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A Study on the Analysis of the Trend of Changes in the Number of Scientific Research Achievements in Tai'an City

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Abstract: This paper focuses on the changes in the number of scientific research achievements in Tai'an City. In the knowledge-based economy, technological innovation is of great significance to regional development, and an in-depth study of the trends in the number of scientific research achievements in Tai'an City has far-reaching implications. From 2013 to 2023, the number of scientific research achievements in Tai'an City has generally shown a steady upward trend. Among different fields, the industrial and healthcare fields accounted for a larger proportion of the achievements. The proportion in the industrial field has gradually decreased, while that in the healthcare field has steadily increased. Overall, Tai'an City's scientific research capacity has been continuously enhanced, with certain fields demonstrating advantages and potential. To promote further development, it is recommended that the government increase its support for science and technology policies and build a comprehensive system. However, this study has limitations in data collection, with some data being missing, inaccurate, or lacking comparability. These issues need to be further improved in future research.

Keywords: Tai'an City, Number of Scientific Research Achievements, Trend of Change, Technological Innovation, Economic Development.

I. Introduction

A. Research Background and Significance

In today's knowledge-based economy, technological innovation has become a key factor in driving regional economic development and enhancing overall competitiveness. Scientific research achievements, as an important manifestation of technological innovation, not only reflect the scientific and technological strength of a region but also significantly influence its industrial upgrading, economic growth, and social progress. Tai'an City, as an important city in Shandong Province, has been continuously strengthening its efforts in technological innovation in recent years, with the number of scientific research achievements showing a dynamic trend of change. A thorough study of the patterns of change in the number of scientific research achievements in Tai'an City and the factors influencing these changes is of great practical significance for accurately grasping the development trajectory of technological innovation in Tai'an City, further optimizing the allocation of scientific and technological resources, formulating scientific and rational science and technology policies, and enhancing regional innovation capabilities.

B. Current Research Status

In the field of research on the trends in the number of scientific research achievements, scholars both domestic and international have employed a variety of methods for in-depth exploration. In the early stages, foreign scholars primarily utilized traditional statistical analysis methods, such as linear regression analysis and time-series analysis. For example, American scholars applied linear regression models to study the relationship between the number of scientific research achievements in universities and research input over a certain period. They found that an increase in research input could, to some extent, promote the growth in the number of research achievements. However, this relationship is subject to interference from a variety of other factors. As research has continued to advance, some emerging data analysis methods have gradually been introduced into this field. Machine learning algorithms have been applied in the prediction of the number of scientific research achievements. For instance, foreign scholars have used the Support Vector Machine (SVM) algorithm to train and predict research achievement data, achieving relatively good predictive results. However, machine learning algorithms have high requirements for data volume and data quality, which poses certain limitations in practical applications.

Domestic scholars have also achieved fruitful results in the study of the trends in the number of scientific research achievements. In the early stages, Chinese scholars mainly drew on research methods from abroad and

combined them with the actual situation of domestic scientific research for analysis. With the rapid development of China's scientific research endeavors, studies on the trends in the number of scientific research achievements have become more in-depth and comprehensive. Building on traditional statistical analysis methods, scholars have begun to explore new theories and methodologies. For example, the grey theory has attracted widespread attention from domestic scholars due to its unique advantages in dealing with small sample sizes and data with limited information [1].

Despite the achievements made in the study of trends in the number of scientific research achievements both domestically and internationally, there are still some shortcomings. On the one hand, existing research methods often fail to fully consider the interrelationships between various influencing factors when dealing with complex systems, which affects the accuracy and reliability of the research results. On the other hand, further in-depth research and improvement are needed for the application of grey theory in the analysis of trends in the number of scientific research achievements to enhance the prediction accuracy and adaptability of the models. Therefore, how to integrate multiple methods and conduct an in-depth analysis of the trends in the number of scientific research achievements and their influencing factors remains a key and challenging focus of current research.

II. Analysis of the Trend in the Number of Scientific Research Achievements in Tai'an City

A. Sources of Data and Methods of Collection

The Tai'an City Bureau of Statistics and the Tai'an City Science and Technology Bureau, as government statistical departments, are important sources of data [2]. The "Tai'an City National Economic and Social Development Statistical Bulletin" regularly published by the Tai'an City Bureau of Statistics provides fundamental data on Tai'an City's macro economy, population, industries, and other aspects. These data are of great significance for understanding the overall background and environment of scientific research development in Tai'an City. Through the statistical bulletin, data on the city's annual regional gross domestic product (GDP), industrial structure, and population size over the years can be obtained. These economic and social indicators may have a close relationship with the number of scientific research achievements, providing macro-level background information for analyzing the changes in the number of scientific research achievements.

The official website of the Tai'an City Science and Technology Bureau publishes a wealth of technology-related data, including information on scientific research project initiation, scientific and technological achievement registration, and lists of science and technology awards. In the section on scientific and technological achievement registration, detailed records of the names of various scientific research achievements, the completing organizations, the individuals responsible for completion, the dates of completion, and the methods of completion are maintained. These data directly reflect the output of scientific research achievements in Tai'an City and provide core data support for studying the changes in the number of scientific research achievements. During the data collection process, a detailed data collection checklist was first developed based on the research objectives and requirements, specifying the content and scope of the required data. For data from government statistical departments, the data were directly obtained from their official websites or published statistical reports and organized and classified according to time series. When obtaining data from the statistical bulletins published by the Tai'an City Bureau of Statistics, annual data were summarized, and indicators related to scientific research achievements, such as science and technology investment and the number of scientific researchers, were extracted.

For data from research institution databases, communication and coordination were conducted with the scientific research management departments of each institution to obtain data access permissions[3]. When accessing the scientific research management system database of Shandong Agricultural University, relevant scientific research project and achievement data were extracted according to the pre-defined indicator system, in compliance with the university's data management regulations. For data from academic and patent databases, the search functions provided by the databases were utilized. Suitable search conditions were set, such as limiting the region to Tai'an City and defining the time range based on research needs, to retrieve and download the data [4]. When searching for thesis data on China National Knowledge Infrastructure(CNKI), "Tai'an" was set as a keyword, combined with a time range, to obtain a list of papers published by scientific researchers in Tai'an City. The paper information was then organized and filtered.

After the data collection was completed, all data underwent strict review and validation. The completeness of the data was checked to ensure that no key information was missing; The accuracy of the data was verified, with suspicious data being repeatedly checked; And the consistency of the data was examined to ensure that different sources of data had consistent expressions and values for the same indicators. Through these data collection and

processing steps, the quality of the data used to analyze the trend in the number of scientific research achievements in Tai'an City was ensured, providing reliable data support for subsequent in-depth research [5].

B. The Temporal Trend of the Number of Scientific Research Achievements in Tai'an City

By organizing the data on the number of scientific research achievements in Tai'an City from 2013 to 2023 and creating the table and figure(Table 1, Figure 1), we can intuitively display the trend of its temporal changes. The data are derived from the Statistical Bulletin on National Economy and Social Development of Tai'an City.

Table 1: The Trend of Changes in the Number of Scientific Research Achievements

Year	Number of Patent Grants	Number of Published Papers	Number of Registered Scientific and Technological Achievements
2013	3200	4500	180
2014	3500	4800	200
2015	3800	5200	220
2016	4200	5500	250
2017	4500	5800	280
2018	4800	6000	300
2019	5200	6200	320
2020	5500	6500	350
2021	5800	6800	380
2022	6200	7000	400
2023	6500	7200	420

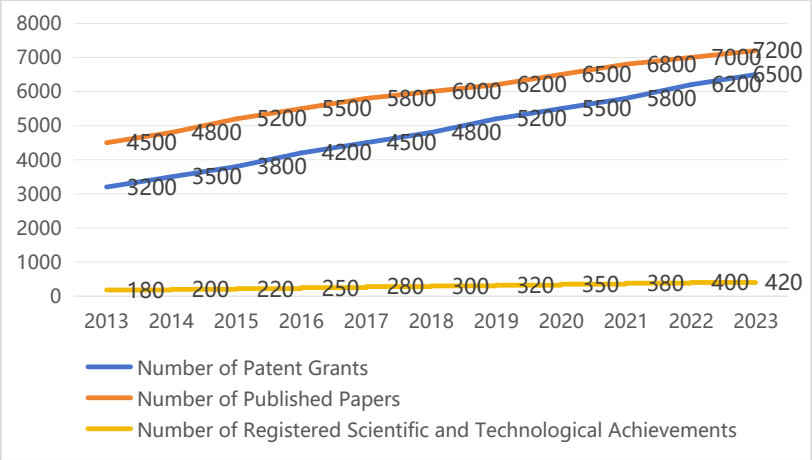

Figure 1

As can be clearly seen from Figure 1, the number of scientific research achievements in Tai'an City has generally shown a steady upward trend from 2013 to 2023. The number of patent grants increased from 3,200 in 2013 to 6,500 in 2023, with an average annual growth rate of approximately 7.4%. The number of published papers rose from 4,500 in 2013 to 7,200 in 2023, with an average annual growth rate of about 4.9%. The number of registered scientific and technological achievements grew from 180 in 2013 to 420 in 2023, with an average annual growth rate of around 9.2%. This indicates that Tai'an City has made positive progress in technological innovation and that its scientific research capacity has been continuously enhanced.

Further analysis of the growth trend reveals several key periods. From 2013 to 2016,the growth in the number of scientific research achievements was relatively stable, with relatively gentle growth rates for each indicator. During this stage, Tai'an City was in a period of steady accumulation in technological innovation, with gradually increasing scientific and technological investment and a gradually expanding scientific research talent pool. However, explosive growth had not yet emerged.

From 2017 to 2019, there was a more noticeable acceleration in the growth of scientific research achievements. The growth rates of patent grants and published papers increased, while the number of registered scientific and technological achievements saw even more significant growth. This may have been due to the increased support for technological innovation during this period, with a series of policies introduced to encourage scientific research innovation, attracting more scientific research talents and resources, and promoting the implementation of scientific research projects and the output of achievements.

From 2020 to 2023, despite the impact of changes in the external environment, such as the restrictions on scientific research activities caused by the pandemic, the number of scientific research achievements in Tai'an City still maintained stable growth. This demonstrates that the scientific research system in Tai'an City has strong resilience and adaptability. Researchers overcame difficulties by adjusting their research methods, using online collaboration and remote experiments, and continued to advance scientific research.

During the growth process, there were also some fluctuations. For example, in some years, the growth rate of patent grants or published papers might have been relatively small. This could be due to the uncertainty of research project cycles, adjustments in research directions, and changes in market demand. Some research projects may require a longer period of research and experimentation before achieving results and applying for patents. When multiple projects are in the research phase, it may lead to a slowdown in the short-term growth of patent grants. Changes in market demand may affect the research direction of researchers, causing some research results to fail to be promptly published as papers or applied for patents. However, overall, these fluctuations did not change the general trend of steady growth in the number of scientific research achievements in Tai'an City.

C. Distribution and Changes in the Number of Scientific Research Achievements Across Different Fields

To gain a deeper understanding of the distribution and development trends of scientific research achievements in Tai'an City across different fields, the research achievements were categorized and statistically analyzed by fields such as agriculture, industry, healthcare, education, and information technology. A chart showing the changes in the proportion of research achievements in each field from 2013 to 2023 was created (Figure 2).

Table 2: Changes in the Proportion of Scientific Research Achievements in Various Fields in Tai'an City

Year	Agricultural Field	Industrial Field	Healthcare Field	Educational Field	Information Technology Field	Other Fields
2013	20%	35%	25%	10%	5%	5%
2014	22%	33%	26%	9%	5%	5%
2015	23%	32%	27%	8%	5%	5%
2016	24%	30%	28%	7%	6%	5%
2017	25%	28%	29%	7%	6%	5%
2018	26%	27%	30%	6%	6%	5%
2019	27%	26%	31%	6%	6%	4%
2020	28%	25%	32%	5%	6%	4%
2021	29%	24%	33%	5%	6%	3%
2022	30%	23%	34%	4%	7%	2%
2023	31%	22%	35%	4%	7%	1%

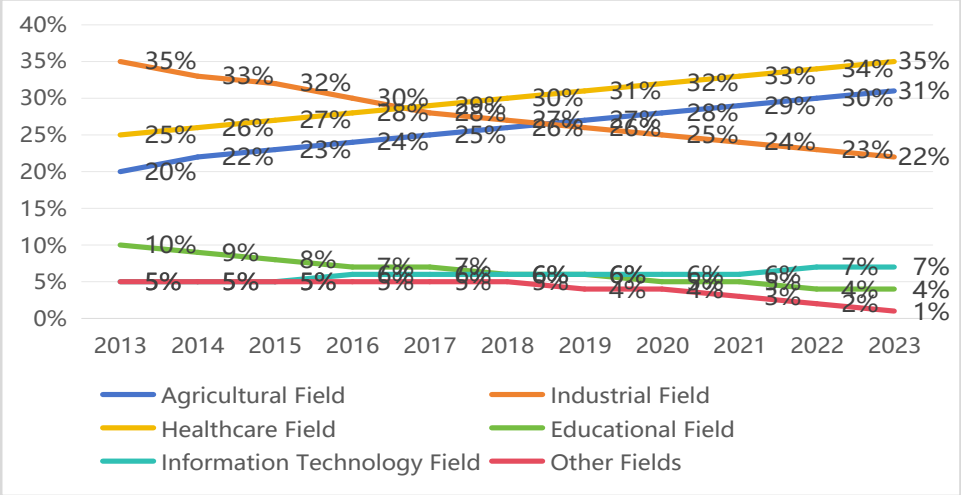

Figure 2

In terms of proportion, the industrial and healthcare fields account for a significant share of the number of scientific research achievements. From 2013 to 2023, the proportion of scientific research achievements in the industrial field fluctuated between 22%and 35%, showing a gradual downward trend overall. This may be due to the adjustment and transformation of industrial structure, as the research focus in the industrial field has gradually shifted from quantitative expansion to in-depth development of quality improvement and technological innovation. Higher demands are now placed on the quality and application of research achievements, leading to a relatively slower growth rate in the number of research achievements. In contrast, the proportion of scientific research achievements in the healthcare field steadily increased from 25%to 35%, reflecting Tai'an City's increasing emphasis on the healthcare sector. Continuous investment in medical research, disease prevention and control, and medical technology innovation has driven the continuous emergence of research achievements in this field.

The proportion of scientific research achievements in the agricultural field has shown a steady upward trend, increasing from 20% in 2013 to 31% in 2023. This is attributed to Tai'an City's status as a major agricultural area and its continuous efforts in agricultural technological innovation. Research institutions such as Shandong Agricultural University have provided strong technical support for the output of agricultural research achievements through in-depth studies in this field. In the area of new crop variety breeding, several high-yielding, high-quality, and stress-resistant crop varieties have been successfully developed. For example, a new type of wheat variety has shown significant improvements in both yield and quality, adapting well to the soil and climatic conditions of Tai'an City and making an important contribution to agricultural production and income growth. In terms of agricultural production technology innovation, a series of green and efficient agricultural production technologies have been widely promoted and applied, such as precision fertilization, water-saving irrigation, and green pest and disease control. These innovations have improved agricultural production efficiency, reduced agricultural non-point source pollution, and promoted sustainable agricultural development.

The proportion of scientific research achievements in the information technology field gradually increased from 5% in 2013 to 7% in 2023. Although the proportion is relatively small, the growth trend is evident. With the rapid development of the digital economy and the widespread application of information technology, Tai'an City has actively developed its information technology industry and increased research investment in this field. Many high-tech companies have undertaken numerous research projects in software development, big data analysis, and artificial intelligence, achieving a number of innovative research results. For example, a company developed a big data analysis platform that can quickly process and analyze large amounts of data, providing strong support for corporate decision-making and enhancing market competitiveness. In the field of artificial intelligence, some companies have also conducted related research, such as the application of intelligent robots in industrial production and service sectors, offering new solutions to improve production efficiency and service quality.

The proportion of scientific research achievements in the educational field has remained relatively stable, fluctuating between 4% and 10%. Research in this field mainly focuses on innovation in teaching methods, educational management reform, and exploration of talent cultivation models. Universities and educational

research institutions in Tai'an City have actively conducted research and achieved certain results. For example, Tai'an University has proposed a series of innovative teaching methods and curriculum systems in the field of educational reform, improving the quality of talent cultivation. However, due to the particularities of educational research, the output of research achievements is relatively slow and is influenced by various factors such as educational policies and practices, resulting in relatively stable changes in the proportion of research achievements in the educational field [6].

Through the analysis of the proportion and trends of scientific research achievements in various fields, it is evident that agriculture, industry, and healthcare are key areas of scientific research development in Tai'an City and play an important role in economic and social development. Although the information technology field, as an emerging area, currently has a relatively small proportion, it has great potential for development and is expected to become a new growth point for scientific and technological innovation in Tai'an City in the future. In future science and technology development strategies, Tai'an City should continue to increase support for key areas to consolidate and enhance its research advantages. At the same time, it should pay attention to the development of emerging fields, strengthen policy guidance and resource investment, and promote the rapid output and application of research achievements in these fields, driving the comprehensive development of scientific and technological innovation in Tai'an City.

III. Conclusions and Prospects

A. Conclusion

Trend in the Growth of Scientific Research Achievements: From 2013 to 2023, the number of scientific research achievements in Tai'an City showed a steady upward trend. The number of patent grants increased from 3,200 in 2013 to 6,500 in 2023, with an average annual growth rate of approximately 7.4%. The number of published papers rose from 4,500 in 2013 to 7,200 in 2023, with an average annual growth rate of about 4.9%. The number of registered scientific and technological achievements grew from 180 in 2013 to 420 in 2023, with an average annual growth rate of around 9.2%. These figures indicate that Tai'an City has made significant progress in technological innovation and that its scientific research capacity has been continuously enhanced.

Distribution of Scientific Research Achievements across Different Fields: In terms of the distribution of scientific research achievements across different fields, the industrial and healthcare fields accounted for a larger proportion of the total number of achievements. The proportion of scientific research achievements in the industrial field fluctuated between 22% and 35%, showing a gradual downward trend overall. This is related to the increased demands for the quality and application of research achievements during the process of industrial structure adjustment and transformation. In contrast, the proportion of scientific research achievements in the healthcare field steadily increased from 25% to 35%, reflecting Tai'an City's emphasis on and continuous investment in the healthcare sector. The proportion of scientific research achievements in the agricultural field increased steadily from 20% in 2013 to 31% in 2023. This is attributed to Tai'an City's continuous efforts in agricultural technological innovation as a major agricultural area, as well as the in-depth research and technical support provided by research institutions such as Shandong Agricultural University. Although the proportion of scientific research achievements in the information technology field was relatively small, it increased gradually from 5% in 2013 to 7% in 2023, showing a clear upward trend. This reflects Tai'an City's active layout and increasing research investment in the information technology field against the backdrop of digital economic development.

B. Suggestion and Prospects

The government should increase its support for science and technology policies, build a comprehensive policy system, and provide a solid policy guarantee for the enhancement of the number of scientific research achievements in Tai'an City. In policy formulation, it is essential to fully consider the industrial characteristics and technological development needs of Tai'an City, and clarify the key areas and directions for support. Targeting Tai'an City's strengths in agriculture, new energy, and new materials, specialized science and technology policies should be developed to guide the aggregation of scientific research resources towards these fields [7]. Policies should be introduced to encourage agricultural technological innovation, increase funding support for agricultural research projects, and support agricultural research institutions in conducting research on new crop variety breeding and agricultural production technology innovation, thereby improving the efficiency of agricultural research achievements [8].

Continuously increasing investment in R&D is an important guarantee for enhancing the number of scientific research achievements in Tai'an City. The government should intensify its financial investment in science and technology, ensuring that the growth rate of financial expenditure on science and technology exceeds the growth rate of regular fiscal revenue. A special fund for scientific and technological development should be established, with a certain proportion of fiscal funds allocated annually to support the implementation of research projects and the construction of scientific research infrastructure. Enterprises should be encouraged to increase their R&D investment. Through preferential tax policies and financial subsidies, enterprises should be guided to raise the proportion of R&D expenditure in their sales revenue [9]. For enterprises that reach a certain proportion of R&D investment, tax exemptions and financial subsidies should be provided to reduce their R&D costs and enhance their enthusiasm for conducting scientific research activities [10]. Channels for funding sources should be broadened, and social capital should be actively attracted to participate in scientific research investment. Risk investment funds and industrial investment funds should be established to guide social capital towards the field of scientific research, providing diversified financial support for research projects. Financial institutions should be encouraged to innovate financial products and services, offering intellectual property rights mortgage loans and science and technology insurance to research enterprises, thereby alleviating the financial pressure on research enterprises.

This study has achieved certain results in the analysis of the changes in the number of scientific research achievements in Tai'an City, but there are also some shortcomings. In terms of data collection, although efforts were made to obtain data from a wide range of sources, some data still suffer from missing or incomplete information. When collecting information on researchers from certain small-scale research institutions, the lack of standardized management within these institutions led to issues such as incomplete records of personnel turnover and vague records of participation in research projects. This made it impossible to accurately obtain the specific research directions and achievement outputs of these researchers. In the statistical process of some science and technology investment data, the accuracy and comparability of the data were affected due to inconsistent statistical calibers and diverse data sources. When it comes to the statistics of government science and technology grants, differences in statistical calibers among different departments make it difficult to accurately aggregate and analyze the data.

IV. Acknowledgment

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