Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 15, No. 1, 2024

Research on Manufacturing Industry and Key Core Technology Breakthroughs

Suchen Tang, Yihao Li, Mengting Han

School of Business Administration, Anhui University of Finance and Economics, Bengbu City, Anhui Province, Postal Code 233000, China
* Corresponding author: Tang Suchen

Abstract: This project mainly studies how China's manufacturing industry can effectively coordinate with government, industry, academia, and research in the context of the traditional global trade system, in order to achieve breakthroughs in key core technologies and modernization of the supply chain. Focusing on the collaborative efficiency of manufacturing enterprises among multiple entities including government, industry, and enterprises, as well as the impact of various capabilities such as industrial agglomeration, capital investment, and institutional construction on key core technology breakthroughs. Secondly, further analyze the current innovation situation in China, taking into account the impact of the innovation environment on achieving innovation breakthroughs in the manufacturing and related industries. Furthermore, based on the relevant cases of key core technology innovation breakthroughs achieved by excellent enterprises in China and existing experience and theories, analyze and summarize new ideas. Finally, summarize the relationship between government, industry, academia, research, and enterprises in achieving key core breakthrough capabilities, as well as the mechanism of synergistic effects among various entities, and propose relevant suggestions based on the results.

Keywords: Integration of industry, academia, and research; Key core technologies; Innovation environment; Industrial synergy effect.

1. Introduction

1.1. Reason for topic selection and research significance

There are still a series of difficulties for Chinese manufacturing enterprises in achieving breakthroughs in key core technologies. Compared with developed countries, China's technological accumulation in certain fields is relatively weak, which leads to a lack of sufficient technological reserves and talent support in breakthroughs in key core technologies; In terms of research and development investment, although China has continuously increased related investment in recent years, it still cannot fully meet the research and development needs, which will to some extent limit the depth and breadth of enterprises in key core technology research and development; In terms of innovation environment, China still needs further improvement in intellectual property protection, innovation policies, and innovation ecology to stimulate the innovation enthusiasm and ability of enterprises. According to the current development status of manufacturing enterprises, due to insufficient investment in basic research, incomplete tackling system, and limited integration of industry, academia, and research, Chinese manufacturing enterprises are still constrained in breaking through key core technologies and cultivating breakthrough capabilities in some key fields and industries. This study supplements new perspectives and refines the relevant theories of technological innovation and industrial synergy in China by analyzing successful cases and theories of key core technologies implemented by some enterprises in China. This study comprehensively and deeply investigates how China's enterprise industry chain achieves key core technological innovation, revealing the mechanisms and laws behind it.

1.2. Research status

By reviewing relevant research reviews, we have learned that research on key core technologies in the field of innovation in China is still in its early stages. From a theoretical perspective, the definition of key core technologies and their related concepts in China is chaotic, and research on the fundamental problem is not sufficient. At the same time, research on the underlying logic is also very scarce, especially on the microstructure and evolution mechanism of key core technologies. From a practical perspective, both mainstream technology innovation theory and technology catch-up theory focus on specialized research on key core technologies, and most literature only emphasizes conceptual exposition, thus lacking truly practical and systematic research.

Through the research of Zhang Yufei and others, I have learned that the intensity and depth of the integration of industry, academia, and research have significantly improved the key core technology breakthrough capabilities of leading enterprises. The intensity of industry university research integration refers to the comprehensive reflection of the degree of closeness and cooperation effect between industry, academia, and research institutions in the cooperation process. The intensity of this integration directly affects the effectiveness and quality of results of industry university research cooperation. The deep integration of industry, academia, and research effectively connects research and development with market activities, bridges the gap between technology and industry, and can bridge the gap from basic research to production and listing. The study mentioned that the unique path of Chinese style innovation for key core technology breakthroughs of Chinese leading enterprises needs to be achieved through the deep integration of industry, academia, and research. Secondly, the government's leading role and institutional advantages can provide strong support

for enterprises. However, research on the deep integration of industry, academia, and research is still in its early stages, with only partial qualitative analysis and a lack of verifiable quantitative analysis.

In the research of Li Tianzhu et al., it is mentioned that the innovation ecosystem is a complex and ever-changing system. Over time, there are evolutionary phenomena such as participant entry, exit, relocation, differentiation of connections, structural changes, and environmental changes. This dynamic process provides opportunities for breakthroughs in key core technologies, and only by correctly grasping the laws of innovation ecosystem evolution towards higher levels can we effectively promote breakthroughs in key core technologies. Their research found that in the context of innovation ecosystem evolution, through vertical analysis and horizontal comparison of typical cases, the innovation ecosystem is the carrier of key core technology breakthroughs, and international leaders and domestic catchers have different path preferences for implementing key core technology breakthroughs. Therefore, further exploration in future research on how to cultivate and optimize an innovative ecological environment suitable for domestic enterprises to achieve technological catch-up has gradually become a new hot topic in international industrial competition.

2. The Research Objectives and Innovative Ideas of This Article

2.1. Research objectives

The research objective of this article is to explore the path for manufacturing to achieve breakthroughs in key core technologies and propose innovative ideas. The main idea is to cross integrate and innovate technologies based on different fields, in order to explore new technological paths. By applying cutting-edge technologies in the manufacturing industry, such as AI, digital and intelligent production modes can be achieved in industrial manufacturing, enabling cross integration and mutual promotion of different disciplines. Committed to promoting communication and cooperation among experts from different fields on the basis of interdisciplinary teams or platforms, in order to accelerate the realization of technological breakthroughs. By carrying out and promoting cross-border technology integration, we aim to create more new technological paths in the manufacturing industry. The so-called cross-border integration innovation is an important strategy adopted to combine the most advanced technology from different fields with the manufacturing industry, with the aim of vigorously exploring new horizons of innovative development on the basis of promoting digital and intelligent production. We will introduce cutting-edge technologies such as artificial intelligence, the Internet of Things, and big data into the manufacturing industry to achieve technological integration and development applications. Utilizing IoT sensors and big data analysis to optimize the production process, and utilizing machine learning algorithms to improve production efficiency and quality.

It is very beneficial to engage in academic and professional exchanges and cooperation with experts from different fields, in order to break down barriers between disciplines, promote collision of ideas and exchange of innovative thinking, and thus friction sparks of innovative thinking. This kind of communication can not only stimulate understanding of problems and problem-solving ideas, but also promote the emergence of interdisciplinary innovative thinking. Further establish interdisciplinary research teams and platforms, bringing together experts with expertise in different fields to facilitate brainstorming and explore innovative development paths in the manufacturing industry by combining knowledge and technology from different fields. Cross boundary integration innovation is conducive to accelerating the breakthrough and application of key core technologies. Through cross integration between different fields, it can bring new technologies and methods to the manufacturing industry, stimulate new business models and market opportunities, achieve automation, intelligence, and efficiency in the production process, and make the manufacturing industry more competitive and innovative in responding to rapid market changes and diversified customer needs. Therefore, cross-border integrated innovation is of great significance for the development of the manufacturing industry. It is not only conducive to promoting the transformation and upgrading of the manufacturing industry, but also has a positive effect on enhancing the market competitiveness of the manufacturing industry and responding to the ever-changing market demand.

In summary, cross-border integrated innovation is an important strategy to promote the development and transformation of manufacturing technology, which includes three aspects: introducing scientific and professional technologies from different cutting-edge fields; Encourage cooperation and communication among different disciplines; To provide support for establishing interdisciplinary teams and platforms, thereby accelerating breakthroughs in key core technologies; Promoting the rapid advancement of manufacturing towards digitalization and intelligence plays a crucial role in technological development and transformation and upgrading.

2.2. Innovative ideas

(1) Establishing an open innovation platform to attract forces from all walks of life to participate in the research and breakthrough of key core technologies is an important measure we have taken. Firstly, through open innovation development, external resources and knowledge can be obtained more quickly, promoting technological innovation and application, thereby ensuring the pertinence and effectiveness of research. Secondly, based on identifying key areas and key directions for technological breakthroughs, establishing an open innovation platform will provide opportunities for people from all walks of life to jointly participate in the research and development of key core technologies, which is a very forward-looking approach. This can not only bring broader ideas and resources to participants from different fields and backgrounds, but also promote technological research and breakthroughs, which is of great significance. Furthermore, through innovation platforms, we can quickly access external resources and knowledge, such as research results and market information on technology patents, thereby avoiding duplicate research and the dispersion and waste of resources. On an open innovation platform, not only can we have a clear understanding of core goals and key areas, and position the direction and focus of technological breakthroughs, but we can also ensure the pertinence and effectiveness of research through joint discussions and negotiations, thereby avoiding waste and dispersion of resources. Finally, on the basis of establishing an open innovation platform, it can promote the establishment

of a sustainable ecosystem, thus forming a virtuous cycle between technological innovation and industrial development - which can promote breakthroughs in key core technologies and bring new market opportunities for the development of new industries. Through this approach, we can not only promote technological progress and development, but also contribute new forces to the sustainable development of the economy.

In summary, establishing an open innovation platform is a very important measure to promote the research and development of key core technologies and breakthroughs. It is conducive to quickly obtaining external resources and knowledge by attracting multiple parties to participate, clearly defining core goals and key areas, and promoting cooperation and communication. Therefore, it plays a positive role in promoting the realization of technological innovation, and can also effectively promote industrial development and economic growth.

(2) Maintain close contact with partners in the supply chain and jointly build a manufacturing ecosystem to promote breakthroughs in key core technologies. The cooperation of ecosystems can enhance the synergistic effects of resource sharing and complementary advantages, thereby accelerating the landing and commercialization of technology. Be able to identify key technologies that have a breakthrough impact on the future based on forward-looking technological predictions, and plan ahead and invest research and development resources. So as to help the manufacturing industry maintain a leading position in technological competition and achieve continuous breakthroughs in key core technologies. Taking key strategic measures in building a manufacturing ecosystem plays a very positive role in accelerating breakthroughs in key core technologies and promoting industrial and economic development. By establishing close cooperative relationships with suppliers, partners, and customers, a interconnected ecosystem is formed. This cooperative relationship can provide stronger support for technological breakthroughs and commercialization, promote information sharing, resource integration, and technological exchange. Within the ecosystem, resource sharing, mutual complementarity, and overall competitiveness are enhanced. Customers can provide feedback on their needs, partners can provide technical support in specific fields, and manufacturers can cooperate with suppliers for new product development. This collaborative approach can accelerate the landing and commercialization of technology, enabling technology to be transformed into practical products and solutions more quickly through ecosystem cooperation to accelerate the landing and commercialization process. This will contribute to meeting customer needs, achieving business growth, and improving product market competitiveness. Ecosystem members can work together to make forward-looking technology predictions and advance the layout and investment of research and development resources to ensure a leading position in key areas.

Overall, building a manufacturing ecosystem can promote closer collaboration and cooperation among various links in the industrial chain; Promote resource sharing and complementary advantages; Accelerate the promotion and application of technology; Through efforts in forward-looking technology prediction and continuous research and development investment; Promote members of the ecosystem to remain at the forefront of the industry; Thus promoting the development and innovation of the industry.

(3) We need to formulate policy measures to support technological innovation and industrial development, and strengthen collaborative innovation among the government, enterprises, and research institutions. The collaborative innovation of policies and industries can promote the optimization and rapid development of key core technologies. Improve technological breakthroughs, promote effective integration of technology research and application, and fully utilize government support policies and industrial development plans. Relevant personnel should have a deep understanding of the policy environment and market demand in the manufacturing industry, and organically combine policy and industry development with technological innovation to form a synergy between policy and industry innovation. To promote technological innovation and industry development through policy and industry collaboration, it is also necessary to strengthen collaborative innovation among government, enterprises, and research institutions. Firstly, while encouraging enterprises and research institutions to actively participate in innovation activities, the government can provide policy support and resource guarantee for industries by formulating policy measures to support technological innovation and industrial development. Governments, enterprises, and research institutions each have their own strengths, and collaborative innovation can achieve optimal resource allocation. The government provides policy support and financial investment, enterprises provide market demand and practical scenarios, and research institutions collaborate to promote technological innovation and industrial development, provide cutting-edge technology and professional knowledge, and maximize the utilization of resources from all parties. Secondly, the government should formulate policies to support the development of key core technologies, providing financial support, tax incentives, industrial policies, and other favorable innovation environments and policy support for enterprises and research institutions to accelerate the research and application of key core technologies, enhance industrial core competitiveness. The collaborative innovation between policies and industries can promote each other, enabling various participants in the industrial chain to achieve the goal of collaborative development. Government policy support can promote enterprises to increase innovation investment, encourage research institutions to conduct cutting-edge scientific and technological research, and ultimately form a virtuous cycle system of promoting industrial development and technological innovation through policies. Therefore, the synergistic effect between policies and industries is of great significance for promoting economic development, and it is also a major challenge that China is currently facing in the process of economic development. Collaborative innovation between policies and industries is an effective way to promote technological innovation and industrial development, which is conducive to optimizing resource allocation and promoting the rapid development of key core technologies, ultimately forming a joint force led by policies, industries, and technological innovation to promote sustained and healthy economic development. Therefore, this article elaborates and analyzes from multiple aspects.

3. Literature Review

3.1. Key core technology breakthroughs and key core technology breakthrough capabilities

Firstly, breakthroughs in key core technologies mainly refer to significant progress and significant innovation in the field of core technologies. These technologies are usually those that have gaps with other countries in the short term and are still constrained by them, but can maintain national security, lead future development, and play a decisive role in the technology and industry chains in the medium to long term. These technologies include but are not limited to key common technologies, cutting-edge leading technologies, modern engineering technologies, and disruptive technologies. The breakthrough of key core technologies is not only related to high-quality economic development, but also directly related to national security.

Secondly, the breakthrough capability of key core technologies refers to the innovation capability that a country or enterprise possesses in the field of key core technologies. This ability is reflected in the ability to systematically and deeply integrate innovative resources from multiple disciplines and fields, integrate multiple innovative forces across departments, regions, and levels, and effectively coordinate multiple innovative elements to achieve significant breakthroughs in key core technologies. This ability not only requires strong research and development capabilities, but also efficient innovation mechanisms, excellent innovation teams, and a good innovation environment.

From a more macro perspective, breakthroughs in key core technologies and breakthrough capabilities are undoubtedly the key ways for the effective implementation of national strategic scientific and technological forces in the future. This requires the country to continuously strengthen the systematic layout and construction of scientific and technological innovation, improve the innovation capabilities of key core technologies of enterprises, and more manufacturing industries will have the opportunity to firmly grasp the initiative of scientific and technological development in their own hands. This is not only the lofty goal of achieving socialist modernization, but also an important guarantee for promoting high-quality economic development and national security.

In summary, the theoretical definition of key core technology breakthroughs and key core technology breakthrough capabilities encompasses multiple aspects such as the importance of technology itself, the complexity of the innovation process, and the roles played by countries and enterprises in it. These theoretical definitions not only provide a framework for us to understand key core technologies, but also provide guidance for us to promote breakthroughs in key core technologies in practice.

3.2. The intensity of industry university research integration

The intensity of industry university research integration refers to the comprehensive reflection of the degree of closeness and cooperation effect between industry, academia, and research institutions in the cooperation process. The intensity of this integration directly affects the effectiveness and quality of results of industry university research cooperation. The specific manifestations of the intensity of industry university research integration can include the following aspects:

(1) Cooperation depth: The degree of investment from industry, academia, and research parties in cooperation, the scale and complexity of cooperation projects, and the duration of cooperation are important indicators for measuring the strength of integration. Deep cooperation means that all parties share and exchange resources, technology, talent, and other aspects more fully, which is conducive to forming long-term and stable cooperative relationships.

(2) Efficiency of achievement transformation: The core goal of industry university research cooperation is to achieve the transformation and application of scientific and technological achievements. Therefore, an important manifestation of the strength of integration is the speed and efficiency of the transformation of cooperative results. Efficient achievement transformation can promote industrial upgrading and innovative development, and enhance overall competitiveness.

(3) Talent cultivation and exchange: Industry university research cooperation can not only achieve the combination of technology and economy, but also provide an important platform for talent cultivation and exchange. Therefore, deep cooperation between industry, academia, and research institutions can promote the flow and sharing of talents among industries, academia, and research institutions, and enhance the quality and innovation ability of talents.

(4) Strengthening cooperation among all parties: In order to enhance the integration of industry, academia, and research, it is necessary for all parties to strengthen communication and cooperation, establish long-term and stable cooperative relationships, jointly invest resources and technological strength, and promote the transformation and application of scientific and technological achievements. At the same time, the government and all sectors of society should also pay more attention and support to industry university research cooperation, and create a good innovation environment and atmosphere.

3.3. Government support plays a universal role in enabling enterprises to achieve breakthroughs in key core technologies

Firstly, from the perspective of market failure theory, the government plays an important role in the research and development of key core technologies. Due to the high risk and uncertainty of technological innovation, as well as externalities and information asymmetry, market mechanisms may malfunction in resource allocation. At this point, the government can reduce the research and development costs and risks of enterprises by providing funding, policies, and other support, and promote breakthroughs in key core technologies.

Secondly, according to the theory of innovation systems, the government is an important component of the innovation system. The innovation system includes multiple entities such as enterprises, research institutions, and universities, while the government promotes cooperation and interaction among various entities through policy formulation, provision of infrastructure and public services, and promotes the optimization and efficient utilization of innovation resources. In terms of breakthroughs in key core technologies, the government can guide and support enterprises, research institutions, and other entities to conduct joint research and

development, form an innovative synergy, and accelerate the process of technological breakthroughs.

In addition, industrial policy theory also provides important basis for the government to support enterprises in achieving breakthroughs in key core technologies. As is well known, industrial policy is a means for the government to intervene and regulate the development and structural adjustment of industries, usually reflecting several important objectives. In the field of key core technologies, the government generally adopts methods such as formulating industrial development plans, providing tax incentives, and establishing special funds to guide and motivate enterprises to increase research and development investment, and promote the research and application of key core technologies in related fields.

4. Taking an Typical Example

The breakthrough in key core technologies of the new generation of communication technology is an important support for promoting digital transformation and a key factor for enterprises to gain competitive advantages in global digital competition. Enterprises are the main body of technological innovation. In recent years, the number of patent applications for next-generation communication technology by Chinese enterprises has reached the world's first. Among them, companies such as Huawei and ZTE have grown into leading international enterprises. At the same time, it is necessary to recognize that the basic research of Chinese enterprises is still weak, and there are still significant shortcomings in breakthroughs in the underlying technology field. Especially in the face of the global supply chain crisis under the impact of the COVID-19, as well as uncertainties such as the United States' inclusion of emerging key technologies in export controls, how Huawei 5G-A, a new generation of communication technology enterprise in China, should achieve breakthroughs in key core technologies has become the subject of this study.

4.1. Research methods

This case study adopts grounded theory to conduct a structured analysis of Huawei's vertical case, because the catch-up of complex core technologies is an exploratory problem. Vertical case studies are suitable for in-depth analysis of the research object, discovering the essence through complex phenomena, obtaining more comprehensive and inspiring views, and constructing theories. At the same time, the time span of the research object is large, and vertical cases can fully present the dynamic evolution process of the research object. Combined with rich materials and data, structured analysis of the formed key concepts is carried out to further improve the rigor of qualitative research.

The Huawei 5G project was chosen as the case study object, mainly following the principle of theoretical sampling. Huawei's 5G technology breakthrough is a typical successful case of China achieving key core technology breakthroughs through core enterprise leadership. The development of new generation communication technology carries enormous research and development risks, but Huawei, guided by a strong vision and entrepreneurial spirit, relies on its own technological reserves to deeply integrate industry, academia, and research, ultimately achieving breakthroughs in key core technologies and mastering the qualification for international standard setting.

4.2. Case analysis

(1) Phase 1: Basic accumulation stage

Huawei attaches great importance to long-term planning and has been researching and laying out 5G technology since the 4G era. The senior management of the company has a clear strategic positioning and regards it as a key point for the future development of the enterprise.

In order to promote the research and development of 5G mobile communication technology, the Ministry of Industry and Information Technology, the National Development and Reform Commission, and the Ministry of Science and Technology of China have jointly established the IMT-2020 (5G) Promotion Group, which focuses on domestic "industry university research and application" advantageous units, and jointly carries out research on 5G strategies, requirements, technology, spectrum, standards, intellectual property, and international cooperation, achieving phased research progress. In May 2021, the Ministry of Industry and Information Technology organized a 5G/6G special meeting, which pointed out that with the joint efforts of the industry, China has achieved a leading advantage in 5G development, with a total of over 819000 5G base stations built, accounting for about 70% of the global proportion; The number of 5G mobile terminal users connected reached 280 million, accounting for over 80% of the global proportion; The proportion of 5G standard essential patent declarations exceeds 38%, ranking first in the world.

(2) Phase 2: Technical Exploration Phase

On September 11, 2023, under the organization of the IMT-2020 (5G) Promotion Group, Huawei took the lead in completing all functional test cases of 5G-A. This test covered the key technologies of uplink and downlink ultra wideband and broadband real-time interaction 5G-A. 5G-A (5G-Advanced), also known as 5.5G, is a critical stage in the evolution of 5G to 6G.

From the latest progress, Huawei has for the first time applied technologies such as business differentiation scheduling and end-to-end cross layer collaboration to XR business, ensuring the speed, latency, and reliability requirements of users. Among them, in terms of end-to-end cross layer collaboration, Huawei achieved XR single sector capacity exceeding 70 users for the first time through frame service recognition, which is a significant improvement compared to traditional solutions in the industry.

At present, major research enterprises and institutions in China are actively investing in innovative research and testing verification of 5G-A, and gradually moving from key technology innovation to cross industry cooperation and innovation oriented towards application scenarios. Relying on the school enterprise cooperation platform and deepening the integration of industry, academia, and research, Huawei has achieved significant performance breakthroughs in multiple 5G-A technologies, which means that 5G-A has a broad application foundation in daily communication and high bandwidth, low latency application needs. Meanwhile, Huawei's 5G-A technology can further enhance the performance and efficiency of operator networks.

(3) Phase 3: Marketization and Industrial Chain Layout

At present, the overall scale of China's ultra-high definition industry has reached trillions of yuan. The establishment of ultra-high definition technology laboratories is expected to further promote the coordinated and coordinated development of the entire industry chain, including ultra-high definition standards, terminal hardware, transmission, and

content production, through the leadership of ultra-high definition video alliances and the driving force of leading enterprises such as Huawei. This will drive the gradual improvement of the industry chain and the rapid landing of ultra-high definition technology in applications such as 5G and artificial intelligence.

Huawei will deeply participate in the ultra high definition industry chain and further build a more open audio and video technology standard system, with industry chain enterprises promoting industrial development through joint investment. By collaborating with global operators, we aim to promote Huawei's 5G solutions and accelerate the commercial deployment of 5G. In the future, as the 5.5G policy, industrial chain commercial scenarios, and technology become increasingly mature, related industries will usher in more business opportunities, and 5G investment is expected to enter a new cycle.

4.3. Technological innovation

The current technological innovation is no longer limited to activities between laboratories or enterprises, and technology dissemination not only needs to consider market factors, but also needs to establish alliances through certain political strategies to resist unexpected political risks. From a technical perspective, the Polar code supported by Huawei is currently the only encoding method that can reach the Shannon limit, but this is only theoretical; In practical engineering applications, Polar codes and their competing LDPC codes and Turbo codes each have their own advantages and disadvantages.

Huawei continuously adjusts its strategy to generate autonomy in technological innovation through openness. On the one hand, it is necessary to rely on the cumulative cycle to bring knowledge back and redefine it as the center of the cumulative cycle; On the other hand, in the process of technology commercialization, open consultations with other key technology development competitors are conducted to make relevant technologies international standards in the industry and define "mandatory channels". The 5G industry chain is constantly improving. In 2023, Haier Smart Home, China Mobile Research Institute, and Huawei signed a strategic cooperation MOU for the 5G-A dual chain integration action plan, achieving deep industry integration under technological breakthroughs.

5. Existing Problems, Countermeasures, And Suggestions

5.1. Existing problems

At present, the root cause of the bottleneck problem of key core technologies in manufacturing enterprises lies in weak basic research. To overcome the difficulties of key core technologies, it is necessary to solidly carry out basic research and applied basic research, and guide enterprises and other entities to increase investment in basic research. The promotion effect of R&D funding on enterprise technological innovation has been verified by scholars such as Mao Yichong and Yang Wu. Key core technology research and development essentially belongs to technological innovation, and also cannot do without the support of technology research and development investment.

(1) High technological barriers and monopolistic issues:

Some key core technologies are restricted by high technological barriers, making it difficult for enterprises to break through. In addition, the supply of high-end talents in related technology fields is insufficient, which affects the level of technological research and development of enterprises. Due to the need for a large amount of capital investment in the research and development of key core technologies, some small and medium-sized manufacturing enterprises often face funding shortages. Over time, the "Matthew Effect" becomes increasingly severe.

(2) The uniqueness of key core technology breakthroughs:

Having high-quality technical talents is the key to achieving technological breakthroughs in manufacturing enterprises. However, in terms of breakthroughs in key core technologies, there is a mindset of seeking quick success and instant benefits, a lack of systematic thinking, and a lack of progressive approaches and methods. This is usually reflected in the lack of the fastest solution to key problems from a global perspective, which can easily lead to the problem of setting a single solution with minimal investment without considering parallel or backup solutions, resulting in the delay of breakthroughs in key core problems.

Enterprises have a wait-and-see mentality, and when there are obvious shortcomings or weaknesses in a certain link at the front of the industrial chain, they believe that the current problem only exists in that area and ignore the problems that also exist in their own link; Some manufacturing enterprises do not have a technology research and development direction that is close to market demand, resulting in the inability to effectively apply key core technologies.

(3) Systematic issues related to breakthroughs in key core technologies:

In the process of promoting technological breakthroughs, enterprises need to effectively integrate internal and external R&D resources, including talent, funds, equipment, and intellectual property. The efficiency of resource allocation directly affects the speed and quality of technological innovation; In addition, if the collaborative development of the supply chain cannot be achieved, it will affect the process of technology development.

The compatibility and integration between products and technology are not mature enough, and the development of breakthrough technologies often involves improving existing product lines or creating new products. This requires ensuring good compatibility between technology and product design to facilitate technology integration, adoption, and large-scale application.

5.2. Countermeasures

(1) Realize high-level embedding of cooperative network relationships. The embedding of high-level cooperative network relationships manifests as more enterprise connections, which can achieve value co creation between organizations, obtain more complementary resources, and thereby reduce the monopoly of critical resources. The improvement of the embedding degree of enterprise cooperation network relationships helps to improve the timeliness of information transmission and reduce information asymmetry; And it can shorten the communication distance between enterprises and other organizations, facilitate the establishment of trust and collaboration mechanisms among research and development entities, and reduce the risk of key core technology breakthroughs. In addition, embedding cooperative network relationships helps to widely detect the latest research and development trends and market trends, helping enterprises to

timely formulate and adjust the direction of technology research and product development, and thus cross the "valley of death" to achieve breakthroughs in key core technology scale commercial barriers.

(2) Understand market demand and open up innovative models. Manufacturing enterprises often need to cooperate with suppliers, partners, research institutions, etc. to jointly carry out technological innovation and research and development activities. Open innovation models can accelerate the realization of technological breakthroughs; Different manufacturing industries have different technological challenges. Enterprises should strengthen market research, deeply understand market demand, adjust technology research and development direction based on market feedback, and ensure that key core technology research is closely integrated with market demand.

(3) Realize the coordinated and diversified development of industry, academia, and research. Strengthening cooperation among multiple entities is essentially the cross collaboration of knowledge in different fields, alleviating the problem of homogenization of enterprise resources, promoting cross learning in the technical field, providing diversified and heterogeneous technological and knowledge conditions for breakthroughs in key core technologies, stimulating enterprise research and development vitality, and achieving breakthroughs in key core technologies. Enhanced sensitivity to breakthroughs in key core technologies can help overcome cognitive locking barriers, promote enterprises to explore and integrate core technologies and knowledge within different technological tracks, and thus jump to the original technological track to achieve breakthroughs in key core technologies. It helps to communicate with various research subjects in industry, academia, and research, collaborate upstream and downstream in the industrial chain and innovation chain, and achieve breakthroughs in key core technologies that are collaborative and systematic.

5.3. Suggestions

With the deep integration of new generation information technology and manufacturing industry, the single operation mode of employees is changing, which puts higher requirements on the quality of skilled talents. It has become a consensus among all parties to focus on building a team of industrial workers with more professional knowledge and higher skill levels, injecting innovative vitality into the high-quality development of the manufacturing industry. Through the following three dimensions, we will gather the collaborative efforts of the government, academia and research, and manufacturing enterprises to tackle key technologies and empower the high-quality development of the manufacturing industry.

(1) Strengthen top-level design and strategic coordination, and deepen the collaborative research and development of industry, academia, and research

Deepen the reform of the scientific and technological system, establish a technology innovation system with enterprises as the main body, market orientation, and deep integration of industry, academia, and research, strengthen support for innovation in small and medium-sized enterprises, and promote the transformation of scientific and technological achievements. The innovation model of industry university research is established on the basis of tripartite cooperation between industry university research, and promotes the transformation of scientific and technological achievements and economic development through optimized resource allocation and collaborative innovation.

(2) Actively integrating into the regional innovation system, enhancing basic research and applied basic research capabilities

Regarding the construction of high-level scientific and technological innovation regions, the government needs to systematically deploy and strengthen basic research, issue relevant opinions on strengthening basic and applied basic research, formulate corresponding strategies, and actively solve major scientific and technological problems in key areas through measures such as strengthening top-level design, increasing financial investment, introducing social forces, and building talent highlands, striving to provide inexhaustible source power for scientific and technological innovation. Basic research is the source of scientific and technological innovation, and manufacturing enterprises should actively integrate into the regional innovation system.

(3) Strengthen the cultivation of leading enterprises, and give full play to the leading role of leading enterprises in supplementing, strengthening, and extending chains

Support leading enterprises to fully play their leading role in the industry, actively address national strategic needs and industry chain shortcomings, lead the development of independent innovation projects, seek funding from superiors, strive to strengthen upstream and downstream linkage, and deepen the depth and intensity of "industry university research" cooperation; Supporting leading enterprises to lead the formation of innovation consortia, guided by industrial chain security and national security, comprehensively linking the innovation chain, industrial chain, capital chain, and talent chain, promoting the strengthening, supplementation, and extension of the manufacturing production industry chain, and striving to build enterprises into a manufacturing industry aggregation with international influence and leading domestic capabilities.

6. Conclusion

Technological innovation is the key to achieving breakthroughs in key core technologies in the manufacturing industry. With the continuous development and transformation of technology, the manufacturing industry needs to continuously promote technological innovation, especially in the areas of digitization, intelligence, automation, etc. to improve production efficiency, reduce costs, and improve product quality. Breakthroughs in key core technologies and cross-border cooperation are an effective path. Cross border cooperation can facilitate resource integration, accelerate technological exchange and transfer, and provide broader space and richer resources for breakthroughs in key core technologies. There is interdependence and mutual influence between different fields of manufacturing. The important guarantee for technological breakthroughs is to strengthen talent cultivation. The manufacturing industry requires a large number of talents with professional skills and innovative abilities, and talent cultivation, including strengthening education and training, motivating talents to innovate, and other aspects, requires long-term investment and continuous attention. Promoting technological breakthroughs and policy support are important guarantees. The government should increase its support for technological innovation in the manufacturing industry by introducing relevant policies, providing financial support,

optimizing the industrial environment, and better providing policy environment and support to break through key core technologies in the manufacturing industry. The important path for technological breakthroughs is to strengthen international cooperation. Faced with the trend of global competition and technological exchange, in order to achieve global leadership in key core technologies, the manufacturing industry needs to strengthen cooperation and communication with the international community, work together to address challenges, and share achievements.

In summary, in order for the manufacturing industry to make breakthrough progress in key technologies, it is necessary to work together from multiple parties to promote technological innovation, strengthen cross-border cooperation, strengthen talent cultivation, increase policy support, and strengthen international cooperation. These are all key paths and important guarantees. Only by adhering to a multi pronged approach can the sustainable development of the manufacturing industry be guaranteed.

The progress of technology and the rapid development of the manufacturing industry have given us confidence to achieve breakthroughs in more key core technologies through persistent efforts and cooperation, enabling the manufacturing industry to continuously move towards digital, intelligent, green, and high-quality development, injecting new impetus into economic development.

Acknowledgment

This work was supported in part by a grant from Anhui University of Finance and Economics Undergraduate Research Foundation. Project number: XSKY23129.

References

[1] G. O. Young, “Synthetic structure of industrial plastics (Book style with paper title and editor),” in Plastics, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp.

[2] Zhang Yufei, Zhang Shuman, Liu Bing Theoretical analysis and empirical testing of the impact of deep integration of industry, academia, and research on the breakthrough ability of key core technologies in leading enterprises [J] Journal of Management, 2024, 21 (04): 568-576+615

[3] Li Tianzhu, Ma Jia, Gao Haotian, etc Key core technological breakthroughs in the context of innovative ecosystem evolution [J] Research Management, 2024, 45 (01): 51-63 DOI: 10.19571/j.cnki.1000-2995.2024.01.006

[4] Feng Kun, Li Xianjun, Xiong Yu, etc Review of Key Core Technology Research: Concepts, Structures, Breakthrough Paths and Mechanisms [J] Research Management, 2023, 44 (12): 21-30 DOI: 10.19571/j.cnki.1000-2995.2023.12.003. [1] Han Shuhui, Wang Tao. Enterprise Leading Logic and Key Core Technology Breakthroughs: A Case Study Based on Huawei's 5G Project Interview. Science and Industry, 2024, 24 (02): 7-14

[5] Zhang Yi, Yan Qiang. The catching up and driving mechanism of complex core technologies in enterprises: a longitudinal case study based on Huawei wireless network technology [J]. Science and Technology Progress and Countermeasures, 2024, 41 (05): 150-160

[6] Jia Li. Huawei's comprehensive completion of 5.5G key technology testing will accumulate technological advantages and business models for 6G communication. Securities Daily, 2023-10-23 (A03) DOI: 10.28096/n.cnki.ncjrb.2023.005687

[7] Xu Li, Lv Jianming, Li Po, et al. Curriculum construction and exploration of "5G mobile communication technology" in the context of vocational undergraduate education [J]. Industrial and Information Education, 2022, (12): 16-20

[8] Wang Fuxiang Research on Huawei's Innovation and Overcoming Path of Smartphone Technology Innovation from the Perspective of Innovation Ecosystem [D]. Harbin Institute of Technology, 2021. DOI: 10.27063/d. cnki. ghlgu.2021.000718

[9] Jia Li. Huawei will establish an ultra-high definition technology laboratory and industrial chain company to jointly lay out a trillion yuan new track. Securities Daily, December 27, 2023 (B02) DOI: 10.28096/n.cnki.ncjrb.2023.007002

[10] Dai Xiangyang, Cai Zhong. Why does independent innovation need to be open—— Research on Huawei 5G Technology Innovation Based on Actor Network Theory [J]. Scientific Research, 2022, 40 (09): 1691-1697+1728. DOI: 10.16192/j.cnki.1003-2053.20220309.002

[11] Zhen Meirong, Cao Jinru. Self organized Breakthrough Path of Key Core Technologies in Manufacturing Enterprises: A Vertical Case Study Based on Shangshang Cable Group [J]. Management Case Study and Review, 2023,16 (03): 306-322

[12] Yin Ana. The Strategy, Path, and Impact of China's Open Economy Transformation and Upgrading