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# Analysis Model and Application of China's Industrial Innovation Competition Situation from the Perspective of Patent Quality

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**Abstract:** Patent quality is an important factor affecting the industrial transformation and upgrading in China. Under the background of economic globalization, with the industrial innovation competition gradually evolving into the global industrial value chain competition, in addition to patent quality issues, the integration of industrial innovation has become a reality that must be faced by the industrial development of China. The effectiveness of innovative competitive intelligence analysis method is of great importance to the implementation of national innovation strategy and the influence of industrial development direction. This paper analyzes deeply the phenomenon of "problem patent" and "patent jungle" at home and abroad. To construct an analytical model based on the endogenous factors of innovation and the market as the criterion can effectively deal with the current situation of industrial innovation in China. Taking the innovation level of foreign industries as the benchmark, this paper puts forward a competitive analysis framework of industrial innovation from the perspective of patent quality. The framework is based on the impact of patent jungle on the development of industrial innovation, and takes patent stock and patentee density as measure index. The research finds that the analytical framework can effectively identify the position of industrial innovation in China, and then provide effective support for guiding industrial innovation in China.

**Keywords:** Patent Quality, Industry Innovation Competition, Analytical Model

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## 1. Introduction

In order to effectively use the patent system for improving the ability of industrial innovation-driven development, speeding up the adjustment of industrial structure, improving the overall quality and competitiveness of the industry, China began to implement the pilot project of patent navigation in 2013, aiming to establish a deep integration of patent information analysis with industrial operation decision-making and foster a new model for the development of patent navigation industry. In 2015, with the increasing pressure of industrial transformation and upgrading caused by overcapacity, the state proposed to actively promote supply-side structural reform, adjusting and optimizing the allocation of factors among industries, releasing new demand through innovation drive and creating new supplies. Meanwhile, developed countries represented by Europe and

the United States have taken advantage of their leading advantages in industrial technical field to implement trade protectionism, so as to strike the development of China's industrial economy and hinder the process of the industrial transformation and upgrading. In general, under new development situation, the industrial innovation ability has become the key element of the game of comprehensive competitiveness between countries.

Under the comprehensive effect of internal and external factors, the pressure of industrial transformation and upgrading of China is also increasing. Meeting the challenge, the Party made it clear in the reports of the 19th National Congress of the CPC that, "To build a modern economic system, we must take improvement of quality of supply system as the main direction, and significantly enhance China's economic quality advantage", and the introduction of the strategic action plan for manufacturing power represented

by *Made in China 2025* is a specific performance that we positively respond to industrial competitiveness at home and abroad. However, whether patent exploitation and industrial innovation ability can be highly matched, whether patent portfolio can effectively guarantee the competitive position of the industry, and whether patent value can effectively support the industrial operation benefit is crucial to the development, transformation and upgrading of industrial innovation in China. Based on the industrial level, this paper makes an exploratory study on the patent phenomenon existing in China's current innovation field, aiming to clarify the competitive situation of China's industrial patent innovation from the perspective of patent quality, thus providing support for the innovation and transformation of China's industries guided by patents.

## 2. Research Background

Since 1980, on the basis of high innovation and wide application of information technology, under the influence and impact of the "pro-patent" policy in the United States, there has been a rapid increase in patent applications and authorizations worldwide. This has been followed by a global surge in the number of patents. The legal exclusivity of the patent right encourages enterprises to apply for more patents in related fields, especially in complex technical fields, where the knowledge fragments are more complex and trivial and the number of potential patents that can be applied is huge, and the possibility of interdependence of patent rights is increasing at the same time [1]. With the increasing number of patents, in particular when the number of patents in a certain industrial field is growing to a certain extent, the patent technology in the industry is often affected by iterative innovation model, resulting in many overlapping patent rights; therefore, people who research and develop new technologies have to face more difficulties and spend more money to acquire patent rights [2]. American economist Shapiro (2001) restated it from an economic point as a densely overlapping network formed by all intellectual property rights owned by multiple innovation subjects, namely the concept of "patent jungle" accepted by scholars at home and abroad [3-4]. American economists Adam B. Jaffe and Josh Lerner emphasized in *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It* that, the current patent system in the United States has lost the functionality it was designed for, and the explosive increase in patent application and patent lawsuit is not consistent with the real increase in creativity in the country, which is caused by more powerful patent protection, decrease in patent grant standard as well as the emergence of a large number of worthless patents in industries with rapid technological changes, among other factors. In recent years, the Chinese government has done a lot of work in allocating relevant social resources according to the principle of patent technology development and making incentive policies to promote its efficient operation. All provinces and cities

across the country have issued various patent subsidy policy and have made huge process. From 2011 to 2017, China patent application quantity has taken the first place for 7 years in a row. On the whole, however, there is still a gap between China and western countries in terms of the maturity of patent system and technological innovation ecology. As a result, the relevant incentive and subsidy policies in China are more likely to lead to an irrational increase in patent application quantity, which might induce a potential patent bubble [5]. In 2016 alone, research and development expenditure of China was RMB 1567.67 billion, the intensity of input of research and development expenditure was 2.11%, compared with 2.40 % in OECD (Organization for Economic Cooperation and Development) countries in the same period. In terms of per capita input, in 2016, the per capita input of China was only RMB 404,000, and that of Japan was RMB 1.25 million in the same period. In addition, according to the statistics, in 2016, research and development expenditure used for the year's patent activities in 47.0% of enterprises accounts for below 10%; research and development expenditure used for the year's patent activities in 60.7% and 52.3% of universities and scientific research unit patent holders accounts for below 10% [6]. The huge contrast in input and output and the low level of input in real patent activities lead to many problem patents in China [7-8], which are generally of low quality and difficult to achieve innovation benefits.

## 3. Theoretical Basis of Model Building

### 3.1. Generation and Influence Model of Patent Jungle

No matter at home and abroad, the issue of patent jungle is not prominent in non-related technical fields, such as pharmaceutical industry, but in complex technical fields, such as semiconductors, telecommunications, computers and the like, patent rights often overlap with each other, forming the so-called patent jungle [9]. Cumulative innovations are of vital importance in complex technical fields. The innovation of latecomers depends on the achievements of predecessors in this field, that is, new entrants in complex technology fields must obtain many basic or blocked patent licenses [10]. Especially under the background of economic globalization, the international competition of the industrial innovation is intensifying. The formation of patent jungle is no longer confined to a certain country, but gradually becomes open with the development of global industrial innovation. If a certain industrial innovation of a country cannot be at the top of global innovation chain in the industry or can hardly find another way, it will be greatly influenced by the patent jungle.

#### (1) Generation and Strengthening of Patent Jungle

Technical complexity is the foundation of patent jungle, and in addition, strategic patent layout of enterprises, patent troll and a large number of "problem patents" may all lead to patent jungle. Meanwhile, patent jungle has a strong self-reinforcement function, enterprises in patent jungle have

more incentive to apply for more patents; the more patents an enterprise has, the easier it will be to win in patent lawsuits. Moreover, in market competition, enterprises with more quantities of patents have larger strategic advantages (such as the dominant position of cross license agreement, patent royalties and the like). For example, the IBM's former president Smith described the patent strategy of the company as that, "In the cross-license agreement, IBM's patent portfolio strategy can give us great freedom, for example, we can use inventions of other companies, which is of vital importance to innovations. Using patents of other companies is more valuable than acquiring license fee in 9000 existing patents; the value subjects to no direct calculation, maybe it is 10 times the fee income. Therefore, this motivates enterprises to apply for more patents, and enable requirements of patent rights to be vague and wide, so as to build a stronger patent portfolio.

### (2) Impact of Patent Jungle on the Entry of New Enterprises

Enterprises entering a new market must invest in fixed assets, such as sunk cost, which generally comprises brand building, technological innovation investment and the like. Based on advantages of brands and technological leadership, existing enterprises in the market form competition advantages over new entrants, so that sunk cost can effectively reduce market entry and competition. Whether new enterprises can successfully enter the market mainly depends on sunk cost which forms obstacles for market entry of enterprises [11].

Patent right is an exclusive right given by the Law to patent holders. Fundamentally, patent rights of existing enterprises increase fixed cost of market entry of enterprises. Patent rights make up for the fixed investment of innovations of existing enterprises, and also build a barrier for market entry within the term of patent protection.

In complex technical fields, existing enterprises in the market will be encouraged to adopt a strategic patent layout. Large quantities of patent portfolio held by many existing enterprises form a dense patent jungle which has negative influence on market entry of enterprises. If existing enterprises already have patents covering the field, new entrants need to acquire the technical license of existing enterprises. When new entrants negotiate with existing enterprises, their transaction cost of patents will increase significantly, and they must pay high patent licensing fees. Although an enterprise may obtain the right to use patents through patent pool, cross authorization or open technical standards, these solutions all have inherent defects, as new entrants, who are in a vulnerable position, are unable to obtain equal opportunities in the relevant patent negotiations, which makes it difficult for new entrants to enter the market under the background of patent jungle.

### (3) Impact of the Patent Jungle on Innovation

In complex technical fields, the innovation of technology is often based on predecessors. Strong patent rights will have the negative influence on later innovation due to the exclusive protection of technologies. The influence of patent

jungle on innovations is mainly reflected on two aspects: 1) increasing entrants' innovation cost, which comprises patent design cost, the cost of using patent technology and the like; 2) decreasing the incentive of R&D investment.

As quantities of patents in specific technical fields increase, the possibility of fragmentation phenomenon of patent rights is also on rise. Due to the cumulative innovations of inventions, the downstream innovations cannot be separated from the upstream patented technology. In this case, innovators have to negotiate with multiple patent holders, while it is very difficult for them to sign patent licensing agreements with all patent holders. Therefore, innovators have to pay plenty of patent royalties, so that the innovation cost increases.

Firstly, competitions of patent portfolio among enterprises in the patent jungle will lead to increase in operation cost of enterprises, may lead to a reduction in R&D investment and other innovation activities. In addition, under the background of patent jungle, patent portfolio held by enterprises has influence on patent application of enterprises to different degrees. Enterprises with a larger patent portfolio tend to increase patent filings, while those with a smaller portfolio tend to do the opposite. The consequence is a more concentrated market and, more importantly, a squeeze on innovation space for new entrants and vulnerable enterprises [12].

Problems brought by patent jungle may be alleviated by adopting cross authorization, which, however, has a negative influence on incentives for R&D investment [13]. Based on a model of innovation competition between two companies, Bessen (2003) found that compared with the "winner takes all" patent competition model, the results of innovation must be shared with other patent owners in the context of cross authorization. More specifically, innovators' welfare is lost in negotiations and solution of cross authorization, which reduces incentives for innovation [14]. Meanwhile, the key factor of incentives for R&D investment of enterprises is the advantage of time lead, and cross authorization also eliminates the time lead effect of innovation. Besides, to acquire more advantageous position of negotiations in cross authorization, enterprises will often increase incentives for patent application, which will also cause some loss of social welfare. Similarly, the patent pool also has the problem of reducing R & D investment incentives. Innovation achievements of members in the patent pool are partially or fully shared by other members according to patent pool agreements, which will lead to the behavior that members in the patent pool take use of innovation achievements of others, thus reducing the incentive of innovation investment [15].

### 3.2. Analysis on the Mechanism of Problem Patent

Since the establishment of the patent system of China, government departments have been committed to playing a leading role in innovations in industrial fields through incentive policies or science and technology projects, which results in the birth of a large number of problem patents. Although Government departments have also been working

through institutional reforms to correct patent quality problems caused by excessive policy incentives, influence of Pro-Patent policy on innovation ecology is difficult to reverse in the short term [16]. First of all, with the total quantities and intensity of R&D expenditure input as well as huge input on aspects of innovations of personnel training and introduction, compared with the beginning of the establishment of patent system, China has made great progress in industrial development, and has continuously optimized industrial structure. At the same time, the contradiction between the lagging of policy reform and the upgrading of industrial structure has been continuously intensified [17], while the industrial innovation cannot provide enough support for industrial transformation and development due to issues of industrial patent quality, which is specific in that enterprises in the industry lack of core competitiveness, and most of their production and management are still mainly in the low-end manufacturing, so they are in a lower position in the international industrial chain. Justin Yifu Lin (2010) suggested in *New Institutional Economics* that "in the progress of economic development, a synergy between the market and the government must be brought into play, and at the same time, the structural characteristics of different levels of development must be taken into account in policies of the government and arrangements of various systems" [18]. Obviously, the various institutional arrangements in China are not well integrated with the industrial development structure or the needs of transformation and development, among which the problem patent is the result of inappropriate institutional arrangements.

Specifically, there are two main reasons for the emergence of problematic patents. First, the external factor, which is caused by the difference in the degree of mutual intervention between the government and the market. The government's excessive involvement in industrial innovation activities has led to the inability of the market mechanism to dominate the allocation of innovation resources, resulting in the mismatching between patents of innovation output and the development of the market. Generally speaking, although the western countries are also experiencing the phenomenon that the innovation output deviates from the original intention of the patent system design, due to the long development period of their patent system and the high maturity of the market economy, their government departments are more efficient in controlling the degree of intervention, so their scientific and technological innovation is closer to the real demand of the market; therefore, the level of our corresponding industries can be reflected to some degree on the basis of western benchmarking industries. Second, the internal factor, i.e., the endogenous factor. At present, the innovation ecology system of China has not yet formed, which exacerbates the impact of government intervention. It may be counterproductive to provide financial returns to individuals involved in innovation activities from the outset. Instead, innovation is a kind of creativity with an internal reward mechanism, that is to say, innovation is driven internally [19]. Innovation

requires the inventor's endogenous passion and motivation, honor and so on to play a role. According to the investigations of types of innovation subjects such as Apple Inc. and the University of Utah<sup>1</sup>, all the innovations take root in development demands of regional economy and even the global market, which is the key factor for innovation to be successful in the field of business. The endogenous factor has a significant influence on the innovation quality due to the fact that innovation motivation and behavior are the fundamental factors that determine an innovation marketing prospect. Therefore, when we inspect the innovation level of a certain industry, patent scale can only reflect the absolute innovation level of the industry. The comprehensive strength evaluation of industrial innovation also needs to be comprehensively considered in combination with the endogenous variables of industrial innovation.

## 4. Construction of Analytical Model of Situation of Industry Innovation Competition

### 4.1. Basic Issues of Model Building

The building of the analysis model is firstly based on the external factors that lead to the problem patents. Foreign industrial patents should be considered as comparative industries, because foreign industrial innovation is developed under the guidance of market mechanism. Compared with China, their scale and structure of industrial patents are more optimized and the contribution level of output patents is higher. Therefore, the positions of corresponding industries in China can be recognized through comparison. Secondly, when comparing industrial patents at home and abroad, due to the great promotion influence of China's patent incentive policies, patent applications in many industries have increased abnormally, which leads to the lack of basis for comparability between the scales of our industrial patents and the industrial patents of foreign benchmarking industries. Therefore, based on the significant positive correlation between patent maintenance time [20-21], i.e., patent duration, and patent quality, this paper starts from the endogenous factor of innovation, and selects the average duration of industrial patents as the correction coefficient to eliminate differences of innovation behaviors and innovation quantity caused by different policy environments as far as possible. Whether a patent holder maintains the patent or not is closely related to the trade-off between the potential benefits of the patent and the investment cost. Generally, the longer a patent lasts, the greater the potential benefits it can bring. However, both at home and abroad, the patent duration is consistent with the fundamental judgement of innovation achievement quality by patent holders, while the average duration of industrial patents can reflect the overall level of

<sup>1</sup> The University of Utah ranks first in *U.S. Technology Transfer Report 2017*, and has made outstanding achievements in the field of innovation and commercialization.

industry innovation quality.

#### 4.2. Framework Design for Model Building

The density of patent holders is taken as a typical measurement of patent quality measured in technical field, and represents the proportional relationship between the number of patents authorized and the corresponding number of patent holders in a specific technical field. Obviously, when the density of patent holders in the field is higher, the number of owners in the field is relatively small, the monopoly level is higher, the leaders who realize patent technology value are more concentrated, which is relatively ideal in the sense of technological innovation. However, the low density of patent holders represents the situation that many holders own patents, which is similar to the development trend of patent jungle. In fact, it is the state where patent technology innovation activities are most likely to suffer from friction and mutual restraint, and it is a typical state of highly competitive development. Therefore, the inspection of the density of patent holders is an important basis for measurement of the situation of industry innovation competitions.

#### 4.3. Industry Innovation Competition Situation Model

Combined with the basic problems and model framework above, this study gives the following analytical model of industry innovation competition situation from the perspective of patent quality, which is used to show the competitive situation of industrial innovation.

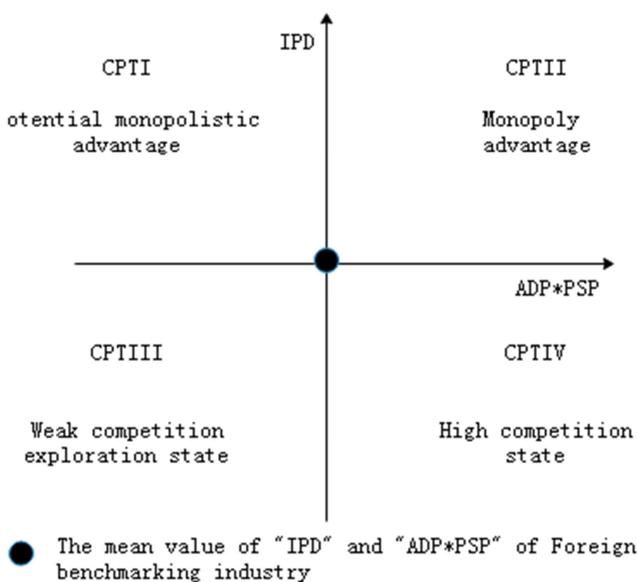


Figure 1. Industry Innovation Competition Situation Model.

*Abbreviation:* Proportion of the stock of industry patent (PSP); Industry patent density (IPD); Average duration of industrial patents (ADP); Competitive position of Technology (CPT).

The following four different situation of industry innovation competition is shown in Figure 1 above:

Competitive position I of technology is characterized by a smaller patent stock or share and a higher density of patent holders, which shows that patent holders in this range have a dominant position in pioneering technology development;

Competitive position II of technology is characterized by a larger patent stock or share and a higher density of patent holders, which shows that patent holders in this range have a monopolistic competitive advantage in corresponding fields and the state of the highest competitive position of current technologies;

Competitive position III of technology is characterized by a smaller patent stock or share and a lower density of patent holders, which shows that patent holders in this range are in an irregular state of technical exploration in corresponding fields, and that there is no outstanding competitive advantage among different subjects, nor can it represent the technical fields with obvious development trend at present. It belongs to the development state of patent technologies in a period of chaos.

Competitive position IV of technology is characterized by a larger patent stock or share and a higher density of patent holders, which shows that patent holders in this range have a state of saturated and highly competitive patent development in the corresponding field; the regions or enterprise groups in the collection contain each other, and patent technology cannot play a great monopoly role.

Above all, in the competitive position IV of technology, patent technologies cannot play a great monopoly role, and technological innovation will bring about a situation in which the marginal income from the implementation of patents and tax relief in the industry is approaching zero, that is, the patent output of a particular industry has exceeded the optimal patent scale matching the level of development of the industry, so that technological progress will no longer bring about an increase in industrial economy.

## 5. Case Study

To actually explore the implementation and effectiveness of the model, this paper measures the positions of patents in China based on the average share and density of patents of foreign countries by collecting effective patent data of USPTO in the technical field of electrical and electronic information from 2006 to 2016 based on the matching table of technology industry (IPC8 -Technology Concordance) published by the World Intellectual Property Organization in 2016, and calculating the share index and density index of China's patent distribution in the US to compare them with those of other countries (patent data of other countries except China in the US) in the same field.

Figure 2 below shows that the distribution of two groups of patents in the technical field of electronic information based on the average level of total share and density of patents of foreign countries (longitudinal and transverse lines). It can be seen that, according to the analytical model of situation of industry innovation competition, in the foreign ownership group, no field is within the scope of the

development of highly competitive technology of patent, while in China's ownership group, several IPC fields fall into this area. Meanwhile, foreign ownership group belongs to more IPC fields in the dominant state of patent monopoly.

Under the limit condition of factors of patent quality, the innovation of foreign industry is significantly better than that of China in competition intensity and market control within the industry. Besides, foreign countries are more in accordance with the law of industrial innovation development and more effective, in supporting the innovation ecology of industrial development competitiveness. Their industrial competition has a strong gradient from the state of weak competitive technology exploration to the state of technology leading monopoly advantage and then to the state

of technology monopoly advantage. While in the technical field of telecommunications, China's ownership group is not in accordance with the law of industry competition pattern in each IPC field and most of the IPC fields are in the weak competitive state of technology exploration, few of them are in the IPC fields of the leading technology and high monopoly, which shows low competitiveness and potential. At the same time, many IPC fields are in the state of highly competitive technology development, which indicates that the technology innovation bubble of China is serious at present in the telecommunication field, the innovation quality is insufficient, and the effective support of the innovation to the industrial development competitiveness is not enough.

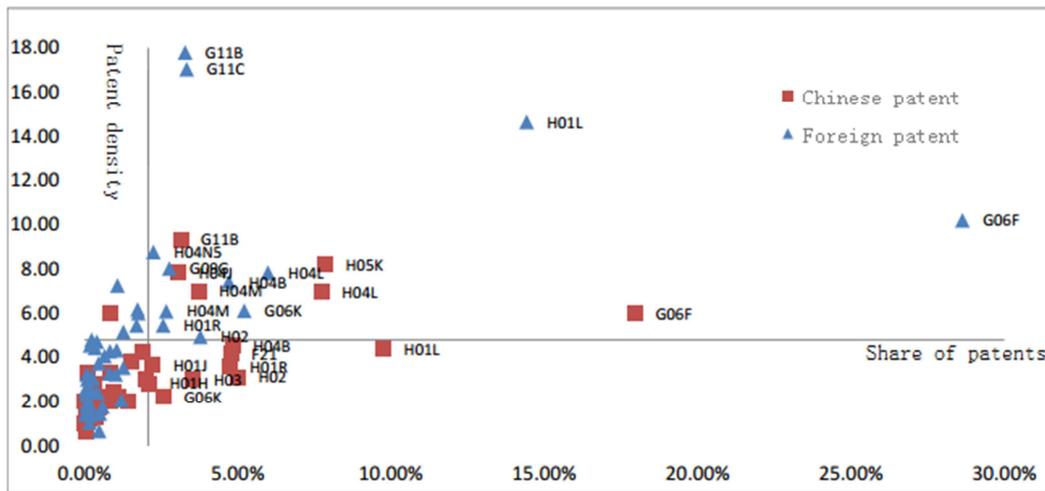


Figure 2. Analysis of the Competitive Situation of Industrial Innovation in Sino-US Telecom Technology Field.

This paper further compares model characteristics under different data bases, and analyzes the distribution of the industry competition situation based on China's patent data on the basis of Figure 2. Table 1 below shows that, based on patent data of foreign countries, there are more IPC fields in the development of highly competitive technology in China's

telecom (telecommunication) field. The results shown in Table 1 verify the effectiveness of using foreign industrial innovation level as a benchmark to some extent under the current situation of foreign-dominated telecom technology competition.

Table 1. China's Highly Competitive Technology Development Field under Domestic and Foreign Comparative Benchmarks.

China's Highly Competitive Technology Development Field	China's patent data base	Foreign patent data base
Different highly competitive technology fields in two analytical results of data base	G06T and H01M	H01L, H04B, H01R, H01J and H01H
Overlapping areas	F21, G06K, H02 and H03	

## 6. Conclusion

Under the current background that Chinese government strongly advocates industrial transformation and upgrading as well as quality and benefits, this paper starts from the typical phenomenon in two types of innovation and development progress of "patent jungle" and "problem patent", deeply analyzes the generation and influence model of patent jungle and the fundamental reason of the generation of problem patent. It also focuses on the problem of "excessive government intervention" that leads to these phenomena and the imperfect industrial innovation ecosystem in China's

specific development environment, and puts forward a framework for analyzing the competitive situation of industrial innovation from the perspective of patent quality and based on the level of foreign industrial innovation. This framework is based on the impact of patent jungle on the development of industrial innovation and takes patent stock (share) and the density of patent holders as measurement indices, which can effectively identify the location of China's benchmarking industrial innovation and provide effective support for guiding China's industrial innovation.

The application case in the technical field of telecommunications shows that, competition potential, competitiveness, competition pattern and the bubble

produced by innovation can be effectively recognized by using the analytical framework and methods designed by this paper and the rationality of analytical framework based on foreign benchmarking industries under the perspective of patent quality. However, at the same time, based on the current policy-driven and huge R&D input in the field of industrial innovation of Chinese government, it is also necessary to comprehensively judge the gap between the industry and the foreign benchmarking industry by combining the industrial competition situation obtained from the analysis framework with the specific industrial innovation. In particular, attention should be paid to controlling the quality level and bubble degree of China's industrial innovation so as to make correct and reasonable conclusions or decisions.

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