



# Research on the Quality of University-Enterprise Patent Cooperation Based on the Analysis of Chinese University Enterprise Patent Cooperation Data

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**Abstract.** The rapid increase in the number of university-enterprise patent cooperation shows that the university-enterprise cooperation innovation has achieved certain results. However, the quality of school enterprise cooperation is still worrying. Therefore, based on the total patent data of China's university-enterprise cooperation from 1985 to 2020, this passage analyzes the innovation performance of China's university enterprise cooperation from the perspective of patent quality from three aspects of technology, economy and law. Based on the analysis of the data, it is found that the quality of university-enterprise cooperation patents has improved, the market layout is relatively perfect, and the legal status of patents is generally good. But there are also some problems, such as low level of patent technology, scattered R & D team, low efficiency of patent operation, poor market competitiveness, poor patent stability, and poor awareness of patent protection. Finally, the corresponding countermeasures and suggestions are put forward.

**Keywords:** patent quality · university-enterprise cooperation · innovation cooperation

## 1 Introduction

The bottleneck problem of enterprises and the difficulty of university patent transformation make university enterprise patent cooperation become an inevitable trend. Existing research and data show that university-enterprise innovation cooperation is the main force to create knowledge and promote innovation. In the era of knowledge economy, all countries pay attention to adopting various methods to enhance their economic strength in the process of globalization. Among them, China attaches great importance to promoting university-enterprise innovation cooperation.

However, with the further deepening of university enterprise patent cooperation, scholars realize that the increase in the number of patents does not necessarily bring technological innovation, but will have a negative impact on the performance of university enterprise innovation cooperation. By integrating the research models and patent indicators of existing scholars, it is found that the novelty, potential value, market influence and transformation ability of patents can be evaluated from the aspects of technical

value [1], economic value [2] and legal value [3], as well as to judge the quality of patents. Therefore, based on the former research, this paper evaluates the performance of university-enterprise innovation cooperation from three perspectives of technology, economy and law, and answers the following two questions: what is the overall quality of university-enterprise patent cooperation? How to further improve the performance of university-enterprise innovation cooperation?

In order to ensure the integrity of the data of the applicants for the joint application of colleges and enterprises, the search formula is set as "(AN/University or AN/School or AN/College) and (AN/Group or AN/Company or AN/Factory) and NS/CHINA and not ANC/1", through consulting the literature and consulting the relevant experts. In addition, in order to make the data more accurate, the patent software was used to clean up the data, and 185961 university-enterprise cooperation patent data were selected. Although the number of patent applications in 2018–2020 is incomplete, it does not affect the judgment on the quality of the cooperative patent between the school and the enterprise.

## **2 Analysis on the Quality of University Enterprise Patent Cooperation at the Technical Level**

### **2.1 Trend Analysis of School-Enterprise Cooperation Based on All Cooperative Patents**

The number of patent applications represents the R & D strength of enterprises and reflects the technological innovation level of enterprises. The number of patent families also shows the technical value of patents in terms of application scope and cost [4]. Therefore, this paper constructs the dynamic change chart of the number of patents, the number of patent holders and the number of patent applicants from 1985 to November 2020 in Chinese mainland. Combined with the technology maturity curve, the overall development trend of R & D cooperation is divided into four main stages, 1985–2005, 1985–2005, 2005–2009, 2010–2011 and 2012 to present.

The first stage is the technology trigger period (1985–2005). During this period, China has absorbed a large number of foreign advanced experience and constantly made preparations for strengthening university-enterprise cooperation. In terms of system, China formally implemented the patent law in 1985 and began to establish its own patent database. In 2000, China revised the patent law again to bring the patent system in line with international standards. In terms of education, the government led educational reform has been gradually deepened, and higher education has been gradually improved and developed at this stage. Economically, China's industrial economy is developing rapidly, and there is a large talent gap. University-enterprise cooperation has begun to sprout, and patents at this stage are mainly concentrated in industrial production to meet the needs of growing industrial enterprises. Therefore, at this stage, the number of university-enterprise patent cooperation in China is growing slowly, and there is no obvious change. In 2001, China formally joined the World Trade Organization (WTO). This behavior prompted China to increase its opening-up, promote the rapid economic growth, and enhance the awareness of patent protection. In practice, the phenomenon of

“Tsinghua University and Peking University” has aroused scholars’ new understanding of innovation. Universities and enterprises actively explore and establish new ways of cooperation, such as “university enterprise cooperation laboratory”, University Science and Technology Park, University Science and technology.

The second stage is the peak period of hype (2005–2009). At this stage, the number of patent applications for university-enterprise cooperation in China increased slowly, but the number of patent families increased significantly, reaching a peak in 2008. This is because this technology has not been fully developed at this stage, and the reason for the increasing number of patent families is the promotion of the media. In the early development stage of the rise of cooperative patent activities, the media’s attention to technology not only affected the public’s attitude towards new technology [5], but also quickly attracted capital forces to settle in [6], which greatly promoted the development of University Enterprise Patent Cooperation in the international market. At the same time, because China attaches great importance to innovation and supports patent cooperation between school and enterprise in the process of globalization, the early accumulation has been fully revealed at this time.

The third stage is the tough period (2009–2011). The number of school-enterprise cooperation patents continued to increase, and the number of patents family reached the bottom in 2010. On the one hand, the economic crisis in 2008 brought heavy damage to the world’s innovation, which affected the choice of innovation strategies by different types of subjects [7]. On the other hand, because China is also aware of the importance of innovation, more school-enterprise participation in the process of school-enterprise patent cooperation has prompted a surge in domestic school-enterprise cooperation patents [2]. However, the quality of university enterprise cooperation patents will be affected by various subjective and objective factors, such as financial strength,

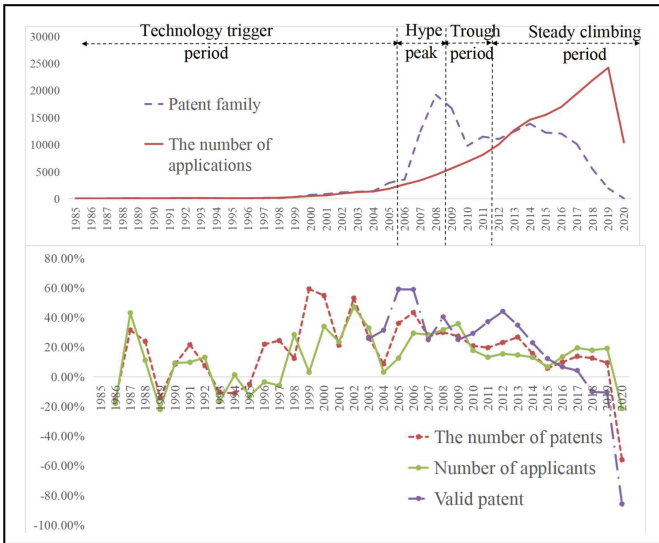


Fig. 1. Time series trend of patent application

technical reserves, the number of R & D personnel, government policies, administrative procedures, which makes the actual effect of university enterprise cooperation far lower than the psychological expectations of investors. The decline of media attention and the objective evaluation of patent cooperation by industry and academia lead to less speculation [8]. Therefore, on the whole, the number of patent families has declined at the present stage, but the number of patent applications for university-enterprise cooperation in China is still on the rise.

The fourth stage is the start-up period (from 2012 to now). At this stage, the number of university-enterprise cooperation patents increased rapidly, but the number of patent families decreased slightly. On the one hand, after several years of development, universities and enterprises have a deeper understanding of patent cooperation, and the media's attention to the cooperation has gradually become objective. On the other hand, the gradual maturity of university enterprise patent cooperation technology, together with the adjustment of government policies, has enhanced the trust of universities and enterprises in university enterprise patent cooperation, and the driving force of technology has stimulated the rapid growth of the number of university enterprise patent cooperation. However, the gradual reduction of the number of patent families also shows that the reemerging university-enterprise cooperation has the problem of insufficient patent protection or patent innovation. In addition, combined with Fig. 1, it is found that the growth rate of university enterprise cooperation patent applicants is slightly higher than that of patent applications. Since 2003, the growth rate of the number of effective cooperation patents and the total number of patents has shown a relatively slow year-on-year downward trend. On the one hand, the growth rate of university enterprise patent cooperation has slowed down due to the saturation of the number of patents brought by the technological growth of university enterprise patent cooperation. On the other hand, it also shows that the technological innovation of university enterprise patent cooperation is hindered to a certain extent, and there is an urgent need for new ways of cooperation to break the current situation of cooperation and promote the breakthrough innovation of university enterprise patent cooperation. Although the technical level of university enterprise patent cooperation has improved, it has not entered the mature stage on the whole, and needs to continue to promote technology upgrading.

### **3 Analysis on the Quality of University-Enterprise Patent Cooperation from the Perspective of Economy**

#### **3.1 The Economic Value Judgment Based on Patent Operation**

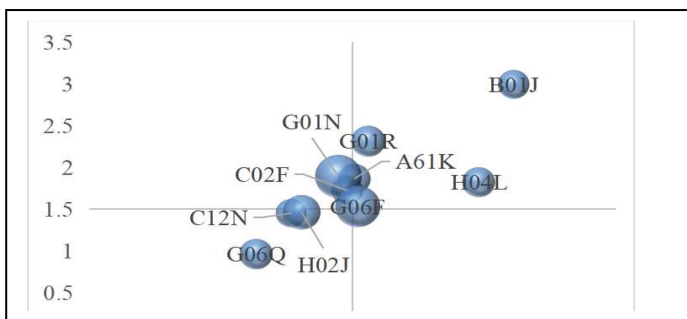
The operating status of cooperative patents is an important indicator of the flow of knowledge between universities and enterprises, and can be used to judge the quality of patents. It is generally believed that patent operation is an important indicator for judging whether a patent has market value, and the transfer of technology indicates that this technology is expected to bring benefits to both schools and enterprises, and therefore has a high market value. The valid patent data is divided into four parts: no transfer, external transfer, internal transfer, external transfer and no patent application by the assignee according to whether the patentee has changed. Among them, the number of patents

transferred within the group was 4,796, accounting for 5.28%; the number of externally transferred patents with patent applications by the assignee was 8,504, accounting for 9.36%; the number of externally transferred patents without patent transfer by the assignee was 2,459, accounting for 2.70%. However, 82.66% of the cooperative patents are still in the state of patent-free transfer. Observing the non-transferred part of applicants, it is found that the first applicants are still mainly universities. An analysis of valid patents without transfer status found that a total of 935 patent pledges and patent licenses occurred, accounting for 1.24%. Therefore, compared with other industries, the patent operation of school-enterprise cooperation patents has always been the focus of school-enterprise cooperation.

### 3.2 The Economic Value Judgment Based on Geographical Distribution

Technology research and development will be affected by market economic value, but not all high-value patents have high market value. It is generally believed that the number of patent applications is an important indicator of the economic value of patents. The more easily the technical field to create economic value, the greater the number of patents. Statistics have found that there are differences between popular technical fields and high-value technical fields, namely: G01R (measurement of electrical variables; measurement of magnetic variables), G06Q (specially applicable to data processing for administrative, commercial, financial, management, supervision or forecasting purposes) System or method), C02F (treatment of water, wastewater, sewage or sludge), A61K (accessories for medical, dental or toiletry), C12N (microorganism or enzyme; its composition). Moreover, the main technical hotspots in different years of school-enterprise cooperation patents are also changing. But on the whole, the hot technology fields are distributed in five fields: physics (G), electricity (H), human life necessity (A), operation (B), and chemistry (C) in order of quantity. The number of patents accounts for 35.19% of the total number of patents shows that the market applicability of school-enterprise cooperation patents is relatively high and covers a wide range.

In order to judge the competitiveness of the existing technology in the market, Fig. 2 is constructed according to the number of patent citations, the number of citations, and the degree of patent. Among them, patent citation refers to the citation analysis of patent documents. The more times a patent is cited, the more basic the patent is in promoting technological progress, the higher its patent quality, and the stronger its competitiveness in the market. Bakker found that there is a logarithmic relationship between patent citations and patent value, so the value of a patent collection (patent portfolio) can be expressed by the number of patent citations [9]. Lee and Sohn [2] believe that forward citation is regarded as a substitute for patent value. The number of citations refers to the number of times a patent has cited other patent documents, and the patent degree can be used to measure the quality of a patent. Therefore, set the X axis as the number of citations, the Y axis as the number of citations, and the size of the bubble chart as the number of special applications. In the quadrant chart, the closer to the lower half of the Y-axis, the more it is considered to have greater technical originality; the closer to the right of the X-axis, the better the quality of the technology; the larger the bubble, the greater the number of applications for the technology. The more, that is, the technical field located in the fourth quadrant has higher market competitiveness.



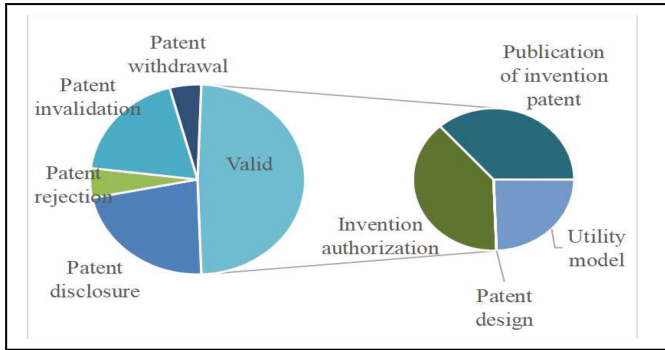
**Fig. 2.** The chart of market competitiveness of different technologies

Among them, some G06F patents belong to the fourth quadrant, indicating that this technology sub-category has strong market competitiveness. B01J, G01R, and H04L belong to hot technical fields with potential. G06Q is located in the third quadrant and belongs to the field of technology imitation, and its market competitiveness is relatively weak. Generally speaking, the patents of popular categories are mainly concentrated in the first, second and third quadrants, which have a certain degree of originality, but also have a high degree of imitation. Comprehensive analysis found that the economic value of school-enterprise cooperation patents is low. Therefore, it is necessary to continuously improve the level of school-enterprise cooperation patents, promote the originality of cooperative patents, and enhance their own market competitiveness.

#### 4 Analysis on the Quality of University Enterprise Patent Cooperation from the Legal Perspective

Studies have shown that the legal status of patents refers to the validity, disclosure, invalidation, rejection, and withdrawal of patents. It is an important indicator of patent quality and can help stakeholders understand the current status of school-enterprise cooperation and the value of patents in a timely manner. Among the three types of patents: utility model, appearance patent and invention patent, invention patents accounted for 80.41% of the first in the school-enterprise cooperation type, far exceeding the other two types of patents. This shows that the school-enterprise cooperation pays attention to patent innovation. Sex. School-enterprise cooperation patents have high value. Further constructing Fig. 3, based on the types of patents and their legal status, it is found that 71.31% of cooperative patents are in a valid and open state, which shows that the overall status of cooperative patents is relatively good.

Patent maintenance time and remaining maintenance time outline the legal protection time range of valid patents and are indicators for judging the stability of patents. Through sorting out, it is found that most of the school-enterprise cooperation patents generally have a maintenance time of 0–10 years, and some patents have a maintenance time of 10–20 years. When analyzing the remaining years, it is found that 27.88% of the cooperative patents are in the abandonment stage, and 72.12% of the cooperative patents have a better maintenance time. Moreover, from the perspective of the remaining years



**Fig. 3.** The chart of patent legal status

of valid patents, among the valid cooperative patents, most of the school-enterprise cooperative patents have remaining maintenance years of 6–19 years.

Patent claims can directly reflect the legal status of patents. The number of independent claims and the number of technical features summarize the scope of patent power, and the number of claims shows the technological innovation and value of patents. These three indicators are also the criteria for judging patent stability. Figure 3 shows the changes in the number of patent applications based on the number of independent patents, the number of claims, and the number of technical features. After statistics, it is found that the average number of technical features of school-enterprise cooperation patents is 26.01, the average number of independent weights is 1.43, and the average number of claims is 8.27. The above research shows that the scope of protection of school-enterprise cooperation patents is relatively small, and the stability of patents also needs to be improved.

## 5 Conclusions

The article systematically analyzes the current status of school-enterprise cooperation patents, and on the basis of combining patent analysis with patent roadmaps, it conducts an overall evaluation of the quality of school-enterprise cooperation patents from the perspectives of technology, economy, and law. Therefore, from the perspective of patent quality, the performance of school-enterprise cooperation patents still needs to be further improved.

The purpose of patent cooperation is the creation and flow of innovative resources. School-enterprise patent cooperation needs to continuously create new resources to avoid the phenomenon that low-value patents are flooded and bad money drives out good money. It also needs to revitalize the circulation of resources to create economic benefits in a timely manner. Deepen the value enhancement of school-enterprise cooperation patents in terms of technology, economy, and law, and firmly grasp the guiding and auxiliary role of the market and the government to school-enterprise cooperation.

(1) Improve the technical quality of universities and enterprises, enhance the overall quality, and form a high-value patent research and development group. First of all,

both schools and enterprises continue to deepen the role of technology in promoting school-enterprise patent cooperation. With the gradual saturation of the school-enterprise patent cooperation market, the number of school-enterprise patents has gradually slowed down. Therefore, schools and enterprises need to build a patent layout around core patents even if they recognize their own advantages. This is not only conducive to improving the technical quality of school-enterprise patent cooperation and increasing the number of high-value patents, but also conducive to reducing the waste of resources. Secondly, from the perspective of the entire process of school-enterprise cooperation, school-enterprise needs to gradually form a core R&D group with the efforts of third-party organizations and the school-enterprise itself. For example, Tsinghua University and China Petrochemical Corporation are expected to become the core of the R&D group and promote the school. The overall improvement of corporate R&D quality. However, building a core R&D group does not mean that all innovation resources are concentrated. All colleges and universities should improve their own patent quality in the process of upgrading their own technology and adjusting patent layout, and promote the balanced development of school-enterprise patent cooperation.

- (2) Improve the operation quality of school-enterprise patent cooperation, enhance the economic layout awareness of school-enterprise patent cooperation, and enhance the market competitiveness of school-enterprise cooperation. The main purpose of school-enterprise patent cooperation is to operate patents and improve the transformation of patents to bring timely benefits to universities or enterprises. Therefore, both schools and enterprises need to clarify their own responsibilities and obligations in the process of patent cooperation, and promote the research and development and operation of patents. Regarding the patents to be developed, with the help of third-party organizations or existing social relationships, strengthen the information communication between schools and enterprises to clarify the technical fields of patent research and development and the details of their cooperation, and improve the possibility of patents being developed or operated. With regard to patents under research, both schools and enterprises can introduce the role of the government and the market in improving the quality of patents and enhancing the performance of school-enterprise innovation cooperation, and further deepen the awareness of market-oriented economic layout. For example, universities are not very sensitive to the market, and companies need to grasp market dynamics or seek help from the government, technical intermediary services and other institutions in the process of improving patent novelty and enhancing market competitiveness. Enterprises pay attention to the timeliness of patents, so both parties can clarify the progress of research and development in the cooperation signing, and shorten the time for technology research and development. Regarding researched and developed patents, we should pay more attention to the information exchange barriers in the process of patent conversion, and consciously seek third-party organizations for purposeful promotion or construct patent layouts based on economic hot spots to reduce the obstacles to patent conversion.
- (3) Enhance the patent protection awareness of universities and enterprises, and enhance the stability of school-enterprise cooperation patents. The law is an important barrier for patent protection, which helps reduce the economic losses of both schools and



enterprises and protects the interests of both parties. However, the awareness of patent protection between schools and enterprises is relatively lacking, and patent protection is also limited. Therefore, in the process of patent cooperation, schools and enterprises can seek the help of patent agencies, law firms, etc., to draft patent claims of higher quality, and effectively clarify the scope of patent protection. At the same time, in the process of patent cooperation, the signing of the contract allows both the school and the enterprise to standardize the responsibilities and obligations of both parties, clarify the patent ownership, and reduce the occurrence of legal disputes.

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