Research on Innovation Research Methodology of Agricultural Machinery Science Based on Patent Analysis

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Keywords: Agricultural machinery; Patent analysis; Competitive situation; Competitive intelligence

Abstract: This paper takes the agricultural machinery related patents included in the Chinese invention patent database as the research object, uses the analysis method of patent measurement and visual analysis tool, and analyzes the development status of agricultural machinery in China from four aspects, including technical trend, analysis of the patentee, legal status and citation frequency. The results show that China's agricultural machinery industry is in a period of vigorous development, so colleges and universities and graduate students are an important force in the research of agricultural machinery innovation.

1. Introduction

Agricultural machinery is the general term for various power machinery used in agricultural production and the supporting work tools. The development level is an important indicator to measure the agricultural modernization in China, and one of the ways to improving the level of agricultural mechanization is an important factor to promote the sustainable development of China's agricultural resources. As a big agricultural country, but not a strong agricultural country^[1]. since the end of the 1990s, China has implemented a series of scientific research projects such as 863, 973 and national science and technology support, and gradually began to promote the agricultural machinery industry, which has enabled the field to develop rapidly. A series of remarkable scientific research achievements have been made in the direction of precision sowing and field harvesting, but the overall level still has a certain gap compared with developed countries. In recent years, the Central Document No. 1 has increased its support for the agricultural machinery field, and clearly pointed out that agricultural machinery and equipment is one of the top ten areas for future manufacturing development in the strong country strategy "Made in China 2025". Therefore, it is of great strategic significance to correctly evaluate the development trend of the agricultural machinery industry and improve the utilization rate of agricultural resources, reduce the production labor force, and enhance the competitiveness of international agriculture.

The patent information has the characteristics of strong practical application, wide transmission channels and perfect legal protection measures. Through systematic research and analysis of patent information, it can accurately reflect the scientific research dynamics in related fields, Forecast of trends thus enabling the realization of future technological development. Under the dual role of relevant policy support and market demand, the number of agricultural machinery related patents has grown rapidly. In order to understand the current state of technology development in China's agricultural machinery field, this paper uses the Chinese Intellectual Property Office's SIPO patent search system, combined with Soopat and PatSnap wisdom buds. The patent search and analysis platform comprehensively analyzes the Chinese patent information in the field of agricultural machinery. Based on the analysis and comparison, it evaluates and judges the risks of the agricultural machinery industry, in order to explore new methods and approaches research on the

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⁴⁷³

high-end innovative research talents in the agricultural machinery industry in China.

2. Agricultural Machinery Industry Chain Map

Agricultural machinery is a typical mechanical equipment product. Its production process is similar to most industrial products. It has the characteristics of industrial design integration, diversified business models and diversified technical fields. The agricultural machinery industry chain diagram and the agricultural machinery industry Covering a wide range, usually based on field operations, post-harvest processing, agricultural product processing three aspects of design, refine the operation requirements, and finally design the finished product, after quality inspection, technical appraisal, market promotion, and ultimately achieve supplier sales. However, compared with sophisticated industrial equipment, most agricultural machinery is not complex, technical barriers are weak, processing is difficult, and market homogeneity is severe, resulting in a harsh competitive environment and slow growth in corporate revenue. In addition, most agricultural machinery purchase subsidies for agricultural machinery, and marketing often takes a long time. In this context, new technologies are not fully applied in agricultural machinery and equipment. At the same time, the agricultural machinery sales target is mostly farmers, which further limits the manufacturing cost and it also affects the use of high-cost technology in agricultural machinery and equipment. Therefore, the research on patent information in the field of agricultural machinery helps to accurately understand the market trends, and then Scientific research and new product development provide adequate protection.

3. Data Source and Data Acquisition Method

The time range of patent information retrieval in this paper is from January 1985 to September 2018. Due to the certain lag of patent disclosure and authorization time, there is a little data incompleteness in 2018, so it is only for reference in patent analysis. The data was collected from the SIPO patent search system of the State Intellectual Property Office of China, supplemented by the Soopat patent search and analysis system. Agricultural machinery patents are collected through three channels. One is to search by IPC classification method, that is, the IPC classification number with obvious agricultural machinery characteristics is searched. The search IPC code is "A01B or A01C or A01D or A01F or A23B9/02 or A23B9. /06 or A23B9/08 or A23F3 or A23F3/06 or B07B or C10N40/00 or F15B or F15C or F26B1/00 or F26B21/00 or G01M17 or G05B19/00", The second is to use the keyword search to collect statistics on patents containing "agricultural machinery" and similar meanings in the title and abstract, and to filter keywords with similar meanings such as "agricultural machinery, agricultural machinery, agricultural product processing, agricultural machinery". Words are searched using Boolean logic and filter duplicate patent information. The third is to collect relevant patents through the exhaustive method, that is, select about 130 agricultural machinery keywords from relevant literature and enterprise product data for retrieval^[2]. Finally, the three parts of the search results are classified, the keyword exclusion, the summary information screening and other measures, which reduce the influencing factors such as food processing machinery and forestry machinery, and finally collate 22,277 patent data that meet the requirements. Conduct a situation analysis in the field of agricultural machinery in China.

4. Results and Analysis

4.1 Technology Development Trend.

The amount of patent applications can reflect the degree of technical activity and development scale in related fields to a certain extent^[3]. Figure 1 shows the changes in the number of agricultural machinery related patent applications received by the SIPO between 1985 and 2018, as the patent disclosure has a patent application date. For a certain lag period, the 2018 data is only for reference. It can be seen from the figure that the change in the number of patent applications is basically divided into three stages: the first stage is from 1985 to 2002, the number of agricultural machinery

patent applications is very small, and the average annual application volume is about 28, at this time China's agricultural machinery Technology has just started, people do not pay much attention to the awareness of patent protection, so the application volume growth is very slow, in the embryonic stage of patent development, The second stage is from 2003 to 2012. At this time, the state's support for the agricultural machinery sector has gradually become more effective. At the same time, the domestic labor structure has undergone a significant change. The scale of the rural labor force entering the non-agricultural sector has been increasing, prompting farmers to adopt more mechanized services. The number of patent applications began to grow steadily, and the number of applications and growth rates in the year were significantly higher than those in the embryonic stage. The third stage is 2013-2017. The number of patent applications has increased substantially, with an average annual growth rate of 35.12%. In 2015, it reached more than 63.33%. At the same time, the number of patents in this stage accounted for 79.24% of the total number of patents, which is at the mature stage of patent development. It shows that China's emphasis on agricultural machinery and R&D investment is increasing, and its technical level and diversity are constantly improving. In the future, it will maintain a high level of activity, which is the birth of key technological innovations and core invention patents. Provided good conditions.



Figure. 1 Number of patent applications in the field of agricultural machinery in China

Focus on the analysis of patented technologies in the field of agricultural machinery, to assess the concentration of patent distribution in the field and the future development direction, through the statistics of the IPC (International Patent Classification) sub-category, the most important 10 classifications are shown in Figure 2. The meanings of each IPC classification number are listed in Table 1. The number of patents in these categories accounts for 65.70% of the total number of patent applications. Therefore, this part of the patent can accurately represent the status quo of agricultural machinery. Among them, A01C, A01D and A01B contain significantly more patents than other fields, accounting for 69.09% of the main categories. According to the meaning of IPC, the three parts of arable land, sowing and harvesting are the main innovation directions, which is also related to the market. The corresponding agricultural machinery types are consistent, such as rotary tillers, no-till seed drills, corn harvesters, etc.[4], and the market presence and economic value are much higher than other agricultural machinery. The patents under the other classifications correspond to crop management and follow-up treatment. The main distribution characteristics are consistent with the structure of agricultural machinery industry chain, but the number is significantly different from the above-mentioned three aspects of "cultivation and harvesting", indicating that China's research on agricultural machinery It is mainly concentrated in the field operation stage, and there are few systematic studies on post-harvest processing and agricultural product processing.



Figure. 2 Main IPC classification of patents in the field of agricultural machinery in China Table 1 Main IPC classification description of patents in agricultural machinery field

IPC	
Classification	IPC Classification Scheme
Codes	
A01C	Plant, Sow, Fwetilize
A01D	Harvest, Mow
A01B	Preparation of land for agriculture or forestry, Parts of general agricultural machinery or tools, Parts or accessories
A01G	Gardening, Vegetables, Flowers, Rice, The fruit trees, Grapes, Cultivation of hopes or seaweed, Forestry, Watering
A01F	Threshing
A01M	The capture, trapping or startle of an animal
F16H	Gearing
A23N	Machinery or devices not included in other classes for processing large quantities of harvested fruits vegetables or flower bulbs; Exfoliation of large quantities of vegetables or fruits; To prepare livestock feed
B62D	equipment A motor vehicle; trailer
B07B	To separate solids from solids by fine screening, coarse screening, screening, or airflow. Other dry methods of separation suitable for bulk materials, such as separation of loose articles suitable for handling as bulk materials.

The patented aggregation analysis can visually represent the technology-intensive areas and correlations, and can quickly understand the technical aspects of the industry. Classify all the patents and extract the keywords, and import the patent data into the PatSnap wisdom bud patent search and analysis platform, and draw the 3D patent map as shown in Figure 3. According to the contour distribution, the peak amplitude is distinguished. The higher the peak, the more patent applications, the more comprehensive the technology in the field. The closer the distance between different regions, the stronger the correlation. It can be seen from the figure that the patents in the field of agricultural machinery in China are mainly concentrated in the upper left, middle lower and upper right areas of the figure, which represent the three stages of field planting, tillage and harvest, which are consistent with the previous IPC classification statistics. The sowing process is mainly composed of paddy field sowing technology and dryland sowing technology. The correlation between the two is strong, indicating that there is a certain technical commonality, The ploughing and finishing process is relatively independent and weakly related to other technologies, the harvesting process is mainly composed of harvesting technology and threshing and cleaning technology, and the correlation between them is extremely strong, indicating that they promote each other and have a positive impact during the technology research and development process. In addition to the above three main links, the power machinery and electronic technology represented

by the lower right corner of the figure also have a certain degree of convergence, which has obvious technical expansion trend, but its development is slower than that of traditional field operations. It shows that the field of agricultural machinery in China has gradually begun to develop intelligently on the basis of the traditional model.



Figure. 3 Technology associated map

4.2 Analysis of the Main Rights Holders.

Figure 4 shows the distribution of the top 15 patent holders in the agricultural machinery field. According to the statistical results, the top 15 major patent holders applied for a total of 5,713 patents, and domestic universities, research institutes and foreign-funded enterprises dominated. Status, including 13 domestic universities and research institutes, and 2 foreign-funded enterprises. The China Academy of Agricultural Mechanization Sciences has the nature of enterprises and scientific research institutes. In the statistical distribution, it can also be counted as domestic enterprises. Combined with the overall data analysis, China's application for agricultural machinery patent institutions are mostly traditional strong agricultural universities and research institutes. The representative universities are China Agricultural University and Jiangsu University. In the latest round of subject evaluation of the Ministry of Education, the evaluation of agricultural engineering disciplines in two universities They are A+ and A-level respectively.[5] They have strong advantages in talent introduction and research funding, and lay a good foundation for agricultural mechanization technology construction. The Nanjing Agricultural Mechanization Research Institute of the Ministry of Agriculture is the most agricultural engineering discipline of the Chinese Academy of Agricultural Sciences. The main supporting units, focusing on the direction of agricultural mechanization projects, the scientific research strength of the three is close, and the number of patent applications is small, which is significantly higher than the subsequent ranking units. Other patent applicants are mostly traditional agricultural institutions (or predecessors of agricultural institutions), such as Northwest A&F University, Northeast Agricultural University, Hunan Agricultural University, etc.[6] The statistical results include three foreign-invested companies, among which Kubota and Yanmar Co., Ltd. are well-known Japanese paddy machinery manufacturers, and their developed machines have high market coverage in the world, so they have a patent protection process in China. More mature experience.



Figure. 4 Number of patent applicants in the field of agricultural machinery

Combined with the analysis of the patentee's overall data, China's agricultural machinery research resources are basically controlled by domestic universities and research institutes, and domestic enterprises and foreign-funded enterprises are in sharp contrast. China's enterprises lack research and development capabilities and innovation, and technical barriers are weak. Agricultural machinery, as a typical industrial product, will rapidly expand its market coverage once mature technology has occupied the market. Obviously, the potential practical value and transformation capacity of China's agricultural machinery patents are inconsistent. Industry-university-research system structure is progressing slowly, Foreign-funded enterprises such as Kubota and Yanmar have firmly controlled the positioning of their products in the market and implemented strict intellectual property protection measures, which further restricts the large-scale development of domestic agricultural machinery enterprises. In contrast, the level of application of intellectual property strategies in China still has a certain gap compared with developed countries.[7]

The classification and statistics of the patent application IPC of the main patentee can visually observe the technical distribution characteristics and technical focus. Figure 5 is a technical difference analysis diagram of the main rights holders in the field of agricultural machinery. The more patent applications the patentee contains in an IPC classification, the larger the bubble shown in the figure, indicating that it is in the field. The technology mastered by the internal technology is stronger.[8] Compared with the common IPCs of all the patents in Figure 2, the main patentee IPC classification does not appear in the A23N, B07B two categories, but added B65G (transport or storage devices, such as loading or tilting conveyors, workshop conveyor systems, Pneumatic pipe conveyor) and G05B (general control or regulation system and its functional unit, monitoring or test equipment for systems or units). The preliminary comparison shows that since the main patentees are mostly universities and research institutes, they have relatively advanced and complete scientific research conditions, and have relatively mature R&D experience in large-scale crop transportation institutions and agricultural intelligent management fields. Therefore, the number of patent applications is large, further Based on the analysis of statistical results, the IPC classification of the main patent holders in the field of agricultural machinery in China can be summarized into three main types: First, China's agricultural universities, the Nanjing Agricultural Mechanization Research Institute of the Ministry of Agriculture, Jiangsu University, Northwest A&F University, and other domestic first-line universities and research institutions are characterized by a wide range of patent applications, [9] comprehensive technical layout, and varying strengths. It is not big, it not only guarantees the intensity of scientific research in the main direction, but also develops in other directions, and forms a relatively complete technical system. Secondly, it is a strong agricultural university and research institute based on Northeast Agricultural University, South China Agricultural University and Guangxi University.[10] The organization is characterized by its particular strength in a certain discipline. Through years of continuous accumulation and innovation, it has a strong scientific research competitiveness, and at the same time it has gradually developed in other fields. The third is Kubota Co., Ltd. The foreign-funded enterprises mainly based on Ma Co., Ltd. are characterized by their outstanding orientation in a certain direction. There is almost no relevant research in other directions. The technical focus is very obvious, and the direction is different from that of domestic universities and scientific research institutions.



Figure. 5 Analysis of the technical differences of the main patentees

Overall analysis, China's universities and research institutions have great differences in technology layout compared with foreign-funded enterprises. Although the number of patents has an absolute advantage over enterprises, in a specific direction, foreign-funded enterprises have initially completed domestic technology. Monopoly, China has no occupation advantage on the international platform; at the same time, China is relatively concentrated in most research directions, and the degree of repetition is relatively high. This also shows that China has insufficient innovation in the field of agricultural machinery, and the degree of cross-coupling of multidisciplinary is relatively low. It is easy to cause repeated research and development, resulting in waste of scientific research resources, which is not conducive to diversified development. In addition, due to the large differences in research between Chinese and foreign competition institutions, it further reflects the lack of intellectual property awareness of agricultural machinery enterprises in China, and the deterioration of scientific research environment, which limits the autonomy of enterprises. Innovation.



Figure. 6 main patentee technical cooperation relationship chord diagram

The cooperation relationship analysis is carried out for the patentee who has cooperated more than 5 times, and the results of drawing the cooperative relationship string diagram are shown in Fig. 7. The different arcs on the outer side indicate the distribution status of different patent holders, and the connection between the arcs indicates cooperation. Relationship, the thickness of the connection indicates the degree of cooperative relationships are relatively close in scope, and all of them have obvious regional characteristics, that is, local universities or research institutes cooperate with local enterprises. The advantage is that they can carry out technical research according to the characteristics of local agronomics, and facilitate testing and production. The shortcomings are technical limitations, and it is not easy to generate coupling and cooperation between technologies in different fields, which is not conducive to the implementation of new technologies and the development of new products.

Table 2 Patent Law Status Statistics					
Legal Status	Number of Patents	Proportion			
Authorization	4725	21.31%			
Substantive Examination	8081	36.28%			
Public	2351	10.55%			
Did not pay the annual fee	1726	7.75%			
Expiration	15	0.06%			
Withdraw	4087	18.35%			
Reject	1236	5.55%			
Give up	56	0.25%			

5. Analysis of Patent Law Status

The legal status statistics of 22,277 patent applications were as shown in Table 2. Among them, 4,725 were valid patents, accounting for 21.21% of all patents, and 10,432 were in trial and public patents, accounting for 46.83% of all patents. Other invalid patents 7,120 pieces, accounting for 31.96% of all patents, most of the patents are concentrated in the state of trial, indicating that the level of scientific research in China's agricultural machinery has increased in recent years, and the number of patent applications has increased significantly. Since the level of agricultural mechanization is closely related to economic benefits, the more patents fail, the worse the economic

transformation capability. Further analysis of the invalid patents, 5,323 patents withdrawn and rejected, accounting for the vast majority of all invalid patents, indicating that the patents In the application process, there are problems of low patent quality and poor innovation.[11] The number of patents that failed due to the failure to pay the annual fee was 1,532. The previous statistics show that the development stage of China's patents began in 2005. Before that, the number of patents applied was very small, indicating that the patents granted in the past 10 years or not have expired. The proportion gradually increases, which further proves that the potential economic value of patents in the field of agricultural machinery in China is relatively low. Although the technology develops rapidly, it cannot be converted into economic value for various reasons. With the rapid increase in the number of patent applications in recent years, it should be improved. The quality of patent innovation ensures the healthy development of the industrial economy.[12]

Table 3 Statistics on the number of patent citations						
	Publication number	Patentee	Cited frequency			
1	CN101273688A	Jiangsu University	73			
2	CN102165880A	Nanjing Agricultural University	58			
3	CN102124866A	Nanjing Agricultural University	54			
4	CN101019484A	Jiangsu University	48			
5	CN101356877A	China Agricultural University	47			
6	CN104255090A	Guangxi wufeng machinery co. LTD	46			
7	CN101066022A	Jiangsu University	46			
8	CN101663972A	Shenyang Agricultural University	42			
9	CN101040581A	Shanghai zhihai information technology co., LTD	40			
10	CN101395989A	Jiangsu University	39			

6. Reference Frequency Analysis

The number of patent citations is the most intuitive indicator to measure the influence of technology. The more patents are cited, the more the patent has the strong technical consensus in the industry, and the patent value and quality are higher.[13] All the patents were sorted according to the number of citations, and the 10 patents with the highest citation frequency were selected as the research objects, and the technical layout of the high citation frequency was further analyzed. Among the 10 high-licensed patents, the patents applied by universities have absolute advantages. There are 4 Jiangsu universities with the highest proportion, indicating that Jiangsu University's research has strong technical influence and industrial value in the industry. It has a strong position; Nanjing Agricultural University has two high-licensed patents, and the number of citations is ranked in the top three, and the scientific research level is also highly competitive; all high-licensing patents include two companies, of which Guangxi Five Feng Machinery Co., Ltd. is a private enterprise specializing in the production of agricultural machinery. Compared with the two foreign-invested companies such as Kubota and Yanmar Co., Ltd. in the statistics of the main patent holders in the previous article, although the number of patents is very different, the core patents also have With certain technical influence, Guangxi Wufeng Machinery Co., Ltd., as a domestic private enterprise, has begun to attach importance to the importance of intellectual property rights, and will provide other companies with a good development strategy to accelerate the R&D structure of the entire industry. Transformation; another domestic company is Shanghai Domain Leader Information Technology Co., Ltd. The company is not an agricultural machinery research and development and sales organization, but the high-licensed patents applied for it belong to the direction of intelligent agriculture. The frequency of citations also indicates that in the field of traditional agricultural machinery, the combination of traditional agricultural machinery and electronic sensing technology has gradually matured, and agricultural intelligence has gradually begun to gradually development.

7. Conclusions

Through the statistics of the above related patents and the analysis of the maps, from the perspectives of patent technology trends, patentee analysis, legal status and validity, and frequency of patent citations, the current development of agricultural machinery in China is revealed, and the following conclusions are drawn.

a) China's agricultural machinery industry is in a period of rapid development and has great development potential, but the research is relatively concentrated, mainly in the direction of field operation machinery, such as farming machinery, seeding machinery, harvesting machinery, and various research institutions have formed fixed technologies. The layout has produced certain scientific research results, but the shortcomings are that the research is repetitive, the technical coupling ability is weak, and the intelligentization trend is slow. Therefore, the coordinated development of various technologies should be strengthened to form strong technical barriers and adapt to agricultural modernization. development of.

b) At present, the main research subjects are mainly concentrated in universities and research institutes. They not only shoulder the task of innovation research in the agricultural machinery industry, but also bear the responsibility of cultivating high-end technical talents in the future agricultural machinery industry, and the development of modern agricultural machinery embodied in patent analysis The trend requires graduate students to further master multidisciplinary knowledge and conduct cross-disciplinary research to meet the major agricultural demand for modern agricultural machinery in the future.

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