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How Does Data Input Drive Enterprise's Technological Innovation: Concepts, Mechanisms and Paths?

Xinyue Ruan[1, *], Xiaohua Feng[2]

[1] Business School, Hubei University, Wuhan 430062, China
[2] Business School, Hubei University, Hubei Open Economic Research Center, Wuhan 430062, China
[*] Corresponding at 2529645804 @qq.com

Abstract: In the era of digital economy, data has become not only a production factor, but also an innovation factor, which has already played a profound impact on technological innovation of enterprises. What is the data factor? How does data input drive technological innovation of enterprises? How to promote the positive effects of data input on enterprise's technological innovation. Such questions have attracted attentionof academic world. This paper first explores the connotation and economic characteristics of data, and further analyzes the mechanism of data input driving enterprise's technological innovation from four aspects:cost reduction, knowledge creation, optimal allocation and enterprise governance. Finally, this paper proposes that reducing the cost of data transactions, reconstructing the cooperation network of industry-university-research, accelerating the integration of elements andconstructing high-level data rules are effective paths for data-input enterprises to developping their technological innovation.

Keywords: Data input, Enterprise, Technological innovation.

1. Introduction

Now, China's economy has been shifted from the stage of high-speed growth to high-quality development, which also puts forward new and higher requirements for enterprise's technology innovation. However, in this new stage, the factor constraints faced by enterprises' technological innovation are increasingly tightened. In addition to the significant rise in factor costs[1], under the dual impact of the outbreak of the epidemic and the rise of protectionism, the global flows of innovation elements such as talents and capital have been obviously blocked. It is evident that the innovation dividend of traditional factors has gradually peaked, and enterprises have fallen into the exhaustion of innovation momentum and urgently need to switch to new momentum. It is worth noting that, along with the accelerated evolution of a new round of scientific and technological revolution and industrial transformation, the world has entered the era of "data is king", and the development of data elements has become an important breakthrough in solving the problem of "where is the new power". After 2010, major economies such as the US, UK and EU have successively elevated data and related issues to the national strategic level, competing to formulate and implement big data strategies in an attempt to seize an advantageous position in the field of data and stimulate the role of data in economic growth and national innovation. As one of the pioneers of big data strategy, China's mobile Internet users rank first in the world, with natural advantages in data scale and application market. According to the International Data Corporation (IDC), China will become the world's largest data circle by 2025. In this context, China is ahead of many other countries in the field of data, and has earlier committed to maximizing the innovation value of data to provide strong support for high-level technological innovation and high-quality development. On August 31, 2015, the State Council released the Action Plan for Promoting the Development of Big Data, which clearly pointed out that "data has become an important basic strategic resource for the country and is leading a new round of scientific and technological innovation." On December 8, 2017, the Political Bureau of the CPC Central Committee conducted the second collective study on the implementation of the national big data strategy, and Xi Jinping General clearly pointed out the need to "play the role of data as a basic resource and innovation engine, and form a data-driven innovation system and development model". In October, 2019, the Fourth Plenary Session of the Nineteenth Central Committee of the Communist Party of China adopted the " Decision of the Central Committee of the Communist Party of China on Several Major Issues Concerning Adhering to and Perfecting the Socialist System with Chinese Characteristics to Promote the Modernization of the National Governance System and Governance Capacity. " It is proposed to " improve the mechanism for the market to evaluate the contribution of production factors such as labor, capital, land, knowledge, technology, management and data, and to determine the remuneration according to the contribution." since then data has officially been a production element. The introduction of this document has directly accelerated the formation and development of data-driven innovation system. The above-mentioned series of government documents have fully demonstrated that data-driven enterprise's technology innovation has become a fundamental and key issue for Chinese enterprises in the period of high-quality development. Globally, Google, Amazon, Alibaba and other large multinational companies are all relying on massive data elements for technological innovation [2].

At present, the theoretical research on data factors promoting enterprise technological innovation can be summarized into two categories. The first type of research focuses on the driving effect of data attributes on enterprise technological innovation. For example, Ghasemaghaei et al. (2020) pointed out that the large-capacity attributes of data elements cannot directly improve enterprise innovation performance, but data speed and data diversity have a significant role in promoting enterprise innovation

performance. The second type of research believes that data elements can indirectly promote enterprise technological innovation by reducing costs, optimizing resource allocation, knowledge innovation, market matching and other ways. Some scholars emphasize that individual data elements do not have a significant innovation incentive effect. The realization of the innovation value of data elements depends on the new combination of data elements, human capital, labor and other elements. For example, the combination of data elements and capital elements can reduce the cost of enterprises to obtain complementary assets, and then promote enterprise technological innovation, but such research is either based on questionnaire data or focuses on a single perspective, and the mechanism is not completely clear and unified, which still needs to be discussed.

In this context, we have to think about the following questions: What is the data as a factor of production? How do data inputs drive enterprise technology innovation? What is the corresponding realization path? It has not only become a frontier issue of concern to scholars and policy makers at present, but also a question about the dynamics of enterprises to achieve a high level of independent innovation. Based on this, this paper aims to reveal the mechanism and realization path of data input-driven enterprise technology innovation, which is conductive to deeply understand the driving effect of data input on enterprise technology innovation, and to provide a clear idea for constructing a theoretical framework of data input-driven enterprise technology innovation and a data-driven innovation system in the context of high-quality development.

2. Concepts and Economic Characteristics of Data

As for data, there is not yet a mature and unified authoritative definition in academic circles, and its economic characteristics are still under discussion. However, the concept of data and its economic characteristics will be the first and foremost issue that must be addressed in the study of data input-driven enterprise technology innovation and related issues at present and for a longer period of time in the future, otherwise it will hinder the accumulation of relevant theories and the construction of theoretical research paradigms.

2.1. The Concept of Data

Up to now, the mainstream research on data has chosen to interpret and define data as a new factor of production from the term information.

According to the International Organization for Standardization (ISO), information is knowledge about an object (e.g., facts, things, events, processes, or ideas) that has a specific meaning in a particular context; data is a formal representation of information that facilitates better communication, interpretation, or processing. Or, facts or information that can be used for analysis and decision making can be broadly defined as data[3].

In the digital economy, data as a new factor of production is defined as "information that can be encoded as a binary sequence of zeros and ones"[4], and data under this definition include both digital products such as digital music, e-books, and online videos, and data products such as statistical data and transaction records[5][6].Similar definitions include data as parts of information (economic goods represented by binary bit strings) that is not knowledge and creativity[7], and data is labor-processed data products with use value[8]. It is worth noting that the same data product can be used as both final consumer goods and intermediate inputs. Synthesizing the above views, it can be found that in the context of digital economy, data as a factor of production is basically equivalent to information, although there are subtle differences between data and information. The data under examination in this paper is the information content contained in data products.

2.2. Economic characteristics of Data

As a new production factor in the era of digital economy, data shows many economic characteristics that are different from traditional production factors such as labor, capital and land.

First, the data is virtual. Clearly different from traditional tangible factors of production such as labor, capital, and land, data is a production factor that has a virtual form and exists in the database and Internet space. The virtual nature of the data means that it must be stored in modern network carriers such as computers and cloud disks, and also determines that it cannot exist in the enterprise production activities in the form of an independent element[9].Data can only release its value in combination with other factors of production such as labor and capital to achieve the effect of improving the efficiency of enterprise operation[10].

Secondly, data is immediacy. The large-scale application of modern information technology such as mobile Internet, 3G/4G/5G communication, artificial intelligence, and basic algorithms, ensures the instantaneous generation (collection), transmission, and processing and analysis of data [11]. Especially in scenarios with strong requirements for timeliness, such as unmanned driving, unmanned retail, and telemedicine, the immediacy of data plays a key role .In recent years, the present-time prediction of the trend of the new crown pneumonia epidemic utilizes the immediacy feature of data as well.

Third, data is non-competitive and the marginal cost tends to be zero. The same data set can be simultaneously accessed and used by multiple economic entities in different scenarios, and the addition of new users does not cause a decrease in the utility of existing users, so the data are non-competitive. In this process, the value of the data itself is also not diminished and even realizes value addition. For example, 100 million browsing records of mom-and-pop websites can be used by any number of e-retailers at the same time, and in the process of use, the direction and magnitude of changes in the market demand of mother and baby products can be predicted with high probability by matching and comparing with data from other sources, thus enhancing the value of the original dataset. In addition, although the first creation of data requires a large one-time investment, its marginal cost has been close to zero, which is the premise that the non-competitive characteristics of data can exist.

Fourth, data is non-exclusive or partial exclusive. Exclusivity refers to the possibility of excluding others from using it. For data, its production process often involves multiple economic agents, while data holders can proliferate data on a large scale with very low or even zero cost of reproduction and dissemination, making it difficult to fully realize the exclusive occupation of data. Therefore, data is non-exclusive in the process of use[12]. In a few cases, some users may also be excluded from data usage due to encryption technology, patent protection, cross-border restrictions, and

other factors. Thus, data can also be partially exclusive.

Fifth, data have the nature of increasing returns to scale in specific situations.Based on non-rivalry, as the size of data grows, the growth of total output will exceed the growth of factor inputs, i.e., data are incrementally rewarded by scale[13]. Some scholars suggest that the payoff nature of data depends on specific contexts, and data are not always able to maintain the incremental payoff of scale, and the incremental payoff of data often appears in complex contexts such as autonomous driving, intelligent healthcare, and face recognition[14].

Finally, data is characterized by externalities. For users, they do not have the ability and access to collect and process personal data [15]. In contrast, various data platforms can collect or even sell user data on a large scale, but such data transactions come at the cost of user privacy and thus have negative privacy externalities. On the other hand, the spillover effect of data is significant, and big data analysis and processing technology usually exhibit the characteristics of "general-purpose technologies", which indirectly promote the productivity of enterprises and thus generating positive externalities [16].

3. Theoretical Mechanism of Data input-driven Enterprise Technology Innovation

Nowadays, companies such as Amazon, Uber, and Twitter have completed the digital transformation of their development models through data-driven innovation[17]. The deep integration of data and technological innovation activities is both the basic fact of current enterprise development and represents the development trend of future innovation models. However, compared with the pioneering practices of enterprises, there are few in-depth theoretical discussions about the mechanism of the role of data elements on enterprise technology innovation, but this driving process is still in the "black box". Therefore, based on the existing literature, this paper proposes that there are cost reduction effect, knowledge creation effect, optimal allocation effect and corporate governance effect between the two, and the positive impact of data input on enterprise technology innovation is realized through these four channels.

3.1. Cost Saving Effect

One of the important motivations for enterprises to introduce data in the process of technological innovation is to reduce costs. The virtual, non-competitive, and instantaneous nature of data enable it to significantly reduce costs and increase profits when it’s invested in the production process, which in turn enhances the motivation of enterprises to engage in technological innovation. Compared with traditional methods, data shows significantly in decreasing marginal cost and reducing transaction cost[18].

First, the diminishing marginal cost effect. For the data itself, thanks to the large-scale commercial application of various new-generation information technologies such as 3G/4G/5G communication, cloud computing, and artificial intelligence, its marginal cost shows a decreasing trend, even close to zero, except for the first production (collection) of data, which requires a large amount of input on time. From the perspective of other production factors, when the prices of other input factors rise rapidly or enter the stage of diminishing marginal returns, enterprises can replace other production factors with data. For example, enterprises can use big data technology to realize online office, thus offsetting the rising land rent. It can be said that, within a certain range, with the gradual increase in the elasticity of substitution between data and other production elements, enterprises' technological innovation activities show the trend of de-landing, de-laboring and de-management, driving the continuous diminishing marginal cost.

Second, the transaction cost reduction effect. It is mainly manifested in the following three dimensions of transaction costs: first, the search cost reduction effect. Based on the virtual, non-competitive and low-cost replication characteristics of data elements, the massive amount of data containing rich information enters into the technological innovation activities of enterprises, which substantially reduces various explicit and invisible costs caused by information asymmetry and greatly reduces the search cost before the transaction[19]. Second, the communication cost reduction effect. With the increasing degree of data on the behavior of each subject within the innovation system, interactive communication becomes convenient and efficient, thus directly reducing the communication costs of negotiation, contracting, and supervision among enterprises. Third, the verification cost reduction effect. For micro enterprises, technological innovation is a high-input, high-risk economic behavior that requires product verification and market validation[20]. With the continuous input of data, the production and operation behavior of enterprises can be tracked and recorded in the form of data, which makes the performance records and market evaluation of enterprises can be obtained by multiple parties at low or even zero cost at the same time, thus effectively reducing the verification cost of the reputation of innovation subjects and the value of innovation results.

3.2. Knowledge Creation Effect

The second motivation for enterprises to introduce data in the process of technological innovation is to create knowledge. From the perspective of knowledge creation, the process of enterprise technological innovation is essentially a process by which firm creates new knowledge by combining its own knowledge with external knowledge, which in turn leads to innovative output.In this sense, a continuous process of knowledge creation is indispensable for the lasting innovation of enterprises[21]. After entering into the digital economy, with the continuous development of machine learning and artificial intelligence technologies, data plays an increasingly important role in knowledge creation.Knowledge creation can be divided into two parts: knowledge exchange and knowledge combination [22], so data can drive enterprise technological innovation by influencing knowledge exchange and knowledge combination respectively.

First, the degree of knowledge exchange is enhanced. Knowledge creation relies on the exchange and sharing of knowledge among knowledge subjects, so knowledge exchange is a necessary precondition for knowledge creation. From the perspective of the breadth of knowledge exchange, the instantaneous, virtual and non-competitive characteristics of data, coupled with the emergence of various data platforms, greatly enhance the scope and frequency of knowledge exchange and accelerate the spatial overflow of knowledge. At the same time, the continuous investment of data will also reduce the cost of knowledge exchange gradually.For example, compared with offline meetings, online meetings

not only spread widely, but also save the expenses of venue and labor. Therefore, data can help enterprises acquire a huge amount of diversified new knowledge. From the perspective of the depth of knowledge exchange, the instantaneous feature of data can realize the time lag of interaction among various knowledge subjects up to the second level, and this high-frequency interaction can not only the strong timeliness of knowledge, but also activate a large amount of inert knowledge, and part of the implicit knowledge is also structured and manifested through data coding, which makes the digestion and understanding of new knowledge by interactors more profound and thorough. Second, the usefulness of knowledge combination is enhanced. The knowledge combination process has the characteristics of high uncertainty, high risk and high mismatch rate, so the process of enterprise technology innovation is often filled with a large number of inefficient and useless knowledge combinations, which seriously hinders the efficiency and level of knowledge creation. From the perspective of data, features such as networking of data effectively break the convention and dependent path of knowledge combinations, increase the chance of interactive integration among high-quality knowledge, and promote the emergence of a large number of knowledge combinations with economic and innovative value. In addition, along with the progress of big data analysis technology, it effectively improves the accuracy of algorithms in predicting the next round of useful knowledge combinations, and at the same time clarifies the optimizing direction of knowledge combination paths, while in the past, the cycle drives knowledge combinations to evolve in the direction of high value in the process of technological innovation.

3.3. Optimal Allocation Effect

The third motivation for enterprises to introduce data in the process of technological innovation is to optimize the allocation of innovation elements. Spatial mismatch, proportional mismatch and differences in input structure of innovation elements may lead to the loss of efficiency of enterprises' technological innovation [23]. The problem of innovation element mismatch has been difficult to eradicate due to the limited rationality of corporate managers, the limited marginal technological substitution rate of factors and the objective existence of information asymmetry [24]. It is worth noting that data, as a new innovation element, has a significant role in optimizing the allocation of other innovation elements, which can mitigate or even offset the negative effects of misallocation [25]. Specifically, the data can optimize the allocation of innovation elements through three channels: enhancing the mobility of innovation elements, improving the matching of supply and demand of innovation elements, and improving the precision of enterprise allocation decisions, so that it can continuously converge to the Pareto optimal state and thus drivng the improvement of enterprise technological innovation performance.

First, enhance the mobility of innovation elements. Good mobility is the main method to improve the mismatch of innovation factors[26]. Under the traditional innovation paradigm, the mobility of innovation elements, such as talent and capital, is weak due to physical time and space constraints. Entering into the digital economy, the characteristics of non-competitive, non-exclusive, and instantaneous data can greatly reduce the time and cost of innovation elements mobility by creating a good circulation channel and environment[27]. For example, the emergence of new mobile payment means, such as e-CNY, Alipay, and WeChat Pay, has made the time lag of R&D capital flow across zones in seconds [28]. Second, the supply and demand matching of innovation elements is improved. How to match the supply and demand of innovation elements is a key issue for the sustainable development of enterprise technological innovation. Compared with traditional elements such as labor, capital, and land, the greatest value of data is to provide real and reliable economic information and reduce the uncertainty of economic activities[29]. Therefore, data can lead to precise matching between supply and demand by reducing market failures generated by information asymmetry and releasing immediate and accurate market signals. Third, it improves the precision of enterprise allocation decisions. In the process of technological innovation, compared with the manager-driven empirical decision-making model, the data-driven allocation model, as an "unconscious" allocation model that highly relies on the results of data analysis [30], takes the advantage of making allocation decisions based on factual evidence rather than personal intuition by enterprises or relevant stakeholders, which makes up for the problem of limited rationality of enterprise managers. The advantage of this model is that companies or stakeholders make allocation decisions based on factual evidence rather than personal intuition, which compensates for the limited rationality of managers and other problems that lead to resource mismatch, and achieves scientific allocation of innovation factors.

3.4. Corporate governance effect

The fourth motivation of introducing data in the process of technological innovation is to improve the effectiveness of corporate governance. Good internal governance is the institutional basis for technological innovation for enterprises[31].Good corporate governance is conducive to the establishment of a long-term investment mechanism for technological innovation. There are two paths of corporate governance, namely internal governance and external governance, which complement each other and together constitute a complete corporate governance structure. In the era of big data, data has the dual attributes of production element and governance element[32].The data directly drives enterprise technological innovation through two governance paths:enhancing information disclosure and improving innovation opportunity identification.

First, it enhances the degree of corporate information disclosure. From the perspective of an external governance, based on signaling theory, the characteristics of data such as non-competition, non-exclusion, and immediacy compensate for the information disadvantage of external investors and the public sector, helping them to monitor the dynamic changes of firms in real time, which will directly increases the risk and economic cost of firms' disclosure of false information [33]. For example, once the government discovers the illegitimacy of a firm's activities, it will immediately stop providing innovative support such as financing incentives, tax breaks and financial subsidies to the firm and pursue its related legal responsibilities. From the perspective of an internal governance, advantages in big data analytics reduce the likelihood of management concealing private information or disclosing false information, and the quality of voluntary information disclosure is improved, not only alleviating conflicts between principal and agent, but also reducing the

damage to technological innovation activities caused by manager's short-sighted behavior [34]. In summary, the information sharing environment created by data will force firms to improve the degree and quality of information disclosure, which in turn will draw an effect of enhancing reputation and attracting R&D investment. Second, it enhances the ability of enterprises to identify technological innovation opportunities. In reality, most companies often miss innovation opportunities and incur significant sunk costs due to risk aversion, lack of knowledge, and time lag of information of managers. Nowadays, benefiting from the rise of various data platforms and the continuous progress of big data analysis, enterprises can collect massive data resources from market feedback and extract valuable information from them, so as to accurately analyze the timing and cost of implementing innovation investment[35], which reduces the number of trial and error of technological innovation, avoids the duplication and waste of R&D investment, and can even predict industry trends and market demand changes, thus seizing new round of innovation opportunities.

4. The Realization Path of Data input-driven Enterprise Technology Innovation

The emergence and rise of data-input-driven enterprise technology innovation model has undoubtedly created a new opportunity for China to "overtake" in the new round of global innovation competition.However, behind the vigorous development of this new model, there are still certain blindness, confusion and inefficiency, and it is urgent to plan a realization path that can promote its benign development. This paper proposes the corresponding realization paths from the four levels of cost reduction, knowledge creation, optimal allocation and enterprise governance in turn.

4.1. Cost Reduction: Promoting low- cost Data Transaction

Data trading is a market-oriented tool that plays a decisive role in the allocation of data resources. However, the value of data is difficult to be clarified, and the relevant pricing mechanism and trading rules are not yet clear, especially under the continuous impact of the global spread of the new crown epidemic, most enterprises are facing the pressure of financing difficulties and capital shortage, and can hardly afford the large amount of capital investment for the first production (collection) of data , which directly leads to the weakened willingness of enterprises to innovate and the lack of innovation backbone. Therefore, it is not only necessary but also urgent to promote the diversified development of data trading mode with low cost as the main feature under the realistic constraint of insufficient innovation funds. The so-called low-cost data trading mainly refers to the value of materialized data. For example,in a "data-for-data" trading model, enterprises can transfer their own data to other data pools as the consideration or "open condition" for obtaining other data, saving the input cost of data elements. For startups with insufficient technical resources, the transaction mode of "data-for-technology" and "data-for-talent" can directly or indirectly reduce the technical cost and R&D time of enterprises and improve the efficiency of technological innovation.

4.2. Knowledge Creation: Reconstructing Industry-University-Research Cooperation Network

Industry-university-research cooperation can provide knowledge sources for enterprise technology innovation system, promote knowledge exchange and sharing, and facilitate the application and transformation of advanced innovation knowledge to solve practical problems. The report of the 19th National Congress of the Communist Party of China pointed out that we should "establish a technological innovation system with enterprises as the main body, market as the guide, and deep integration of industry, academia and research". On April 27, 2020, General Secretary Xi Jinping presided over the 13th meeting of the Central Committee for Comprehensively Deepening Reform and pointed out that "the innovation chain, industry chain and value chain of industry-university-research should be opened up". Therefore, in the era of digital economy, it is necessary to reconstruct the chain of industry-university-research from the perspective of data elements to eliminate the adverse effects of spatial distribution differences and communication barriers. For example, big data technology can be applied to the construction process of virtual reality industry-university-research platform.Through mining and processing data resources, the application value of data can be better brought into play, and a scientific and efficient virtual reality industry-university research platform can be established, so as to improve the effect of industry-university-research. For instance, enterprises take the initiative to open real data and business scenarios to the cooperative research units in the industry-university-research chain to achieve instant communication and supervision among three parties and break the docking barriers.

4.3. Optimization of allocation: accelerating the integration of elements

In the era of digital economy, the emergence of data elements implies an inevitable reform of factor allocation methods. Based on the perspective of efficiency standard, the efficiency standard should be fully reflected on the decision of data flow and full factor combination, rather than the standard of ownership difference, scale difference, industry difference, etc. For example, among innovation activities, when land rent is too high, the degree of substitution between land and data factors should be determined by the efficiency of innovation output. This will not only guide the factor resources to be concentrated to high-efficiency enterprises, but also stimulate the innovation energy of the whole industry. Based on the perspective of circular supply chain development, enterprises should efficiently dock capital flow, information flow and logistics, and promote the efficient concentration of various data resources at the end of the chain. Based on this, enterprises should build a unified application platform for the application of various data resources and unblock the data resource gathering point. On the other hand, in order to promote the full influx of all-factor resources, enterprises should establish an efficient all-factor resource flow system based on the unified all-factor resource application platform and around technological innovation, so as to complete the unblocking of all kinds of factors and strengthen technological innovation capability.

4.4. Enterprise governance: accelerate the high-level construction of data rules

Although the data input-driven enterprise technology innovation model is in a rapid development stage, the matching data rules have not yet been formed. Influenced by industry characteristics, institutional environment, development stage and other factors, data rules show strong enterprise heterogeneity in terms of formation mode, formation time and content. There are significant differences in the effects of data rules of different breadth, depth and quality on the technological innovation capability of enterprises. Specifically, compared with large data platform enterprises such as Huawei, Alibaba and Tencent, the data rules construction of many startups or small and medium-sized enterprises has lagging, low-quality and non-standardized problems, which will seriously hinder the ability of enterprises to release data innovation value to improve, and will likely lead to enterprises being locked in a disadvantageous position of global data competition for a long time. Therefore, it can be expected that the construction of unified standardization and high quality of data rules is undoubtedly an important governance direction for carrying out data input to realize enterprise technology innovation in the future. Therefore, a data standard sharing and co-construction platform can be built among enterprises to promote the coordinated and unified development of data standards and realize the high-level construction of standardization and internationalization, thus reducing the data trial and error costs and learning costs of enterprisesas well as driving the development of enterprise technology innovation.

5. Conclusion and Prospect

This paper aims to reveal the mechanism and realization path of data input-driven enterprise technology innovation, firstly, we analyze the connotation of data factor, and point out that it has the economic characteristics of virtual, non-competitive, instantaneous, non-exclusive/partially exclusive, which are obviously different from traditional factors such as land, labor and capital. After that, this paper proposes that with the increase of data investment, it can make a positive driving influence on enterprise technological innovation through cost-saving effect, knowledge creation effect, optimal allocation effect and enterprise governance effect, and accordingly distills four realization paths of data transaction cost reduction, reconstructing the cooperation network of industry-academia-research, accelerating factor integration construction, and accelerating the high-level construction of data rules. However, we must realize that the development and application of data elements are still in the initial stage, and the related academic research and theoretical construction are obviously lagging behind, so there are still many crucial issues to be studied in the future.

1.How to take into account the stability of enterprise technology innovation and effective risk prevention when data elements drive the efficiency and performance of technology innovation. In the future, how to play the role of data elements as the engine of innovation, and at the same time, how to prospectively prevent new types of risks arising from improper data application, and how to use new technologies and policy systems to prevent data risks and maintain the stability of the innovation system is also undoubtedly an important research direction.

2. How regulators from all sectors can formulate policies that not only encourage data elements to play an innovative role but also at the same time effectively curb the negative effects they may generate. Some studies have identified the negative economic effects of data elements, such as data monopoly derived through algorithmic collusion which seriously undermines fair competition and cuts public welfare. At the same time, some data trading institutions take advantage of the lack of regulation to illegally arbitrage by innovation in a brutal way. Therefore, the future development of data elements must be placed under effective government regulation, while at the same time it must be fully stimulated to develop continuously in a positive direction.

3. The dynamic issue of how to quantify the data elements for technological innovation development in a multi-dimensional manner. This, in turn, involves the definition of the basic concept of data elements and the balance between data sharing and privacy protection. At present, scholars' disagreement on the concept of data elements has blurred the understanding of its essence, thus also hindering the quantitative research on the relationship between data elements and technological innovation.

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