

# Industry-university-research cooperation and enterprise innovation performance: A review and a research agenda

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**Abstract.** Industry-university-research cooperation promotes the effective combination of production factors required for technological innovation. In this context, the size of the enterprise, the internal investment in R&D, the closeness of inter-enterprise cooperation, the training of quality personnel in universities and the introduction of professionals from society, and the planning of technology development and research directions by research institutions all have different degrees of influence on the innovation performance of enterprises at the enterprise level. Based on this, this paper defines the connotation of industry-university-research cooperation and innovation performance, and sorts out the influencing factors and effects of enterprise innovation performance under industry-university-research cooperation, so as to help enterprises improve their innovation capability and promote the construction of a scientific and effective industry-university-research cooperation innovation mechanism, thereby achieving sustainable development.

**Keywords:** Industry-University-Research Cooperation; Enterprise Innovation Performance; Influencing Factors; Role Effect.

## 1. Introduction

Innovation is the first driving force leading development. General Secretary Xi Jinping pointed out in his report to the 20th National Congress of the Communist Party of China that it is necessary to adhere to the principles of righteousness and innovation, and that innovation is the only way to grasp the times and lead the way. In a knowledge-based economy where science and technology are changing rapidly, continuous innovation is an important source of organisational competitiveness. In academia, most existing studies have taken innovation performance as an outcome variable and analysed its influencing factors, such as digital technology(Usai et al., 2021)<sup>[1]</sup>, open innovation(Audretsch & Belitski, 2023)<sup>[2]</sup>, strategic and operational reconfiguration(Ovuakporie et al., 2021)<sup>[3]</sup>, cooperation network (Zeng et al., 2010)<sup>[4]</sup>, and knowledge management (Mardani et al., 2018)<sup>[5]</sup>. Innovation is an enduring concept, and research in this area is becoming increasingly rich. The report of the 19th Party Congress clearly puts forward the need to deepen the reform of the science and technology system and to establish a technological innovation system with enterprises as the mainstay, the market as the guide and the deep integration of industry, academia and research. However, there is a lack of comprehensive understanding of the relationship between industry-university-research cooperation and enterprise innovation performance. Therefore, this paper aims to promote the in-depth cooperation between universities and enterprises and enhance the innovation capability of enterprises by summarising the existing results on University-Industry-Research Cooperation and the innovation performance of enterprises.

## 2. The connotation and research status of industry-university-research cooperation

### 2.1. The connotation of industry-university-research cooperation

Industry-university-research cooperation is an important component of the national innovation system. As university-industry cooperation is associated with the transfer of knowledge and technology, this collaboration is an extremely important field of study for the world's economies that helps companies become more competitive(Mascarenhas et al., 2018)<sup>[6]</sup>. The term "industry" refers

to industry or modern enterprises that rely on industry for technological innovation, "university" refers to academia, and "research" refers to research institutes or institutions that conduct basic research, applied basic research and research institutes or research institutions that conduct basic research, applied basic research and various types of technological research and development. At the micro level, university-industry cooperation can achieve a deeper integration of enterprises, universities and research institutes, so that they can join forces with each other to promote innovation; in turn, it can promote the way of economic growth at the macro level and achieve the goal of innovation-driven economic growth. The reasons for the emergence of industry-university-research cooperation have been extensively researched by academics, and Williamson explains the emergence of industry-university-research cooperation from the perspective of transaction cost economics - to reduce transaction costs (Williamson, 1991)<sup>[7]</sup>. Moreover, Fischer suggests that due to its ability to create and disseminate knowledge, the modern university is understood as a central agent in innovation systems and technology upgrading dynamics (Fischer et al., 2019)<sup>[8]</sup>.

## 2.2. Research status of industry-university-research cooperation

The technological innovation of countries around the world is generally convergent, with the main body of innovation concentrated in enterprises and efficient collaboration between industry, academia and research, but the cultural background of each country is different and the innovation mechanism is unique. China's research on industry-university research is increasing, and Li Wenjuan and Zhu Chunkui have analysed the hotspots and found that the combination of industry-university research, industry-university-research cooperation in education technology innovation, transformation of scientific and technological achievements, and enterprise technology innovation have become new important research hotspots (Li Wenjuan & Zhu Chunkui, 2018)<sup>[9]</sup>. The internal environment of the system mainly includes the cooperation between enterprises, universities and research institutes (scientific research institutions) and the characteristics of each subject. The cooperation of the three subjects of industry-university-research cooperation is focused on the cooperation in knowledge circulation, and the efficiency of knowledge transfer, absorption, sharing, utilization and re-creation will affect the whole system of industry-university-research cooperation (Chang Jie & Qiao Bin, 2020)<sup>[10]</sup>. Although industry-university-research involves three subjects, each subject also has different types. For example, enterprises can be divided into state-owned enterprises and non-state-owned enterprises according to the nature of their property rights; universities can be divided into universities directly under the central government and local universities; and research institutes can be divided into state-owned, converted, and social organisations. The diversity of subjects in industry-university-research cooperation can make the knowledge circulating in the system richer and broader (Zhang Shuman et al., 2021)<sup>[11]</sup>. Song et al uses data envelopment analysis (DEA) to study regional differences in industry-university-research collaborative innovation efficiency (ICIE) and shows that the average efficiency of China's industry-university-research collaboration innovation is 0.65, and many provinces have not reached the effective frontier (Song et al., 2020)<sup>[12]</sup>. Zeng applies the social cooperation network and multi-period DID and shows that the IUR transformation efficiency is always less than IUR R&D efficiency and the pilot policy has a positive effect on improving IUR innovation efficiency (Zeng et al., 2023)<sup>[13]</sup>. Different types of contractual governance mechanisms have different effects on knowledge transfer. The contractual coordination mechanism significantly promotes explicit knowledge transfer in an IUR cooperation but has no significant impact on tacit knowledge transfer, whereas the contractual control mechanism significantly promotes explicit knowledge transfer but hinders tacit knowledge transfer (Li et al., 2022)<sup>[14]</sup>. In general, scholars have focused on improving the effectiveness of industry-university-research cooperation and its influencing factors.

### **3. The connotation and measurement of enterprise innovation performance**

#### **3.1. The connotation of enterprise innovation performance**

Innovation creates new dynamics for development and is a key driver for organisations to maintain a competitive edge in a rapidly changing market environment. Schumpeter pioneered the study of 'innovation' in 1912, dividing it into 'four new' categories according to their content: new products, new production methods, new markets, and new ways of organising a business. Innovation must be able to create new value, and the subject of innovation is the firm, and the scope of innovation usually includes products, business models and processes. Subsequently, mainstream scholars 'tacitly' focused on technological innovation until 2008, when Birkinshaw and others focused on non-technological innovation - management innovation - at a theoretical level (Birkinshaw et al., 2008)<sup>[15]</sup>. When existing scholars' conduct innovation performance analysis, they usually refer to technological innovation performance. Academic research on innovation performance has focused on three levels: innovation inputs, innovation processes and innovation outputs.

#### **3.2. Measurement of enterprise innovation performance**

As the innovation process is particularly complex and diverse, even though scholars at home and abroad have conducted a large number of studies on corporate innovation, scholars hold different views on the evaluation indicators of innovation performance: Hagedoorn believes that R&D investment, the number of patent applications, and the number of patent citations can all be used as indicators to measure innovation, and given the overlap between indicators, it is sufficient to use one of them (Hagedoorn, 2002)<sup>[16]</sup>. Patent data is currently commonly used as a measure of corporate innovation performance in academia. Zhang Sifei and Chen Yongqi measured innovation performance by averaging the number of patent applications and the total number of patents in order to study the innovation performance improvement path of SMEs (Zhang Sifei & Chen Yongqi, 2023)<sup>[17]</sup>. Based on existing research findings, this paper argues that innovation performance can be divided into direct innovation performance and indirect innovation performance. Direct innovation performance is measured using the number of patents applied for and granted and the number of new products as well as the cash inflow from new products, while indirect performance is evaluated using the company's market competitiveness, innovation power and changes in employee qualifications.

In recent years, the methods of measuring the innovation performance of enterprises under industry-university-research cooperation mainly include hierarchical analysis, data envelopment analysis, factor analysis and qualitative comparative analysis. Sun Shanlin and Peng Can used factor analysis to analyse the reliability and validity of the data, and constructed a set of performance evaluation index system for collaborative innovation projects between universities and industries (Sun Shanlin & Peng Can, 2017)<sup>[18]</sup>. Using matching and difference-in-difference estimation, Szücs find a positive effect on a range of innovation indicators and that spillovers increase with a universities' academic quality (Szücs, 2018)<sup>[19]</sup>.

### **4. The influencing factors and effects of enterprise innovation performance under industry-university-research cooperation**

#### **4.1. Effects of industry-university-research cooperation on enterprise innovation performance**

Industry-university-research cooperation, at the micro level, can achieve the deep integration of various industry-university-research subjects, such as enterprises, universities and research institutes, so that they can unite with each other to promote innovation; and then promote the way of economic growth at the macro level, to achieve the goal of innovation-driven economic growth. Industry-university-research cooperation can promote the improvement of the company's innovation performance, and industry-university-research cooperation can reduce the R&D costs of biomedical companies (George et al., 2002)<sup>[20]</sup>. Xu Xin and Liu Mengran pointed out that industry-university-

research cooperation has a positive effect on the promotion of technological diversification of companies (Xu Xin and Liu Mengran, 2020)<sup>[21]</sup>. Karno and Purwanto find that the inter-firm cooperation, cooperation with research institution, and cooperation with government have a positive and significant impact on innovation, and the innovation has a positive and significant effect on business performance (Karno & Purwanto, 2017)<sup>[22]</sup>. Through industry-university-research cooperation and R&D, companies can share the necessary research facilities and human resources with relevant research experience owned by universities and research institutes, thus sharing the company's innovation costs. Overall, in times of saturated markets and decreasing product life cycles, the continuous development and successful launch of innovations are essential for profit-oriented organizations of any kind. Interorganizational cooperation enables companies to get better access to knowledge and capabilities in order to generate and successfully introduce innovations (Weber & Heidenreich, 2018)<sup>[23]</sup>.

In his study of the Haidian Science and Technology Park in Zhongguancun, Fu Shouqing divided the period of collaborative R&D between industry, university and research into five stages: initial innovation, discrete innovation, integrated innovation, cluster innovation and superior innovation (Fu, 2010)<sup>[24]</sup>. Through industry-university-research cooperation, the company can effectively prevent some inert behaviors in the process of internal research and development, help the company break through the technical bottleneck, and then achieve technological innovation, bring the company more competitive new products or improved products, and improve the company's economic benefits (Ahuja & Morris Lampert, 2001)<sup>[25]</sup>.

Some scholars have found that industry-university-research cooperation also produces undesirable outcomes for firms. The higher the frequency of interaction, the more firms tend to rely on universities and research institutes for innovation (Liu Firan et al., 2023)<sup>[26]</sup>. And frequent interactions are prone to the problem of blind trust, as well as increasing the risk of leakage of core corporate secrets, which can negatively affect a company's innovation performance. When the cooperative objects of a company involve not only the fields of education and scientific research, but also too many other industries, it will lead to path dependence of the company and inhibit the innovation of the company (Yang, Chen Ning & Zhao, Hong, 2020)<sup>[27]</sup>.

#### **4.2. Influencing factors of enterprise innovation performance in the context of industry-university-research cooperation**

In January 2019, General Secretary Xi Jinping stressed the need to make full use of innovation resources to gather advantages and create an important source of independent and original innovation. Industry-university-research cooperation innovation integrates and interacts resources, and in this context, the innovation performance of enterprises is influenced by factors at multiple levels, which are summarised in this paper from four aspects: enterprises, universities and research institutes, government, and mixed factors.

At the firm level, the relationship between industry-university-research cooperation and firm innovation performance is influenced by the role of in-house R&D investment, and firm size (Eom & Lee, 2010; Freitas et al., 2013)<sup>[28, 29]</sup>. Schwartz et al. found that the larger the firm, the stronger it was in competing for access to high technology and the higher the innovation performance of industry-university-research cooperation (Schwartz et al., 2012)<sup>[30]</sup>. Hewitt-Dundas find that if a business is located close to a research excellent university, cooperation tends to remain local, however, the distance between businesses and the nearest university is not a significant determinant of university-business cooperation<sup>[31]</sup>. Apa researched University-SME collaboration and innovation performance from two aspects. The first aspect is the variety of forms that UIC can take, including formal and informal collaborations. The second aspect is the absorptive capacity of firms. And they find university-industry collaborations effectively increase small and medium enterprises' innovation performance<sup>[32]</sup>. Considering the location impacts of industry-university-research (IUR) cooperation bases on innovation performance, Cui finds that the joint establishment of scientific research bases is more conducive to promoting the enterprise innovation than joint research, commissioned research

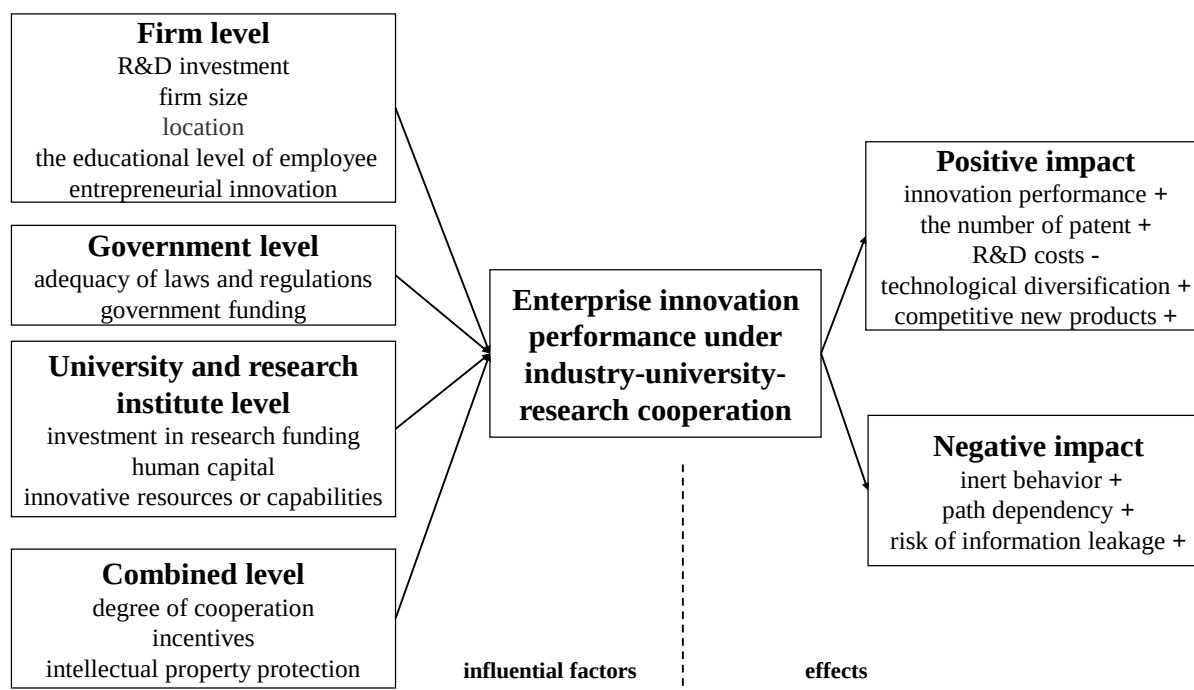
and technology transfer and other IUR cooperation modes. Moreover, the higher the educational level of employees is, the more significant promotion effect may become (Cui et al., 2022)<sup>[33]</sup>.

At the government level, the adequacy of laws and regulations, government funding, etc. influence the innovation performance of firms. Government financial support and the improvement of laws and regulations at the regional level can significantly improve the innovation performance of industry-university-research cooperation (Li et al., 2020)<sup>[34]</sup>. The closer the communication and integration between the various subjects of industry-university-research cooperation, the stronger the innovation capacity. The government's ability to guide R&D has a catalytic effect on industry-university-research cooperation (Fu, 2010)<sup>[24]</sup>. Government supported industry-university research centers: Issues for successful technology transfer Guo et al. found that for technology-based SMEs in China, government funding had a significant positive impact on the technological and socialised innovation outcomes of firms (Guo et al., 2016)<sup>[35]</sup>.

At the level of universities and research institutes, the level of cooperation with universities and research institutes, investment in research funding and human capital have an impact on the innovation performance of companies. Industry-university-research cooperation differs from independent innovation in that it is an act of R&D involving the cooperation of multiple parties, and the behaviour of each participant has an impact on the R&D. Passive inaction by a single party can affect the transfer of knowledge and technology and will lead to the failure of collaborative R&D results (Fang & Gu, 2019)<sup>[36]</sup>. Therefore, when choosing a partner for industry-university-research cooperation, synergy of goals and cultural compatibility are the basis of the collaboration, and whether the partner has innovative resources or capabilities that are complementary to their own is the key, and these three complement each other, which is an important guarantee for the smooth implementation of industry-university-research cooperation (Ma et al., 2018)<sup>[37]</sup>. Mohnen and Hoareau studied the collaborative innovation system in the United States and found that the larger the company, the deeper the collaboration with the university and the better the innovation performance (Mohnen & Hoareau, 2003)<sup>[38]</sup>.

At the combined level of a mixture of factors, the investment of human capital, the degree of cooperation with other agents and the degree of openness of capital combine to influence the innovation performance of the firm. Factors such as human capital, the development of translation platforms and interdisciplinary platforms, incentives, and intellectual property protection have a significant impact on innovation performance. Based on the "university- enterprise -government" triple helix model, Cui Zhixin and Chen Yao identified the human capital of knowledge, the intensity of corporate innovation inputs, the autonomy of subject innovation, and the degree of capital openness as the main factors influencing the output of regional collaborative innovation (Cui & Chen, 2019)<sup>[39]</sup>. Moreover, companies are able to access more resources from universities and research institutes for their own innovation through a wider range of collaborations (Kafouros et al., 2015)<sup>[40]</sup>, which ultimately improves the innovation performance of the company.

Based on the literature combing of industry-university-research cooperation and enterprise innovation performance, the influencing factors and effects of the innovation performance of enterprises under industry-university-research cooperation are summarised in Figure 1.



**Fig. 1** The influencing factors and effects of enterprise innovation performance under industry-university-research cooperation

## 5. Theoretical basis

### 5.1. Collaborative innovation theory

Collaborative innovation was first defined by Teece in 1986 as a model where firms combine with each other to carry out innovative activities, ultimately achieving a win-win situation for the participating firms in terms of innovation activities. Collaborative innovation theory is derived from synergy theory and is an extension of synergy theory in the field of innovation. For the initial research on collaborative innovation mainly focused on enterprises. According to the relationship between the partner and the enterprise in the industrial chain, collaborative innovation can be divided into horizontal collaborative innovation and vertical collaborative innovation. As the application of collaborative innovation spreads, regional collaborative innovation - cross-border cooperation of multiple entities within a certain region - emerges.

Collaborative innovation is a complex form of innovation, both formally and operationally. Firstly it involves the participation of two or more subjects, and secondly it involves the systematic optimisation of each innovation subject (mainly including government, enterprises, universities, research institutes, as well as intermediaries and users), balancing the relationship of each subject within the system, ensuring the integrity and consistency of the whole collaborative innovation system, and ultimately achieving the purpose of collaborative innovation. A core component of collaborative innovation is the process of adding value to knowledge. It requires that the knowledge possessed by each subject in the system is shared among them, and that the system optimises the allocation of resources to help the subjects in the system to achieve the same frequency and promote innovation in the system as a whole. It follows that collaborative innovation is based on communication - coordination - synergy - cooperation, and the process of "communication-coordination" may need to be repeated before the goal of "collaboration-collaboration" can be achieved finally.

### 5.2. Triple helix theory

The triple helix theory was first used in the field of biology to explain the relationship between genes, tissues and the environment. In 1995, Etzkowitz first proposed the triple helix theory and used

it to analyse the relationship between government, industry and universities. The triple helix theory is the theoretical basis for industry-academia-research cooperation. The triple helix theory suggests that in the knowledge economy, where knowledge drives economic growth, academia, industry and government should break down the boundaries and promote the flow of knowledge and resources among the three parties to facilitate the output, transformation, application and upgrading of knowledge, thereby continuously enhancing the system as a whole. The triple helix theory argues that there is no subject position and considers that the focus is on the ability of the three parties to develop their own capabilities while maintaining close cooperation and maximising benefits.

The goal of the triple helix theory is to create an environment of collaborative innovation that guarantees strategic alliances between academia and industry for the effective flow of knowledge. At the same time, knowledge flows can be divided into three categories according to the triple helix theory: firstly, one-sided internal flows; secondly, two-two interactive flows; and thirdly, arbitrary flows between three parties. The theory emphasises cooperation between the three. Academia takes on the role of knowledge creation, industry the role of wealth production and government the role of policy coordination. And new functions will emerge as the three communicate with each other, creating an innovative society (Galvao et al., 2019)<sup>[41]</sup>. The parts of the system that overlap between the three are the core units in the innovation system.

The triple helix theory sees the interaction between the three elevated not in a simple linear pattern, but in a complex spiral. The triad of subjects in the triple helix theory has seen the emergence of a growing fourth helix - the intervention of intermediaries - due to the breaking down of communication barriers, which has also driven the emergence of new theoretical speculations - the fourth helix, the double triple helix, etc. At the same time this has led to an increasingly close relationship between the three actors - academia, industry and government - in a complex spiral that has resulted in a structure of individual independence, mutual cooperation and cross-border development.

## **6. Conclusion and outlook of the study**

### **6.1. Conclusion**

Industry-university-research cooperation is an important component of the national innovation system. In recent years there has been an increasing number of articles on industry-university cooperation and innovation performance. By combing through existing studies, this paper finds that scholars have mainly explored the factors influencing the innovation performance of enterprises under industry-university-research cooperation at the enterprise, government, university and comprehensive levels. As for the effects, most of the literature has confirmed that industry-university-research cooperation can help diversify enterprises' technology, significantly increase the number of patent applications and authorizations, and reduce the cost and risk of innovation, but some scholars believe that frequent interaction between enterprises and universities can lead to problems such as path dependency and information leakage. The research approach to measuring the innovation performance of companies is mainly empirical. The data for the study comes from a number of sources, including data on financial indicators of listed companies and innovation performance data of provinces and municipalities.

### **6.2. Research agenda**

At this stage, there is increasingly close cooperation between industry, academia and research. As the overall social environment changes, the factors influencing the innovation performance of firms are becoming richer, including not only modern companies and universities, but also many other elements, and the influence of government in innovation performance continues to deepen. At present, most of the domestic research on the factors influencing enterprise performance is focused on the combination of government, industry, academia, research and application, and a series of research results have been achieved. The shortcoming, however, is that substantive studies tend to discuss the relationship between a limited number of influencing factors for firms in specific sectors, which

makes the findings not universally applicable and highly precise, and future studies could include more factors for firms and universities. In addition, current research has focused on the direct impact of industry-academia-research collaboration on innovation performance, with few studies examining the mediating effects between. There may be some intermediate variables that have an impact, so the mechanisms and pathways of influence need to be further explored.

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