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Research on the Mechanism of Data Factor Marketization Driving Enterprise Technological Innovation: A Literature Review Based on Data Assetization, Financing Constraints, and Digital Transformation

Yuqing Sun[1,a]

[1]*School of Business, University of Shanghai for Science and Technology, Shanghai, China*
[a]*2790766512@qq.com*

Abstract: *In the era of the digital economy, data factor marketization has become a core force driving enterprise technological innovation, and the complexity and multi-path characteristics of its operational mechanism urgently require systematic sorting. This paper takes literature research as the core method, focusing on two mediating variables: data assetization and financing constraints, to systematically review the impact mechanism of data factor marketization on enterprise technological innovation. This study provides a literature supplement for clarifying the internal connection between data factor marketization and enterprise technological innovation, and also offers references for enterprise practice and policy-making.*

Keywords: *Data Factor Marketization, Enterprise Technological Innovation, Data Assetization, Digital Transformation, Financing Constraints*

1. Introduction

In the current era of vigorous development of the digital economy, data has become a crucial factor of production, which, like land, labor, and capital, plays an important role in economic growth and enterprise development. With the rapid development of information technology, the volume of data generated has shown explosive growth, and data factor marketization has gradually become a research hotspot in the economic field. Data factor marketization refers to the process of treating data as a tradable resource and allocating it through market mechanisms to maximize the value of data. It covers multiple links such as data collection, storage, processing, transaction, and application, aiming to break data silos, promote data circulation and sharing, and improve the efficiency of data utilization [1].

Enterprise technological innovation is the core driving force for promoting enterprise development and economic growth. In the fierce market competition, only by continuously conducting technological innovation can enterprises improve product quality, reduce production costs, explore new markets, and thus gain competitive advantages. There is a close connection between data factor marketization and enterprise technological innovation. On the one hand, data factor marketization can provide enterprises with more and higher-quality data resources, helping enterprises better understand market demands, consumer preferences, and technological development trends, thereby providing strong support for enterprise technological innovation; on the other hand, enterprise technological innovation can also promote the development of data factor marketization. For example, the emergence of new data analysis technologies and application scenarios can expand the value space of data and drive the prosperity of the data transaction market. To deeply explore the impact mechanism of data factor marketization on enterprise technological innovation, this study introduces three mediating variables: data assetization, financing constraints, and digital transformation.

Based on this, the key issues to be explored in this study include: (1) How does data factor marketization affect enterprise technological innovation through thethree mediating variables of data assetization and financing constraints? (2) What are the operational paths and intensity of these three mediating variables between data factor marketization and enterprise technological innovation? (3) Are there differences in the impact mechanism of data factor marketization on technological innovation among enterprises in different industries and of different scales?

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2. Research on Data Factor Marketization

2.1 Concept and Development Context of Data Factor Marketization

Data factor marketization refers to the process of regarding data as a factor of production and allocating it through market mechanisms to maximize the value of data. With the rapid development of the digital economy, data factor marketization has gradually become the focus of attention in the academic and industrial circles. As early as the 1990s, with the popularization of the Internet and the development of information technology, data began to be regarded as a valuable resource. However, it was not until 2015, when the State Council issued the "Action Plan for Promoting the Development of Big Data", that big data was officially elevated to a national strategy, laying a policy foundation for the development of data factor marketization. Since then, a series of relevant policies and regulations have been successively introduced. For instance, the "Opinions of the CPC Central Committee and the State Council on Establishing a More Perfect Market-Oriented Allocation System and Mechanism for Factors of Production" issued in 2020 clearly lists data together with land, labor, capital, technology, etc., as a new type of factor of production, and requires accelerating the cultivation of the data factor market.

In practice, the construction of China's data factor market has experienced a process from scratch and gradual exploration. In the early stage, data transactions were mainly conducted in offline and non-standardized ways, with problems such as unclear data ownership, ambiguous transaction rules, and difficulty in ensuring data security. In recent years, with the continuous emergence of data transaction platforms, the data factor market has gradually moved towards standardization and normalization. Cities such as Shanghai, Beijing, and Shenzhen have successively established data exchanges, which are committed to building infrastructure for data transactions and providing one-stop services such as data registration, transaction matching, settlement, and delivery. The establishment of these exchanges has provided important platform support for data factor marketization and promoted the circulation and transaction of data. However, the current data factor market is still in the initial stage of development and faces many challenges. The issue of data right confirmation has not been fundamentally resolved, and the definition of rights such as ownership, right to use, and right to benefit of data is vague, leading to legal risks in data transactions. The quality of data is uneven, and there is a lack of unified data standards and quality evaluation systems, which affects the use value and transaction price of data. Data security and privacy protection cannot be ignored either. How to ensure data security and privacy in the process of data circulation and transaction is a key issue that needs to be solved urgently.

2.2 Research on the Overall Impact of Data Factor Marketization on Enterprise Development

Data factor marketization has various impacts on enterprise development, bringing both opportunities and challenges. In terms of opportunities, data factor marketization enables enterprises to obtain richer data resources. Through data sharing and transactions, enterprises can break through the limitations of their own data and acquire data from different fields and industries, thereby providing a more comprehensive and accurate basis for enterprise decision-making. In market competition, data has become one of the core competitiveness of enterprises. Enterprises with more and higher-quality data can better understand market demands, grasp market trends, and thus gain advantages in competition. By analyzing a large amount of market data, enterprises can accurately locate target customer groups, develop products and services that are more in line with market demands, and increase market share [2]. In terms of resource allocation, data factor marketization helps enterprises optimize resource allocation and improve production efficiency. Enterprises can reasonably arrange the input of production factors according to the results of data analysis, avoiding resource waste and idleness. By conducting real-time monitoring and analysis of data in the production process, enterprises can adjust production processes and procedures in a timely manner, improve production efficiency, and reduce production costs. Enterprises can also use external data and advanced data analysis technologies to carry out research and development of new products and services, expand business areas, and achieve innovative development.

However, data factor marketization also brings some challenges to enterprises. Data privacy and security risks are the primary problems faced by enterprises. With the circulation and transaction of data, security incidents such as data leakage and tampering occur from time to time, causing huge losses to enterprises and users. The problems of data quality and standardization also plague enterprises. Due to the wide range of data sources and diverse formats, the quality of data is uneven, and there is a

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lack of unified standards and norms, which makes enterprises face great difficulties in the process of data processing and analysis and affects the use value and decision-making effect of data. In addition, data factor marketization also puts forward higher requirements for enterprises' technical capabilities and talent reserves. Enterprises need to have strong data processing, analysis, and application capabilities, as well as professional talents who master relevant technologies and knowledge, in order to gain a foothold in the wave of data factor marketization.

3. Research on the Relationship between Data Assetization and Enterprise Technological Innovation

3.1 Theoretical Analysis of Data Assetization

Data assetization refers to the process of converting data resources into assets with economic value that can be controlled and utilized by enterprises. In terms of definition, data assets are data resources owned or controlled by enterprises, recorded in electronic or other forms, and capable of bringing future economic benefits to enterprises. Different from traditional assets, data assets have the characteristics of non-substantiality, replicability, and value variability. Unlike fixed assets, data assets do not have a physical form, and their value is mainly reflected in the information and knowledge contained in the data. Data assets can be copied and disseminated at low cost, which enables the rapid expansion of their scope of use. Moreover, the value of data assets will change with factors such as time, market environment, and technological development.

In terms of recognition conditions, data assets need to meet the conditions of definability, measurability, relevance, and reliability. Data assets must be clearly defined and identified, that is, enterprises can clearly define the scope and content of the data assets they own. The value of data assets must be measurable in monetary or other reasonable ways so as to be accurately recorded and reflected in financial statements. The information provided by data assets must be relevant to enterprise decision-making and able to help enterprises make more sensible decisions. The relevant information of data assets must be reliable and able to truly and accurately reflect the status and value of data assets.

3.2 Research on the Direct Impact of Data Assetization on Enterprise Technological Innovation

Numerous theoretical and empirical studies show that data assetization has a significant direct driving effect on enterprise technological innovation. From a theoretical perspective, data assetization provides enterprises with rich innovative resources for technological innovation. By collecting, organizing, and analyzing a large amount of data, enterprises can obtain information about market demands, technological trends, competitors, etc., which provides directions and inspirations for enterprise technological innovation. By analyzing consumer behavior data, enterprises can discover the potential needs of consumers, thereby developing new products or services that are more in line with market demands. Data assetization can also enhance enterprises' innovation motivation. The realization of the value of data assets often depends on technological innovation. In order to fully tap the value of data assets, enterprises will actively invest resources in technological innovation to improve the efficiency of data utilization and value creation capabilities. Enterprises with a large amount of customer data will continuously develop new data analysis technologies and marketing models to better use these data for precise marketing.

Empirical studies have also provided strong support for the direct impact of data assetization on enterprise technological innovation. Some scholars have found through research on enterprises in multiple industries that enterprises with a higher degree of data assetization have significantly higher investment in technological innovation and innovation output than enterprises with a lower degree of data assetization[3]. In the research on manufacturing enterprises, it is found that there is a significant positive correlation between the scale of enterprise data assets and the number of patent applications, that is, the more data assets an enterprise has, the more patent applications it has. This indicates that data assetization provides a material foundation for enterprise technological innovation and promotes the development of enterprise technological innovation activities. Another study through a survey of technology-based small and medium-sized enterprises found that data assetization can significantly improve enterprises' new product development capabilities and technological innovation efficiency, helping enterprises gain an advantage in market competition.

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4. Research on the Relationship between Financing Constraints and Enterprise Technological Innovation

4.1 Theoretical Basis of Financing Constraints

The theory of financing constraints is mainly based on the information asymmetry theory and the pecking order theory. The information asymmetry theory holds that there is information asymmetry between enterprises and external investors in the financial market. Enterprises have more sufficient information about their own operating conditions, the risks and returns of investment projects, etc., while external investors have limited access to information and it is difficult for them to fully understand the real situation of enterprises. This information asymmetry will lead to adverse selection and moral hazard problems, making external investors require a higher risk premium when providing funds to enterprises, thereby increasing the financing cost of enterprises and forming financing constraints. When investors cannot accurately judge the credit risk of enterprises, they may treat all enterprises uniformly, increase loan interest rates or reduce loan amounts, resulting in some high-quality enterprises also being unable to obtain sufficient fund support.

The pecking order theory points out that enterprises will follow a certain order preference when financing. Enterprises prefer internal financing because internal financing does not require information communication with external investors, there is no information asymmetry problem, and the financing cost is relatively low. When internal financing is insufficient, enterprises will choose debt financing, because the interest expenditure of debt financing can be deducted before tax, which has a tax shield effect, and compared with equity financing, it has less dilution of enterprise control. Finally, enterprises will choose equity financing, because equity financing will not only dilute the control of existing shareholders, but also may send a signal of poor enterprise operating conditions to the market, leading to a decline in stock prices and an increase in financing costs[4].

4.2 Discussion on the Mechanism of Financing Constraints Affecting Enterprise Technological Innovation

Data factor marketization can improve enterprises' financing environment, alleviate financing constraints, and thus provide capital support for enterprise technological innovation. Data factor marketization can reduce information asymmetry between enterprises and financial institutions. In the traditional financing model, financial institutions have difficulty in accurately evaluating the credit risk and repayment ability of enterprises due to the lack of comprehensive and accurate information about enterprises, resulting in greater financing difficulties for enterprises. With the advancement of data factor marketization, enterprises can integrate and analyze their own operating data, financial data, market data, etc., to form a comprehensive and accurate enterprise credit portrait and provide it to financial institutions. Financial institutions can more accurately evaluate the credit status and risk level of enterprises based on these data, reduce the risk premium caused by information asymmetry, and thus improve the possibility and amount of enterprises obtaining financing. By analyzing the transaction data of enterprises, financial institutions can understand the transaction history, transaction counterparts, transaction frequency and other information of enterprises, judge the operating stability and profitability of enterprises, and provide more reasonable financing solutions for enterprises[5].

Data factor marketization can also enrich enterprises' financing channels. With the development of the data factor market, some new financing models based on data assets have emerged, such as data asset pledge financing and data asset securitization. Enterprises can evaluate and pledge their own data assets, apply for loans from financial institutions, or convert data assets into securitized products for financing in the capital market. These new financing models provide more financing options for enterprises and help alleviate their financing constraints. A certain enterprise has a large amount of user data, and through data assetization, it evaluates and pledges these data, and successfully obtains loans from financial institutions, solving the capital demand for enterprise technological innovation. Data factor marketization can also promote financial innovation, promote financial institutions to develop more financial products and services suitable for enterprises, further improve the financing environment of enterprises, and provide more powerful capital support for enterprise technological innovation.

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5. Research on the Relationship between Digital Transformation and Enterprise Technological Innovation

5.1 Connotation and Driving Factors of Enterprise Digital Transformation

Enterprise digital transformation refers to the comprehensive transformation and reconstruction of enterprises' strategies, business processes, organizational structures, and business models using digital technologies such as cloud computing, big data, artificial intelligence, and the Internet of Things, so as to adapt to the development needs of the digital economy era and realize the sustainable development of enterprises. The core elements of enterprise digital transformation include four aspects: data, technology, business, and organization. Data is the foundation and core of digital transformation; enterprises need to build a sound data governance system, realize the full life cycle management of data collection, storage, management, analysis, and application, fully tap the value of data, and provide support for enterprise decision-making and innovation

Enterprise digital transformation is driven by multiple factors. With the rapid development of information technology, emerging technologies such as cloud computing, big data, and artificial intelligence continue to emerge, providing strong technical support and innovative means for enterprise digital transformation. The development of cloud computing technology enables enterprises to obtain powerful computing and storage resources at a lower cost, realizing flexible allocation and efficient utilization of resources; the application of big data technology enables enterprises to analyze and mine massive data, gain insight into market demands and customer behaviors, and provide a data basis for enterprise decision-making and innovation. Changes in market demands make consumers' demands more personalized, diversified, and real-time; consumers expect to obtain more convenient, efficient, and personalized products and services. Enterprises must realize the innovation of products and services and the transformation of business models through digital transformation. Through digital platforms, enterprises can interact with consumers in real time, understand consumers' demands and feedback, adjust products and services quickly, and realize personalized customization. Policy orientation also plays an important role in promoting enterprise digital transformation; the government has issued a series of policies and regulations to encourage digital transformation, creating a good policy environment and development opportunities for enterprise digital transformation. The government encourages enterprises to increase investment in the R&D and application of digital technologies through financial subsidies, tax incentives, project support, etc., and promotes the process of enterprise digital transformation.

5.2 Research on the Comprehensive Impact of Digital Transformation on Enterprise Technological Innovation

Digital transformation has a positive impact on the improvement of enterprise technological innovation capabilities from multiple dimensions. In the technical dimension, digital transformation provides enterprises with strong technical support and innovative tools for technological innovation. By analyzing user behavior data, enterprises can discover the potential needs and pain points of users, thereby carrying out targeted technology R&D and developing products and technologies that are more in line with market demands. The application of artificial intelligence technology can accelerate the process of technological innovation; for example, using machine learning algorithms for material performance prediction and drug R&D can greatly shorten the R&D cycle and improve R&D efficiency.

In the management dimension, digital transformation helps enterprises optimize the innovation management process and improve the efficiency of innovation management. Through digital platforms, enterprises can realize the full life cycle management of innovation projects, including project approval, progress tracking, resource allocation, and result evaluation, and improve the management transparency and collaboration of innovation projects[6]. Digital transformation can also promote knowledge sharing and communication within enterprises, break knowledge barriers between departments, and stimulate employees' innovative thinking and innovation vitality. Enterprises can establish a digital knowledge management system to precipitate and share employees' innovation experience and technical achievements, and provide knowledge support for technological innovation.

In the market dimension, digital transformation enables enterprises to respond to market changes more quickly, meet customer demands, and thus promote the transformation of technological innovation achievements. Through digital marketing methods, enterprises can accurately locate target

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customer groups, carry out personalized marketing activities, and improve the market promotion effect of technologically innovative products. Digital transformation can also help enterprises expand market channels, realize the integrated development of online and offline, and expand the market coverage of technologically innovative products. By using e-commerce platforms, enterprises can promote technologically innovative products to the global market and improve the market share of products. Digital transformation can also promote collaborative innovation between enterprises and partners; through digital platforms, enterprises can establish close cooperative relationships with suppliers, customers, scientific research institutions, etc., realize resource sharing and complementary advantages, carry out technological innovation activities together, and accelerate the transformation and application of technological innovation achievements.

6. Summary and Prospect of Research Status

Existing studies have explored the relationships between data factor marketization, data assetization, financing constraints, and enterprise technological innovation from multiple dimensions: they have clarified the concept, development context, and impacts on enterprises of data factor marketization—including opportunities and challenges; analyzed the theoretical connotation of data assetization (encompassing its definition, recognition conditions, and measurement methods), and confirmed through theoretical and empirical studies its direct driving effect on enterprise technological innovation; meanwhile, they have discussed the mechanism by which data factor marketization promotes enterprise technological innovation by improving the financing environment and alleviating financing constraints.

Although the relationships between various variables have been discussed to a certain extent, a unified and perfect theoretical framework has not been formed, which makes it difficult to comprehensively and systematically explain the complex process of data factor marketization affecting enterprise technological innovation through multiple mediating variables. The selection of samples in some studies has limitations, which may not represent the general situation of enterprises in different industries and of different scales, and the universality of the research results needs to be improved. Future research can construct a more perfect and systematic theoretical model to comprehensively explain the impact mechanism of data factor marketization on enterprise technological innovation. Meanwhile, future researches need to expand the scope of research samples to cover enterprises in more industries, of different scales, and in different regions, and researchers can comprehensively use a variety of empirical research methods, such as the difference-in-differences method and the propensity score matching method, to cross-validate the research conclusions and enhance the reliability of the research conclusions.

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