Who decided the new energy vehicles policy in China? From the perspective of policy objects and policy makers

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A B S T R A C T

The new energy automobile industry is a comprehensive system that contains Exploration and Manufacture, Consumption and Promotion, Infrastructure Construction and Supporting Industries, which coordinate and supplement with each other. Accordingly, from the perspective of policy object, NEVs policies since 1991 to 2022 could be divided into four fields in China. With policy bibliometric analysis and social network analysis, in each field of policies, its policy networks can be drawn, with statistic of policies released separately, in order to comprehensively analyse the features of NEVs policy making. It is found that: (1) The structure of policy system is balanced among four fields of NEVs policies in China, though with a bias towards Consumption & Promotion, Exploration & Manufacture. (2) Policy makers in all four fields of NEVs policies preferred slightly to formulate policies jointly, rather than acting alone. While policies made by sole actors are part of policy system. (3) GOOSC, MIIT and MOT, as sole actor, played more significant roles in industry-wide, supply-side and demand-side of NEVs industry respectively. (4) Policy networks of all four fields started with the "iron four" (MIIT, NDRC, MOF, MOST), ultimately forming two different ways of development, specialization and sociability. (5) In addition to the government departments, social organizations and enterprises also influenced the policy network, at the edge of network. This paper is of positive significance for understanding the current status and characteristics of policy making in different fields of the NEV industry, beneficial to distinguish potential effective ways to impact on NEVs policy system in China.

1. Introduction

Under the framework of the UN Paris Agreement, at the 75th UN General Assembly, the Chinese government formally proposed the goal of achieving carbon emission peak by 2030 and carbon neutrality by 2060. The new energy vehicles (NEVs) industry is a strategic emerging industry in China to cope with global climate change and achieve the carbon peaking and carbon neutrality goals. China's NEVs industry started late, and since the 1990s, the Chinese government has been introducing relevant policies for the layout of the NEVs industry. After more than 30 years of development, a relatively mature and complete NEVs policy system has been built, prompting the industry competitiveness to the second place in the world [1,2].

Industry policy is the sum of various policies actively intervening in industrial activities, guiding, supporting and promoting the development of strategic emerging industries [3,4]. It is argued that the industrial development is inseparable from the industrial policies [5,6]. The complexity of industrial development determines the intricacy of industrial policy system. The elements of

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industrial policy include policy makers, policy objects, policy resources, policy tools, policy aims and policy areas [7]. Therefore, from the perspective of one or some elements, the systematic exploration of its policies is an effective channel to systematically understand industrial structure and development of NEVs industry in China. Policy network is one valid and effective way. As one of those elements research perspective, under specific spatial-temporal conditions, based on overlapping policies, policy network could be constructed, visualizing the intricate interactions between government and social actors [8].

In parallel with the industry development, to study and depict the sophisticated details of NEVs industrial policy, the perspective of policy networks worthes more attention. According to searching results, main scholarly concern of NEVs policy focuses on policy effects. Through describing it and exploring its influencing factors and improvement paths, scholars tried to provide suggestions to enhance NEVs policy system. Based on bibliometric studies, there are also some conclusions on NEVs policy networks, most of whose evaluation dimensions are policy tools and policy themes, describing the field and channel of NEVs policy attention. Different from others, the integrative perspective of policy makers and policy objects is applied in this study. Policy maker is the institution or organization that promulgates policy documents, and policy object is specific area of industrial activity regulated by the policy, both of which are important variables and core components to consider policy system [9,10]. Over the 30-year development of NEVs policies, with numerous subjects and almost coverage of NEVs industrial fields, a multilateral and multiple policy network has changed since 1990s [11]. Therefore, under diverse areas of policy objects, in order to depict the evolution and interaction of NEVs policy network, and providing some possible suggestions on NEVs policies in China, with social network analysis (SNA), in this article, these questions will be examined: (1) How many areas can NEVs policy objects be divided? (2) On each area of policy objects, how did NEVs policy network changed separately? (3) Under the hostile scene, what are the features of NEVs policy making in China? This research is thought to contribute to showing the further prediction of policy system and possible effective channels to impact on it.

2. Literature review

2.1. Policy effects centred researches regarding NEVs policies

As a result of 'incompleteness' of the market mechanism, there is a scholarly consensus that the government needs to intervene the development of NEVs through industry policy [12,13]. Hence, the effect of the NEVs policy is the main focus of existing research. Some studies focus on the policy effects directly, including stakeholder game mechanism [14], policy public perception [15], purchasing intentions [16], social problem solving [17,18], product output and production efficiency [19,20], industrial technology and industry development [21,22], industrial innovation capacity [23,24], technological innovation and business performance of automobile enterprises [25,26], product market cultivation and stability [27,28], etc. Some studies discuss influencing factors of policies, such as the coupling between different policies [29]. Other studies focused on the international comparison of policies, by comparing the policy content [30,31] and policy tools [32,33], in order to introduce advanced policy experience. The purpose of these researches revolves around how to improve the NEVs policy in China.

2.2. The NEVs policy studies with bibliometric methods

For research methods on policy specifically, there is a long-standing tradition that bibliometric methods were employed. Unlike qualitative analysis, which focuses only on policy text analysis, policy bibliometrics provides a combination of quantitative and qualitative analysis of structural attributes of policy text, to reveal the information and hidden patterns behind policy texts [34,35]. Existing studies used various kinds of software, such as ROST CM6, Gephi, UCINET, and VOS viewer, to quantitatively capture the textual elements of NEVs policies, such as policy themes [36,37], policy objects [38] and policy tools [39]. On this basis, the changing patterns [40] and policy effects [41–43] of NEVs policies were revealed.

In summary, there have been numerous study topics and methods of NEVs policy, forming a solid literature foundation of this article. Among studies mentioned above, however, little research has been carried out focusing on the policy makers and policy networks. Therefore, following previous research, based on the criteria of policy objects, this article attempts to visualize the change of policy networks in diverse fields of NEVs in China, and to reveal the interaction between them and unique roles of some significant policy makers in the policy formation process.

3. Materials and methods

3.1. Methods

This study uses policy bibliometric methods, such as SNA. And the analysis is centred on the NEVs policy networks in China. Policy bibliometrics is a relatively new research method based on computer science and bibliometrics, which can reveal the information and hidden patterns behind policy text [35], through quantitative and qualitative analysis of the structures of policy text. This study used SNA to depict every policy network and its changing pattern. In SNA, social network refers to the set of social actors and their relationships, the former is expressed by "node" and the latter by "line" [44]. In this study, UCINET 6.645 software was chosen to map the policy network, and to quantitatively measure related network indicators with Overall Network Analysis: network size, number of ties, relative density, and clustering coefficient. It's important to note that each cooperation between actors is a two-sided interaction, so the policy network constructed in this paper is a no-oriented network.

3.2. Data and data pre-processing

By looking into NEVs policies, this article constructed a systematic database of NEVs policies. Considering representativeness of the sample to answer the study questions, we (the research team) choose to collect NEVs policies issued nationwide in China. With keywords "new energy vehicles", "electric vehicles", "energy efficient vehicles", "clean energy vehicles", we (the research team) searched on authoritative websites such as the Chinese government websites, PKULAW, and the official website of China Association of Automobile Manufacturers (CAAM). Removing those policies without clear NEVs policy objects and directly related policy text, the search results were also supplemented by internal citations between policies, expert opinions and other literature. Finally, 221 NEVs policies were collected, which were promulgated nationwide from 1991 to 2022 in China.

After constructing the policy database, we pre-processed one of core elements "policy objects". From each one in our policy database, we extracted relevant information on policy object, which means including apparent policy tools and text toward one or more NEVs policy objects, and code it. It is worthy to note that one policy may contain several policy objects. Based on the searching results, in accordance with the complexity of NEVs industrial activities in China, NEVs policy objects also encompass quite rich dimensions, for instance, demonstrated appliance of methanol-fuelled cars, design of charging piles and hydrogen fuelling station, electric buses safety requirements, stepwise recycling of electric vehicle batteries and more. To facilitate research and analysis, in Table 1, NEVs policy objects were summarized and divided into four categories: exploration and manufacture, consumption and promotion, infrastructure construction and supporting industries, which are the four types of NEVs industrial policies consequentially.

As for policy makers who constitute policy networks, it is needed to explain that: (1) Without compromising the accuracy of expression, this study uses the customary abbreviations of policy makers. For example, "Ministry of Industry and Information Technology" is simplified to "MIIT" (see Table S1 in Supplementary Materials for all abbreviations in this paper). (2) After several institutional reforms of the State Council, main functions and names of some NEVs policy makers have changed. Based on the latest reform plan, the policy made by the pre-reform department was incorporated into the policy set of the post-reform institution. For example, the policies made by "State Development Planning Commission" were integrated the policy set of "the National Development and Reform Commission" (NDRC). (3) To simplify data processing, policies issued by different department within one ministry are consolidated under this ministry. For example, policies which were released by diverse divisions within Ministry of Transportation (MOT) would be directly listed under MOT. (4) At the same time, because of the affiliation of the institutions, the State Council governs various administrative ministries and the CPC Central Committee leads all internal party institutions. In order to facilitate the separation from the other policy makers, policies promulgated in the name of the State Council are counted under the General Office of the State Council (GOOSC), and policies enacted by the CPC Central Committee are counted under the General Office of the CPC Central Committee (GOCPCCC).

And in this study: (1) For policies made by a single department (hereinafter referred to as "sole actor"), through word frequency analysis, this study calculated the number and type of individual policy releases per department, in order to observe the influence of each department on the China's NEVs policy system. (2) For policies jointly made by two or more departments (hereafter referred to as "multiple actors"), the policy networks in four fields of policy objects are drawn to show the interaction between them, distinguishing their various roles and influences.

4. Results and discussion

4.1. The three stages of NEVs policies in China

As shown in a previous study [45], the development of NEVs policies can be divided into three typical stages. (1) Stage 1: Exploring and Promotion (1991–2011). R&D encouragement, technical support, and demonstration promotion constituted policy goals at this stage. In 2001, the "863" Pro-gram Electric Vehicle Project established the "three horizontals and three verticals" industrial development layout. In 2007, the "New Energy Vehicle Production Access Management Rules" marked the formal standardization of China's NEVs industry market. With the addition of policies such as demonstration and promotion, public procurement and fiscal subsidies, the market size and sales of NEVs have increased significantly. (2) Stage 2: Maturation of System (2012–2016). After "Energy Conservation and New Energy Vehicle Industry Development Plan (2012–2020)" was promulgated, the NEVs entered in a new development stage, as a national strategic industry. And in the face of negative results due to unsound industrial structure, the Chinese government continued to introduce fiscal and tax incentives. At the same time, to further solve the lack of technical standards and charging infrastructure, more policies were introduced. And the policy system was gradually improved. (3) Stage 3: Advanced Development (2017-present). At this stage, brought by single fiscal incentives, the problem of overcapacity and low quality revealed. Then since 2016, the government has been decreasing the subsidy level, and the introduction of the Double Credit Policy marked the arrival of the post-subsidy era. The New Energy Vehicle Industry Development Plan (2021–2035) and related supporting measures have pushed China's NEVs industry to a higher level.

This study analysed and compared the activities of policy makers and forms of policy network at different three stages under each category of policy objects.

4.2. The three-stage statistics on the number and structure of policies

The focus of this study was patterns and change of NEVs policy networks in China, based on different four types of policy objects. Therefore, we first count the numbers of all policies, policies of four types in the three stages. It's worth noting that one policy may

contain more than one type of policy objects. And ss long as one policy contains such policy objects, it is counted and counted only as having one enactment in this field of policy object. As shown in Table 2, the total number of policies enactment in the first, second and third stages is 37, 103, 163.

The three-stage distribution of policy types are shown in Table 2. In summary, as the number of policy enactments grows steeply and then slowly, the distribution of policy types is broadly balanced, with the exception of a bias in favour of Exploration & Manufacture and Consumption & Promotion. (1) In Stage 1, Exploration & Manufacture earned the most policy concerns, nearly a half. The proportions of Infrastructure Construction and Supporting Industries are less than 1/4 of it, 1/2 of it, respectively. (2) In Stage 2, the shares of four types of policy enactment are almost equal. (3) In Stage 3, with the concern bias back to Exploration & Manufacture and Consumption & Promotion, the share of Supporting Industries is less than a half of Consumption & Promotion. But the inequality gap is narrowing. It can reflect that: NEVs industry as a strategic emerging industry, the Chinese government has made great efforts to stimulate the expansion and development of the industry from both the production and consumption sides, while also taking into account the support of infrastructure and supporting industries. Overall, the NEVs policy layout also shows an increasingly balanced state. Infrastructure and supporting industries, as a must for the high-quality development of the industry, will occupy an increasingly important position in the policy system in the future.

A three-stage comparison of ways of policy making can be seen in Table 3. All in all, joint making (the enactment way of policies made by multiple actors) occupies a more important place among the four types of policies, while the contribution of separate making (the enactment way of policies made by sole actor) also cannot be ignored. Although in Exploration & Manufacture, the total amount of policies made by multiple actors is a bit less than the total number of policies made by sole actor, in Stage 2 & 3, joint making overtook separate making as the more dominant way of policy enactment. Therefore, the perspective of policy network is workable to analyse policy making activities of four types of NEVs policies. Then, the three-stage policy networks will be analysed in each of the four policy types, as well as the characteristics of separate making, in an effort to comprehensively understand the mechanisms and characteristics of NEV policy system.

4.3. Analysis according to policy types

For analysis on each of policy types, the tables (Tables 4, 6, 8 and 10) will display the features of separate policy making of each type of policies. In order to have an objective measure, from the perspective of policy efficiency, the different influence abilities of each sole actor can be shown more. It is worth mentioning that these policies are totally of national level. With a five-level measure of the strength of policy efficiency, these policies were classified into five levels: Level V: laws (5 points); Level IV: regulations of the State Council and the decrees from every ministry (4 points); Level III: temporary regulations of the State Council and regulations and provisions of ministries (3 points); Level II: opinions, measures and temporary provisions from ministries (2 points); Level I: notices and others (1 point) [46].

As for policy makers, with UCINET 6.645 software, based on the data of multiple actors in three stages, related symmetric adjacency matrixes were constructed, and three-stage policy network maps of multiple actors of each type of policies were drawn. As shown in Figure 1, 2, 3 and 4. In each map, "node" indicates policy maker, and "line" indicates the relationship between two policy makers. Considering the visualization of the maps, the bigger "node" with different colours indicates the actor which has participated in joint making more, the thicker "line" between two actors indicates the more times of cooperation. In addition, to quantitatively characterize policy networks, these indicators were applied: (1) Network size refers to the number of actors in the network at that stage. (2) Number of ties refers to the sum of the number of cooperation frequency among actors. And they describe the absolute characteristics of the network: the higher the number of ties, the larger the network size, the more connected the actors and the more complex the network. (3) Relative density [47] and clustering coefficient describe the relative characteristics: the higher relative density, the more connected the network; the higher clustering coefficient, the more balanced and decentralized the network structure, the more equal the status of actors, and the more effective the flow of resources and information in network.

4.3.1. Exploration and manufacture

Table 4 showed three-stage statistics of policies made by sole actor of Exploration & Manufacture. There are 8 sole actors in total. The following analysis can be drawn:

In terms of number of policies, (1) MIIT had made the greatest number of policies separately, the absolute actual industrial policy implementation department and responsible institution, especially in Stage 3. In addition, from policy objects, the most policy concern of MIIT was focus on safety regulation and access requirements of NEVs. (2) GOOSC and NDRC ranked the first in Stage 1, indicating

Table 1

Four categories of NEVs policy objects (Four types of NEVs policies).

Category	Definition
Exploration and Manufacture	All policies to develop the R&D and manufacture of NEVs vehicle production, as well as related policies to promote and regulate it.
Consumption and Promotion	All policies to promote the consumption and application, and expand the market size of NEVs.
Infrastructure Construction	All policies that incite the construction of necessary infrastructures for NEVs, such as charging piles, hydrogen fuelling stations and more.
Supporting Industries	All policies to promote and regulate supporting industries of NEVs, such as parts production, traction battery and more.

Table 2
Three-stage distribution of policy types.

Type Stage	EM		CP		IC		SI		Total
	Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion	
1	16	43.24 %	11	29.73 %	3	8.11 %	7	18.92 %	37
2	25	24.27 %	26	25.24 %	26	25.24 %	26	25.24 %	103
3	45	27.61 %	54	33.13 %	38	23.31 %	26	15.95 %	163
Total	86	28.38 %	91	30.03 %	67	22.11 %	59	19.47 %	303

EM=Exploration and Manufacture; CP=Consumption and Promotion; IC=Infrastructure Construction; SI=Supporting Industries; All values of percentages in Table 2 are retained to two decimal places, meaning the ratio of the number of policy enactments to the total for the same stage.

Table 3
Three-stage statistics on the number of policies made by multiple actors and policies made by sole actor.

Type Stage	EM		CP		IC		SI	
	SOLE	MULTIPLE	SOLE	MULTIPLE	SOLE	MULTIPLE	SOLE	MULTIPLE
1	11	5	4	7	1	2	5	2
2	12	13	10	16	14	12	16	10
3	22	23	20	34	14	24	7	19
Total	45	41	34	57	29	38	28	31

EM=Exploration and Manufacture; CP=Consumption and Promotion; IC=Infrastructure Construction; SI=Supporting Industries; SOLE = the number of policies made by sole actor; MULTIPLE = the number of policies made by multiple actors.

Table 4
Three-stage statistics of policies made by sole actors of Exploration & Manufacture[a].

Sole actor	Stage 1		Stage 2		Stage 3		Total		
	Number	Level	Number	Level	Number	Level	Number	Level	
								SUM	AVG
MIIT	2	III(1) I(1)	4	I(4)	12	IV(1) III(1) II(3) I(7)	18	28	1.56
GOOSC	3	IV(3)	5	IV(5)	2	IV(2)	10	40	4
MOST	2	I(2)	3	I(3)	1	I(1)	6	6	1
NDRC	3	IV(1) III(1) II(1)	0		2	IV(2)	5	17	3.4
MOT	0		0		2	III(1) I(1)	2	4	2
SAMR	0		0		2	I(2)	2	2	1
NRC and the Standing Committee	1	V(1)	0		0		1	5	5
CBIRC	0		0		1	I(1)	1	1	1

[a] In Tables 4, 6, 8 and 10, "Level" means the value of policy efficiency of policies made by this sole actor, for instance, in Stage 1, MIIT has released two policies, one of Level III, one of Level I. "SUM" indicates three-stage total value of policy efficiency of policies made by this sole actor. "AVG" is the average value of policy efficiency, derived from the total value of policy efficiency divided by the total number of policies.

that during the infancy period of industrial development, they were the initial departments responsible for NEVs industrial planning. (3) The number of sole actors in each stage is 5, 3, 7, with the entrance of MOT, SAMR and CBIRC, showing an enlarging expansion of NEVs manufacture activities.

As for policy efficiency, (1) GOOSC ranked first in sum value of policy efficiency. Actually, representing the State Council, which is the highest-level decision-making centre of China's central government, every policy documents made by GOOSC has high effectiveness. (2) Although with the most policy amount and various levels of policy efficiency, the average of policy efficiency of MIIT doesn't distinguish, indicating that MIIT tends to implement many specific, relatively short-term NEVs policy activities in Exploration & Manufacture, just like Notice of Annual Safety Hazard Detection for NEVs, Notice of Establishment of Serial Numbers for Passenger Car Double-Credit Allocation Information. (3) NDRC ranked third in average value of policy efficiency, second only to NRC and the Standing Committee & GOOSC, showing its greater administrative authority in NEVs explorations. Specifically, NDRC enacted a number of cross-industry regulations and administrative directives, not only focusing on NEVs. (4) NRC and the Standing Committee, as the only legislature at the central level in China, also has to be mentioned, and the law enacted by it is Law of the People's Republic of China on Conserving Energy, demonstrating the attitude and determination of Chinese government to develop environment-friendly new energy vehicles at the legislative level.
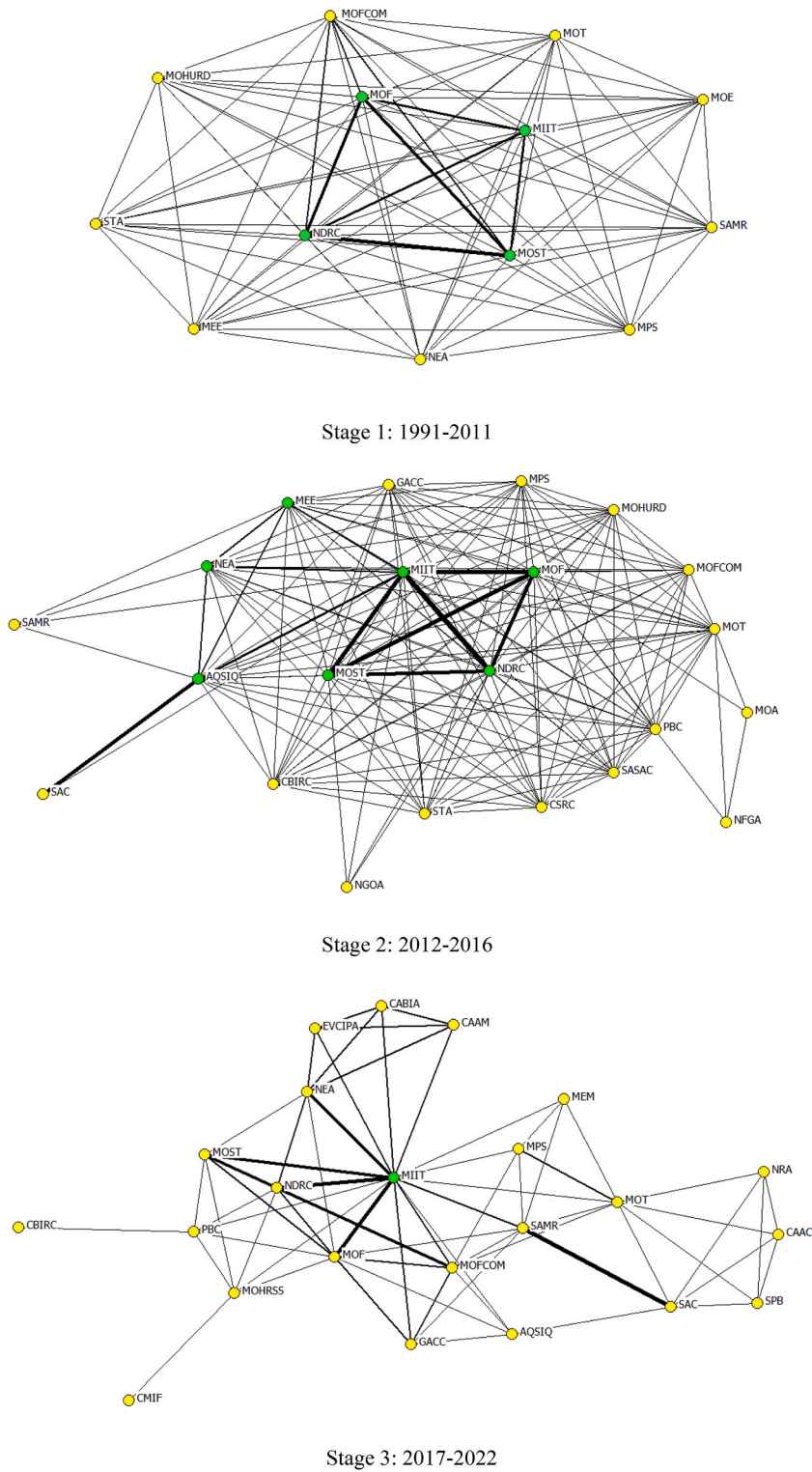
Stage 1: 1991-2011

Stage 2: 2012-2016

Stage 3: 2017-2022

Fig. 1. The three-stage policy networks of Exploration & Manufacture.

Fig. 1 and Table 5 exhibited the changing process of policy networks of Exploration & Manufacture, it was reflected that: (1) As for forms of policy network, according to the values of network size and number of ties, from Stage 1 to Stage2, with a rapid increase of multiple actors, the two-circle pattern became more flexible, having an incomplete third circle consisting of SAMR, SAC, NGOA, NFGA
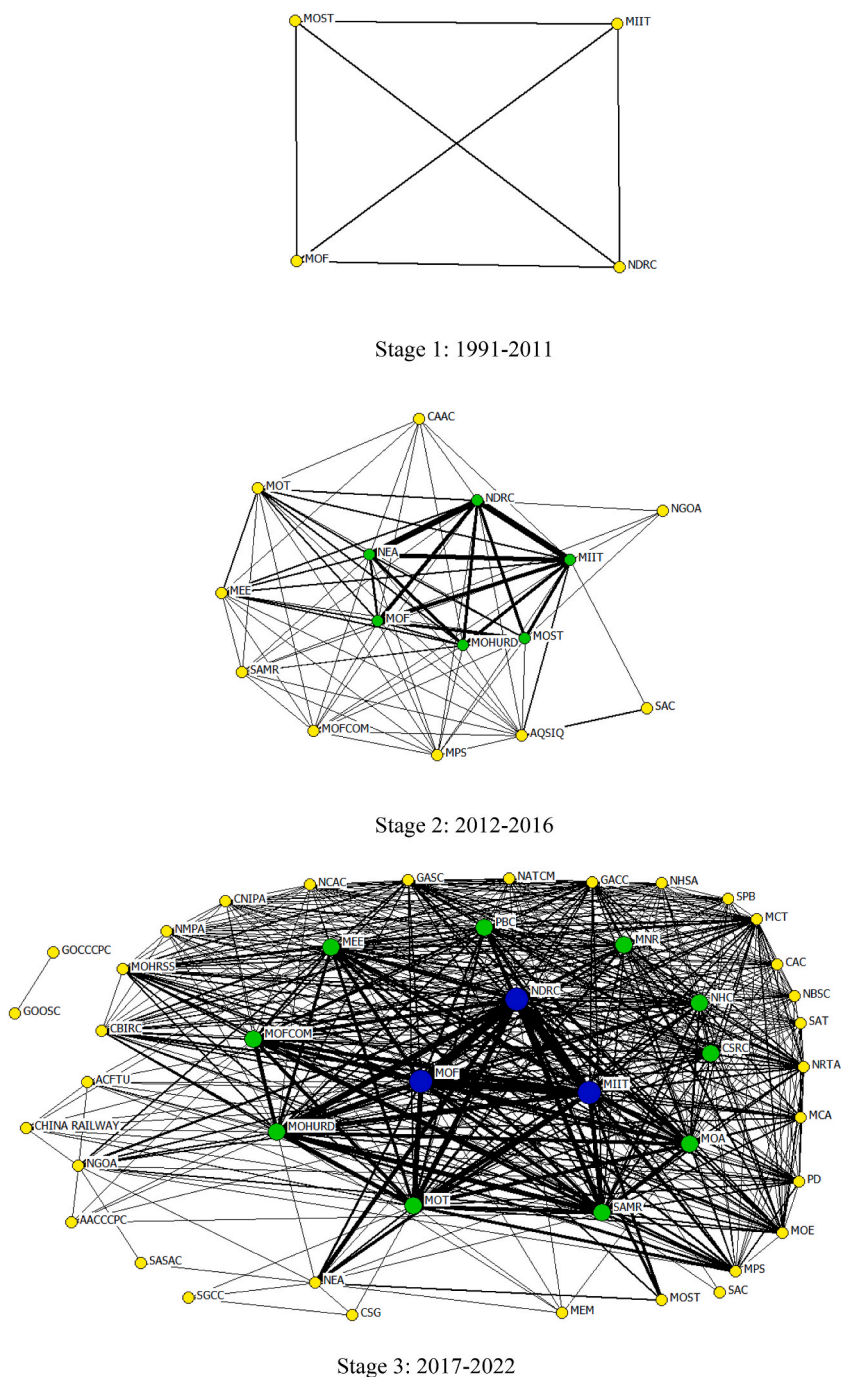
Stage 1: 1991-2011

Stage 2: 2012-2016

Stage 3: 2017-2022

Fig. 2. The three-stage policy networks of Consumption & Promotion.

and MOA. However, in Stage 3, with a still grow of network size, the interaction among actors slumped, approximately the same as Stage 1, the form of policy network turned into multi-incomplete pattern. It showed that, with NEVs manufacture higher level of professionalization, though more actors came in, industrial activities were narrowed within several fixed actors, without extensive

Stage 1: 1991-2011

Stage 2: 2012-2016

Stage 3: 2017-2022

Fig. 3. The three-stage policy networks of Infrastructure Construction.

Table 5
The three-stage values of indicators of policy networks of Exploration & Manufacture.

Indicators	Stage 1	Stage 2	Stage 3
network size	13	22	23
number of ties	97	184	104
relative density	1.244	0.797	0.275
clustering coefficient	1.000	0.941	0.749

interaction among actors. (2) As for structure and equilibrium of policy network, from Stage 1 to Stage3, with decreasing values of related density and clustering coefficient, the policy network turned more unbalanced. The core of policy network was moved from the fixed-four (MOF, NDRC, MIIT & MOST) to MIIT, verifying its absolute director to regulate NEVs manufacture. (3) Besides, there existed the good partnerships between SAC & AQSIA in Stage 2, SAC & SAMR in Stage 3 (the line between them were thick), in due to enactment of industrial manufacturing standards. The entrance of social organizations, CAAM, CMIF, CABIC and EVCIPA, means more type of actors, from internal government departments to social actors.

4.3.2. Consumption and promotion

Table 6 showed three-stage statistics of policies made by sole actor of Consumption & Promotion, a total of 7 sole actors. Here followed the analysis: (1) GOOSC ranked first in total number of separate policy-making, with MOT the second. It can reflect that the one of the country's top-level policies is to vigorously and continuously stimulate consumption and demonstration and promotion, so as to achieve the purpose of expanding the market share of NEVs. Besides, the demonstration and appliance of NEVs in transportation is one of the most typical methods, such as fewer traffic restrictions for private NEVs owners, the widespread use of electric buses and more. Therefore, utilizing policy forms such as notices, opinions, decisions, plans, etc., GOOSC directly and indirectly promoted NEV consumption in the areas of air pollution prevention, energy industry planning, logistics synergy, transportation transformation, carbon peaking and emerging industry development. As a subordinate executing department, MOT undertook and implemented the work plan of GOOSC, stimulating the ubiquitous application of NEVs in transportation. (2) NRC and the Standing Committee ranked the third in policy number and the first in policy efficiency, owing to promulgation of some laws of taxes, e.g., vehicle and vessel tax, including tax relief for NEVs. (3) The number of sole actors in each stage is 3, 3, 6, showing an enlarging expansion of NEVs consumption activities, for instance, in Stage 3, MOFCOM prompted to strengthen the sales and after-sales service network of NEVs, and CBIRC enacted a policy to reduce the costs of consumers in the acquisition, use and ownership of NEVs.

Fig. 2 and Table 7 exhibited the changing process of policy networks of Consumption & Promotion, it was reflected that: (1) As actors continued to join in, the pattern of policy network came from "two-circle" form into "three-circle" form, with number of actors (network size) tripling and more, from 11 to 37. It indicated that different from Exploration & Manufacture, increasing the market share of NEVs needed more and more actors. And owing to quite evident determination and strength of the Chinese government to promote NEVs, NEVs can be seen in more fields now, such as logistics vehicles, clean energy use, car rental industry, official vehicles, rural revitalization and cultural tourism, etc.. (2) As for the structure of policy network, with higher growth rate of number of ties (amount of cooperations), though plenty of new actors coming in, related density of network rose again in Stage 3 after a fall of Stage 2, showing closer and broader linkages among policy makers. Continued decline in clustering coefficient shows evidence of centralization of network resources and greater prominence of the network core. (3) From the perspective of actors, in Stage 1, the iron-four (MIIT, NDRC, MOF & MOST) was the main promoter of the demonstration and promotion of NEVs, continuously stimulate the selection of model cities and regions of NEVs promotion, accumulating operational experience and enhancing the domestic market's awareness of NEVs. In Stage 2, the promotion of NEVs in the areas of official vehicles and transportation has already begun, with ways for tax relief and reducing appearing. This can be seen in the new entrance of the GOCPCCC, NGOA, MOT, STA and more. In Stage 3, with the quality of NEVs production reaching higher level, Chinese government chose to link up with more departments to expand the promotion of NEVs in areas such as high-end consumption, cleaner production, and rural revitalization, while the introduction of convenient transportation policies continues to stimulate the private purchase of NEVs. As a result of the restructuring of sectoral competencies, the original four-cornered structure was also broken, with the Ministry of Industry and Information Technology (MIIT), the Ministry of Finance (MOF), and the National Development and Reform Commission (NDRC) becoming the new core.

4.3.3. Infrastructure construction

Table 8 displayed three-stage statistics of policies made by sole actor of Infrastructure Construction, a total of 7 sole actors. Here followed the analysis:

In terms of number of policies, (1) GOOSC, as the representative of the highest governmental departments in China, planned the layout of the entire industry, ranked the first in number of policies too, with no one other than GOCPCCC to unite in joint enactment for

Table 6

Three-stage statistics of policies made by sole actors of Consumption & Promotion.

Sole actor	Stage 1		Stage 2		Stage 3		Total		
	Number	Level	Number	Level	Number	Level	Number	Level	
								SUM	AVG
GOOSC	1	IV(1)	6	IV(6)	7	IV(7)	14	56	4
MOT	0		3	II(1) I(2)	6	IV(1) II(2) I(3)	9	15	1.67
NRC and the Standing Committee	1	V(1)	0		2	V(2)	3	15	5
NDRC	2	IV(1) I(1)	0		0		2	5	2.5
MIIT	0		1	I(1)	1	I(1)	2	2	1
MOFCOM	0		0		1	II(1)	1	2	2
CBIRC	0		0		1	I(1)	1	1	1

Table 7
The three-stage values of indicators of policy networks of Consumption & Promotion.

Indicators	Stage 1	Stage 2	Stage 3
network size	11	19	37
number of ties	81	137	670
relative density	1.473	0.801	1.103
clustering coefficient	1.000	0.915	0.872

hierarchical reasons. (2) MOT, MOHURD ranked second and third respectively, for it is within their authorities and responsibilities of site selection and construction of NEVs infrastructure, for example, the construction of charging posts alongside highways and in urban residential neighbourhoods. (3) NDRC facilitated infrastructure construction in the use and pricing of electricity. NEA, MOST and MIIT have separately introduced policies to promote and safeguard infrastructure development in terms of safety inspections, pilot demonstration and technology exploration.

As for policy efficiency, (1) GOOSC earned the most important role in separate policy-making, with the highest value of policy efficiency, whose policy concern was enriched from single plan of infrastructure construction to specific opinions on how to achieve this. In summary, high authority of GOOSC ensured the complete implementation of infrastructure establishment. (2) Transportation one of most large scale of NEVs appliance, MOT put lots of effort to stimulate NEVs infrastructure with methos of more power, consisting of regulations and opinions in public bus management, car rental and transportation, putting itself the second place in policy efficiency, giving NEV infrastructure substantial part of transport sector. (3) One opinion of none cost of electric power of NEVs charging & battery swap infrastructure and one opinion of standardization of NEVs infrastructure gave NDRC & NEA a bit higher level of policy efficiency.

According to Fig. 3 and Table 9, these conclusions can be drawn for the changing process of policy networks of Infrastructure Construction: (1) As for the form of policy network, it could be said that the most dramatic changes occurred in this policy network, with around threefold increase in the number of nodes (network size), about tenfold increase in the number of ties. The form of network turned from "iron-four" pattern to "three-circle" pattern, showing that as time passing by, joint making became the dominant form of policy enactment of Infrastructure Construction. And this is due to the fact that as one of key points to elevate consumption and production environment, infrastructure construction would be considered by large-scale collaboration among actors. (2) Considering the structure of policy network, with the entry of quite large number of actors of multiple identities, the value of network density and clustering coefficient slumped. The network was becoming less balanced, with its core and circles beginning to diverge. (3) In terms of actors, in first stage, the initial measures for NEVs infrastructure development appeared in the policy documents of NEVs pilot cities, made by MOST, MIIT, NDRC and MOF. In Stage 2, in order to better complement the vigorous promotion of NEVs, the iron-four, with the help of NEA & MOHURD, enacted incentive policy and development guide for charging facility construction. They were thus at the heart of the network. In Stage 3, owing to infrastructure development needs as a result of the strong push on production and consumption in the previous two stages, related methods started to boost in electricity substitution, urban planning and more fields, with relevant construction standards also being developed and introduced.

4.3.4. Supporting industries

Table 10 showed three-stage statistics of policies made by sole actor of Supporting Industries, a total of 5 sole actors. Here followed the analysis:

From the division of policy number, (1) As an essential foundation for NEVs production, batteries and other key parts and components, also are in the main policy concern of MIIT, under the direction and leadership of GOOSC. That's why they're at the top of this table. (2) MOST is mainly responsible for the preliminary technology development, while NDRC and MEE are more concerned with promoting battery recycling and reuse.

Table 8
Three-stage statistics of policies made by sole actors of Infrastructure Construction.

Sole actor	Stage 1		Stage 2		Stage 3		Total		
	Number	Level	Number	Level	Number	Level	Number	Level	
								SUM	AVG
GOOSC	1	IV(1)	5	IV(5)	3	IV(3)	9	36	4
MOT	0		1	II(1)	5	III(1) II(3) I(1)	6	12	2
MOHURD	0		2	I(2)	2	I(2)	4	4	1
NEA	0		2	II(1) I(1)	1	II(1)	3	5	1.67
NDRC	0		1	I(1)	2	II(1) I(1)	3	4	1.33
MIIT	0		2	I(2)	1	I(1)	3	3	1
MOST	0		0		1	I(1)	1	1	1

Table 9
The three-stage values of indicators of policy networks of Infrastructure Construction.

Indicators	Stage 1	Stage 2	Stage 3
network size	4	15	45
number of ties	12	141	925
relative density	2.000	1.342	0.936
clustering coefficient	1.000	0.919	0.902

Table 10
Three-stage statistics of policies made by sole actors of Supporting Industries.

Sole actor	Stage 1		Stage 2		Stage 3		Total		
	Number	Level	Number	Level	Number	Level	Number	Level	
								SUM	AVG
MIIT	1	I(1)	7	II(3) I(4)	6	II(2) I(4)	14	19	1.36
GOOSC	2	IV(2)	7	IV(7)	1	IV(1)	10	40	4
MOST	2	I(2)	1	I(1)	0		3	3	1
MEE	0		2	II(1)	0		2	1	2
NDRC	0		0		1	I(1)	1	1	1

In addition, considering the value of policy efficiency, (1) GOOSC was the absolute first. (2) The only one policy released by the Ministry of Ecology and Environment (MEE) was an announcement of policies to prohibit and remedies the battery contamination, whose policy efficiency was of Level II, crowning the second place of average value of policy efficiency to MEE.

Based on Fig. 4 and Table 11, these conclusions can be drawn for the changing process of policy networks of Supporting Industries: (1) The form of policy network experienced a dynamic change from streamlining in Stage 2 to stretching of Stage 3, including both the scale and frequency of cooperation. (2) With less growth of number of ties than the number of actors, comprehensively related density continued to decline in three stages. While because of the increase of neighbouring actors of each actor, the clustering coefficient showed a slight rebound in the third stage, indicating that the information communication among actors in this stage was more fluid than in Stage 2, and the network structure was more balanced. (3) After deeper exploring the causes behind the phenomenon, it can be found that, in Stage 1, Air Purification Project - Clean Energy Vehicle Initiative was prompted by 12 actors together, while only stopping at encourage technology development, including nickel-metal hydride batteries, lithium-ion batteries and fuel cells. In Stage 2, in response to the call of the previous stage, specifically, measures such as real-time management, laddering of utilization, introduction of foreign capital, and setting of standards are used to promote the development of support industries. The increase in specialization has also brought about a streamlining and restructuring of the composition of nodes. In Stage 3, as the rising level of industrial development, more actors are coming in to enrich the composition of policy network, consisting of renew and update, safety construction, energy storage application, recycling service system and more. And MIIT, the department directly responsible for actual implementation, became the absolute core of policy network.

4.4. Holistic analysis on policy makers

Based on the analysis of the characteristics of the four types of policy making, a comparative analysis across the types is applied in anticipation of further analysis and conclusions from a macro perspective. The following section will be organized into two parts: sole actors and policy networks, in order to understand who decided NEVs policies and how they can do it.

4.4.1. Sole actors

4.4.1.1. The three-stage analysis. Based on the statistics of four types of policies made by sole actor, it could be drawn three-stage summary of all sole actors in Table 12. (1) With the progress of three stages, the value of policy number increased at a rapid and then slow rate, indicating that cooperation in policy-making tends to become popular. So did the total value of policy efficiency. (2) The figures of average policy efficiency in three stages are 2.9, 2.46, 2,25, an apparent and slow decline, showing that in the infant period of NEVs industry development, in order to ensure long-term industrial prosperity and lead a clear direction, the policy system was mainly consisted of several macro strategies and plans of huge authorities, like GOOSC, NRC and NDRC. While as the industrial maturity appearing, more numerous specific and short-term policies flooded in, whose policy makers included SAMR, MOHURD, CBIRC and more, in need to deal with concrete issues at a larger scale.

The average values of policy efficiency of each sole actor are able to uncover their diverse roles in NEVs industry to some extent. (1) NRC and the Standing Committee is the only central legislature body, holding the highest level of policy effect, without any potential cooperation selection. Among four of the laws promulgated by NRC and the Standing Committee NEVs-related provision was found, including exploration encouragement, vehicle tax relief and NEVs appliance, engendering status of NEVs industry strongly supported nationally. (2) With consistent impetus and clearly macro layout, GOOSC expedited NEVs industrial development from all four fields:
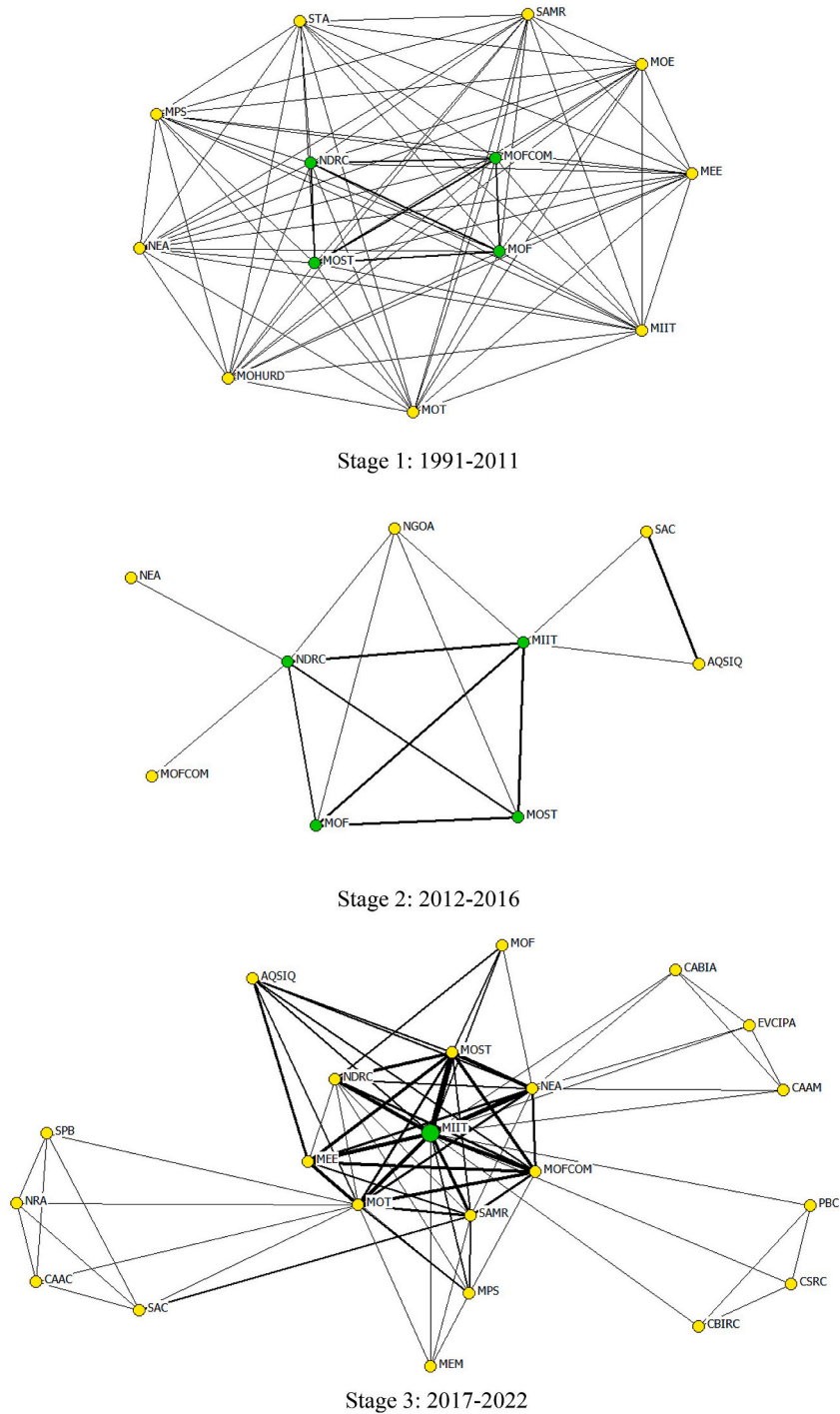
Stage 1: 1991-2011

Stage 2: 2012-2016

Stage 3: 2017-2022

Fig. 4. The three-stage policy networks of Supporting Industries.

manufacture, consumption, infrastructure and supporting industries. Therefore, GOOSC become one of the driving forces of NEVs industry with the greatest number of policy releases and highest sum value of policy proficiency. (3) Ranking the third is independent from NDRC's authority in NEVs industry. As the most main manage department in the initial period, NDRC enacted New Energy Vehicle Production Access Management Rules, the first manufacture regulation in high administrative power. Besides, some opinions from NDRC incited establishment of high-quality business environment and low-cost charging infrastructure. (4) The higher average policy efficiency of MEE and MOFCOM is due to one policy of level II respectively, the former battery pollution prohibition, the latter after-sales service network, displaying their own policy concerns and administrative authorities to NEVs industry. (5) The average

Table 11

The three-stage values of indicators of policy networks of Supporting Industries.

Indicators	Stage 1	Stage 2	Stage 3
network size	13	9	22
number of ties	84	27	158
relative density	1.077	0.751	0.683
clustering coefficient	1.000	0.838	0.858

Table 12

Three-stage statistics of policies made by sole actors.

Sole actor	Stage 1		Stage 2		Stage 3		Total		
	Number	Level	Number	Level	Number	Level	Number	Level	
								SUM	AVG
GOOSC	7	28	23	92	13	52	43	172	4
MIIT	3	5	14	17	20	30	37	52	1.41
MOT	0	0	4	6	13	25	17	31	1.82
NDRC	5	14	1	1	5	12	11	27	2.45
MOST	4	4	5	5	1	1	10	10	1
NRC and the Standing Committee	2	10	0	0	2	10	4	20	5
MOHURD	0	0	2	2	2	2	4	4	1
NEA	0	0	2	3	1	2	3	5	1.67
SAMR	0	0	0	0	2	2	2	2	1
MOFCOM	0	0	0	0	1	2	1	2	2
MEE	0	0	1	2	0	0	1	2	2
CBIRC	0	0	0	0	2	2	1	1	1
Total	21	61	52	128	62	140	134	318	2.37

values and roles of MIIT, MOT, NEA and other actors has been explicated and mentioned before. No need for further words.

4.4.1.2. "GOOSC-MIIT-MOT". Comparison of the top two in terms of the number of policies made by sole actor for each type of policy, it reveals that GOOSC, MIIT, and MOT are always at the top of the list. Their individual article data were extracted and made into Fig. 5.

In terms of policy type, the top two sole actors for the production side and the support industry side are GOOSC & MIIT, while MOT promulgated less in these two types. Similarly, GOOSC and MOT have enacted the most policies on the consumption and infrastructure sides, while less policy concern of MIIT focus on these two fields of policy objects. From the point of view of the total number of policies made by sole actor, GOOSC, MIIT and MOT ranked first, second and third respectively.

First, these evidences demonstrate their fields of authorities and the ways with which they specifically promote the NEV industry. (1) The General Office of the State Council (GOOSC), from a macro perspective, has taken the lead in the overall development of the industry, and has led the government departments under its jurisdiction to utilize a variety of policy tools at different levels and in different fields to promote the overall development of the NEV industry system. At the same time, as the highest level of the central government, it is actually the direct promoter of the NEV industry policy network. (2) The Ministry of Industry and Information
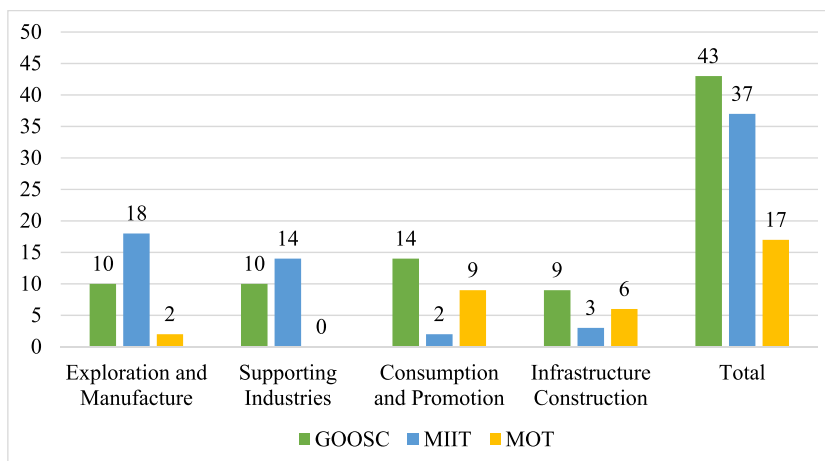

Fig. 5. A comparison of main sole actors.

Technology (MIIT), mainly from the perspective of the supply side, supports and regulates the development of a series of vehicle product manufacturing and supporting industries. For example, it is responsible for the admission management of NEV enterprises and products. (3) The Ministry of Transportation (MOT), mainly from the demand-side perspective, on the one hand, has been vigorously promoting the application of NEVs in the transportation sector, such as the full coverage of electric buses. At the same time, it is responsible for facilitating the introduction of transportation management measures to promote the purchase of NEVs by private consumers. On the other hand, it promotes the laying of NEV infrastructure networks together with other government departments.

Second, it indicated that policy objects are related to each other. (1) Exploration & Manufacture has similar characteristics to Supporting Industries, both enhancing the supply capacity of NEV-related products from the supply side. As a basic condition, the development of supporting industries will be able to promote the R&D and production of vehicle manufacturing, improve the industrial chain, enhance the industrial scale and manufacturing level, ultimately forming a synergistic effect. (2) Consumer promotion has similar characteristics to infrastructure in that both stimulate NEV market size from the demand side. As the immediate needs of NEVs, the continuous enhancement and improvement of the infrastructure system, such as charging piles and hydrogen refuelling stations, can escort the continuous development of the NEV market. Convenient, safe and high-quality energy supply conditions will also make public and private consumers more willing to adopt new energy vehicles.

4.4.2. Policy networks

The following will summarize the characteristics of the four types of policy networks from two perspectives. First, along the time line, the state of the four types of policy networks within each stage will be analysed, concluding the common features. Second, based on the network indicators, the structure and characteristics of the four types of policy networks are compared, with further conclusions drawn.

4.4.2.1. Policy networks of four types in each stage

4.4.2.1.1. Stage 1: the "iron-four". According to the maps of the four types of policy networks, the "iron-four" (MOST, MOF, NDRC and MIIT) played a central role. As directed by the central government, they put forward the initial call for development and policy support for NEVs industry. Initially, the Ministry of Science and Technology (MOST) was more inclined to take the lead in promoting the research and development of key technologies in preparation for subsequent industrialization. Subsequently, the four departments will jointly support the promotion of NEVs in pilot cities.

4.4.2.1.2. Stage 2: division centred the "iron-four". In the second stage, a new structure of policy actors emerged around the "iron-four" corners, indicating a differentiation of development priorities of different type of policies. On the Exploration & Manufacture side, SAC, AQSIQ and NEA joined in response to the need for standardization. For the "iron-four", MIIT and NDRC hosted safety inspections of NEVs productions and NEVs enterprise management regulations. On the Consumption & Promotion side, the "iron-four" continued to enlarge the promotion of NEVs, with multiple stimulating policy like tax relief. On the Infrastructure Construction side, MOHURD and NEA participating in, promote urban and rural construction and safety inspections of infrastructure. On the Supporting Industries side, SAC and AQSIQ worked for the introduction of related standards.

4.4.2.1.3. Stage 3: two paths: specialization and sociability. In Stage 3, it can be seen two trends of policy networks: streamlining in Exploration & Manufacture, Supporting Industries; expanding in Consumption & Promotion, Infrastructure Construction. And it showed the different paths of development in the field. The two areas on the supply side, which are Exploration & Manufacture and Supporting Industries, took the path of specialization. Due to industrial refinement and higher level of specialization, policy cooperation occurred only among fixed actors, causing the shrink of network size. While, the path of sociability is highly favoured by two policy areas on the demand side, which are Consumption & Promotion, Infrastructure Construction. As the scale of NEV promotion continues to expand, in order to obtain a larger market size, it is necessary for more actors to join in and explore the application of NEVs in more fields. Accordingly, the scale of infrastructure construction also needs to be expanded, resulting the boom of network size.

4.4.2.2. Comparison of network indicators.

By comparing the four indicators of the four types of policy networks, the following conclusions can be drawn.

(1) Overall, all four types of policy networks are becoming larger in size and more complex in structure, suggesting that joint making is deepening in the four fields of NEVs policy system.

(2) Relatively speaking, the two types of policy networks on the demand side (Consumption & Promotion, Infrastructure Construction) have expanded more rapidly in terms of network size and number of ties, and more in total number of nodes and ties, validating the sociability route mentioned on the previous article.

(3) At the same time, the relative densities and clustering coefficients of the two types of policy networks on the demand side (Exploration & Manufacture and Supporting Industries) shrank faster and ended up with fewer values, confirming the path of specialization mentioned before.

(4) The shape of the network core is also different: the network core on the demand side eventually becomes the "MIIT-NDRC-MOF", while policy networks of supply side were hosted by MIIT. First, to some extent, it reflects a greater love of collaboration on the demand side and a greater preference for specialization on the supply side. Second, it reflects the imbalance of resources between the two types of policy networks on the supply side, with information and resources centralized in MIIT. It also echoes the previous analysis of the competence of the MIIT. Thirdly, the promotion & consumption and the construction of

infrastructure require national financial investment and corresponding future planning, which is the responsibility of the Ministry of Finance and the Development and Reform Commission.

5. Conclusion and policy implications

Based on the results of the above policy bibliometric analysis, the following conclusions can be drawn from this study. The NEV policy network system can be divided into the following four parts: Exploration and Manufacture, Consumption and Promotion, Infrastructure Construction, Supporting Industries. The percentages of the four types of policies are 28.38 %, 30.03 %, 22.11 %, 19.47 %, showing a balanced structure of policy system, though with a bias towards consumer promotion and vehicle manufacturing.

In terms of the number of policies, the number of policy posts has been on the rise. As for the way to enact NEVs policies, in each type of policies, policy makers preferred slightly to formulate policies jointly, rather than acting alone. While policies made sole actor are part of policy system. Further analysis and conclusions on separate and joint policy making followed:

Conclusion 1: In terms of separate making, four areas of policy areas have different characteristics, due to different industrial development paths and special needs. Overall, the top three are GOOSC, MIIT and MOT.

(1) GOOSC & MIIT ranked top in Exploration and Manufacture, Supporting Industries, while GOOSC & MOT ranked top in Consumption & Promotion, Infrastructure Construction. Partly owing to similar feature and relations between them. The former two can be called supply side, Exploration and Manufacture, Supporting Industries, prompting high level of production and complete industry chain. The latter two can be called demand side, stimulating larger market size of NEVs.

(2) It also indicated the way of them, GOOSC, MIIT, MOT, to influence the NEVs policy making. GOOSC takes the lead in the overall development of the industry from a macro perspective, assigns diverse policy aims for other subordinate functional departments, being the pusher to policy cooperation as the same time. MIIT, mainly from the perspective of the supply side, supports the development of a series of vehicle product manufacturing and supporting industries, and regulates production activities of related enterprises. MOT, mainly from the demand-side perspective, has been vigorously promoting the application of NEVs and infrastructure construction in the transportation sector.

(3) From the perspective of policy efficiency, there are some other sole actors in need to analyse. NRC and its Standing Committee provided tax relief and exploration encouragement from the legal division. NDRC, as the initial management department for NEVs industry, made the first permission regulation, and the average of its policy effect is a bit higher. MOHURD, MOFCOM, NEA, MEE & CBIRC implemented the decisions of GOOSC in the fields of urban & rural charging infrastructure, after-sales service network, standardization of infrastructure, pollution remedy & prohibition and favourable car loans & financing environment.

Conclusion 2: Although in different development processes, the four types of policy networks all started with the "iron four" (MIIT, NDRC, MOF, MOST). After experiencing path division, they form two routes of specialization and sociability.

(1) According to the maps of the four types of policy networks, the "iron-four" (MOST, MOF, NDRC and MIIT) played a central role in Stage 1. Being initial policy implementation sector in the infancy of NEVs industry, they reached the aim of industrialization with several measures and continuous investment of exploration, promotion.

(2) The division in the second stage emerged owing to different needs of development, with a still centralization on the "iron four". The policies of Exploration & Manufacture side consisted of standardization, safety inspections and management regulations. On the Consumption & Promotion side, there was still the promotion of NEVs, with multiple stimulating policy like tax relief. For Infrastructure Construction, actors promoted urban and rural construction and safety inspections of infrastructure. For Supporting Industries, the introduction of related standards was the direction of division.

(3) Because of different characterization between supply and demand side, they chose different routes: With higher level of industrial specialization and refinement, actors in two types of policy networks of supply side had fixed friends, holding the absolute network core of MIIT. In the meantime, actors in two types of policy networks of demand side favoured to make more new friends, with "MIIT-MOF-NDRC" their core circle in policy network.

Conclusion 3: From the perspective of network indicators, all four types of policy networks are becoming larger in size and more complex in structure, showing a deepening trend of joint making of NEVs system in China, while with two different ways of specialization and sociability.

(1) The two types of policy networks on the demand performed better in terms of expansion of network size and number of ties, both from the total amount and increasing rapid, validating the sociability route.

(2) At the same time, there was more obvious decline in terms the relative densities and clustering coefficients in the two types of policy networks on the demand side, confirming the path of specialization.

Conclusion 4: There are more influential actors, MIIT, NDRC, MOT and MOF, of NEVs policy networks in China.

(1) MIIT was the core actor of four types of NEVs policy network in China. As the data show, MIIT was the sole actor making the highest number of policies. And among all sole actors, its score of policy effect was second only to GOOSC. In the analysis of

policy network, though not always in core circle of network, it became the absolute core of four types of policy network in Stage 3. In summary, MIIT has the strongest ability to influence other policy makers and control resources of any of the policy network.

(2) NDRC was second only to MIIT in the policy network. As a sole actor, NDRC had separate policy release in the four fields of policy objects. As one of multiple actors, in Stage 1 and 2, NDRC was part of the core circle in the policy network. While in the Stage 3, NDRC belonged to the core circle of policy networks of demand side, holding the most network information and resources with MIIT, MOF.

(3) MOT, as a great promotor in the demand side, had a strong influence on NEVs industry development. In Stage 1, in any field of policy making, MOT didn't make policies alone, nor entering the core circle of the policy network as one of multiple actors. But with the industry developing, its influence grew. In Stage 3, as a sole actor, MOT was second only to GOOSC & MIIT in the total number of policies; and active in the map of policy networks of demand side. MOT has vigorously promoted the development of NEVs industry, through NEVs' large-scale appliance in public transport and the promulgation of traffic rules.

(4) MOF, with its financial resources, was the best partner for actors to jointly make policies. Not active on separate making, but in the analysis of policy network, MOF has belonged to the core circle of policy network of demand side, showing its strong influence and ability to make friends in the policy network.

Conclusion 5: In addition to the government departments, social organizations and enterprises also influenced the policy network. In Stage 3, four social organizations, namely CMIF, CAAM, CABIA and EVCIPA, and two enterprises, namely SGCC & CSG, also entered the edge of policy network. In addition, three organizations, CAAM, CABIA and EVCIPA, also formed a small cooperation network together. So did the two corporations. These social organizations, as the nature of industry associations, were established by well-known industry enterprises, research institutes, social organizations and government agencies, with the goal of promoting relative technology of traction battery and construction of charging infrastructure. And an effective channel to influence NEVs policy making in China is provided by them.

In conclusion, by analysing the NEVs policy makers and their policy networks, the study attempts to answer the key question "Who decided NEVs policies in China?" And it won't only help to understand the shaping mechanisms and future evolutions of NEVs policies, but to identify effective ways to influence these policies. This study shows that NEVs policy makers in China are not a single actor, but a dynamic policy network, consisting of connected and different four parts. Over the past three decades, this network has grown in size and complexity, differing two different ways to develop, specialization and sociability. As NEVs industry continues to grow and face new and more complex situations in China, the policy making is supposed to become more inclusive and diverse. Will it show new characteristics? This study will continue to explore this research area.

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Data availability statement

Policies database constructed in this study has been deposited at OSF project, https://osf.io/puc9v/, account: sxsr1105@163.com, password: NEVspolicy19912022.

Additional information

It is shown the full names and abbreviations of all actors appearing in this paper in Table S1. No other additional information is available for this paper.

Ethics declarations

Review and approval by an ethics committee was not needed for this article, which is a study on NEVs policy system in China and doesn't involve any ethics issue defined by *Heliyon*.

CRediT authorship contribution statement

Wenwen Xu: Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Xuan Shi:** Writing – original draft, Software, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e21480.

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