

# Identification of Key Policy Factors for Technological Innovation in China's New Energy Vehicle Industry based on Complex Network Model

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**Abstract:** At present, the rapid development of China's new energy vehicle industry has put forward new requirements for the breadth and depth of technological innovation. Combined with the technical status of China's new energy vehicle industry, the policy of China's new energy vehicle industry was collected and sorted, and policy text mining was used to mine high-frequency policy words that promote industrial technological innovation. Therefore, this paper uses UCINET software to construct a symbiosis network model of policy high-frequency words, identifies key policy factors of technological innovation in the new energy vehicle industry according to the network topology characteristics, and provides theoretical support for further analysis of policy-driven industrial technological innovation.

## 1 INTRODUCTION

As an important measure for the state to guide industrial transformation and upgrading and promote industrial sustainable development, industrial policy needs various policy tools to complement each other and form a joint force, so as to achieve the purpose of the policy. Many scholars have conducted in-depth discussions on this, Li (Li 2021) found that the uncertainty of trade policy is positively related to the effect of scientific and technological R & D, and government subsidies reduce the strength of this relationship. Guo (Guo 2021) used the diamond model to analyze the correlation of various factors in China's new energy vehicle industry, and pointed out that the key to the endogenous development of subsidy incentive in the post subsidy era depends on the interaction of various factors. Zhang (Zhang 2021) based on the social system transformation theory and from a multi-level perspective, proposed a business model innovation path consistent with China's new energy vehicle industry. Hanna and Deborah (Hanna, Deborah, 2018) analyzed the cost of traditional vehicles, hybrid vehicles and pure electric vehicles in 14 cities and believed that they should continue to make efforts in the tax preference and R & D investment policies of new energy vehicles. Zhou and Pan (Zhou, Pan, 2019) explored

the marginal benefits of subsidy and tax policies based on the transaction cost theory, and pointed out that in order to ensure reasonable market competition, the industrial policy of new energy vehicles should change from subsidy policy to tax policy. Xiong and Li (Xiong, Li, 2019) pointed out that China's new energy vehicle policy does not match the consumer market well in the implementation process, and differentiation policies should be formulated by region, stage and intensity, so as to promote industrial development. Chen (Chen 2021) built a dynamic game model based on system dynamics, analyzed the impact of subsidy decline on the new energy vehicle market, and pointed out that under the trend of subsidy decline, improving their own technological innovation ability and promoting consumer demand are the key to ensure the stable development of the industry.

As an important part of China's strategic emerging industry, the new energy vehicle industry was faced with the embarrassing situation of high price, low quality, high supply and low demand, and the income could not be internalized in the early stage of promotion, which led to practical problems such as low resource allocation and insufficient investment in independent innovation and R & D. Using different types of policies to promote industrial innovation and development has become the primary

choice of countries all over the world. However, different types of policies have different focus, and there are significant differences in the operation mechanism of promoting industrial development. At the historical intersection of a new round of scientific and technological revolution and industrial innovation reform, clarify the action mechanism and connotation of new energy vehicle industrial policy, improve the leading and driving role of industrial policy system in the development of new energy vehicle industry, and summarize and analyze the elements of industrial policy that can not be ignored.

Since the promulgation of the development plan for energy saving and new energy vehicle industry (2012-2020), the upstream and downstream of China's new energy vehicle industry chain has gradually increased R & D investment, and the production and sales volume has increased year by year. So far, China's new energy vehicles have entered a new stage of promotion and application. At the same time, the policy orientation of China's new energy vehicle industry has gradually changed from selective industrial policy to functional industrial policy. In this process, how to further promote the technological innovation and development of China's new energy vehicle industry and guide the new energy vehicle industry from the decline of subsidies to the "upslope" of innovation is very important.

## 2 MATERIALS AND METHODS

There are many upstream and downstream related industries in the new energy vehicle industry, and all technical links cooperate closely, gradually forming a large-scale complex system with multi-body participation and multi industry linkage development. The high-quality sustainable development of complex systems plays a leading role in industrial development. Technological innovation is the top priority. It is essential to explore the key factors of industrial technological innovation. Promoting industrial technological innovation is not achieved overnight. We must clarify the system structure of the fresh energy vehicle industry chain, abstract the system structure by model, and clarify the key factors driving technological innovation.

Firstly, the laws, regulations, plans, notices and other policy texts related to the development of new energy vehicle industry from 2012 to 2020 are selected on the website of the Chinese government, the website of the national development and Reform Commission, the China new energy vehicle industry alliance and the national laws and regulations

database, and the comprehensiveness of the policy texts is ensured through related content retrieval. Because the local policy is the expansion of the central policy and has certain regional characteristics, the policies issued by provinces and cities are excluded during retrieval. According to the analysis and comparison of the retrieved policies by China automotive industry information network and Peking University magic weapon, eliminate the duplicate and irrelevant industrial policies, classify the policies according to different types and different publishing departments, and preliminarily determine 427 policies related to the new energy vehicle industry. Then, after intensive reading of the preliminarily selected industrial policies from the aspects of policy measures, policy types and policy timeliness, it is found that a large number of policies mention new energy vehicles, but there is no substantive planning for the development of new energy vehicle industry, and the policy specifications are low. After repeated discussion with relevant experts and team teachers of industrial policies, the new energy vehicle industrial policy database is finally determined, including the State Council, the national development and Reform Commission, the Ministry of public security, the Ministry of housing and urban rural development, the Ministry of industry and information technology, the Ministry of finance, the Ministry of science and technology, the Ministry of environmental protection, the Ministry of Commerce, the Ministry of communications, the State Administration of Taxation, the state energy administration, the State Administration of quality supervision, inspection and quarantine, the State Standardization Commission, the State Grid, the State Railway Administration, the General Administration of customs, the head office of the people's Bank of China, the CBRC 105 national new energy vehicle industry policies issued by more than 20 departments such as China Automobile Association. Finally, according to the relevance between different elements of the policy text, build a co-occurrence network of technological innovation policies in the new energy vehicle industry, systematically analyze the evolution process of China's new energy vehicle industry policies by combining quantitative and qualitative methods and using the topological structure characteristics of the network, and extract the key policy factors to promote technological innovation in the new energy vehicle industry in combination with the new energy vehicle industry, Lay a theoretical foundation for promoting the development of industrial technology innovation.

### 3 RESULT & DISCUSSION

Combined with relevant literature, this paper further discusses the content of China's new energy vehicle industry policy from 2012 to 2020 with four professors in the field of industrial policy and two experts in the field of technological innovation in the new energy vehicle industry, determines the element boundary, and analyzes and summarizes the policy elements promoting industrial technological innovation. In order to ensure the scientificity and effectiveness of policy elements, the existing new energy vehicle industry policy database is randomly screened and marked, and finally determined as ten types of policy elements, namely financial support, production access, fiscal and tax support, integral compliance, market supervision, transportation, infrastructure, achievement incentive, government procurement and talent support. The classification and definition of policy elements are shown in table 1. Thus, a co-occurrence matrix of policies to promote technological innovation in new energy vehicle industry is constructed, as shown in Table 2.

Table 1: Policy Elements for Promoting Technological Innovation in China's New Energy Vehicle Industry.

classification	definition
Financial Support (FS)	Promote the popularization, application and innovative development of new energy vehicles through differentiated loan interest rates.
Production Access (PA)	Adapt to the needs of industrial development, adjust the access standards of relevant enterprises in the upstream, middle and downstream of the new energy vehicle industry chain, and guide the market-oriented transformation of the industry.
Tax Support (TS)	Promote the promotion, application and technological development of China's new energy vehicle industry, and give certain financial and tax support to relevant enterprises and individuals based on the mileage, battery energy density and other indicators of new energy vehicles.
Integral Compliance (IC)	Establish a point trading mechanism to promote the market-oriented means of energy-saving of traditional fuel vehicles and innovation of new energy vehicle industry.
Market Supervision (MS)	Product quality and safety supervision and management, product inspection system,

Transportation (T)	construction of supervision platform, setting some technical safety thresholds, etc. Increase the promotion and application of new energy vehicles in public transportation, leasing, logistics, ports and other fields, and implement the right of way priority policy for new energy vehicles in some cities.
Infrastructure (I)	Increase the proportion of infrastructure construction such as charging and replacement pile stations, encourage relevant enterprises to join the service operation of charging facilities, and broaden charging financing channels.
Achievement Incentive (AI)	Strengthen the protection of intellectual property rights, strengthen the support for scientific and technological research and development of new energy vehicle related technologies, and set up special projects for scientific and technological research and development.
Government Procurement (GP)	Through the purchase of new energy vehicles by government organs and public institutions, we will further strengthen the promotion and application of new energy vehicles and promote the accelerated development of the industry.
Personnel Support (PS)	Colleges and universities are encouraged to set up interdisciplinary majors related to new energy vehicles, add relevant research institutes in the field of new energy vehicles, and promote the in-depth integration of industry, University and research.

Table 2: Co-occurrence Matrix of Policy Elements Driving Technological Innovation of China's New Energy Vehicle Industry.

	FS	TS	IC	PA	MS	T	I	AI	PS	GP
FS	0	7	1	1	1	4	4	2	2	3
TS	7	0	8	6	4	12	18	11	11	7
IC	1	8	0	10	6	8	10	12	13	1
PA	1	6	10	0	4	5	9	11	11	2
MS	1	4	6	4	0	6	6	3	3	3
T	4	12	8	5	6	0	17	12	12	8
I	4	18	10	9	6	17	0	15	14	9
AI	2	11	12	11	3	12	15	0	29	2
PS	2	11	13	11	3	12	14	29	0	1
GP	3	7	1	2	3	8	9	2	1	0

Use UCINET software to draw the co-occurrence matrix into the co-occurrence network of policy elements of China's new energy vehicle industry, as shown in Figure 1. Among them, the larger the node, the greater the degree value, that is, the better the implementation effect of this type of policy elements in the current new energy vehicle industry policy system.

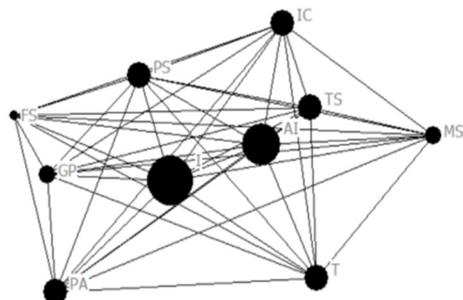


Figure 1: Co occurrence network of policy elements of China's new energy vehicle industry.

It can be seen from Figure 1 that in the co-occurrence network of China's new energy vehicle industry policies, the nodes of infrastructure, achievement incentive and talent support are large, while the nodes of financial support, government procurement and market supervision are significantly smaller than other nodes, which can reflect that China pays more attention to infrastructure construction. Achievement incentive and talent support promote industrial technological innovation, while financial support, government procurement and market supervision play a small role in promoting industrial technological innovation.

The co-occurrence relationship of policy elements in the new energy vehicle industry has been steadily developed for a long time, and the gradually formed co-occurrence network can be regarded as a static complex network. This static co-occurrence network represents the interaction of policy elements in the evolution of policy system. The co-occurrence network of policy elements can be used to measure the characteristics of network topology (as shown in table 3) and further analyze the key policy elements in China's new energy vehicle industry policy.

Table 3: Topology Characteristics of Policy Element Co-occurrence Network.

	Degree	Clustering coefficient	Effective scale	Efficiency
AS	25	8.861	4.069	0.452
TS	84	7.222	4.478	0.498
IC	69	7.639	4.33	0.481

PA	59	7.917	4.268	0.474
MS	36	8.556	4.484	0.498
T	84	7.222	4.456	0.495
I	102	6.722	4.745	0.527
AI	97	6.861	4.111	0.457
PS	96	6.889	4.085	0.454
GP	36	8.556	4.216	0.468

## 4 CONCLUSIONS

In the co-occurrence network of policy factors, the node degree indicates the frequency of the role of policy factors in promoting industrial technological innovation in the existing policy system. It can be seen from table III that the degree of infrastructure is the largest, followed by achievement incentive, talent support, transportation, fiscal and tax support, integral compliance, production access market supervision, government procurement and financial support. It can be seen that in China's existing new energy vehicle industry policies, strengthening infrastructure construction can alleviate the mileage anxiety of new energy vehicles. The promotion and application of new energy vehicles can greatly promote the technological innovation of the current industry, followed by the incentive of scientific and technological achievements and talent support. However, government procurement and financial support have not shown much in the promotion of technological innovation in the current policy system. In the actual network, the high clustering coefficient leads to the poor robustness of the network as a whole, which is not conducive to the development and evolution of the industrial policy system. It can be seen that the policy elements of infrastructure construction, achievement incentive, talent support, fiscal and tax support, integral compliance and transportation are more in line with the evolution of the technological innovation policy system of the new energy vehicle industry, while government procurement. The performance of financial support and market supervision is poor, with a fault gap. From the characteristics of network structure, the effective scale and efficiency of co-occurrence network can measure the synergy of different policy factors in the technological innovation policy system of new energy vehicle industry. Among them, infrastructure has the best synergy in the industrial policy system, followed by fiscal and tax support, transportation, integral compliance, production access, market supervision, achievement incentive, talent support. Government procurement and financial support.

According to the analysis of the characteristics of the comprehensive network structure, infrastructure is the most important factor in the technological innovation policy system of the new energy vehicle industry, and there are many fault gaps in financial support, government procurement and market supervision compared with other policy factors. Therefore, through the analysis of the co-occurrence network, it is found that infrastructure, transportation, achievement incentive, talent support, fiscal and tax support Integration compliance and production access are key policy elements to promote industrial technological innovation.

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