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Understanding the evolution of China's technology standard policy from 1949 to 2019 through the lens of policy learning

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Abstract: Understanding the evolution of Chinese technology standards policy and clarifying the pathways of policy advancement may assist in shaping and improving future technology standards policy. By extracting policy keywords from the policy text, this paper analyzes the periodical characteristics of China's technology standard policy from 1949 to 2019 through the lens of policy learning. The findings suggest that China's technology standards policy has evolved from "passive reaction" to "active promotion" and finally to "comprehensive domination". The technology standard policy themes develop through distinct stages, initially focusing on ensuring product quality, then shifting towards promoting the technological transformation of enterprises, and subsequently advancing to promoting the upgrading of industrial technology, followed by the formulation of technology standards with independent innovation, and finally, constructing a new system of technology standards. In addition, the endogenous learning pattern dominated the evolution of Chinese technology standard policy, while rarely showing the characteristics of an exogenous learning pattern.

Keywords: *China, Endogenous learning, Exogenous learning, Policy bibliometric, Policy evolution, Policy learning, Technology standard policy.*

1. Introduction

With the acceleration of a new round of global scientific and technological revolution, the development of a new generation of information technology such as cloud computing, Internet of Things, and artificial intelligence is increasingly dependent on the establishment of technology standards. Governments worldwide are accelerating their innovative strategies and competing for the opportunity to influence the development of technology standards to lead in industrial competition. In June 2017, China released *the 13th Five-Year Plan for Technology Standard Innovation*", aiming to drive industrial transformation, upgrade product quality, and enhance the development of emerging technology standards. In August 2019, the United States published *How the United States Leads Artificial Intelligence: A Plan for Federal Engagement in Developing Technology Standards and Related Tools*, which elevate the development of technology standards to a national strategy level. In August 2020, South Korea introduced *Future Mobile Communication R&D Strategy Leading the 6G Era*, with the goal of focusing on setting the 6G international standards and actively developing a strong industrial ecosystem. Against this background, it is important to clarify the process of developing technology standard policy and analyze how these policies change over time, which may contribute to improving China's technology standard policy in the future.

As the "carrier" of public policy, policy documents are taken by researchers to analyze policy targets, policy formulation processes, and policy instruments (Gao and Tisdell, 2004). At present, there

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exists a series of mature analysis frameworks that are useful for conducting in-depth analysis of policy evolution, such as Advocacy Coalition Framework (ACF) (Sabatier, 1988; Sabatier and Weible, 2007), the Institutional Analysis and Development framework (IAD) (Ostrom, 2011), and the Serial and Comparative Analysis framework (SCA) (Niinikoski and Moisander, 2014). However, these frameworks rely mostly on qualitative methods. Since qualitative analyses based on the policy instrument perspective are often unable to deal with large number of policy documents involving multiple domains, government departments, and periods, it is difficult to identify and utilize the semantic information contained in policy documents (Yang, Huang, Su, 2020). Therefore, some recent studies have used bibliometric methods which can deal with a huge amount of data and identify the core semantic information derived from each policy documents, e.g. the thematic distribution and structural characteristics of Artificial Intelligence (AI) policy (Zhang and Li, 2019), and comparative analysis of online content policies both domestically and internationally (Huang and Cheng, 2019).

Despite much effort, however, few literature addresses the evolution of technology standard policy in the Chinese context. Moreover, the existing literature focuses on analyzing the policy content itself, while neglecting the analysis of how the policy changes. For a long time, policy change has been mainly explained by a conflict-oriented perspective, which emphasizes the negative role of government and ignores the subjective initiative and efforts of policymakers to solve public problems. The policy learning perspective has changed the negative role of government in the process of policy change under the original conflict-oriented perspective, and has great potential for supplementing and developing policy change theory. The allure of policy learning is undeniable as it yields instrumental transformations, from achieving policy targets to improving public service performance and disaster management (O'Donovan 2017). The salience of learning is emphasized by the very nature of public administration and its longstanding tradition of responding to new challenges and shortcomings, particularly in an era of wicked and complex policy problems where varieties of learning can empower sense making and enable better responses to pressing challenges (Peters 2017; George et al. 2020; Zaki and Wayenberg 2021; Zaki and George 2021).

In order to deeply understand the pattern of evolution of China's technology standard policy, it is necessary to put it into a long-term policy time series and trace back a complete policy development history. In view of this, we aim to aims to analyze 134 technical standard policy documents at the central government level from 1949 to 2019. We first extract the policy keywords from policy documents, then use co-occurrence of policy keywords and clustering methods to examine the evolution of themes in technology standard policies, and finally analyze the evolution pattern of China's technology standard policies from the policy learning perspective. The goal is to offer insights for interpreting China's technology standard policy and to guide future technology standard policy development and enhancement.

The contributions and main innovation of the paper are as follows: (1) leverage the policy bibliometrics methods to process large-scale policy literature data, which provide an empirical supplement or test to existing qualitative research. (2) Construct a policy keywords network to identify the thematic changes of China's technology standard policy. (3) Based on the policy learning perspective, we can therefore identify the core policy themes at different time intervals as well as their appearance and disappearance, so as to better understand China's technology standard policy and to guide future policy development.

The rest of the article is structured as follows. Section 2 provides an overview of the policy change model based on the perspective of policy learning. Section 3 details the data and methods. Section 4 traces the evolution of China's technology standard policy between 1949 and 2019 and analyzes the thematic changes in China's technology standard policy in-depth. Section 5 discusses the main findings and concludes the article.

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2. Policy Change and Policy Learning Perspective

A policy is a government-sponsored plan with certain targets, values and strategies (Lasswell and Kaplan 2013). Specifically, it is a political action that governments take during a given period of time to achieve certain political, economic and social targets (Yang, Huang & Su 2020). According to the conflict-oriented perspective, government policy is viewed as the balance achieved through competition, negotiation, and bargaining among various parties striving to maximize their own economic or political interests. Accordingly, policy change is attributed to a relatively passive government's response to social forces or social conflicts. The policy learning perspective shifted the negative view of the government's role in the policy change process from the original conflict-oriented perspective. It suggests that those engaged in policy learning are motivated to actively improve or update the legitimacy of governance. As Heclo (1974) pointed out in his seminal book, *Modern Social Politics in Britain and Sweden*, the policy learning perspective offers a valuable approach to comprehending and clarifying policy change, which serves as a useful complement to the traditional conflict-oriented perspective. Heclo (1974) argues that learning can be defined as a relatively lasting behavioral change caused by experience. Policy learning involves intentionally utilizing the experiences and insights gained from relevant policies or systems at a specific time and place to adapt policies or systems in the present context. From the perspective of policy learning, decision-makers in various countries and fields encounter similar challenges. Despite the apparent differences in national political systems and decisions across fields, there exist universal principles that allow them to exchange and adopt solutions from one another (Xue and Lin, 2013). Therefore, policy learning can be viewed as the process of adjusting current policies by analyzing past experiences and new information to enhance the government's policy governance objectives.

Howlett & Ramesh (2003) argue that policy learning may arise from external changes or internal adjustments. They also distinguish between endogenous learning and exogenous learning. Endogenous learning refers to learning that is confined to a small policy network with limited subjects and aims at improving policy scenarios or policy tools. Endogenous learning is akin to the "lessons-learning" policy suggested by Rose (1993). In terms of endogenous learning, policy learning is a deliberate and active process started by policymakers to encourage policy adjustments through learning. In contrast, exogenous learning involves adapting policy issues, goals, or programs based on changes in the external world. From an exogenous learning standpoint, policy learning is seen as a type of learning that is unconscious, passive, and not self-directed. It is influenced by changes in external policy environments. Exogenous learning entails a wide-ranging interaction among internal and external actors within the political system concerning specific policies. This interaction leads to a reevaluation of policy matters, a redefinition of policy objectives, and a realignment of the government's policy development process to bring about a significant shift in policy paradigms. In other words, exogenous learning is a process of social interaction, and the realization of this process often depends on the emergence of profound social crises, because the impact and influence of external factors on the policy process often leads to a major transformation of policy thinking and policy process.

Based on the above reasoning, we argue that explaining policy change through policy learning is essential because, when there are no suitable policies to address particular issues, policymakers may gain experience by trying different alternatives. Over time, they create and improve policy tools and systems based on this accumulated experience. This study aims to thoroughly explain the evolution of China's technology standard policy through the lens of policy learning. It seeks to analyze and enhance the understanding of the internal mechanisms driving changes in China's technology standard policy. The findings are intended to serve as a valuable reference for enhancing and refining China's technology standard policy in the future.

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3. Research Design

3.1. Data Sources

The technology standard policy documents involved in this study are primarily sourced from the Peking University Magic Treasure Database, which is complemented by policy documents released on the websites of the Ministry of Science and Technology, the National Development and Reform Commission, the National Standards Commission, the State Administration of Market Regulation, and other relevant agencies. The search strategies are as follows. On the homepage of Peking University's Magic Treasure Database, we select the default setting "central regulation" and use the keywords such as "技术(technology)", "标准(standard)", "科学技术(science and technology)", "知识产权(intellectual property right)", "专利(patent)", and "创新(innovation)". After removing duplicates, 196 policy documents are retrieved. Blind & Thumm (2004) note that standards serve several key functions, such as ensuring compatibility (interface), providing information and measurement, reducing diversity, and setting minimum quality requirements. This study primarily focuses on technology standards related to compatibility or interface functions, which serve as specifications to ensure smooth integration among the components of a technological system and to encourage coordination among stakeholders' actions (Lee and Song, 2017). By reading 196 policy documents manually, we identified and kept policies that are closely linked to creating and applying technology standards for various areas like computers, office equipment, communication devices, opto-mechatronics equipment, electronic components, aerospace vehicles, biomedicine, computer software, new materials, and other high-tech manufacturing sectors. The 134 policy documents selected in the final constitute the objects of analysis for this research, including laws, regulations, plans, opinions, measures, announcements, and other types of policies.

This study divides the evolution of China's technology standard policy into five stages based on key events (see Table 1). The division is anchored on significant milestones such as the establishment of the State Administration of Standards in 1978, which aims to increase economic growth by focusing on standardization efforts, indicating a revival in China's standardization management. Subsequently, after China's entry into the WTO in 2001, the General Administration of Quality Supervision, Inspection and Quarantine, the CNCA, and the National Standards Commission were successively formed. In 2006, the State Council introduced the *Outline of the National Medium and Long-term Science and Technology Development Plan* (2006-2020) (hereafter referred to as the *Medium and Long-term Development Plan*), which advocate for the creation of technology standards driven by independent innovation and emphasize the role of science and technology initiatives in shaping technical standards. In 2012, the Ministry of Science and Technology, the General Administration of Quality Supervision, Inspection and Quarantine, and the National Standards Commission jointly issued *The 12th Five-Year Plan for Technology Standards and the Development of Science and Technology*, which, for the first time, underscores the crucial role of technology standards in the advancement of science and technology at a policy level, ushering in a new era of symbiotic growth and collaboration between technology standards and technological progress.

Table 1.
Division of Chinese standard policy evolution (1949~2019).

Timeline	Stages	Milestone events
1949~1977	Stage 1: The initial exploration stage of technology standards	*The ten-year plan for standardization development* laid the foundation for the Chinese technology standards development
1978~2000	Stage 2: The establishment stage of the technology standard system framework	The year 1978 marked China's return as a full member of the ISO
2001~2005	Stage 3: The international convergence stage of technology	After China's entry into the WTO in 2001, the ministry of science and technology

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	standards	promptly initiated the *talent, patent, and technical standards strategies* to address the challenges of the new era.
2006-2011	Stage 4: The technology standard-setting stage based on independent innovation	The Chinese government introduced the *national medium- and long-term science and technology development plan (2006-2020)*, aiming to encourage independent innovation among enterprises.
2012-2019	Stage 5: The construction stage of new technology standard system jointly led by the government and the market	the State council introduced the *deepening standardization reform program* and the *national standardization system construction development plan (2016~2020)*, with the aim of transitioning from government-dominated to a combination of government and market-dominated technology standards supply.

3.2. Research Methods

In this study, policy bibliometrics are used to analyze the evolution of the Chinese technology standard policy. Since the structure of policy documents closely resembles that of journal papers, it is feasible to apply bibliometric methods to the field of policy literature (Yang, Huang, Su, 2020). However, since the policy documents did not clearly specify the keywords, this study uses the high-frequency words in the policy documents as the keywords that represent the policy themes. The analysis of policy documents based on keywords is primarily grounded on the assumption that the keywords in each policy document can effectively describe its contents (Huang, Su, Xie, 2015). The policy bibliometric method based on keywords primarily includes co-word analysis and cluster analysis. In this study, we initially utilized ROSTCOM6 software to extract high-frequency policy keywords. We removed auxiliaries and adverbs from the high-frequency keywords. Subsequently, we selected 3 to 15 keywords for each policy using the *State Council Official Document Thematic Vocabulary List*. Secondly, by creating a matrix of high-frequency policy keywords that co-occur and performing cluster analysis, we can assess the evolution of technology standard policy themes across various stages.

4. Analyses of the Evolution of Technology Standard Policy Themes

As shown in Figure 1, the annual distribution of 134 technology standard policy documents is relatively uneven, with a relatively small number of policies issued before 2000 and dramatically large since China joined the WTO in 2001. The peak periods for the release of policies were in the years of 2006, 2011, and 2017. This trend occurs both before and after the implementation of *The 7th Five-Year National Science and Technology Innovation Plans*, *The 12th Five-Year National Science and Technology Innovation Plans*, and *The 13th Five-Year National Science and Technology Innovation Plans*. This pattern emphasizes the important impact of technology standard policies on science and technology planning, as well as the growing recognition and emphasis on technology standard policies by policymakers.

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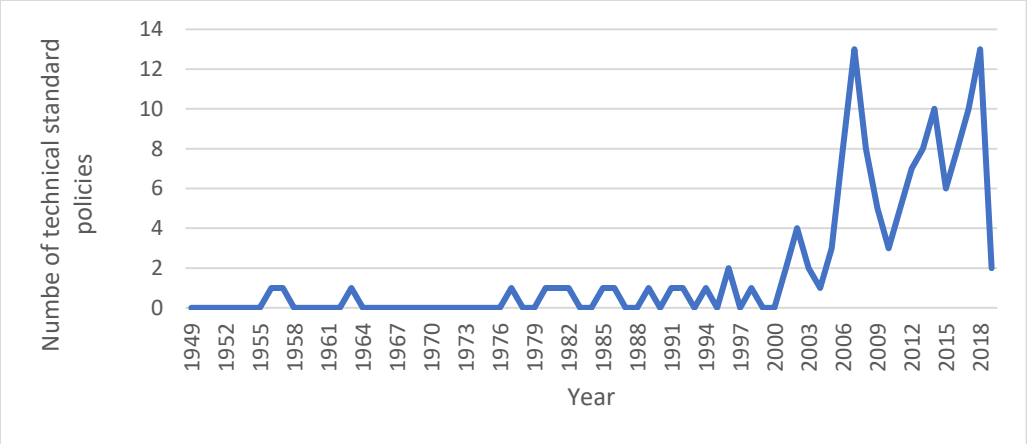

Figure 1.
The annual distribution of Chinese technical standard policy.

4.1. The Characteristics of Chinese Technology Standards Policy in Different Stages.

4.1.1. The Initial Exploration Stage of Technology Standards (1949~1977)

The years between 1949 and 1977 marked the beginning of China's technology standards development. According to *the 1st Five-Year Plan of the People's Republic of China for the Development of the National Economy (hereafter referred to as the 1st Five-Year Plan)*, the key to ensuring and enhancing industrial product quality lies in the gradual establishment of uniform technology standards and national institutions for their management. The initial strategic blueprint for standardization in China, known as *The Ten-Year Plan for Standardization Development from 1963 to 1972*, laid the foundation for the country's technology standards progress. During this period, the primary emphasis was on fulfilling the requirements outlined in *the 1st Five-Year Plan*, with technology standard serving as a key factor in ensuring efficient industrial manufacturing and enhancing the quality of products.

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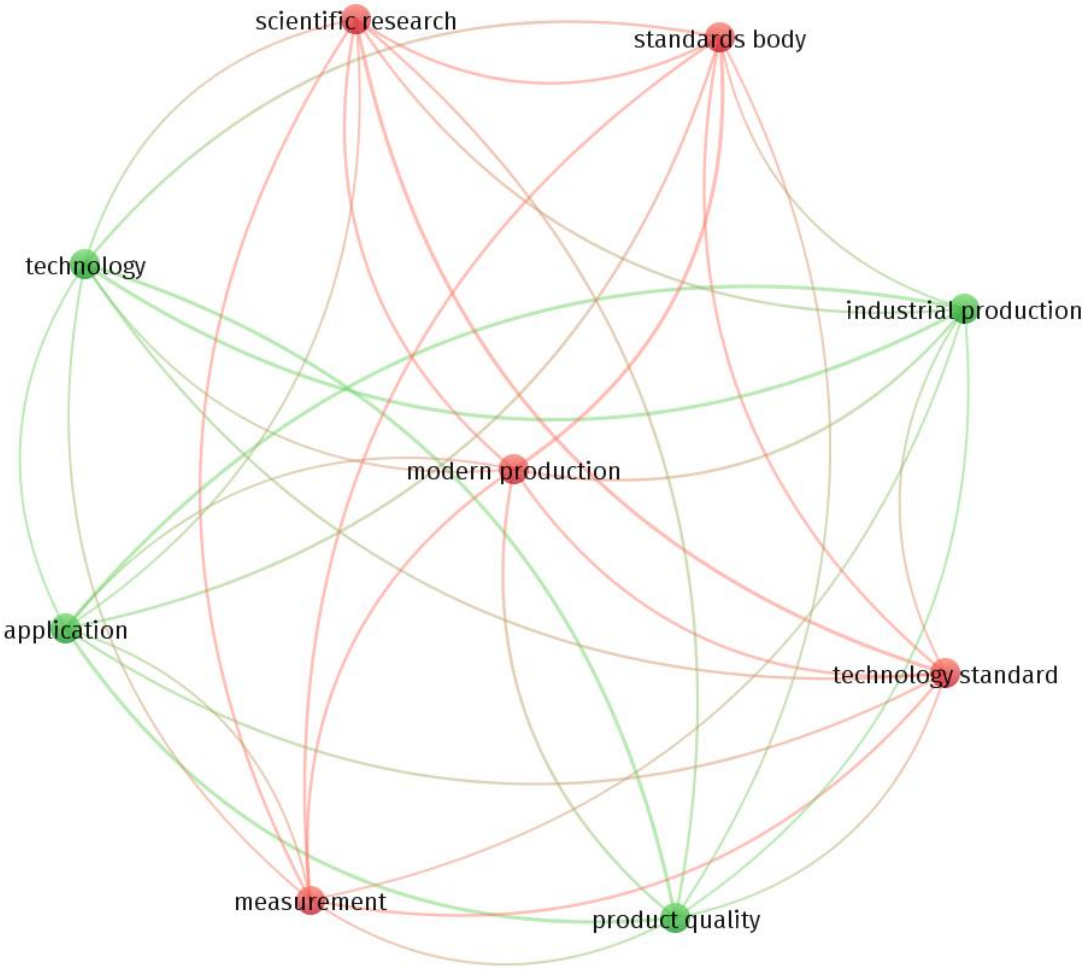

Figure 2.
The cluster of technology standard policy keywords (1949~1977).

In this stage, the 3 policy documents contain 9 high-frequency policy keywords that fall into two clusters, as shown in Figure 2. Cluster 1 focuses on the technology standard policy, with a strong emphasis on the significance of technology standards in industrial production and ensuring the quality of products, while Cluster 2 highlights how the formulation of technology standards can stimulate the growth and utilization of technology.

4.1.2. The Establishment Stage of Technology Standard System Framework (1978~2000)

The year 1978 marked China's return as a full member of ISO, followed by the promotion of international standards in product manufacturing through government initiatives in 1979. While governmental influence persisted in technology standardization, Chinese firms were increasingly operating with more autonomy as a result of reform efforts, thereby boosting market vitality. *The Standardization Law of the People's Republic of China* was enacted by the National People's Congress in 1988, giving the State Council authority over standardization across the nation, with standards categorized into various types such as national, industry, local, and enterprise standards, including mandatory and recommended standards for national and industry levels, thus establishing the initial China's technology standard system.

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In this stage, 14 policy documents consist of 34 high-frequency policy keywords, which are divided into three clusters (see Figure 3). Cluster 1 underscores the importance of technology standards as a key tool for enterprises to drive innovation, modernize their production processes, and improve product quality. The autonomy of enterprises has been broadening as a result of reforms and opening-up initiatives. According to the *Summary of National Standardization Work in 1980* and the *Guidance on Unleashing the Potential of Standardization in Enterprises for Innovation and Transformation*, technology standards play a vital role in facilitating innovation, overhauling outdated processes, and streamlining industrial modernization efforts within companies. In response to the economic system reform demands, the standardization system reform was gradually implemented in The *7th Five-Year Plan* after *The 6th Five-Year Plan*. In 1988, the National People's Congress approved *The Standardization Law of the People's Republic of China*, which laid down the initial structure for the technology standard system.

Cluster 2 indicates the government's strategy to foster the growth of high-tech industries with technology standards. In 1988, *The Key Points of Information Technology Development Policy* was released by the General Office of the State Council, emphasizing the rapid growth of the information technology industry. To gain a competitive edge globally, it is crucial to boost information technology development and offer products that meet high international standards. The government is advised to enhance the procurement of high-tech products, steer industrial development, and achieve high-tech industrialization to effectively convert scientific and technological advancements into productive forces and advance technology standards, as stated in *The Decision on Deepening the Reform of High-tech Industrial Development Zones and Promoting the Development of High-tech Industries*.

Cluster 3 shows China's initial steps towards aligning its technology standards with global market requirements. To establish a presence in the global market, it is crucial to manufacture products that meet market standards and are competitive. According to *The Key Points of National Standardization Work in 1998*, there is a need to bolster the international standardization endeavors, actively take part in global standardization undertakings, and expedite worldwide integration.

During this stage, China's technology standards policy began to align with the broader context of reform and opening up, as well as the socialist market economy, although it continued to be impacted by the planned economic system. During the initial phase of this stage, the primary focus of the technology standard policy was on industrial modernization production and product quality. In the later stages, there was a gradual transition towards high-tech industries and involvement in international standardization initiatives.

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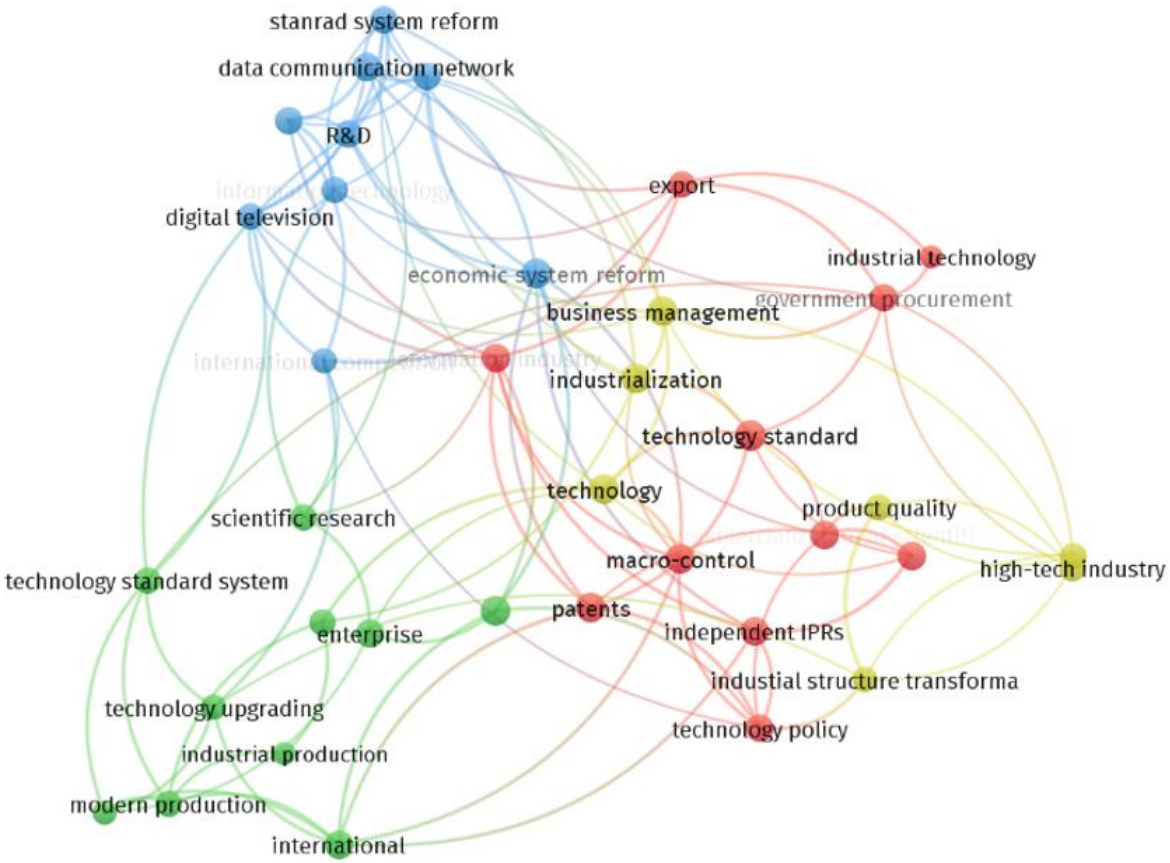

Figure 3.
The cluster of technology standard policy keywords (1978~2000).

4.1.3. International Convergence Stage of Technology Standards (2001~2005)

In light of China's membership in the WTO in 2001, the Ministry of Science and Technology promptly initiated *The Talent, Patent, and Technical Standards* strategies to address the challenges and opportunities of the new era. In this stage, *The 10th Five-Year Plan* includes significant research funding on technical standards, which is a key initiative to advance the technology standards strategy. This research is being carried out collaboratively by the Ministry of Science and Technology, the State Administration of Quality Inspection, and the State Standards Commission with the goal of enhancing China's technological standards comprehensively.

In this stage, a total of 15 policy documents have been issued, covering 40 high-frequency policy keywords, which have been organized into three clusters as indicated in Figure 4. Cluster 1 focuses on utilizing technology standards to enhance industrial technology advancement and economic reorganization, aiming to boost the global competitiveness of the industry. To facilitate industrial restructuring, the technology standards policy highlighted the need for a technological innovation system centered around enterprises, the development of intermediary services for innovation, and the encouragement of Industry-University-Research partnerships in setting technology standards to drive industrial technology advancement.

Cluster 2 primarily concentrates on developing technology standards that align with global market requirements. To adjust to the wave of economic globalization, China is proactively establishing a technology standard system that conforms to international standards and advocating for promoting trade through science and technology. A key element of the strategy to enhance trade through science

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and technology involved creating sophisticated and uniform technology standards, as well as embracing global advanced norms to address foreign technology trade barriers effectively.

Cluster 3 is dedicated to improving technology standards and promoting the progress of high-technology industries. *The High-tech Industry Development Plan* issued by the National Development and Reform Commission in 2001 pointed out that during *The 10th Five-Year Plan* period, China concentrated resources on breakthroughs in the development of key technological fields, combining independent development with the introduction of advanced foreign technologies, actively strengthening international cooperation, implementing the twelve high-tech projects, accelerating the formulation of standards such as digital television, intelligent transportation systems and third-generation mobile communications, breaking the international technology monopoly, and promoting the overall development level of high-tech industries. At the same time, China is striving to establish a favorable market environment and policy instruments for the advancement of high-technology sectors, enhancing technical standards that promote enterprise innovation, and driving standardization in high-tech industries via government procurement policies.

The clustering of policy keywords reveals that the technology standard policy during this period is built upon industrial technology advancement and economic reorganization, with a focus on high-tech industries as the main focus to address international competition by creating unified and advanced technical standards. Furthermore, a large portion of contemporary technology standards are developed through a combination of self-driven progress and technology integration, without adequate focus on fostering independent innovation and self-sufficiency in research and development.

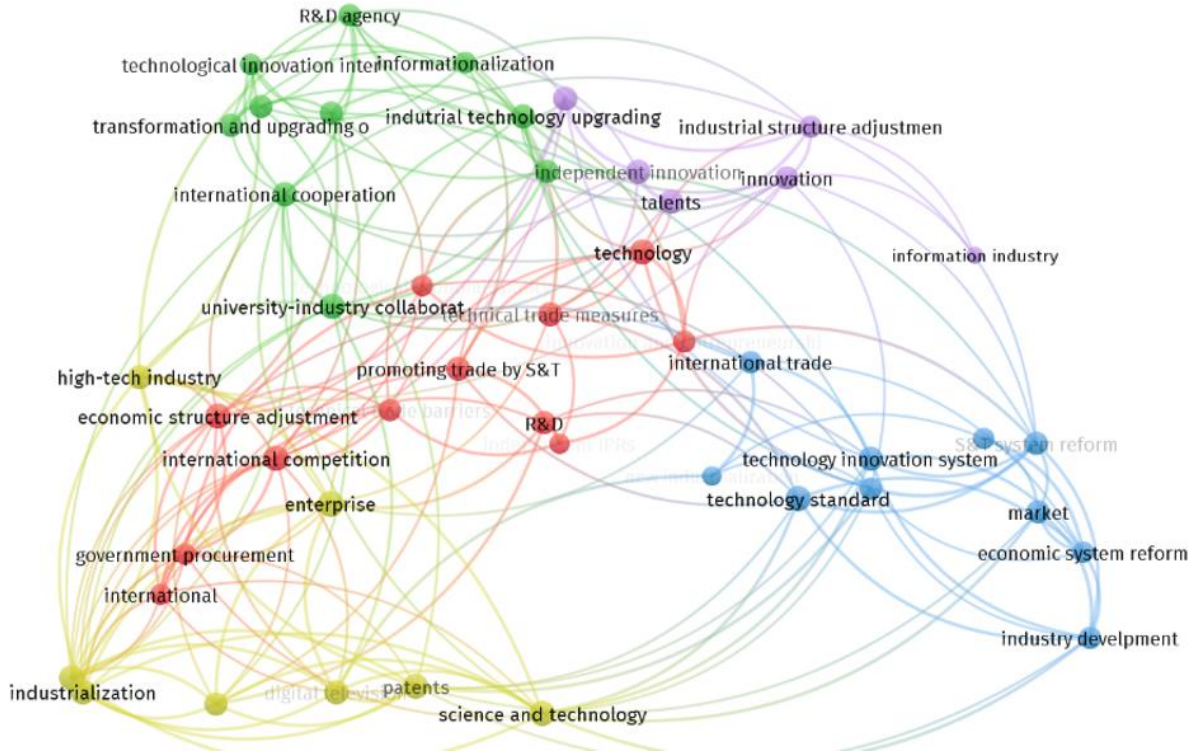

Figure 4.
The cluster of technology standard policy keywords (2001~2005).

4.1.4. The Technology Standard-Setting Stage Based on Independent Innovation (2006-2011)

As economic globalization unfolded, China's integration into the world economic system led to its emergence as the primary manufacturing hub globally. This development prompted worries among

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government policymakers and companies about the potential pitfalls of relying on manufacturing, potentially falling into the "patent trap. In an effort to decrease dependence on foreign technologies, the Chinese government introduced The *Medium and Long-term Development Plan*, aiming to encourage independent innovation among enterprises. The implementation of technology standard and intellectual property strategies helped decrease the dependency on foreign technology through the promotion of independent innovation.

The 46 policy documents released at this stage involve 65 high-frequency policy keywords, forming 4 clusters as shown in Figure 5. Cluster 1 highlights that the standard policy prioritizes the development of standards through independent innovation and research. To enforce the strategy of technology standards centered on independent innovation, the Chinese government explicitly outlined the support provided by science and technology plans in technology standards, and actively guided the participation of various entities like Industry-University-Research in formulating international technical standards. To this end, the Ministry of Science and Technology, the National Quality Supervision Administration, the National Development and Reform Commission, and the Ministry of Finance have successively issued the *Several Opinions on the Management Reform of National Science and Technology Plans* and the *Implementation Rules for the Research and Application of Important Technology Standards Supported by Science and Technology Plans*. In 2009, the Ministry of Science and Technology, the Ministry of Finance, and the Ministry of Education collectively released *The General Implementation Plan of National Technological Innovation Project*, which underscored the importance of Industry-University-Research collaboration, with enterprises taking the lead, in developing technology standards and strengthening the national technological innovation system through the establishment of enduring cooperative relationships and industrial alliances.

Cluster 2 is centered on improving technology standards through independent innovation to increase the industry's international competitiveness. One example is the implementation of the "*Technical Standards Promotion Project*" with the aim of developing a service platform for technology standard development, establishing a high-tech industry standardization demonstration zone, enhancing participation in ISO, ITU, and other global standardization organizations, and improving the capacity to influence the formulation of technical standards.

Cluster 3 highlights the importance of developing technology standards for key emerging sectors and promoting innovation within the nation. After the 2008 financial crisis, the State Council introduced *The Decision of the State Council on Quickening the Cultivation and Growth of Strategic Emerging Sectors*, which underscored the role of these industries as the fundamental pillars of the future economy and society. To advance strategic emerging sectors effectively, there is a need to ensure proper standardization in the realm of cutting-edge information technology, carry out significant industrial innovation initiatives, enhance global scientific collaboration, and enlist leading companies to drive the establishment of technical benchmarks for relevant sectors. In addition, China has initiated the process of gradually examining, encouraging, and establishing a new framework for military-civilian integration within the realm of standardization, as outlined in documents such as *The Main Points of National Standardization Work in 2009,2010, and 2011*, and *The 12th Five-Year Plan for Standardization Development*.

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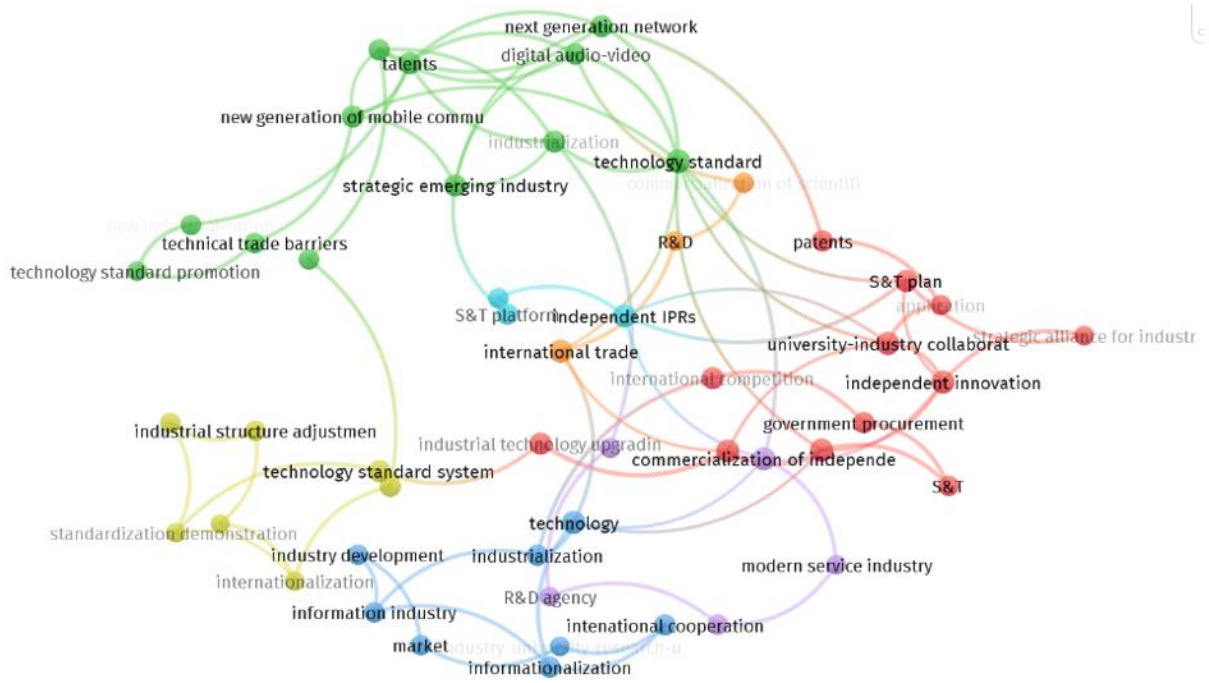

Figure 5.
The cluster of technology standard policy keywords (2006~2011).

Cluster 4 is predominantly concerned with setting technology standards in the realm of strategic emerging industries, with a key emphasis on strengthening independent innovation capabilities and consistently advancing technology standards in critical areas like next-generation Internet and new-generation mobile communications. To improve industries' technological advantages, it is crucial to promote the industrialization of scientific and technological achievements through government procurement and to encourage the adoption of technology standards.

To conclude, the focus of technology standard policy in this stage is primarily on fostering independent innovation as the fundamental element, and by guiding and supporting scientific and technological blueprints, it encourages the development of technology standards in critical domains, enhances the central competitiveness of strategic emerging sectors, and initiates the exploration of a new civil-military integration mechanism in the standardization realm.

4.1.5. The Construction Stage of New Technology Standard System Jointly Led by the Government and the Market (2012-2019)

The role of technology standards in China has been enhanced through the implementation of science and technology policies. Nevertheless, there are significant issues with developing and enforcing technology standards, including the limited conversion of scientific and technological advancements into technology standards, the overall lack of widespread use of technology standards, the need for a stronger connection between technology standards, science, technology, and market demands, and the pressing requirement to enhance the role of businesses in creating and applying technology standards. To tackle these challenges, the State Council has issued *The Deepening Standardization Reform Program* and *The National Standardization System Construction Development Plan* (2016~2020) and other official documents. The objective is to overhaul the current technology standards system, transition from government-dominated to a hybrid of government and market-driven technical standards supply, and build a fresh technology standard system.

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The 56 policy documents released contain 75 high-frequency policy keywords, which are grouped into 4 clusters as illustrated in Figure 6. Cluster 1 highlights the importance of allowing enterprises to actively participate in setting technology standards. In 2017, *the Standardization Law of the People's Republic of China* was revised during the 30th session of the National People's Congress, establishing the legal characteristics of technical standards and transitioning the primary provider of standards from government-led to market-driven. Both *The 12th Five-Year Plan* and *The 13th Five-Year Plan* highlighted the importance of enterprises in driving the technical standards strategy and encouraged them to take an active role in creating and implementing these standards. High-frequency policy keywords such as "strategic alliance of industrial technology innovation", "market", "service platform of technology innovation", "technology innovation center", and "Industry-University-Research Collaboration" further reflected the focus of policy attention: that is, taking enterprises as the main body to play the role of production, learning, and research in the process of formulating technology standards, establishing industrial alliances and technology innovation centers, etc., and promoting the research and development of core technologies.

Cluster 2 focuses on advancing the establishment of China's intelligent manufacturing technology standard system. Intelligent manufacturing was the main direction of the transformation and upgrading of China's manufacturing industry. It is necessary to deeply integrate manufacturing technology with the new generation of information technology, give full play to the application of the Internet in manufacturing industry, and strengthen the construction of intelligent manufacturing technology standard system. In an effort to boost the development of technology standards for intelligent manufacturing, the Chinese government suggested prioritizing information technology and collaborating with all parties in Industry-University-Research collaboration, industrial chain, and innovation chain. This approach aims to unify the intelligent manufacturing standard system with the integration of the two industries. Following the introduction of the idea of "high-quality development" by the Chinese government in 2017, there has been a shift in the focus of China's technology standards system towards enhancing industries' high-quality development and elevating China's technology standards and global competitiveness.

Cluster 3 indicates a strong integration of technology standards with science and technology. In areas where technological innovation is more active, such as new-generation information technology, intelligent manufacturing technology, and next-generation information infrastructure, the formulation of technology standards has accelerated the process of industrialization and marketization of products and technologies, and has promoted the transformation and upgrading of industries. In view of the low proportion of China's scientific and technological achievements that have been transformed at the present stage, the Chinese government is actively constructing service platforms for developing technology standards and expand the ways of applying scientific and technological achievements. For key areas that need to be vigorously cultivated and developed, Chinese government aims to build the technology standard innovation bases and platforms to promote the transformation and application of scientific and technological achievements.

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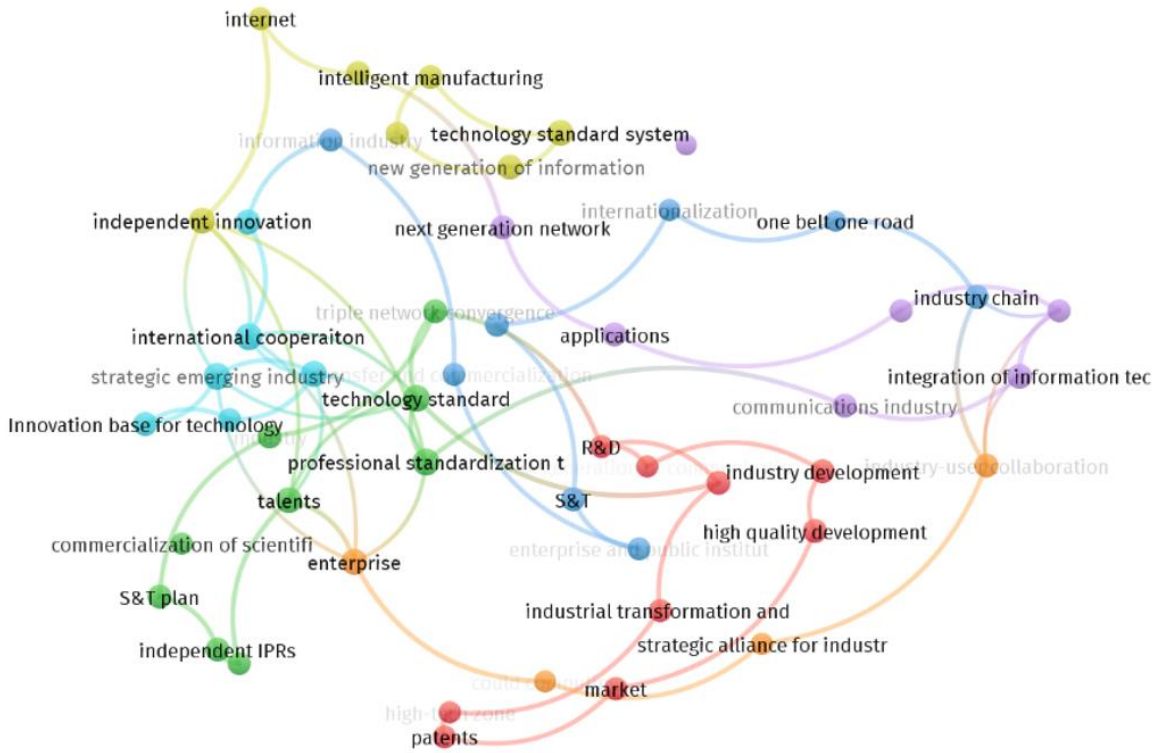

Figure 6.
The cluster of technology standard policy keywords (2012~2019).

Cluster 4 focuses on standard-setting in key technology areas in China. The rise of networking and digitization is leading to a new era of informatization, with technology merging with various industries to drive industrial transformation. *The 2016 National Informatization Development Strategy Outline* aims to make significant advancements in areas like integrated circuits, basic software, and core components, while also pushing for the establishment of standards in key technological fields such as big data, the next-generation Internet, new-generation mobile communications, and intelligent manufacturing.

To summarize, the primary aim of the technology standard policy at this stage is to underscore the important role of enterprises in shaping technology standards, establish a collaborative technology standard system jointly led by the government and the market, promote the development of intelligent manufacturing standards, and facilitate a deep integration of the manufacturing industry with the information technology field. It also seeks to strengthen the interactive support between science, technology, and technical standards, and drive the integration of civil and military standards.

4.2. The Evolution of Chinese Technology Standard Policy: Endogenous Learning or Exogenous Learning?

Policy learning is the response of policymakers to internal information or external environmental stimuli, and is also the main source of policy evolution. As discussed above, policy learning is divided into endogenous learning and exogenous learning. Endogenous learning entails reflecting on past policy outcomes to determine how to modify future plans. Therefore, endogenous learning may also be called the "lessons-learned" learning. The development of China's technology standard policy across the first four stages was predominantly a process of acquiring knowledge from the former Soviet Union and Western developed nations. During the era spanning from the establishment of New China to the commencement of reform and opening-up policy (1949-1977), technology standards were under compulsory state control, with the state being responsible for creating, distributing, and enforcing them uniformly. The technology standard policies during this era involved learning from the former Soviet

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Union's experience, primarily through endogenous learning to drive policy evolution. On one hand, *The 1st Five-Year Plan* clearly states that, in order to improve and ensure the quality of industrial products, it is necessary to progressively formulate unified national technical standards and to set up a national agency for the management of technology standards, and to unify the formulation of Chinese national standards with reference to the national standards of the former Soviet Union in the light of the specific conditions of China's industrial development. On the other hand, the contents of the technology standards issued since the founding of New China were formulated under the direct guidance of the experts of the former Soviet Union, and some of the contents were even translated directly from standards of the former Soviet Union. Because of this, the structure of China's technology standard system is very similar to that of the former Soviet Union's national standard system, and because of the acute struggle between the two camps led by the United States and the former Soviet Union since the founding of New China, China's foreign policy of "alliance with the Soviet Union and resistance to the United States" has led to led to China's "one-sided" reliance on the former Soviet Union's experience in economic development, and thus China's technology standard policy at this stage was characterized by "passive adaptation".

Throughout the years spanning from 1978 to 2000, there was a growing awareness of the necessity to enhance China's technology standards to match international norms, as part of the reform and opening-up policy. During this period, China's technology standard policy showed signs of emulation from Western developed nations, reflecting a shift towards endogenous learning to drive policy reform. During this period, technology standard policies have been introduced by the European Union, the United States, Japan, and other countries to encourage the worldwide use of technology standards. The EU's *New Approach* in 1985 underscored the crucial role of standardization in the growth of the European single market. Subsequently, the EU released *The Green Paper on Standardization Development in Europe, The Role of Standardization in the European Economy*, and *The Resolution on the Broad Utilization of Standardization in EU Policies*. At the same time, The United States promulgated *The American National Standards Strategy* in 2000, emphasizing the formation of international standards dominated by American technology. *The Sixth Long-Term Plan for Japanese Industrial Standardization* (1985) attempted to integrate Japanese industrial standards with international standards and to promote international mutual recognition of Japanese industrial standard certifications through active participation in international standardization activities. In order to meet the needs of developing a socialist market economy and international trade, the State Administration for Market Regulation of China issued *The Administrative Measures for the Adoption of International Standards and Advanced Foreign Standards* in 1992 to improve the quality of China's products and technology by promoting the adoption of international standards and advanced foreign standards, indicating that the Chinese government has begun to draw on the policy experience of developed Western countries to actively promote China's technology standards (c) Formulation.

The year 2001~2005 is the stage of internationalization of technology standards. After China's entry into the WTO in December 2001, China's technology standard system has produced positive changes to comply with the Agreement on Technical Barriers to Trade (WTO/TBT Agreement). In April 2001, the State Council set up the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and established the National Standardization Administration Committee (NSAC) to unify the management of national standardization work. In contrast to the period of 1949~1977 and 1978~2000, where Chinese government bodies held complete control over technology standardization, a more open approach was adopted by the standardization administration during 2001~2005, ensuring technology standards were enforced through market-oriented methods. The policy orientation of endogenous learning was continued from 2012 to 2019. With the efforts of *The 11th Five-Year Plan*, the strategic position of China's technology standards has been further strengthened. In 2012, China released *the 12th Five-Year Plan for the Development of Technology and Standards*, which emphasized the role of enterprises in the development of technology standards. In 2015, the State Council of China introduced *The Plan for Enhancing Standardization Work* and updated *The Standardization Law* in 2017

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to align technology standards with the market. In terms of the government's learning motivation for technology standard policy, the policy orientation in this period mainly addresses the problem of a large gap between the application level of technology standards and social demand with a pragmatic attitude, and therefore exhibits the characteristics of an endogenous learning mode.

Exogenous learning occurs mainly within larger policy communities with the participation of more public actors and focuses on learning about the perception of policy problems and the adjustment of policy goals, which originates from outside the policy process and affects society as a whole, often accompanied by a change in policy thinking, and is therefore also referred to as "social learning". The period from 2006 to 2011 of Chinese technology standard policy was marked by policy learning that primarily exhibited the traits of exogenous learning. In the early stages of the strategic discussion on *The Medium and Long-term Development Plan* (2006-2020), stakeholders from the scientific, educational, economic, and governmental domains shared their perspectives thoroughly, leading to a considerable enhancement in the inclusivity of policy contributors. Following the reform and opening-up policy, the implementation of the "bring in" strategy has been instrumental in shaping the "Chinese economic miracle", while the idea of "market for technology" in technology acquisition has garnered considerable support. Nonetheless, the lack of innovation in China's manufacturing industry might result in falling into the "patent trap" and assuming a subordinate role in the global production chain. Therefore, the main point of contention was whether to "exchange market access for technology" or "pursue an independent innovation strategy." *The Medium and Long-term Development Plan* introduced a technology standard strategy to support independent innovation, prompting enterprises to independently innovate to decrease their reliance on foreign technology, representing a notable shift in China's technology standard policy.

5. Conclusion

Policy documents serve as a means for policy researchers to assess policy content, the development of policies, and policy instruments. The examination of policies through analyzing policy documents has emerged as a popular research focus in various disciplines. By leveraging the policy bibliometrics methods to process large-scale policy literature data, we examine the evolution of China's technology standard policy spanning 1949 to 2019. The findings suggest that China's technology standards policy has evolved from "passive reaction" to "active promotion" and finally to "comprehensive domination". The technology standard policy themes develop through distinct stages, initially focusing on ensuring the quality of products, then shifting towards promoting the technological transformation of enterprises, and subsequently advancing to promoting the upgrading of industrial technology, followed by the formulation of independent innovation technology standards, and finally, constructing a new system of technology standards. In addition, the endogenous learning pattern dominated the policy evolution of Chinese technology standard policy, while rarely showing the characteristics of an exogenous or social learning pattern.

Learning from the experiences of the former Soviet Union and other developed Western countries has played a significant role in shaping China's technology standard policy Since 1949. While lessons have been drawn from developed nations, the primary focus of this policy learning remains within a restricted policy network, addressing urgent issues with a pragmatic approach. However, the process of developing technology standards through independent innovation adopts an exogenous learning approach, with experts and scholars from various fields engaging in thorough discussions, exchanges, and interactions. This shift transforms the focus from a "market for technology" policy to implementing a strategy centered on independent innovation in technology standards, breaking away from reliance on foreign technologies. Consequently, the underlying principles and approach of the technology standard policy have undergone a significant transformation. The future research direction should aim to understand why China's technical standards policy exhibits a stronger inclination towards endogenous learning rather than exogenous learning.

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