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A Study on the Impact of Patent Quantity on Business Performance in Aerospace Enterprises

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Abstract
This paper focuses on exploring the relationship between the number of patents and business performance of listed aerospace enterprises in China. By utilizing panel data of listed companies in this industry from 2014 to 2023, short-term and long-term performance models are established to empirically examine the direct impact of patent quantity on business performance through data analysis. The research findings reveal a positive correlation between the number of enterprise patents and both short-term performance indicators (Return on Assets, ROA) and long-term performance indicators (Return on Equity, ROE). These results are expected to provide theoretical and practical support for aerospace enterprises to enhance their business performance.

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Keywords: Aerospace Enterprises, Patent Quantity, Business Performance, Panel Data, ROA, ROE, Intellectual Property

1. Introduction

With the deepening of global integration, the strategic position of intellectual property in an enterprise's core competitiveness has been gradually elevated. As a representative of China's strategic industries, aerospace enterprises are characterized by high technology and capital intensity, and their technological innovation capabilities are directly related to the security of the industrial chain and the process of industrial upgrading. As a major carrier of intellectual property, patents not only possess the feature of quantifiable technological reserves but also serve as a core factor driving enterprises to create value. A review of existing literature indicates that the number of patents has been proven to exert a significant positive impact on the business performance of enterprises in fields such as manufacturing and the IT industry.

However, existing studies have two notable limitations. Firstly, they mainly concentrate on traditional manufacturing and emerging industries, with insufficient attention paid to aerospace enterprises. Secondly, most of these studies focus on performance aspects including financial performance and innovation performance, while few investigate the direct relationship between the number of enterprise patents and business performance. Aerospace enterprises differ from other industries due to their longer R&D cycles and stricter government regulations. Therefore, a key question of common concern in both the academic and industrial circles currently is how to more effectively improve corporate business performance by optimizing patent strategies under the current situation.

This paper constructs a model regarding the direct impact of enterprise patent quantity on business performance and conducts a discussion with Chinese aerospace enterprises as the research object. Compared with existing studies, this paper breaks through the research framework of previous literature and constructs evaluation indicators based on the characteristics of Chinese aerospace enterprises. The research results of this paper will not only help Chinese aerospace enterprises optimize their patent layout and reduce technology transfer costs but also improve China's intellectual property management theory and strengthen the practical operation of Chinese aerospace enterprises in implementing patent strategies.

2. Literature Review

Research on the interaction mechanism between intellectual property and economic development has shown a multi-level upward trend. Scholars have conducted studies at the micro-level on how the intellectual property system promotes economic growth in a structured manner. Ford (2021) proposed the embedded theory of the intellectual property legal system and industrial

development and extended it to the field of technology transfer [1]. After conducting an empirical study using panel data from developing countries [1], Mrad Fatma found that the input of technology carriers can enhance the intensity of intellectual property protection, and trade liberalization under the WTO framework has a stronger regulatory effect [2]. Yu Changlin (2020) put forward the theoretical hypothesis of differentiated protection of inter-regional technological endowments based on differences in regional economic development levels [3]. After analyzing the heterogeneity of patent protection in China, Zhuang Ziyin *et al*. (2021) concluded that the patent system has a more significant role in improving the economic development level of developed regions than that of underdeveloped regions [4].

From the perspective of meso-industry research, the system dynamics method is adopted to explore the mechanism of action of intellectual property. Yang Xiran *et al*. (2019) constructed a multi-agent dynamic model with enterprises as the main body of innovation and concluded that intellectual property plays a decisive role in resource allocation [5]. Cao Min (2020), through a study on Chinese GEM enterprises, found that there is a mediating effect between the degree of intellectual property protection and corporate financial performance, and it also has a certain correlation with industrial technology density [6]. Chen Ya (2021) obtained the conclusion that patent quality and patent application volume have a significant effect on enterprise performance through a study on the pharmaceutical industry [7]. Qian Cheng *et al*. (2023) focused on media enterprises and conducted an empirical study on the impact and mechanism of IP mergers and acquisitions on the performance of listed media companies [8].

In recent years, research at the micro-enterprise level has gradually developed towards refinement, but there are still obvious structural limitations. For example, previous studies have paid more attention to traditional manufacturing and used panel data to test the time-lag effect of patent quantity on enterprise performance. Although scholars such as Cao Min (2020) and Chen Ya (2021) have introduced regulatory variables, their research mainly focuses on financial performance and fails to take into account the characteristics of emerging industries such as aerospace. In addition, current studies also have a significant timeliness issue: most studies use samples with a time span of less than 5 years and ignore the time-lag effect of patent value realization, which makes it impossible to accurately identify the transmission mechanism between the long-term and short-term performance of enterprises.

The innovations of this paper are reflected in the following three aspects. Firstly, it takes into account the characteristics of Chinese aerospace enterprises, such as high R&D investment and strong policy orientation. Secondly, this paper combines the event study method with the panel model to analyze the short-term market response and economic value added of enterprises from two dimensions. Finally, instead of selecting data from earlier years, this paper uses the latest data of aerospace enterprises from 2014 to 2023 to more accurately identify the impact of patent accumulation. Based on the above three innovations, this paper is expected to provide more effective theoretical support for the optimization of patent strategies in China's high-tech enterprises.

3. Theoretical Analysis and Impact Mechanism

3.1. Theoretical Analysis

3.1.1. Extension of the Resource-Based View (RBV) The value-creation

mechanism of intellectual property, as a strategic intangible resource of enterprises, can be traced back to the theoretical paradigm of the Resource-Based View. Intellectual capital, including patents, trademarks, copyrights, and trade secrets, possesses three attributes: scarcity, inimitability, and non-substitutability. It can be classified into the category of enterprise heterogeneous resources, thereby forming an institutionalized source of sustainable competitive advantage [9]. Specifically, the exclusivity endowed by patent layout through law helps enterprises form technical barriers, while brand assets and trade secrets rely on organizational isolation mechanisms to block the imitation paths of competitors.

3.1.2. Dynamic Capability Theory

The Dynamic Capability Theory was proposed by scholars such as Pan Jing. This theory emphasizes the evolutionary ability of enterprises to achieve adaptive competitive advantages by continuously integrating, building, and reconstructing resources in a dynamic environment [10]. In the field of intellectual property (IP) management, this theory focuses on how organizations cope with multiple uncertainties such as technological disruption, market fluctuations, and institutional changes by dynamically managing the process of IP creation, protection, and commercialization [11]. Its core idea is that the value of intellectual property lies not only in its legal rights but also in the realization of continuous value-added through its dynamic capabilities.

3.2. Impact Mechanism

3.2.1. Cost Control

Enterprises can utilize the technical monopoly right granted by patents to reduce market friction costs, minimize price wars and imitation competition, thereby optimizing resource allocation and improving efficiency. Additionally, enterprises can directly obtain revenue through patent licensing, reducing their reliance on financing. Furthermore, enterprises can achieve economies of scale, promote large-scale industrial production by standardizing patent technologies, and lower marginal costs. However, as the number of patents surges, the annual patent fees and litigation costs of enterprises will lead to the expansion of maintenance costs. Moreover, excessive reliance on old patents may cause enterprises to lag behind in transformation [12].

3.2.2. Risk Control

Enterprises can build defensive barriers, such as implementing patent portfolios, to block competitors' imitation. Some enterprises establish cross-licensing agreements to resolve infringement disputes and reduce litigation risks [13]; patent pledge financing helps technology-based enterprises break through credit constraints and enhance financing credibility. Through the above approaches, the innovation environment and market order of enterprises can be stabilized. Nevertheless, risk control also has potential negative risks. For instance, the risk of low-quality patents may easily lead to resource waste, and the abuse of patents by some enterprises may trigger regulatory

penalties.

3.2.3. The Double-Edged Sword Effect of Patent Quantity

Enterprises can realize innovation incentives, convey innovation capabilities, and attract foreign investment through the path of increasing patent quantity [14]. Additionally, an appropriate number of patents can promote knowledge spillover. Although increasing the number of patents has positive effects on enterprises, there are still certain risks. If enterprises blindly pursue the quantity of patents, it may lead to a decline in quality, which will inhibit subsequent innovation [15].

Based on existing literature and theoretical analysis, this paper proposes the following research hypotheses:

H1: In the short term, the intellectual property level (measured by the number of patents) of aerospace enterprises has a significant positive impact on their financial performance (ROA).

H2: In the long term, the intellectual property level (measured by the number of patents) of aerospace enterprises has a significant positive impact on their financial performance (ROE).

4. Empirical Analysis

4.1. Selection and Processing of Data

4.1.1. Sample

This paper uses the corporate financial data of aerospace enterprises from the CSMAR database, as well as patent application data from the "China Science and Technology Statistics Yearbook" and the State Intellectual Property Office for the period 2014-2023. After excluding ST, *ST enterprises, and samples with severely missing data using STATA 18.0 software for analysis, a total of 110 complete and valid data points are obtained.

4.2. Selection and Construction of Variables

4.2.1. Dependent Variables

In this paper, Return on Assets (ROA) and Return on Equity (ROE) are used to represent the short-term and long-term performance of enterprises, respectively. An increase in their values indicates an improvement in the short-term and long-term performance of enterprises.

4.2.2. Independent Variables

Since the number of patents owned by an enterprise can reflect the degree of intellectual property utilization and the ability of innovation output of the enterprise to a certain extent, and enterprises can also obtain certain benefits from it, this paper uses the number of patent applications (PA) of listed aerospace enterprises to represent the degree of intellectual property utilization.

4.2.3. Control Variables

Considering that the business performance of an enterprise is jointly affected by the internal and external environment of the enterprise, this paper selects indicators such as company size (SIZE), asset-liability ratio (LEV), and company growth rate (GROWTH) from the perspective of financial performance, which are measured by the logarithm of total assets, the ratio of total liabilities to total assets, and the growth rate of main business revenue, respectively.

Based on the above, this paper conducts a brief analysis of each variable using descriptive statistics, correlation analysis, and regression analysis.

Table 1: Descriptive Statistics of Variables

	N	Mean	Standard Deviation	Minimum Value	Maximum Value
Roa	110	0.0288	0.0384	-0.133	0.12
Roe	110	0.0514	0.0972	-0.663	0.185
Patent	110	43.55	93.81	0	408
Leverage	110	47.78	18.09	-7.45	80.76
Growth	110	25.32	152	-52.89	1,586
Size	110	5.579	1.771	2.833	9.496

Table 1 presents the descriptive statistical results of the main variables. The mean value of ROA, an indicator of business performance, is 0.0288, and the mean value of ROE is 0.0514, which indicates that the overall financial condition of China's listed aerospace enterprises is relatively good from a long-term perspective. The extreme value results show that there is a large gap between individual enterprises, and some enterprises suffer from severe losses. The average number of patent applications is 43.55 (with a maximum of 47), which indicates that enterprises have a relatively high level of innovation capability and intellectual property utilization.

Table 2: Correlation Analysis of Variables in Model 1

	Roa	Patent	Leverage	Growth	Size
Roa	1				
Patent	0.3906*	1			
Leverage	-0.2772*	-0.2192*	1		
Growth	0.0309	-0.0256	0.114	1	
Size	-0.0124	-0.0685	0.2064*	-0.005	1

Table 3: Correlation Analysis of Variables in Model 2

	Roa	Patent	Leverage	Growth	Size
Roa	1				
Patent	0.277***	1			
Leverage	-0.194	-0.219	1		
Growth	0.0803	-0.0256	0.114	1	
Size	0.156	-0.0685	0.206	-0.005	1

The results of the correlation analysis of variables in Table 2 show that the correlation coefficient between the number of patent applications and ROA is 0.3906, which passes the 10% significance test. This indicates a positive correlation between the number of patent applications and corporate business performance in the short term. The conclusion that the asset-liability ratio is negatively correlated with both short-term corporate performance and the number of patent applications is derived from the fact that the correlation coefficient between the asset-liability ratio and short-term corporate performance is -0.2772 (passing the 10% significance test) and the correlation coefficient between the asset-liability ratio and the number of patent applications is -0.2192 (also passing the 10% significance test). Similarly, from Table 3, it can be concluded that the level of intellectual property utilization has a significant positive correlation with long-term corporate performance. This is supported by the correlation coefficient of 0.277 between the level of intellectual property utilization and long-term corporate performance (ROE), which passes the 1% significance test. In addition, by comparing the significance results in Table 2 and Table 3, it can be found that the increase in the number of enterprise patent applications has a more significant positive impact on corporate performance in the long term than in the short term.

4.3. Model Construction

This paper constructs Model 1 and Model 2 to test the impact of the number of patent applications on the short-term and long-term performance of enterprises and proposes Hypotheses H1 and H2.

$$ROA_{i,t} = \beta_0 + \beta_1 Patent_{i,t-1} + \beta_2 Controls_{i,t} + \epsilon_{i,t}$$

$$ROE_{i,t} = \beta_0 + \beta_1 Patent_{i,t-1} + \beta_2 Controls_{i,t} + \epsilon_{i,t}$$

Where, ROA represents the short-term performance of the enterprise, and ROE represents the long-term performance of the enterprise; “Patent” denotes the number of patent applications of the enterprise; “Controls”are the control variables of the model, including enterprise size “Size”, asset-liability ratio “Leverage”, and enterprise growth “Growth”; $\epsilon_{i,t}$ is the random error term; “t” refers to the year, and “i” refers to the enterprise. In addition, the panel data analysis is conducted with reference to the method of Cao Min *et al*.

4.4. Empirical Process

4.4.1. Analysis of Regression Results

Table 4: Regression Results of Model 1 and Model 2

Variables	Roa	Roe
patent	0.000***	0.000***
	5.41	5.33
leverage	-0.000*	-0.001
	(-1.71)	(-1.19)
growth	0.000*	0.000**
	1.69	2.14
size	0.001	0.012*
	0.59	1.69
Constant	0.038**	0.023
	2.55	0.92
Observations	110	110
R-squared	0.198	0.15
Ftest	9.48E-08	4.86E-06
r2_a	0.168	0.117
F	11.45	8.595

The second column of Table 4 presents the regression analysis results for Model 1, and the third column shows the regression analysis results for Model 2. According to the results of the Hausman test, a fixed-effects model is adopted for the estimation and analysis of all models.

The results of the regression analysis indicate that in both the short term and the long term, the regression coefficients between the number of enterprise patent applications and ROA, as well as between the number of enterprise patent applications and ROE, are 0.000, and all pass the 1% significance test. This shows that there is a positive relationship between the number of enterprise patent applications and the short-term and long-term performance of enterprises in both the short and long term. That is, regardless of the short term or the long term, the business performance of enterprises (i.e., innovation output) will improve as the number of enterprise patent applications increases.

From the perspective of the asset-liability ratio, it can be seen that there is a negative relationship between the asset-liability ratio and ROA, with a regression coefficient of 0.000 that passes the 1% significance test. This data suggests that there is a negative correlation between the asset-liability ratio and corporate performance in the short term, meaning that the higher the asset-liability ratio of an enterprise in the short term, the worse its business performance will be.

4.4.2. Robustness Test

To verify the robustness of the results, this paper conducts the following robustness test by excluding the data during the epidemic period (2021-2023):

Data Exclusion: Due to the special circumstances during the epidemic period, which may have a short-term inhibitory effect on the number of patent applications of aerospace enterprises, and with economic recovery and policy support, patent competition in fields such as green aviation and commercial aerospace will intensify, and industry innovation

may show a "structural growth" characteristic. Therefore, the sample data during the epidemic period is excluded to ensure the accuracy and reliability of the results. After excluding the epidemic period, 77 valid samples are retained.

Table 5: Regression Analysis of Samples After Excluding Special Data During the Epidemic Period

Variables	Roa	Roe
patent	0.000***	0.000***
	-4.5	-2.95
leverage	-0.001***	-0.002***
	(-2.97)	(-2.80)
growth	0	0
	-0.81	-1.27
size	0.002	0.014**
	-0.94	-2.29
Constant	0.037**	0.032
	-2.63	-0.74
Observations	77	77
R-squared	0.3	0.22
F test	3.08E-05	0.00118
r2_a	0.261	0.176
F	7.727	5.065

The results of the robustness test show that: As can be seen from Table 5, after excluding the special data during the epidemic period, the regression results still show a significant positive correlation between the number of patent applications and corporate performance in both the short term and the long term. Additionally, the asset-liability ratio remains significantly negatively correlated with corporate performance in both the short term and the long term. The main conclusions remain consistent under different conditions, indicating that the research results of this paper have high robustness.

4.5. Analysis of Empirical Results

Based on the panel data of listed aerospace companies from 2014 to 2023, this paper constructs short-term and long-term performance models and empirically tests the impact of the intellectual property level (measured by the number of patents) on corporate performance. The research results are as follows:

4.5.1. Significant Positive Impact in Both Short and Long Terms

In the short term, the number of enterprise patent applications (i.e., the level of intellectual property) has a significant positive promoting effect on financial performance (ROA); in the long term, the number of enterprise patent applications (i.e., the level of intellectual property) also shows a significant positive effect on financial performance (ROE). This indicates that the patent accumulation of aerospace enterprises can continuously improve their performance.

4.5.2. Impact of Control Variables

The asset-liability ratio (LEV) is significantly negatively correlated with short-term performance, suggesting that high leverage may inhibit the short-term profitability of enterprises; while the increase in enterprise size (SIZE) will lead to an increase in the long-term performance (ROE) of enterprises, indicating that achieving sustained returns through economies of scale is more applicable in large enterprises.

4.5.3. Robustness Test Supports the Core Conclusion

After excluding the data during the epidemic period (2021-2023), the positive impact of the number of enterprise patent applications on both short-term and long-term corporate performance remains significant, which further verifies the reliability of the results.

5. Recommendations and Conclusions

5.1. Countermeasure Recommendations

Based on the research conclusions, this paper puts forward recommendations from both the enterprise and policy levels:

5.1.1. Enterprise Level

Firstly, regarding intellectual property protection, enterprises should take reducing R&D spillovers and alleviating external financing constraints as the impact mechanism. The role of the number of enterprise patents in improving business performance will become more significant with the enhancement of intellectual property protection. Secondly, enterprises should take actions to balance R&D and financial risks, such as reasonably controlling the asset-liability ratio, and alleviating the impact of R&D investment on short-term cash flow by making full use of government subsidies and equity financing. Finally, enterprises should improve the intellectual property management system: establish a full-life-cycle patent management mechanism covering application, maintenance, commercialization, and infringement defense, and strive to improve the efficiency of intellectual property utilization.

5.1.2. Policy Level

Firstly, at the national level, targeted support should be strengthened according to the characteristics of aerospace enterprises, such as providing special tax reductions to reduce the innovation costs of enterprises. At the same time, the relationship between the abuse of intellectual property rights, technological innovation, and economic development should be properly handled. Secondly, from the perspective of local governments, they should increase the enforcement of intellectual property rights to encourage local enterprises to

increase R&D investment intensity and improve patent output.

5.2. Research Conclusions

This paper focuses on the impact of the number of patents on the business performance of aerospace enterprises. By analyzing the panel data of relevant listed companies from 2014 to 2023, short-term and long-term performance models are constructed. The study finds that the number of patents has a significant positive impact on corporate business performance (ROA) in the short term and a similar effect on corporate business performance (ROE) in the long term. Based on the Resource-Based View and the Dynamic Capability Theory, this paper discusses the impact mechanisms of cost control, risk control, and patent quantity control. The empirical results show that the number of patents has a continuous promoting effect on corporate performance, and the results are reliable after the robustness test. Finally, the paper puts forward recommendations from the enterprise and policy levels, emphasizing the strengthening of intellectual property protection, balancing R&D and financial risks, improving the management system, and suggesting that the government increase support and strengthen law enforcement.

The sample size of aerospace enterprise data selected in this paper is relatively small, mainly due to the following reasons. Firstly, the number of listed companies in the aerospace field is inherently limited, resulting in scarce available data resources. Secondly, as most enterprises in this field are high-tech enterprises, with the advancement of science and technology in recent years, many related enterprises have been listed only after 2014, which overlaps partially with the time range of 2014-2023 selected in this paper. This has led to the exclusion of a large number of enterprises due to their late listing, further reducing the sample size. In addition, although military-industry enterprises occupy an important position in this field, their business characteristics and data sensitivity make it difficult to obtain representative public data, so they cannot be included in the research sample. Therefore, the sample size of this paper has certain limitations, which is mainly due to the combined constraints of industry characteristics, listing time nodes, and data availability.

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