as a suitable tool for policy analysis. Jiang et al. (2021) applied co-word analysis to analyze policy topic evolution, revealing the differing focal points and emphases of national and local "double innovation" policies.

The policy theme analysis is to perform word segmentation, word frequency statistics, high-frequency word extraction and co-word network analysis on the processed policy text. This can quantify and visualize the policy content and intuitively understand the industry hotspots and policy trends of new energy vehicle charging infrastructure. Segmentation and word frequency statistics are performed on the policy text to convert coherent central governments in the policy text into researchable and quantifiable data. By analyzing the high-frequency words, we can observe the focus of the central and local policies on the construction of new energy vehicle charging infrastructure, thus reflecting the focus of the policy content. The co-occurrence network analysis of high-frequency words can further reveal the focus of the policy on the theme, and can intuitively reflect the semantic connection between the high-frequency words of the policy. Through the above three steps, we can gain a deeper understanding of the overall situation of the current policies on new energy vehicle charging infrastructure construction, identify the "weak points" of the existing policies and improve them, so as to provide suggestions for the government to formulate policies and operators to make decisions.

# 2.2. Construction of a Policy Analysis Framework

# 2.2.1. Dimensions of Assessment

The text analyses the infrastructure of new energy vehicles from the dual perspective of "policy tools - policy objectives", and analyses it in the dimension of time.

1) Policy instrument perspective.

Policy tools are specific means and methods used to solve a social problem or reach a certain social goal. This paper adopts the theory proposed by Rothwell & Zegveld (1981), which divides Policy tools into three categories: supply-side, demand-side, and environment-side so that the division of dimensions can better reveal the structure of the policy as well as the scope of the role of different policies. Among them, supply-side policies are reflected in the direct financial input and technical support of the government; demand-side policies are mainly reflected in the pulling effect on demand, including demonstration and promotion, service outsourcing, and pulling social participation; and environment-side policies play an indirect influence, such as tax incentives and proposed regulations and controls.

2) Policy objective perspective

Policy objectives are the effects and purposes expected to be achieved by policy implementation, which are used to guide policymakers to choose appropriate Policy tools. In the field of the new energy vehicle industry, the division of policy objectives depends on different policy contents, and different scholars have differences in the formulation of policy objectives. Based on the six key tasks in the Action Plan to Enhance the Charging Security Capability of New Energy Vehicles (2018.11.09), this paper classifies the policy objectives into six items: technical quality, operational efficiency, planning layout, power supply security, interconnection, and standard system, which can better encompass all the policies in the field of new energy vehicle infrastructure. The six objectives can better encompass all the objectives of all policies in the field of new energy vehicle infrastructure.

Considering the above, each policy corresponds to a specific policy instrument and has a clear policy objective, this paper constructs a policy analysis framework as shown in **Figure 1**.

#### 2.2.2. Quantitative Criteria

Policy quantification involves assigning scores to relevant indicators based on specific criteria. In this paper, we primarily adopt the quantitative framework established by Zhong et al. (2009) and other scholars. This framework employs a 5-point system to assign scores ranging from 5 to 1. It formulates the quantitative standards for policy measures from both Policy tools and policy objectives perspectives.

**Table 1** and **Table 2** present the quantitative criteria for supply-based Policy tools and technology quality policy objectives, respectively.

### 2.3. Indicators of Central Government Coherence

In this research, we employ the concept of affiliation degree from fuzzy mathematics proposed by Si (2008) to quantify the extent of coherence existing among centralized policy objectives and between centralized Policy tools.

First, extract a time series dataset TPG<sub>i</sub> based on the quantified policies, where "i" represents different years from 2015 to 2022, and TPG represents the annual values of a specific policy tool or policy objective. These values are the arithmetic averages of various policy measures for that specific policy tool or objective in each year.

Next, establish a central government coherence function (taking the coherence



Figure 1. Framework for analyzing new energy vehicle infrastructure policy texts.

**Policy Target** 

Table 1. Quantitative criteria for China's new energy vehicle infrastructure policy tools (supply-based tools).

#### Score Quantitative criteria for Policy tools

- 5 Mentions content related to capital investment, infrastructure, public services, talent development, and technical support, providing highly detailed and specific objectives and measures.
- 4 Mentions content related to capital investment, infrastructure, public services, talent development, and technical support in some aspects, providing fairly detailed and specific objectives and measures.
- 3 Mentions content related to capital investment, infrastructure, public services, talent development, and technical support in some aspects, providing fairly detailed and specific objectives and measures.
- 2 Mentions content related to capital investment, infrastructure, public services, talent development, and technical support in one aspect or some aspects, providing only brief objectives or measures.
- 1 Only mentions keywords related to capital investment, infrastructure, public services, talent development, and technical support, without providing detailed explanations.

Table 2. Quantitative criteria for China's new energy vehicle infrastructure policy objectives (technical quality objectives).

#### Score Quantitative criteria for policy objectives

- 5 Clearly articulates the aim of enhancing the technical quality of new energy vehicle charging infrastructure, with highly detailed and specific descriptions. Encourages accelerated technology research and development, emphasizes quality control, and proposes a comprehensive range of measures, including the improvement of industry standards and the promotion of facility intelligence, to enhance charging reliability.
- 4 Explicitly central governments the objective of improving the technical quality of new energy vehicle charging infrastructure, with relatively specific descriptions. Encourages accelerated technology research and development and highlights quality control. Provides specific descriptions of charging reliability measures, although these may not cover all aspects.
- 3 Explicitly central governments the objective of improving the technical quality of new energy vehicle charging infrastructure, with relatively specific descriptions. Encourages accelerated technology research and development and highlights quality control. Provides specific descriptions of charging reliability measures, although these may not cover all aspects.
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between the central and provincial governments regarding the same policy objective as an example; the calculation method for synergy between tools is similar):

$$u(e/f) = \exp\left[-\left(TPG_i - TPG'_i\right)^2 / S^2\right]$$

In this formula, u(e/f) represents the central government coherence of central policy objective "e" relative to a local policy objective "f".  $TPG_i$  represents the actual value of measure "e" in year "*i*",  $TPG_i$  represents the fitted value of local

policy objective "f" requiring central policy objective "e" in year "i", and  $S^2$  represents the variance of central policy objective's actual values.

The calculation of  $TPG'_i$  involves first using "*x*" as the independent variable and "*y*" as the dependent variable. "*x*" represents the annual values of scores for local policy objective "f"" and "*y*" represents the annual values of scores for central policy objective "e". Using data from 2015 to 2022 as the analysis sample, a regression equation " $y = \alpha + \beta_1 x$ " is employed for regression fitting. This yields the regression coefficient  $\beta_1$ . Finally, by substituting the actual values of scores for provincial government objectives into the equation, you can obtain the fitted values of central policy objective "e" for year "*t*".

Using the same method, calculate the central government coherence U(f/e) of policy objective "f" relative to "e". Then, utilize these two central government coherence indicators to construct a coherence function:

$$U(\mathbf{e},\mathbf{f}) = \min \left\{ u(\mathbf{e}/\mathbf{f}), u(\mathbf{f}/\mathbf{e}) \right\} / \max \left\{ u(\mathbf{e}/\mathbf{f}), u(\mathbf{f}/\mathbf{e}) \right\}$$

From the above equation, when the difference between u(e/f) and u(f/e) is smaller, U(e, f) is larger, indicating a higher level of coherence between the two objectives. Conversely, when the difference between u(e/f) and u(f/e) is larger, the coherence between the two objectives is lower. When U(e, f) equals 1, it signifies complete coherence between the two systems.

It should also be added that one of the underlying logics of this study is that we believe that the synergy between central and local policies should be as high as possible. This is based on the following two assumptions: first, the new energy vehicle policy formulated by the central government is optimal and can take into account the country's strategic goals and the needs of socioeconomic development; second, it is necessary for provincial governments to implement the central government's new energy vehicle policy to ensure effective implementation and monitoring of the policy. Therefore, we expect the central government and provincial governments to reach a high degree of consistency and coordination in new energy vehicle policies, thus promoting the healthy development of the new energy vehicle industry.

# **3. Empirical Analysis**

# 3.1. Data Sources and Codes

The central government Council first introduced the construction of charging piles in the "Development Plan for Energy Conservation and New Energy Vehicle Industry (2012-2020)" issued in 2012. Therefore, this paper selects the new energy vehicle charging infrastructure policies issued between 2012 and 2022 as the research object. The policies are categorized into two levels: central and local (provincial). Provincial localities are further grouped into four major economic regions: Northeast, West, East, and Central. The primary data source for this research is the "Beida Faber" policy database. Policy texts were identified using keywords such as "new energy vehicles" and "charging infrastructure". Addi-

tionally, websites of the central government Council, NDRC, and provincial government were searched using the keyword "charging infrastructure" to ensure comprehensive data collection.

In total, 55 central-level policy texts and 648 local-level policy texts were initially retrieved. Through careful sorting, reading, and filtering out irrelevant information such as issue numbers and publication dates, the final dataset consisted of 53 central-level policy texts and 595 local-level policy texts. Among these, 67 policies originated from the Northeast region, 144 from the West region, 258 from the East region, and 126 from the Central region.

# 3.2. Statistical Analysis of Basic Policy Situation

### 3.2.1. Issuance of Central Policies

As can be seen in **Figure 2**, among the central policy issuing departments in 2012-2022, the National Development and Reform Commission (NDRC) issued the most documents, accounting for about 15 per cent of the total, followed by the National Energy Administration (NEA), the central government Council (SC), the Ministry of Finance (MOF) and the Ministry of Transportation (MOT), which all accounted for about 10 per cent of the total.

## 3.2.2. Issuances of Local Policies

According to **Figure 3**, the East and West have the highest number of policies related to new energy vehicle charging piles, 44% and 24% respectively, while the



Figure 2. Percentage of central policy subjects' issuances, 2012-2022.

Northeast has issued the fewest.

Trends in the number of policies show more growth in the West and East, and more stability and fewer issuances in the Centre and West.

According to **Figure 4**, in the realm of provincial-level policies, Beijing emerged as the foremost contributor in terms of policy volume, closely trailed by Fujian. Conversely, Guizhou exhibited the least policy issuance, with Sichuan following suit. The observed distribution indicates a lack of substantial regional disparities in terms of policy count.

## 3.3. Policy Co-Word Analysis

#### 3.3.1. Extraction of Policy Keywords

The keywords of a policy text can express the theme and policy focus of that policy. In this study, the ROSTCM 6 software was used to classify the central and local policy texts and count the word frequency of the words. In order to ensure that the obtained words are related to the policy theme, the deactivated words such as "several" and "further" are eliminated, and the synonyms such as





Figure 3. Percentage of policies by region, 2012-2022.



Figure 4. number of provincial policies 2012-2022.

"neighborhood" and "residential area" are removed. The synonyms such as "neighborhood" and "residential area" were merged, and the top 20 words in terms of word frequency were finally obtained, as shown in Table 3 and Table 4.

From the subject word frequency, it can be seen that the central new energy vehicle charging infrastructure policy mainly focuses on the key words such as standard, system, technology, promotion and charging service, of which, the word frequency of standard and system are 57 and 42 respectively, and the word frequency of technology, promotion and charging service are all 37 and above. Local new energy vehicle charging infrastructure policy mainly focuses on keywords

 Table 3. Word frequency statistics of central new energy vehicle charging infrastructure policies.

No.	keyword	Frequency	No.	Keyword	Frequency
1	Standard	57	11	Intelligent	25
2	System	42	12	Parking space	25
3	Technology	42	13	Supporting Power Grid	20
4	Popularize	37	14	Along	18
5	Charging Service	37	15	Motorway Service Area	18
6	Equipped with Construction	33	16	Connectivity	17
7	Platform	31	17	proportion	14
8	Demonstration	27	18	Charge and Swap	14
9	Innovation	26	19	Power Grid Enterprises	14
10	Residential Community	26	20	Moderately Ahead of its Time	13

 Table 4. Word frequency statistics of local new energy vehicle charging infrastructure policies.

No.	keyword	Frequency	No.	Keyword	Frequency
1	Platform	708	11	Proportion	288
2	Popularize	615	12	Charging Service	265
3	Charge and Swap	578	13	Innovation	260
4	Equipped with Construction	548	14	Investment	250
5	Standard	481	15	Permit	232
6	Demonstration	437	16	Public Parking	231
7	Technology	387	17	Motorway Service Area	206
8	System	380	18	Converter Station	193
9	Charging Stations	341	19	Share	189
10	Intelligent	315	20	Social Capital	168

such as platform, promotion, charging and switching, distribution and standard, of which the word frequencies of platform and promotion are 708 and 615 respectively, and the word frequencies of charging and switching and distribution are all above 500. This indicates that the current construction of new energy vehicle charging facilities and the construction and promotion of charging service platforms are hotspots of concern for the government and society.

From the content of the theme words, we can find that the three words: platform, promotion and charging service indicate that the central government attaches great importance to the construction of charging service platform for new energy vehicles. The improvement of charging infrastructure is a prerequisite for the promotion of new energy vehicles, and the construction and operation system of the charging facilities platform will optimize the charging service experience of consumers and effectively contribute to the popularization and promotion of charging infrastructure. Standards and systems show that our government is committed to standardizing and improving the process of construction, operation and approval of charging facilities for new energy vehicles, providing a good environment for the development of charging infrastructure. The words "demonstration", "proportion" and "charging and switching" indicate that the central government attaches great importance to the proportional allocation of charging infrastructure in public service areas, and encourages the construction of demonstration areas for charging facilities to meet the charging needs of new energy vehicle owners.

From the comparison of the theme words, it can be found that in the first 20 extracted high-frequency words of central and local policy texts, 13 high-frequency words overlap, especially in the first 6 high-frequency words, 3 of which are identical, and the rest of the high-frequency words have differences in the order of the word frequency and the content, and there is a greater overlap of the theme words of the central and local policy texts. This shows that the core spirit and direction of provincial government policies are in harmony with those of the central government, and that they have different focuses when formulating policies, and are better able to formulate policies that match the actual situation of each place according to their different realities.

#### 3.3.2. Analysis of Co-Word Networks

To facilitate the visualization of essential policy elements and the interrelation and arrangement of high-frequency thematic terms, we employed the co-occurrence matrix and point centrality to construct co-occurrence networks for high-frequency terms within central and local policies. This process was realized using the UCINET 6 and NetDraw software tools, resulting in the creation of **Figure 5** and **Figure 6**, respectively. These figures provide a graphical representation that enables us to delve into the similarities and disparities between the high-frequency thematic terms present within central and local policies.

As can be seen in the network diagram of high-frequency words in central government policies, the core words in the policy text are "standard" and



Figure 5. Co-word network of country-level policy subject terms.



Figure 6. Co-word network of provincial local policy subject terms.

"system", reflecting the fact that the relevant policies are aimed at standardizing the construction and management system of charging facilities; the sub-core words are The sub-core words are "technology", "promotion", "charging service", "distribution" and "platform", reflecting that the central government's objectives in formulating policies include promoting technological advances related to charging facilities, accelerating the construction of charging piles, promoting the use of charging piles and charging service platforms, and optimizing users' charging experience. Meanwhile, the core words and sub-core words form a cohesive subgroup.

As can be seen from the provincial government policy high-frequency word co-occurrence network diagram, the themes of provincial government policy are "platform" and "promotion", reflecting that the focus of provincial government policy is on the promotion of charging facilities and charging service platforms. The sub-core words are "charging and switching", "distribution", "standard", "demonstration" and "technology", which reflect the focus of provincial government policies on the promotion of charging facilities and charging service platforms. "technology", reflecting the policy objectives of provincial governments, including promoting the development of new energy vehicle charging and switching, ensuring that new energy vehicle parking spaces meet the demand, carrying out demonstration units for new energy vehicle use, promoting the construction of charging piles, and promoting the development of charging technology. Also these core keywords constitute a cohesive subgroup.

It can be seen that the focus of central and provincial government policies on charging infrastructure for new energy vehicles and the content of the policy text are highly relevant, both focusing on the construction of standardized charging facilities, improving charging infrastructure technology, perfecting charging service platforms, guaranteeing demand for charging piles as well as promoting the use of charging piles. However, there are also differences, such as the provincial government policy also focuses on the introduction of social capital to accelerate the construction of charging piles.

A comparison of the central and provincial governments' thematic word co-occurrence network diagrams shows that the central government focuses more on the macro and overall situation when formulating policies, while provincial governments formulate policies based on more practical scenarios.

#### 3.4. Policy Coherence Analysis

#### 3.4.1. Policy Quantification

Policies were first categorised, with each policy being classified according to the definitions of policy instrument and policy objective. After the categorisation was completed, the policies were scored by each of the four members of the group. After the first scoring, policies with identical assessment results were re-tained, and policies with disagreeing assessment results were discussed. The final re-scoring was done by the four members of the group. After independent quantification as well as analysis and discussion, the variance of the mean score of each policy breakdown of the final policy quantification among the group members was less than 0.1, indicating a high degree of stability and good reliability of the quantification results.

#### 3.4.2. Statistical Analysis of Policy Objectives and Use of Policy Tools

1) Use of Policy tools

The rate of policy instrument use indicates the likelihood of that policy instrument being used in a policy. As can be seen in **Figure 7**, the supply category has the highest share of policies; the use of different Policy tools for the same policy is more frequent in the Northeast.

The tendency to use Policy tools indicates the likelihood that the type of policy instrument will be present when the provincial government chooses the policy instrument. As can be seen in **Figure 8**, both national and provincial governments

are more inclined to choose supply-type Policy tools.

2) Coverage of policy objectives

The policy purpose involvement rate indicates the likelihood of the policy purpose being mentioned in a policy. As can be seen in **Figure 9**, the policy objective of planning layout is mentioned the most; the Western Region has fewer







Figure 8. Propensity to use policy tools.





policy objectives included in a policy.

The tendency of policy purpose involvement indicates the priority of the policy purpose chosen to be realized. As can be seen in **Figure 10**, provincial governments focus on the objectives of planning and layout; technical quality and connectivity have a lower priority; and the western region places the least emphasis on the standards system.

#### 3.4.3. Empirical Findings and Policy Synergies Analysis

In order to study the policy synergies between the Northeast, West, East, and Central regions and the Central region, regression analyses of the policy scores for each year are required. Due to the small number of policy releases in multiple regions before 2015, the scoring results are not accurate and objective, and the regression results of policy scores released after 2015 are significant. Therefore, using 2015 as the starting point for policy analysis, the central government coherence model was used to analyze the status of central synergies between Policy tools and policy objectives of new energy vehicle infrastructure policies in the four economic regions.

1) Policy instrument coherence level

Using the central government coherence model of central and provincial government policies, the level of coherence of new energy vehicle infrastructure Policy tools in each region from 2015 to 2022 is measured, as shown in the following figure.

According to **Figure 11**, it can be seen that overall, in terms of supply-type Policy tools, the supply-type Policy tools of each region have a high level of central-local coherence. From 2015 to 2016, the synergies of all four regions did not change much and were close to 1. After 2016, the central-local synergies of the western region began to diverge from the other regions, with the synergies dropping to around 0.8 and fluctuating around 0.7 after 2018. The central-local policy synergies in the Northeast, East and Central regions have remained above 0.8.



According to Figure 12, there is a huge difference between the central-local





Figure 11. Central-local policy synergies of supply instruments across regions.



Figure 12. Central-local policy synergies of environmental instruments across regions.

policy synergies of the Policy tools in the four regions in terms of environment-based tools. The central region's central-local policy coherence has been stable at around 1, which shows that the central region has maintained a high degree of coherence with the policies issued by the central government for environmental Policy tools, and the policies have been implemented with high precision. The western and northeastern regions have better synergies overall, both above 0.6. From 2015 to 2017, both regions maintained a high degree of coherence with the central government, with synergies above 0.8; from 2017 to 2019, the central synergies of the two regions suffered a decline and fluctuation. Among them, the coherence of the western region drops to about 0.6, and then rises slowly year by year; the central coherence of the northeastern region first continues to rise, and then begins to decline in 2020. For the eastern region, the central-local coherence of environment-based Policy tools has been unsatisfactory, with a coherence of around 0.25 in 2015, and after a slow rise year by year, the coherence reaches around 0.4 in 2020, but it is still much lower than the central-local coherence of other regions.

According to **Figure 13**, it can be seen that for demand-based Policy tools, the central-local synergies of the four regions first tend to unify, then diverge, and finally converge again. Specifically, from 2015 to 2017, the central-local policy synergies of the four regions show an upward trend, with the central region staying around 1. The trends in the northeast and the west are not significantly different, and the synergies are both rising from 0.7 to around 1. Between 2017 and 2020, the synergies of the four regions begin to diverge, showing a W-shaped pattern, with a less stable coherence effect. In 2019, the coherence of the Northeast region falls to the lowest value of about 0.4 and is in a central government of disequilibrium, and then rises back to about 0.7. Meanwhile the other three regions show varying degrees of fluctuation. Between 2020 and 2021, the central government of central-regional coherence remains stable in all four regions. In 2022, the central-land coherence of the western, eastern and central regions are all around 1, showing a high degree of coherence, while the northeast tern region is around 0.6, with better coherence.

2) Policy target coherence level

Using the central government coherence model of central and provincial government policies, the coherence level of new energy vehicle infrastructure policy objectives in each region from 2015 to 2022 is measured, as shown in the following figure.

According to **Figure 14**, it can be seen that for the policy objectives of technical quality, the western, eastern and central regions have maintained good central-local coherence, with synergies fluctuating between 0.8 and 1. The central-local coherence of the northeastern region fluctuates tremendously, with a





high level of coherence in 2020 and 2021, however, in 2015, 2018, and 2022, the degree of coherence converges to 0, indicating a serious disequilibrium , and in the other years, central-land coherence in the Northeast is in a moderate central government of coherence.

According to **Figure 15**, for the policy objective of operational efficiency, the central-local consistency in the central and western regions has been at a high level of coordination, indicating that the two regions have a high degree of dependence on the central government in terms of the operational efficiency objective, and the precision of policy implementation is strong. On the other hand, the central-local coherence of the Northeast and Eastern regions has been in a fluctuating central government. In 2015 and 2021, the central-land coherence of the Northeast region was extremely high; in 2017, the central-land coherence of



Figure 14. Regional variation in central-local policy coherence for technical quality objectives.



**Figure 15.** Regional variation in central-local policy coherence for operational efficiency objectives.

the Northeast region was below 0.6, and the central-land consistency was average. The central-land coherence in the eastern region has been fluctuating under the moderate coherence level of 0.4 to 0.7.

According to **Figure 16**, for the policy objective of planning layout, the central and eastern regions maintain a high level of central-local policy coherence, however, the central-local coherence of the northeastern and western regions fluctuates greatly. In 2015, 2017, 2018 and 2022 the central-land coherence in the Northeast region is in a severe central government of dissonance; in 2017 and 2018, the Western region is in a moderate central government of dissonance. Central-land policy coherence is better in the two regions in other years.

According to **Figure 17**, it can be seen that under the policy objective of power supply security, there is no significant difference in the fluctuating central government of central-land co-ordination among the three regions, except for the eastern region. The Northeast, Western and Central regions are in a high



Figure 16. Regional variation in central-local policy coherence for planning layout objectives.



Figure 17. Regional variation in central-local policy coherence for power supply security objectives.

level of smoothness from 2015 to 2017; they experience a drop from 2017 to 2018, with a barely coordinated central government of 0.4 coherence; in 2020 the coherence climbs to a highly coordinated central government; in 2021 the central-land coherence stays stable; and in 2022 the central-land coherence falls back to an uncoordinated central government. In contrast to the other three regions, the central-land coordination in the Eastern region generally fluctuates and rises, reaching a high level of coordination in 2018 and 2022.

According to **Figure 18**, it can be seen that under the policy objective of interconnection, in general, the central-local policy consistency of the four regions is superior in the rest of the years, except for the Northeast region, which has a coherence degree of 0.3 in 2015, which is in a central government of central-local policy non-coherence, and is in a central government of barely synergistic in 2020.

According to Figure 19, it can be seen that the central and eastern regions



Figure 18. Regional variation in central-local policy coherence for interconnection objectives.



**Figure 19.** Regional variation in central-local policy coherence for standard system objectives.

have been stabilised at a high level of coordination under the policy objectives of the standard system. From 2015 to 2021, the western and northeastern regions have been fluctuating under the better level of 0.7 to 1. In 2022, the northeastern region maintains the coordinated central government, while the coherence degree of the western region falls to about 0.4, which is in the barely coordinated central government.

## 4. Conclusion and Recommendations

Based on a comparative analysis of the Policy tools, policy objectives, policy themes, and central-local synergies of central-local new energy charging infrastructure policies, we draw the following conclusions:

1) For policy theme characteristics, in terms of theme keywords, there is more overlap between central and local policy theme words, but there are differences between the order of high-frequency words, and the core spirit of central and local policies is the same. In terms of the policy theme word co-word network, the high-frequency theme words of the central and local policies each have a strong internal connection, but there are differences in the content and distribution of high-frequency words between the central and local policies.

2) For policy instrument synergies, in terms of supply-based Policy tools, policy synergies between regions and the central government are high, especially in the Northeast, East and Central regions, where the synergies remain above 0.8. However, synergies in the western region are gradually decreasing, and there is a need for greater coordination of policies with the centre. In terms of environmental and demand-based Policy tools, there are differences in synergies between regions, with the central region showing high synergies in all indicators, while the eastern region has relatively low synergies in environmental Policy tools.

3) For the coherence of policy objectives, the central region shows higher coordination with the central government in terms of the objectives of improving technical quality and operational efficiency, and the precision of policy implementation is strong. In contrast, the synergies in the Northeast and Western regions fluctuate widely, and coordination with the central government's objectives needs to be strengthened. In terms of planning and layout objectives, the central and eastern regions show high coherence, while the coherence of the northeastern and western regions varies considerably.

In summary, China's overall policy coherence in new energy vehicle charging infrastructure is strong, with the depth of some of the projects and the new energy vehicle industry is becoming more mature, China's relevant policies centralized policy coherence is also gradually increased, indicating that the development of China's new energy vehicle charging facilities is gradually complete, we also put forward the following recommendations based on the above conclusions reflecting the problem:

Flexible policy formulation in the light of local conditions
 Enhance the landability of the policy. From the analysis of the network of pol-

icy subject words and common words, it can be seen that the central and provincial governments have the same core spirit of charging infrastructure construction policy, and the content of the policy has its own focus: the central policy focuses on the macro and overall situation, while the local policy will be based on the actual scenarios to formulate more specific policies. However, from the order of high-frequency words, we can see that there is still a high degree of overlap between central and local policies. Due to the differences in the economic level, technical level and electric vehicle charging infrastructure construction in different places, provincial governments need to formulate flexible and implementable policies based on the actual situation to promote the sustainable development of local new energy vehicle charging infrastructure while maintaining consistency with the core of the central policy documents and adapting to local conditions.

2) Strengthen communication and cooperation between local and central governments

Establish regular communication channels. provincial governments should establish regular communication mechanisms with the central government, such as holding policy coordination meetings or setting up special working groups, to ensure policy consistency and consensus.

Provide policy advice and feedback. provincial governments should actively provide the central government with issues and suggestions in the process of policy implementation, and provide timely feedback on the effectiveness of policy implementation and local needs, so that the central government can make timely adjustments to policy directions and measures.

Sharing of information and data. Provincial governments should share information and data in relevant areas with the central government so that the central government can more accurately assess the effects of policies and formulate more appropriate Policy tools.

3) Enhance synergies between environment-based and demand-based Policy tools

Harmonize policy objectives. Provincial governments should work with the central government to clarify the objectives of environment-based and demand-based policies and develop consistent indicators and standards to ensure synergies between Policy tools in different areas.

Consider local differences. When formulating specific Policy tools, the central government should fully consider the actual situation and needs of the localities, try to ensure the applicability and operability of the Policy tools, and fully consult with the provincial governments in order to obtain better policy implementation results.

4) Horizontal learning and experience sharing

Establish an exchange platform for policy landing. Provincial governments can establish a cross-regional exchange platform for policy implementation, inviting government representatives and experts and scholars from various regions

to share successful policy implementation cases and experiences to promote mutual learning and reference.

Organize thematic seminars and workshops. Regularly organize thematic seminars and workshops, focusing on specific policy areas and inviting relevant experts and practitioners to share best practices, so as to promote the precision and effectiveness of policy implementation.

5) Customized policy implementation programs

Regional customized policy program. Provincial governments can formulate customized policy implementation programs according to the characteristics and needs of the region, taking full account of local resource endowments, industrial structures and development stages, to ensure that the policies are precise and operable.

Apply scientific and technological means. Make use of advanced scientific and technological means, such as artificial intelligence and big data analysis, to conduct in-depth studies and forecasts of the actual situation in the region, so as to provide a scientific basis and precise guidance for policy implementation.

6) Strengthen research and planning of planning layout

In-depth analysis of regional characteristics. Provincial governments should conduct in-depth analyses of the region's natural, economic and social characteristics, as well as development needs and potentials, in order to provide a scientific basis for the formulation of planning layouts; and then refer to the central government's policy guidance: when formulating the planning layouts of the region, provincial governments should refer to the central government's policy guidance and planning requirements, and ensure coherence with the central government's policies. If necessary, provincial governments and the central government should cooperate in the preparation of planning programs to ensure that the planning layouts of various regions are connected and coordinated, so as to avoid unnecessary conflicts and competition. Meanwhile, when assessing and adjusting in the middle and late stages of the project, the provincial government should regularly assess and adjust the planning layout of the region to meet the needs of economic development and social changes, and communicate and coordinate with the central government in a timely manner to ensure the stability of the planning layout.

The consistency of China's new energy vehicle charging infrastructure policy between the central and provincial governments varies in different regions, which is fundamentally due to the fact that each region has its own development characteristics and geographical advantages, and the central government is unable to meticulously give the corresponding policy directions to all the regions in formulating the development policy, and needs the provincial governments to make fine-tuning on the basis of the general policy guidelines, which makes the difference in the degree of coherence unavoidable. However, in view of the large inconsistency between central and local policies, we can further improve the implementation of China's new energy vehicle charging infrastructure policy and promote the healthy development of the new energy vehicle industry by strengthening the policy coherence mechanism, improving the coherence of environmental Policy tools, reinforcing the consistency of the goals of technical quality and operational efficiency, and improving the coherence of the goals of planning and layout.

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# **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

# References

- Bai, X. J., & Meng, H. (2018). Emerging Industries, Policy Support and Lack of Incentive Constraints—Taking New Energy Vehicle Industry as an Example. *Economist, 2018*, 50-60.
- He, Y., Le, W., & Guo, B. H. (2021). Research on the Policy Synergy of Central and Local Government on New Energy Vehicle Industry under the Perspective of Policy Field and Time Dimension. *China Management Science*, *4*, 1-12.
- Jia, L. J., & Lv, R. Z. (2014). Research of the New Energy Automotive Related Policy Benchmark at Home and Abroad. *Shanghai Automotive, No. 12*, 36-40.
- Jiang, D., Chen, X. L., & Wang, W. (2021). Analysis on the Evolution of Science and Technology Policy Theme of "Mass Entrepreneurship and Innovation" in China. *Innovation and Entrepreneurship Theory Research and Practice*, 4, 12-15.
- Law, J., Bauin, S., Courtial, J. P. et al. (1988). Policy and the Mapping of Scientific Change: A Co-Word Analysis of Research into Environmental Acidification. *Scientometrics*, 14, 251-264. <u>https://doi.org/10.1007/BF02020078</u>
- Liu, H. G., Sun, H. P., & Zhang, X. (2019). Analysis on Policy Evolution and Execution Retardation of China's New Energy Vehicle Industry—Also on the Coordinated Implementation of the Double-Point Policy. *Management Modernisation*, 39, 41-46.
- Rothwell, R., & Zegveld, W. (1981). *Industrial Innovation and Public Policy: Preparing for the 1980's and 1990's*. Francis Pinter.
- Si, G. N. (2008). Coherence Analysis of Population-Economic System. Statistics and Decision Making, No. 256, 48-50.
- Wang, L. Z., & Zhang, Y. J. (2017). Research on Policy Synergy of New Energy Automobile Industry in China-Based on Three-Dimensional Analysis Framework of Structure, Process and Content. *China Administration*, 2017, 101-107.
- Xu, X., Huang, T. Z., & Zhang, X. (2017). Analysis of the Current Status of China's New Energy Vehicle Technology Based on Co-Word Network. *China Science and Technol*ogy Information, 2017, 68-70+72.
- Zhang, G. Q., & Xu, Y. M. (2017). International Mirror and Extension of New Energy Vehicle Policy Tools. *Reform, No. 3*, 130-138.
- Zhang, L., Qin, Q. D., & Xie, L. J. (2020). Policy Coordination of New Energy Vehicle in

China—Evaluation and Evolution. *Journal of Beijing Institute of Technology (Social Science Edition), 22,* 26-35.

- Zhang, X. S. (2021). Discussion on the Coordinated Development of New Energy Automobile Industry Policies between Central and Local Governments. *Times Automotive*, *2021*, 111-112.
- Zhong, W. G., Peng, J. S., & Sun, W. X. (2009). Measurement of Policy, Coordination of Policy and Economic Performance: An Empirical Study on Innovation Policy (1978-2006). *Science and Technology Management*, 30, 54-60+95.
- Zhong, W. J., & Li, J. (2008). The Research of Co-Word Analysis (1)—The Process and Methods of Co-Word Analysis. *Journal of Intelligence, 2008*, 70-72.
- Zuo, S. Q., Zhao, S. J., & Zhu, Y. Y. (2020). Policy Trend and Enlightenment of Foreign New Energy Vehicle Industry. *Economy, No. 1*, 113-122.