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Global Aerospace Patent Policy Analysis

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Abstract: This study explores global aerospace patent trends, examining the impact of national policies, corporate strategies, and cultural contexts on innovation in the aerospace sector. By analyzing patent data, particularly under the B64G classification for space vehicles, the research identifies global and regional innovation trends, evaluates technological outcomes, and discusses policy measures influencing industrialization and competitiveness in key markets. The report focuses on the aerospace sectors of Europe, China, and the United States, highlighting their distinct approaches to promoting technological advancements and commercial growth. Insights from this analysis provide valuable references for policymakers and industry professionals in shaping future strategies.

Keywords: aerospace; patents; innovation policy; B64G classification; technological trends; commercial space; government incentives

1. Introduction

In the aerospace field, patents are regarded as important strategic and commercial tools that not only prevent market infringement by competitors but also ensure the smooth functioning of the market and promote collaboration between companies and research institutions. The relatively standardized technical data contained in patents make them ideal subjects for meaningful analysis. This section aims to delve into the economic value of aerospace patents in different countries and their reliance on national policies, exploring how policies, culture, and incentive measures influence technological topics in various contexts.

The selection and management of patents are influenced not only by internal corporate policies, competitive strategies, and culture but also by government incentive measures. These factors vary across regions and companies. Therefore, this section analyzes the evolution and development of technological topics at both the national and corporate levels, considering the context of different policies, cultures, and incentive measures. Policies, culture, business strategies, and incentive measures significantly impact patent statistics, and these factors play a crucial role in this analysis.

For a long time, aerospace organizations have tended to protect intellectual property through trade secrets, proprietary technologies, and commercial agreements. However, over the past decade, this situation has changed remarkably, with a significant increase in the growth rate of international aerospace patents. National policies, corporate incentive measures, the introduction of new technologies, and a more mature market environment have provided strong motivation for this shift.

Patents are a critical indicator of research success and overall competitiveness. There is a widespread belief that patents, as a product of research, hold significant value. However, the selection and filing of patents are influenced by multiple factors, including corporate policies, competitive strategies, cultural contexts, and government incentive measures. Therefore, when comparing and evaluating patents, it is essential to proceed cautiously and fully understand the dynamic factors underlying them.

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2. Objectives and Methodology

This section aims to delve into global aerospace patent activity to uncover market dynamics and the competitive landscape within the industry. Additionally, it seeks to provide valuable insights into technological and innovation trends at both global and regional levels, offering useful references for policymakers and industry professionals.

To analyze patent trends, this section utilizes data from the World Intellectual Property Organization website, with a specific focus on Patent Cooperation Treaty application publications organized by the International Patent Classification system. Specifically, the B64G classification code related to "space vehicles" was selected for a detailed study and analysis. This code covers patent applications in the fields of design, manufacturing, launching, and related technologies for space vehicles, enabling a comprehensive reflection of innovation activities and development trends within this specific technological domain on a global scale.

Through the analysis of patent data under the B64G classification code, this section aims to reveal the distribution of research and development (R&D) investments and technological outcomes in key countries and regions worldwide within the field of space technology. This not only helps to understand the competitive advantages and strategic priorities of each country in space technology but also provides significant support for future technological collaborations and market competition.

Furthermore, this section explores the policies and measures adopted by various countries to promote innovation and the industrialization of space technology, as well as their effectiveness. By comparing the patent application strategies and innovation incentive policies of different countries, the study seeks to identify key factors driving technological development. This, in turn, offers policy recommendations and strategic guidelines for the further advancement of space technology on a global scale.

3. Global Aerospace Patent Policy Analysis

3.1. Global

In recent years, global patent activity has increased significantly, with patent categories diversifying considerably. In this domain, the United States continues to maintain a leading position, followed by other advanced aerospace technology nations such as China, Russia, Japan, France, and Germany. Technological innovation has effectively reduced the costs of accessing and utilizing space, driving the development of new missions and applications. However, an increase in patent applications does not necessarily indicate major scientific breakthroughs or revolutionary innovations. Public incentive measures often result in patents being granted for minor improvements or optimizations of existing technologies rather than for truly novel inventions or innovations.

Patent ownership has also shown dynamic changes. Some companies previously active in space-related activities no longer appear in recent data due to market exits, mergers, or acquisitions. Conversely, patent application data indicates the entry of new players into the aerospace field. These new entrants include both specialized aerospace startups and companies from other sectors, suggesting an increase in technology transfer from external industries into the aerospace sector.

Figure 1 shows that the patent activity statistics within the academic and governmental sectors vividly demonstrate the highly vibrant and dynamic contributions made by Chinese institutions. Simultaneously, it also showcases a robust presence of institutions hailing from the United States, South Korea, Russia, France, and Germany, highlighting their significant roles in this domain. [1].

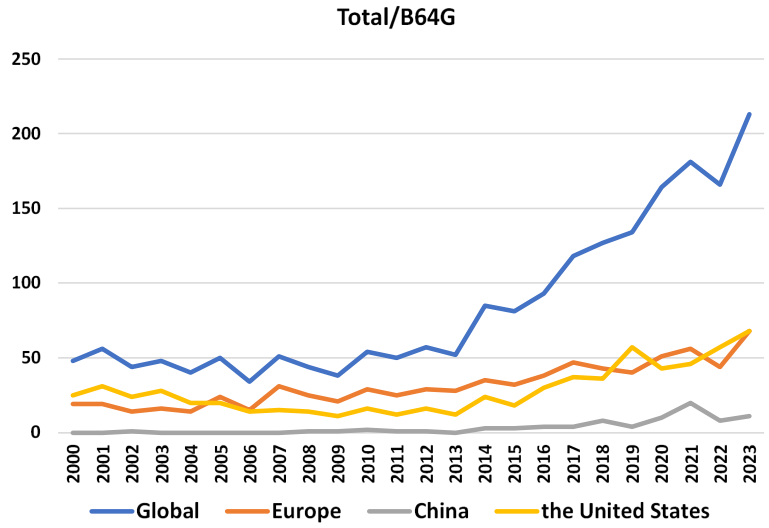

Figure 1. Global Patent Activity Trends.

Next, by analyzing patent data from Europe, China, and the United States, a deeper understanding of each country's level of activity in the aerospace field will be achieved. This will help uncover the specific characteristics of patent policies and market dynamics in different countries, as well as how these policies influence the development of technological innovation and market competitiveness. Such analysis not only provides a comprehensive view of global aerospace patent activity but also offers valuable references for the formulation of policies and strategies by various countries.

3.2. Europe

European organizations and countries have different preferences when it comes to deciding whether to file patent applications through their national patent offices or through the European Patent Office. Figure 2 illustrates the patent application trends in Europe. France's policy stipulates that French inventors must first file their patent applications domestically. On the other hand, Germany encourages patent applications through the Employee Invention Act and its related remuneration guidelines. This law not only provides incentives but also requires the employer to file a patent application once the employee discloses the invention, thus incentivizing individuals to pursue patent applications [2].

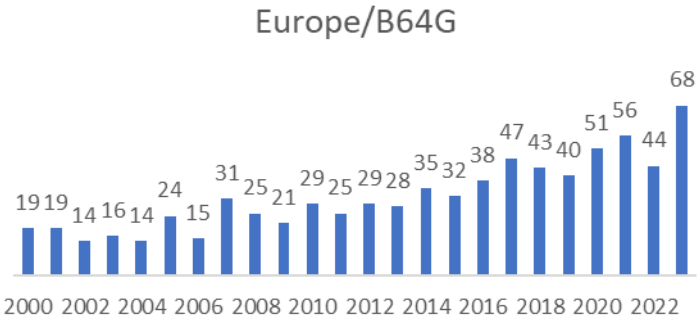

Figure 2. Patent Application Trends in Europe.

The total volume of patent applications in Europe has been increasing year by year, driven largely by incentive policies from the European Union and the European Space Agency, among other organizations [1]. In 2003, the European Union and ESA collabo-

rated to publish the European Space Policy Green Paper, aiming to enhance Europe's position in the space field and optimize the development of European space technology. Since 2020, the volume of European patent applications has grown significantly. In 2022, ESA allocated €16.9 billion as a budget for the next three years to support technological innovation and accelerate industrialization. Additionally, ESA and the European Commission signed a financial partnership agreement, marking the start of a space development investment plan. Under this agreement, from 2021 to 2027, the European Union will allocate approximately €9 billion from its space budget to support the plan. This agreement, through financial support, technical cooperation opportunities, and the promotion of space economy development, has positively impacted commercial space enterprises.

Specifically, this agreement impacts commercial space enterprises in the following ways

1) Financial Support: By allocating funds directly from the space budget, substantial financial assistance is provided to commercial space enterprises. This is particularly beneficial for those in the early stages or those requiring significant capital for technological research and market expansion.
2) Technical and Cooperation Opportunities: Companies winning the bids not only receive financial support but also technical backing from ESA and the opportunity to use commercial operation models to foster space-related commercial activities in Europe. This means that commercial space enterprises, by participating in these projects, can obtain necessary funding and technology while improving their competitiveness and market share through cooperation with other firms.
3) Promotion of Space Economy Development: In the long term, this financial and technical support accelerates the development of the European space economy. According to relevant reports, it is expected that by 2040, the European space economy market will reach a size of trillions of dollars. For commercial space enterprises, this represents enormous market potential and development opportunities.

The financial partnership agreement signed between ESA and the European Commission, through financial support, technical cooperation opportunities, and the promotion of the space economy, has had a positive impact on commercial space enterprises. This not only helps improve Europe's competitiveness in the global space arena but also provides extensive development opportunities for commercial space enterprises.

Additionally, European countries differ in their tax incentive measures for patents. The United Kingdom's Patent Box regime, first proposed in 2009 and in effect since April 1, 2013, offers a corporate tax reduction to 10% on profits derived from patented inventions. France has a similar scheme. Although Germany does not have an equivalent tax relief policy, the Employee Invention Act appears to be more effective in fostering patent applications. Spain and Italy also have policies similar to the Patent Box, but the number of entries in global patent data from these countries remains relatively low. (Institute, 2019)

In summary, the diversity in patent filing policies and incentive measures among European countries not only reflects the different strategies adopted by each country to promote technological innovation and protect intellectual property but also demonstrates Europe's multifaceted efforts to develop aerospace technology and enhance its market competitiveness.

3.3. China

In recent years, Chinese entities have occupied a significant position in global patent applications, particularly in certain fields where their activity has been exceptionally intense. Figure 3 illustrates the patent application trends in China. The Chinese government has implemented innovation support policies during this period, significantly driving the increase in patent applications. The volume of patents and intellectual property filings

submitted to the China National Intellectual Property Administration (CNIPA) is substantial and continues to grow. These applications cover all patentable technologies under the International Patent Classification (IPC), contributing a large number of Chinese patent applications to the prior art. Consequently, the "Chinese phenomenon" can be observed in all patent landscape studies, not just those related to aerospace technology. However, most patent applications in China remain domestic.

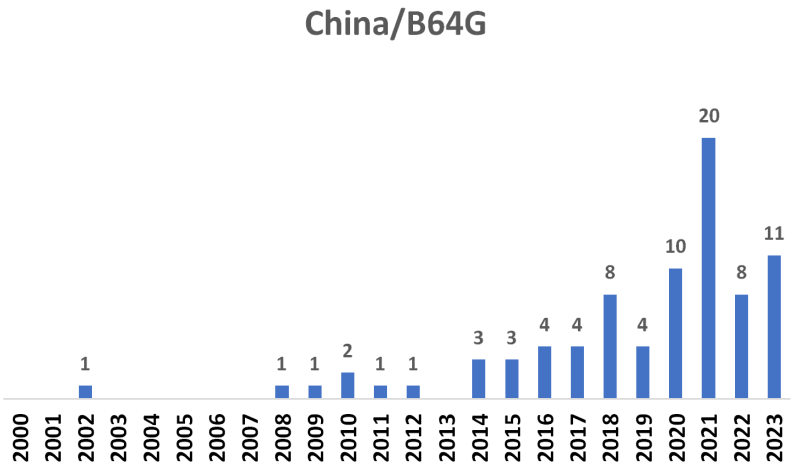

Figure 3. Patent Application Trends in China.

In the aerospace patent field, China's activity was relatively low before 2010 but began increasing in 2015, growing at a very rapid pace in recent years. This trend is closely tied to Chinese government policies. In 2014, the government issued a series of documents aimed at promoting diversified investment and industrial application in the aerospace sector, marking the first opening of the state-monopolized space sector to private capital. Since 2015, China has taken significant steps to transform its space industry from a government-driven model to a commercial one, considered by many as the inaugural year of Chinese commercial space. Within a few years, China's commercial space industry has progressed from nonexistence to an initial solid stage, forming several competitive aerospace companies. With the continued release of "policy dividends," both state-owned and private enterprises have joined the wave of commercial space, with new companies continuously emerging in the sector. Research indicates that commercial space companies founded after 2015 account for approximately 76% of the total in China, while those founded before 2015 represent only 24%, with limited systems and scale.

China's aerospace sector involves the participation of multiple actors. Traditional aerospace companies have strengthened their vertical integration, with organizations such as the China Aerospace Science and Technology Corporation and the China Aerospace Science and Industry Corporation establishing new commercial space enterprises under market-driven models. Research institutions also show strong interest in the commercial space sector, founding companies such as Chenggang Satellite Technology Co., Ltd. and Guangdong Zhonghe Remote Sensing Technology Co., Ltd., promoting the integration of academic research with technological industrialization. New space startups have innovated in commercial space operational models, demonstrating greater flexibility in project management and business operations compared to traditional companies. Notable examples include Galactic Energy, Land Space, and Galaxy Space, which have occupied key technological positions in the commercial space industry, establishing effective operational and business models and driving the industrialization and scaling of commercial space. Internet companies are also enhancing the commercial space sector by leveraging trends such as integrating space products and services with artificial intelligence and big data. Domestic tech giants have entered the space sector, launching related products

and services. For example, Tencent partnered with Sate logic to develop satellite remote sensing technology, and the We Earth platform is building a digital satellite constellation.

The technological engine of China's space sector is also reflected in reduced construction costs and improved service capabilities. The diffusion of high technology has allowed more institutions and individuals to participate in space activities, lowering manufacturing barriers. Simultaneously, the opening and transfer of traditional space technologies, along with the integration of information technologies, new materials, and processes, have driven advancements in space technologies. For instance, reusable rockets, the Internet of Things, cloud computing, and big data have effectively reduced launch costs. Additive manufacturing, new energy sources, carbon fiber manufacturing processes, and mass satellite production have lowered development and deployment costs, accelerating production. Furthermore, space technologies applied to remote sensing, communications, navigation enhancement, and scientific experiments meet various needs. Using big data to address challenges in extracting remote sensing data has made space technology broader and more intelligent.

Regarding patent applications, the increase in domestic filings has been an official policy goal under China's National Patent Development Strategy (2011–2020). This strategy established measures to incentivize patent application volumes. Applicants can receive government subsidies, job opportunities, High-Tech Enterprise (HNTE) status, and a 25% corporate tax reduction, leading to a sharp rise in patent applications. Additionally, in 2018, patent application fees were eliminated to encourage and facilitate filing.

Despite the notable growth in the volume of patent applications in China, most are domestic. Compared to other leading aerospace technology countries, China's number of PCT patent applications is relatively low. Although applicants are encouraged to file patents, there seem to be insufficient incentives to seek long-term protection for their inventions. Generally, due to rising costs, they stop protecting their patents after a few years. Consequently, Chinese patents are primarily domestic.

In summary, China's position and activity in global patent applications demonstrate its significant advances in technological innovation and intellectual property protection. These achievements not only profoundly impact China's scientific and technological development but also introduce new dynamics to global space technology development and the competitive market landscape.

3.4. The United States

The United States is the global leader in the aerospace market, with revenues from the civil aerospace sector accounting for 50% of the global market. Figure 4 illustrates patent application trends in the United States. This achievement would not have been possible without the open and receptive attitude of U.S. government departments and their effective support measures. The government plays a crucial role in three key areas: market access, provision of innovation resources, and procurement policies, comprehensively supporting business innovation.

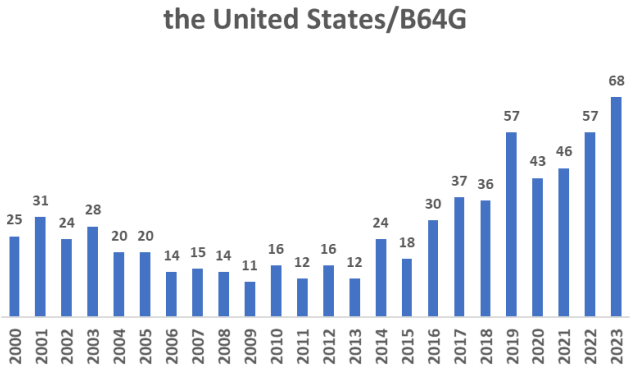

Figure 4. Patent Application Trends in the United States.

First, the U.S. government has opened the domain of low-Earth orbit space launches, granting companies access to the market. Since the early 21st century, the government has regarded emerging space sector companies as an important force in the development of human spaceflight, fostering their rapid growth through national policy adjustments. In 2006, the *National Space Policy* emphasized the continued inclusion and expansion of the U.S. private sector in designing and developing government space systems and infrastructure. In June 2010, the Obama administration issued a new *National Space Policy*, with its primary goal to "revitalize the competitive national space industry and enhance entrepreneurial vitality." The administration declared: "To support the vital national space industry, the U.S. government's research focus in the space domain will center on deep space exploration, using commercial space products and services to meet government needs." To implement these policies, NASA decided to withdraw from low-Earth orbit space launches with potential commercial value, opening this sector to private enterprises [3].

Second, the U.S. government has made technological and talent resources accessible, helping companies gain access to public innovation resources. NASA made a wealth of technical reports on the Apollo program and space shuttle development available to private U.S. aerospace companies like SpaceX, transferring mature technologies. For example, the Merlin engine used in SpaceX's Falcon 9 rocket was modified and enhanced based on an engine used by NASA for the Apollo program. In addition to technological support, NASA allowed its researchers with access to classified information to join private aerospace companies. For instance, David Giger, an aerospace engineer at SpaceX, previously worked at a NASA-affiliated research institution.

Finally, through various government procurement policies, the U.S. government helps innovative products from companies reach the market. In 2013, the U.S. transitioned from the "First to Invent" (FTI) system to the "First to File" (FITF) system, increasing companies' urgency to secure patent rights and significantly influencing patent filing trends in the U.S. aerospace sector. Additionally, the government implements several procurement measures for high-tech companies, such as "risk compensation, priority usage, and monopoly avoidance"

1) Risk Compensation Mechanism: To reduce potential R&D losses, the government established a risk compensation fund. In government procurements, funds are proportionally allocated to this fund based on the nature and amount of the purchase. If high-tech companies fail in their R&D efforts, the fund compensates the losses as stipulated in the procurement contract.
2) Government as Initial User of Products and Technologies: Acting as the initial user of SpaceX's products, the U.S. government provides a stable market for these products, helping to sustain company cash flows and granting them their "first million." In August 2006, NASA signed a commercial orbital transportation services contract with SpaceX. As technology improved, SpaceX expanded its market internationally, and in June 2013, it announced it would launch Turkmenistan's first artificial satellite.
3) Creating a Fairly Competitive Environment for SMEs, Avoiding Monopolies: The U.S. government procurement system prioritizes supporting high-tech SMEs while maintaining sector competitiveness. The Buy American Act stipulates that, as long as a domestic high-tech SME's bid does not exceed a large domestic company's bid by more than 6% or a foreign supplier's bid by more than 12%, priority is given to purchasing products and services from domestic high-tech SMEs. To support emerging high-tech companies, NASA also adopts linked procurement methods, assigning the $6.8 billion "Space Taxi" project jointly to Boeing and SpaceX.

Additionally, U.S. law requires that any patent application for an invention made in the United States must first be filed with the United States Patent and Trademark Office (USPTO). This requirement raises the baseline level of patent filing activities above the industry average, though it does not necessarily result in an increase in high-value patents.

In conclusion, through a series of policies and measures, the United States not only maintains its leading position in the aerospace market but also promotes innovation and development among its domestic aerospace companies. These measures include opening market access, providing public innovation resources, and supporting companies through government procurements, ensuring its leadership in the global aerospace market

4. Summary

Overall, Europe has enhanced its position and technological development capabilities in the space sector through the formulation of long-term space policies and the provision of stable budgetary support, actively coordinating cooperation with other countries and international organizations. For instance, the financial partnership agreement between the European Space Agency (ESA) and the European Commission stipulates that, between 2021 and 2027, the European Union will allocate approximately €9 billion from its space budget to support space development programs. These funds not only target technological innovation and industrialization promotion but, through political incentives and technological cooperation, have also fostered the growth and competitiveness of commercial space companies in Europe.

Meanwhile, China has undergone a critical transition from a government-led to a more commercial model in the space sector, significantly increasing the number of domestic patent applications by strengthening incentive measures. In 2014, the Chinese government issued a series of policies to promote investment diversification and industrial application in the space industry. These policies include government subsidies, tax reductions, and job opportunities, which have greatly stimulated innovation among domestic companies and research institutions. However, these incentives have primarily driven short-term growth in patent applications rather than long-term patent protection and technology accumulation. Despite this, China's rise in commercial space has led to the emergence of several highly competitive companies.

The U.S. government, on the other hand, tends to directly support the development of high-tech companies through various policies, especially risk compensation mechanisms and government procurements, ensuring the continued growth and international competitiveness of the commercial space sector. For example, NASA has not only made numerous technological resources available to private companies but also provided stable market demand to startups through government procurements. The *Buy American Act* prioritizes the acquisition of products and services from domestic small and medium-sized technology enterprises. Combined with risk compensation funds and priority usage policies, this significantly reduces R&D risks for companies and incentivizes technological innovation. Additionally, the U.S. has been active in international cooperation, further consolidating its leadership in the global space market through transnational projects and expansion into international markets.

In conclusion, Europe, China, and the United States have adopted unique strategies and approaches to promoting technological development and industrialization in the space sector. Europe emphasizes policy longevity and international cooperation, China has achieved rapid commercial transition through political incentives, and the United States ensures continuous innovation and competitiveness of its high-tech companies through direct support and market mechanisms. These diverse strategies not only reflect the priorities and development paths of each country in the space sector but also provide a valuable source of experiences and lessons for the diversified development of space technology and industry on a global scale.

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