

Research on the Theoretical Framework of Market-based Allocation of Data Elements

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Abstract. With the advent of the digital economy era, data is increasingly valued as a new factor of production, and the market-based allocation of data elements is an important part of promoting high-quality economic development. Based on the summary of the basic nature and characteristics of data elements, this paper proposes a theoretical model for the market-based allocation of data elements. The article analyzes the four aspects of property rights definition, value assessment, circulation and transaction, and income distribution of data elements, and elaborates on the theoretical and practical problems existing in the market-based allocation of data elements. The article argues that data elements are non-competitive, with increasing returns to scale and strong externalities, which are different from traditional factors of production and pose new challenges to traditional factor market theories. This paper innovatively presents a theoretical framework for market-based allocation of data elements, including a hierarchical data property rights confirmation mechanism, a dynamic value assessment model, and a multi-party collaborative governance framework, and proposes corresponding countermeasures and suggestions for problems such as difficult data rights confirmation, difficult pricing, and difficult trading. The study suggests that to achieve a good market-based allocation of data elements, it is necessary to improve the data property rights system, cultivate the data element market, enhance the efficiency of data resource allocation on the basis of safeguarding personal privacy and protecting data security, give full play to the guiding role of the government, the decisive role of the market, and the joint efforts of all parties to maximize the value of data elements. To boost the quality and efficiency of the real economy.

Keywords: Data elements, Market-based allocation, Property rights system, Value assessment, Co-governance.

1. Introduction

Entering the third decade of the 21st century, the world economy is undergoing a major transformation based on digital technology, with data becoming the fifth factor of production after land, labor, capital and technology. According to the "Global Digital Economy White Paper (2023)" released by the China Academy of Information and Communications Technology, the global digital economy reached \$41.8 trillion in 2022, accounting for more than 45 percent of GDP. China's digital economy exceeded 50 trillion yuan, ranking second in the world. Driven by the data element, the digital economy industry has developed rapidly. New forms of business such as data trading, data services and data applications are emerging one after another. In 2020, the "Opinions of the Central Committee of the Communist Party of China and The State Council on Building a More Complete Market-based Allocation Mechanism for Factors of Production" listed data as a factor of production for the first time, indicating that market-based allocation of data elements has become a national strategy. However, as a new factor of production, data has many problems in terms of property rights definition, value measurement, trading and circulation. Traditional factor market theories cannot well explain the characteristics of data elements, and a set of market-based allocation theories that adapt to the characteristics of data elements needs to be established.

Research on the market-based allocation of data elements is still in its infancy in both academia and industry, and the relevant theories are not yet complete. Data elements have characteristics such as non-competitiveness, low marginal cost, and strong externalities, and play a significant role in the market compared to traditional factors of production. How to allow data elements to flow freely and play their roles while protecting data security and personal privacy is an important issue [1] for promoting the healthy development of the digital economy. Based on a summary and analysis of the

concepts and theoretical basis of data elements and their differences from traditional production factors, this paper explores the market-based allocation mechanism of data elements and proposes a theoretical system of market-based allocation of data elements including aspects such as property rights definition, value assessment, trading and circulation, and income distribution. It is expected to provide some guidance for the development of the data element market in China.

2. Theoretical Basis for Market-based Allocation of Data Elements

2.1 Basic Concepts and Characteristics of Data Elements

Data elements refer to all kinds of data and related information in digital economy activities that can bring economic benefits to the owner or user, can participate in social production activities and are a fundamental strategic resource. Essentially, data elements are the result of digital representation, preservation, processing, and analysis of the objective world, including both raw data and processed data for specific purposes. Data elements have four characteristics: First, they are non-competitive, that is, one piece of data can be used by many individuals or organizations at the same time and will not be reduced because of being used, which is different from traditional elements that can only be used by one person or one organization. The second is the incremental return to scale, that is, the value of the data increases with the number of times it is used and the number of occasions it is used, and the marginal cost tends to zero while the marginal benefit increases. Third, strong externalities, that is, the collection, aggregation and use of data can have a significant positive impact, and the value of a single piece of data often multiplies only when combined with other data. The fourth is highly dependent, that is, the value of data elements is based on certain technical conditions, application scenarios and business models. Without specific application scenarios, it is difficult for data to exert its due economic value [2]. These characteristics determine that the market-based allocation of data elements requires breaking the theoretical framework of the traditional factor market and building new ways that meet the requirements of the digital economy on this basis.

2.2 Theoretical Origins of Market-Based Allocation of Data Elements

The theoretical basis of market-based allocation of data elements is based on the factor allocation theory in neoclassical economics, but it has been expanded and refined. From the perspective of factor market theory, Adam Smith's "invisible hand" of the market and Walras' general equilibrium theory are the fundamental analytical frameworks for factor market-based allocation, that is, the use of the price mechanism to achieve the optimal allocation of resources. Coase's theory of property rights and the theory of transaction costs illustrate the importance of defining property rights and reducing transaction costs for improving the efficiency of factor markets, which also provides guidance on how to define data property rights and how to design data trading systems. From the perspective of information economics, Arrow's research on the particularity of information commodities, Stiglitz's theory of information asymmetry, and Shapiro and Varian's theory of information product pricing are all of great significance for understanding the value creation of data elements and their market transactions. Moreover, the development of platform economy theory, network effect theory and digital economy theory has made people more clearly aware of the bilateral market characteristics and ecosystem value of data elements. These theories constitute the theoretical system of market-based allocation of data elements, but due to the uniqueness of data elements themselves, new theories that meet the needs of The Times need to be creatively proposed on the basis of drawing on traditional theories, in order to establish an allocation method [3] that combines government and market, takes into account efficiency and fairness, and focuses on innovation and security.

2.3 Comparative Analysis of Data Elements With Traditional Production Factors

Data elements are quite different from traditional production factors such as land, labor, capital and technology. In terms of physical form, traditional factors are generally tangible assets that are exclusive, while data elements are intangible assets that can be infinitely replicated and used

simultaneously without physical depletion. In terms of value form, the value of traditional elements is relatively constant and easy to measure, while the value of data elements is highly uncertain and contextual, and its value may vary greatly in different situations. In terms of allocation efficiency, traditional elements follow the law of diminishing marginal returns, while data elements, due to their replicability and network effects, have increasing marginal returns, and the more they are used, the greater their value. From the perspective of market structure, the traditional factor market is relatively mature, while the data factor market is still in its infancy, with obvious platform monopolies and market segmentation. Therefore, traditional production factor market theories cannot be used to guide the operation of the data factor market. Instead, a new set of analytical methods and policy tools should be established based on the characteristics of the data factor.

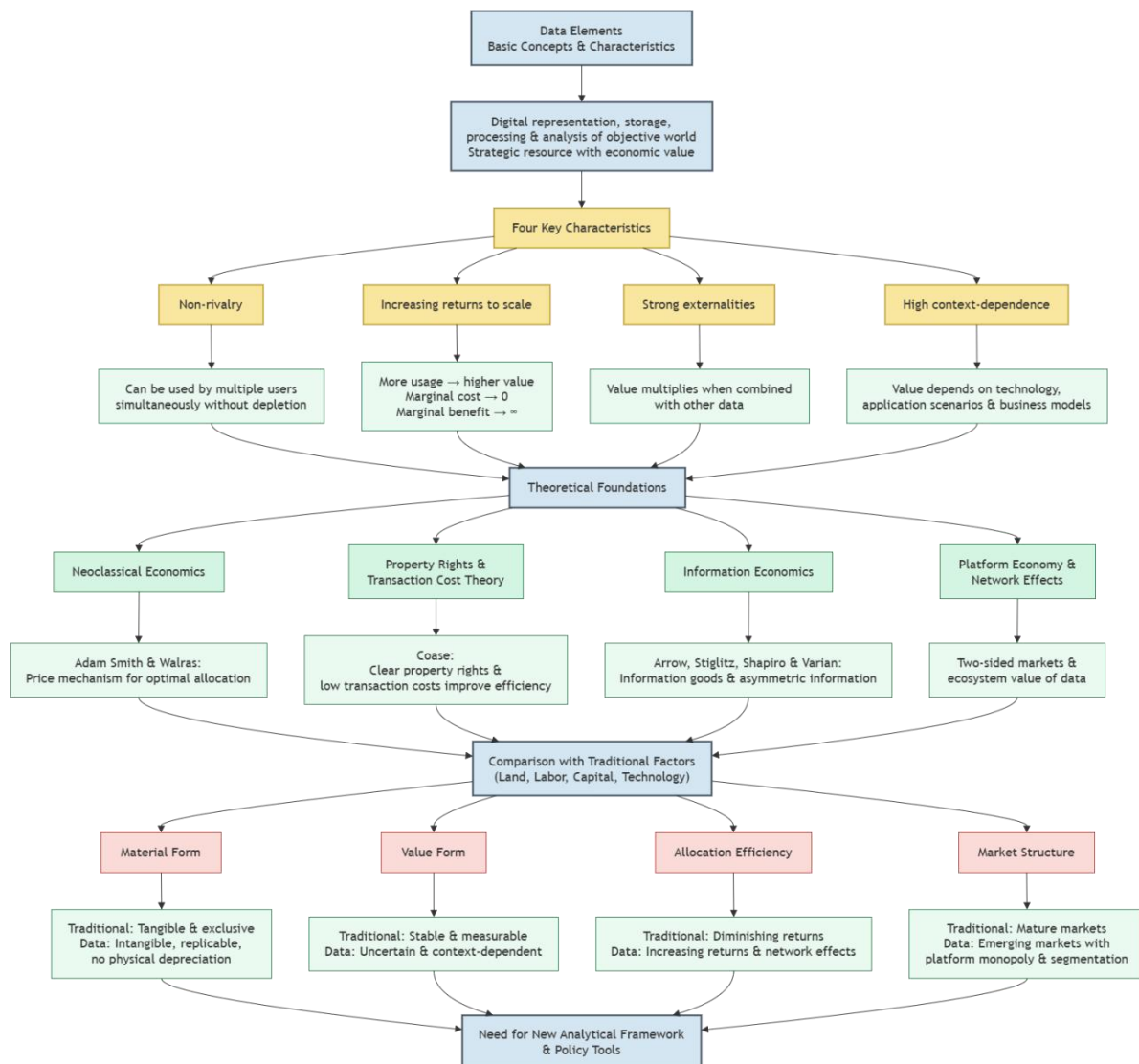


Figure 1. Comparative Analysis of data and traditional factors of Production

3. The Operating Mechanism of Market-based Allocation of Data Elements

3.1 Property Rights Definition Mechanism for Data Elements

Data element property rights definition is a prerequisite and foundation for market-based allocation, but it is difficult [4] due to the multi-subject participation, replicability and value dynamics of data. Current research on data property rights suggests that a hierarchical and categorized property rights model should be adopted, on top of which data rights are divided into three types: data resource ownership rights, data processing and usage rights, and data product operation rights. Data resource

ownership refers to the ownership of the original data, that is, individuals have basic rights to the data they produce, enterprises have ownership of the data they legally obtain, and the government has management rights to public data. The right to use data processing refers to the right to perform tasks such as cleaning, labeling, and modeling of the data, recognizing the value added by the data processor through their work. The right to operate a data product is the right to trade the data product in the market, safeguarding the interests of the creator of the data product. This stratified rights confirmation approach not only safeguards the legitimate rights and interests of data providers, but also stimulates the enthusiasm for processing and adding value to data, which is conducive to the market trading of data products. In practice, the property rights relationship should be fixed through registration and filing, technical identification, contractual agreement, etc., and the traceability of property rights should be achieved through technologies such as blockchain and digital watermarking. At the same time, there should be a property rights dispute resolution system to coordinate the interests of all parties and lay a good property rights foundation for the normal flow of data elements.

3.2 Pricing Mechanism for Data Elements

Data element pricing is an important part of market-based allocation, and the difficulty in pricing lies in the diversity, variability and contextual relevance [5] of data value. Data pricing theory should be considered in terms of cost, utility and market. In terms of cost, data pricing encompasses the entire process of data acquisition, storage, cleaning, tagging, and security assurance, but because the marginal cost of data is close to zero, pricing based solely on cost does not reflect its true value. In terms of utility, the value of data is related to the extent to which it helps users make better decisions, and its value can be measured by using machine learning methods to measure the impact of data on model performance. In terms of the market, data pricing should be in line with supply and demand, but due to certain monopolistic and information asymmetry problems in the data market, there are various ways of data pricing in practice, such as one-time purchase, pay-per-use, subscription service, revenue sharing, etc. Dynamic pricing is based on the freshness, exclusivity, and use of different data. Data with strong scarcity, high freshness, and wide use are priced higher. At the same time, data pricing also requires a third-party evaluation system, introducing professional data evaluation agencies and establishing a unified data asset evaluation standard to make data pricing more reasonable and recognized by the market, which is conducive to the full play of the value of data elements.

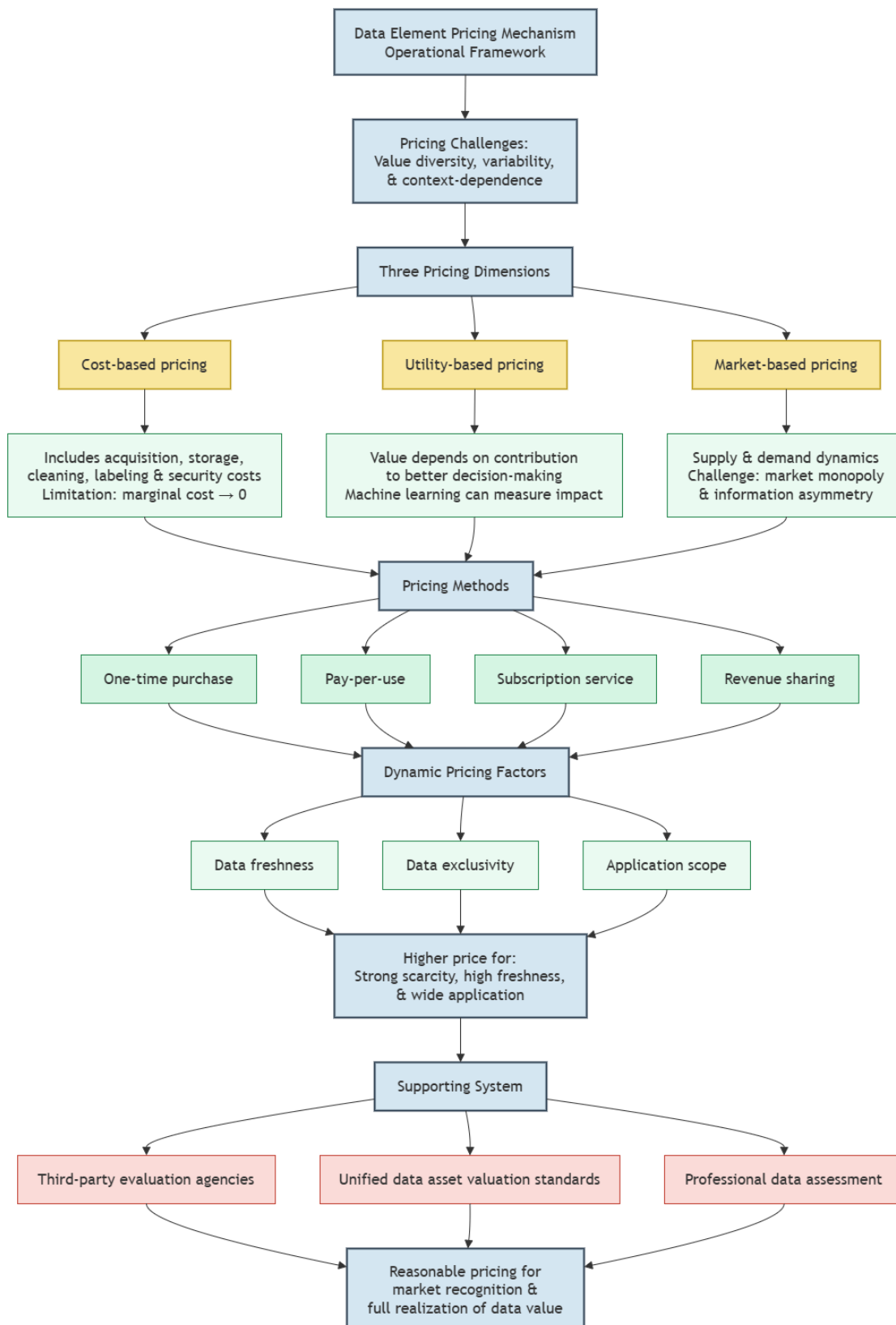


Figure 2. Operational Framework of Data Element Pricing Mechanism

3.3 Trading and Circulation Mechanisms for Data Elements

The trading and circulation mechanism of data elements is a key link in connecting supply and demand and achieving resource allocation, including trading platforms, trading models, circulation rules, etc [6]. At present, China's data trading market is developing rapidly. By the end of 2023, there

are more than 40 local data trading institutions across the country, including Beijing International Big Data Exchange, Shanghai Data Exchange, Shenzhen Data Exchange, etc. The national data trading volume exceeded 70 billion yuan in 2022. The data trading platform is the infrastructure of the market, responsible for information matching, compliance review, transaction settlement, security guarantee, etc. In terms of trading methods, there are both on-exchange and over-the-counter trading. On-exchange trading uses standard contracts and centralized matching to enhance transparency and liquidity, while over-the-counter trading is more about meeting personalized and customized demands. There are various ways of data circulation, including direct data trading, authorized use of data, federated learning, privacy computing, etc., where the value exchange of data is carried out while ensuring data security and privacy. The trading rules include access management, information disclosure, quality certification, compliance review, etc., forming a full-process supervision with traceable data sources, traceable destinations, and accountable responsibilities. In addition, cross-regional and cross-industry data circulation requires breaking down data silos, unifying technical standards and trading rules, building a national-level data circulation infrastructure, reducing transaction costs, improving allocation efficiency, and promoting the construction of a unified national data element market.

3.4 Revenue Distribution Mechanism for Data Elements

The data element revenue distribution mechanism is related to the distribution of interests among all parties and affects the development of the data element market as well as sustainability issues[7]. Data value creation is the result of the joint efforts of multiple parties, including data producers, data processors, platform operators, data users, etc. A reasonable and fair revenue distribution plan needs to be formulated. Revenue distribution should be based on contribution, with each party's efforts and contributions in the data value chain determining the proportion of revenue they receive. Individuals, as data sources, should receive basic revenue; enterprises, as data processors, should receive additional revenue; and platforms, as infrastructure providers, should receive service revenue. The distribution can be in the form of fixed proportion, stepwise, dynamic proportion, etc., adjusted accordingly based on the amount of data used and the revenue generated. Personal data earnings can be considered by setting up a personal data account to return the earnings directly to individuals, or by managing and distributing them centrally in the form of a data trust. Public data should follow the principle of public benefit, and the proceeds should be mainly used for the improvement of public services and the construction of data infrastructure. The distribution of revenue should also take into account data externalities and social value, providing certain support and encouragement for data applications that produce good social effects, while regulating data abuse and improper profit-making behaviors, so that the distribution of revenue from data elements is both conducive to promoting innovation and fairness, achieving the goal of combining economic and social benefits.

4. Factors and Implementation Paths for Market-based Allocation of Data Elements

4.1 Main Obstacles to the Market-Based Allocation of Data Elements

At present, while China's digital economy is developing rapidly, the market-based allocation of data elements is facing many problems, which restrict the realization of its value [8]. First of all, unclear data property rights are the biggest institutional obstacle. Unlike traditional factors of production such as land and capital, data property rights themselves are not clear, and the rights and obligations among data collectors, processors, storers and users are not clear, resulting in a large number of data ownership disputes and enterprises are reluctant to conduct data transactions. Secondly, there is a lack of data value assessment, which affects the market transactions of data elements. According to the results of the 2023 Big Data White Paper survey by the China Academy of Information and Communications Technology, more than 68% of enterprises believe that they

encounter difficulties in pricing when monetizing their data. Due to factors such as data quality, timeliness, and application scenarios, it is difficult to have a unified standard for evaluating the value of data. Third, the weak infrastructure for data circulation and trading is also a major problem. At present, there are more than 40 data exchanges across the country, but the standards among the platforms are inconsistent, the degree of interconnection is not high, and the volume of data transactions is not large. In 2022, the scale of China's data trading market was only 87.6 billion yuan, far below the value contained in the data elements. In addition, data security risks and privacy protection pressures have made data holders more conservative about data openness and sharing, and technical and legal reasons have made market-based allocation of data elements difficult [9].

4.2 Balancing Mechanisms for Data Security and Privacy Protection

In the process of promoting the market-based allocation of data elements, how to strike a balance between the open circulation of data and the protection of security and privacy is a core issue that must be addressed. The release of the value of data elements depends on the full circulation and use of data, but excessive openness may lead to security risks such as data leakage and abuse, and harm the rights and interests of individuals and national security. Building a scientific balance mechanism requires coordinated efforts at multiple levels, including institutional, technological, and management. At the institutional level, a hierarchical and categorized data security management system should be established, and differentiated protection strategies should be implemented based on the sensitivity and importance of the data. The implementation of the Data Security Law and the Personal Information Protection Law provides a legal framework for data security, but operational rules still need to be further refined to clarify the open boundaries and usage norms for different types of data. At the technical level, privacy computing technology provides an effective tool to solve this problem. Federated learning, secure multi-party computation, trusted execution environment and other technologies can achieve "data available but not visible", and complete data value mining [10] while protecting data privacy. According to data from the Ministry of Industry and Information Technology in 2023, China's privacy computing market size has reached 14.5 billion yuan, with an annual growth rate of more than 120%, and the application of technology is becoming increasingly mature. At the management level, it is necessary to establish a full-process supervision mechanism for data usage, achieve traceability and auditable data flow through technical means such as data watermarking and blockchain traceability, and clarify the responsibility boundaries of data users. At the same time, professional third-party data compliance service providers should be cultivated to offer services such as security assessment and compliance review for data transactions, reduce the compliance costs for market entities, and enhance the security and credibility of data circulation.

4.3 A Policy Support System for Market-Based Allocation of Data Elements

The advancement of market-based allocation of data elements cannot do without sound policy support. In recent years, China has developed a relatively complete policy framework for the market-based allocation of data elements, but more efforts are needed in areas such as the property rights system, circulation mechanism, and income distribution. In terms of the property rights system, we need to accelerate the reform of stratified rights confirmation of data property rights, clarify the "three rights separation" model of data resource holding rights, data processing and usage rights, and data product operation rights, and solve the problem of unclear data ownership from the source. The "Opinions on Building a Data Foundation System to Better Play the Role of Data Elements" (also known as the "Data Twenty Articles") released in 2022 is an important measure to promote the construction of China's data property rights system, but the relevant supporting measures still need to be improved [11]. In terms of market cultivation, the government should actively play a guiding role, encourage the establishment of a unified national data trading market, promote the interconnection of data trading platforms among different regions, and introduce unified data trading rules and technical standards. Since the establishment of the National Data Bureau, efforts have been made to build a national integrated data element market system. In 2023, the national data transaction volume

increased by 47% compared with the previous year, and market vitality has significantly increased. From a fiscal, taxation and financial perspective, new models such as data asset inclusion in the balance sheet and data asset pledge financing should be explored, tax policies for data element participation in revenue distribution should be improved, and enterprises should be encouraged to invest more in data. At the same time, it is necessary to enhance communication and cooperation among various departments, eliminate data silos, promote the open sharing of public data, and make public data the basis for the market-based allocation of data elements throughout society.

4.4 A Optimization Paths for Market-Based Allocation of Data Elements

To achieve efficient market-based allocation of data elements, a comprehensive approach is needed in areas such as theoretical innovation, institutional improvement, technical support, and ecological construction. In theory, research on data elements should be strengthened. In light of the characteristics of data elements such as non-competitiveness and increasing returns to scale, theories on factor pricing and revenue distribution mechanisms should be innovated to guide the introduction of relevant policies. Institutionally, it is necessary to establish a multi-level data property rights system, explore the implementation of a data resource registration system, promote data assetization, improve the data intellectual property rights protection system, and protect the interests [12] of data element market entities. In terms of technology, we should strengthen the infrastructure for market-based allocation of data elements, and use technologies such as privacy computing, blockchain, and artificial intelligence in data rights confirmation, pricing, and trading to enhance the security and efficiency of data flow. According to a 2023 report by the China Academy of Information and Communications Technology, data trading projects using privacy computing technology have seen their security scores increase by an average of 35 percent and transaction efficiency increase by more than 40 percent. In terms of the ecosystem, it is necessary to foster diversified market entities, encourage the development of new intermediary service institutions such as data providers and data brokers, and enrich the content of data element market services. At the same time, we should enhance international exchanges and cooperation, actively integrate into the global data governance system, and promote the flow of data internationally. In addition, data literacy education should be strengthened to cultivate talents who understand both data technology and market rules, so as to ensure the smooth market-based allocation of data elements and eventually form a favorable situation of market-based allocation of data elements with the participation of the government, the market and society.

5. Conclusions

The market-based allocation of data elements is an inevitable trend in the digital economy era and a driving force for promoting high-quality economic development. Starting from the characteristics of data elements themselves and the theory of market-based allocation, this article analyzes the problems encountered in the market-based allocation of data elements, such as unclear property rights, difficult pricing, poor circulation, and privacy leakage [13]. Due to the characteristics of data elements such as non-competitiveness, economies of scale, and strong externalities, traditional market-based allocation methods of production factors cannot be simply copied. Instead, reforms and improvements should be made in accordance with their characteristics. The promulgation and implementation of relevant policy documents such as the "Twenty Data Policies" have laid the foundation for the market-based allocation of data elements in China, but there is still a gap from theory to practice. At present, China's data element market is in a period of rapid development. In 2023, the scale of China's data trading market exceeded 100 billion yuan, and technologies such as privacy computing are increasingly improved, which is conducive to the secure circulation of data.

In the future, to promote the market-based allocation of data elements, we should adopt a systems thinking approach and work together to improve the data property rights system, refine the rules for data circulation and trading, and rationally distribute the revenue from data. It is necessary to establish

a data property rights structure that separates data resource ownership rights, data processing and usage rights, and data product operation rights, study dynamic and scenario-based data value assessment methods, and form a cooperative governance model with government guidance, market dominance, and multi-party participation. At the same time, a balance should be struck between data openness and sharing and security and privacy protection, and technical means and institutional arrangements should be used to ensure the safe release of data value. Only by forming a set of scientific, reasonable and practical theories and methods for the market-based allocation of data elements can we effectively play the role of data elements, facilitate the high-quality development of the real economy, and promote the deep integration of the digital economy and the real economy.

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