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Theoretical Reconstruction Research on Data Element Pricing Mechanism in Digital Platform Economy

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Abstract. The in-depth development of the digital economy has made the importance of data, a key production factor, increasingly prominent, and quantification of data value and reasonable pricing are core matters in the development of the platform economy. Based on the particularity of the digital platform economy, this paper systematically explores the theoretical basis and practical difficulties of the data element pricing mechanism. The research shows that traditional economic pricing theories have limitations when dealing with data elements, because the characteristics of data such as non-competitiveness, externalities, and network effects make traditional marginal cost pricing difficult to apply. The article also constructs a multi-dimensional framework for assessing the value of data elements, including the intrinsic attribute value of data (accuracy, completeness, timeliness), use value (application potential, innovation space), and social value (privacy protection, data security). Based on these, the study proposes a pricing mechanism theory reconstruction scheme that integrates marginal utility theory, cooperative game theory, and platform bilateral market characteristics. This scheme emphasizes the realization of the differentiated value of data in different scenarios and introduces a data contribution allocation mechanism to handle the value allocation problem involving multiple parties. The case analysis verified the feasibility of the reconstruction theory in practical application and proposed policy recommendations for improving the data property rights system, establishing a data value assessment standard system, constructing a data trading market mechanism, and strengthening supervision and compliance for the development of China's digital platform economy. This study fills the academic gap in the theory of data element pricing and provides practical guidance for the realization of data value in the digital platform economy.

Keywords: Digital platform economy; Data elements; Pricing mechanism; Value assessment; Theoretical reconstruction.

1. Introduction

The rapid rise of the digital economy has gradually turned data, a new production factor, into a core driver of economic growth. According to the China Digital Economy Development Report (2023) (released by the China Academy of Information and Communications Technology), the scale of China's digital economy reached 50.2 trillion yuan in 2022, accounting for 41.5% of GDP, and the value contribution of data elements has become increasingly prominent. Data elements, unlike traditional production factors, have special attributes such as non-competitiveness, externalities, and diminishing marginal costs. Therefore, their value is difficult to quantify precisely and the pricing mechanism faces huge challenges. In the digital platform economy environment, data elements are the key link connecting supply and demand sides. Its reasonable pricing is related to the efficiency of resource allocation and directly affects the healthy development of the platform ecosystem and the sustainable growth of the digital economy.

At present, China's digital platform economy has entered a critical period of transformation and upgrading, and the market-oriented reform of data elements is still advancing in depth. However, the theoretical system for realizing the value of data elements is not complete, the market pricing mechanism is not sound, and the data ownership and trading rules are not clear. This study intends to re-examine the logic of value formation and pricing mechanism of data elements in the platform economy from a theoretical perspective, and explore the construction of a pricing theory framework that can reflect the multi-faceted value of data elements and the characteristics of the platform

economy, thereby providing theoretical support and practical guidance for promoting the market-based allocation of data elements and the high-quality development of the digital economy.

2. The theoretical basis of data element Pricing in the Digital platform economy

2.1. Economic Attributes and Value Characteristics of Data elements

In the digital economy era, data is a key factor of production and its economic attributes and value characteristics are significantly different from those of[1] traditional factors. Let's start with the non-competitive nature of data. One data can be used by multiple entities simultaneously without reducing its use value, which makes it difficult to apply the traditional theory of scarcity pricing directly. Looking at the value of data, its context-dependent and non-linear characteristics are obvious. The value of the same data varies greatly in different application scenarios, and the realization of value often has a scale-increasing effect, that is, when the data volume reaches a certain scale, the value may increase exponentially. Also, the externalities and network effects of data elements are prominent, and the value of a single piece of data often has to be fully unleashed[2] through data integration and circulation. Since 2020, the Chinese government has explicitly regarded data as the fifth factor of production, which further highlights the economic characteristics of data as a measurable, manageable and priced asset and provides a policy basis for establishing a market-based pricing mechanism for data elements.

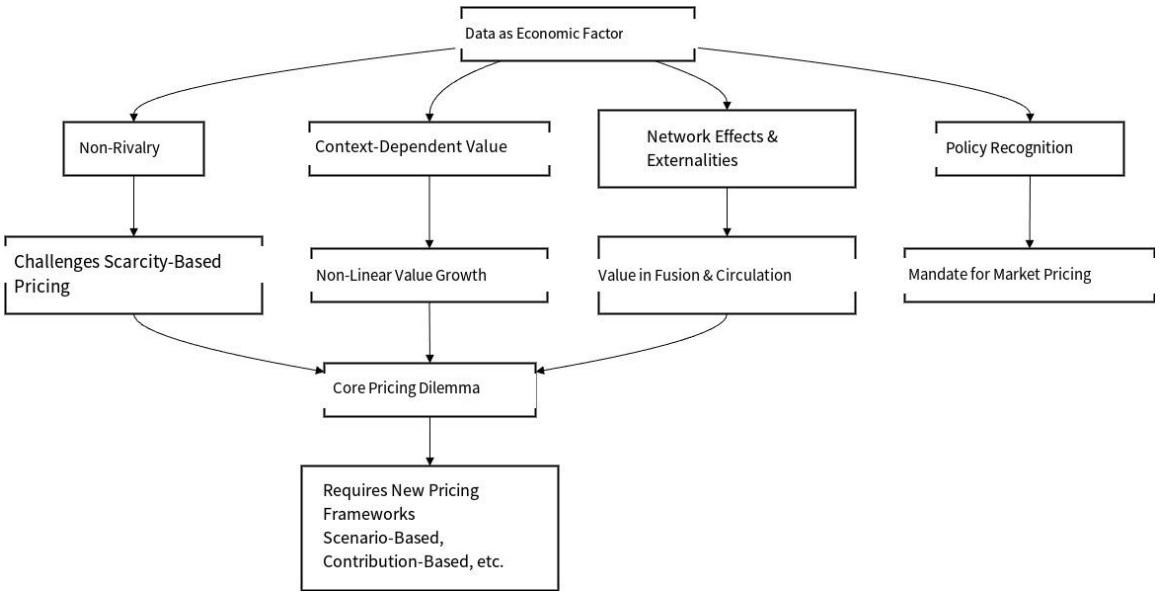

Figure 1. Economic Attributes and Value Characteristics Mechanism of data elements

2.2. Existing theoretical framework for data element pricing in a platform economy

In the platform economy environment, the development of data element pricing theory mainly presents two different paths. On the one hand, it extends from traditional economic theory, covering the adaptive application of cost pricing, market pricing, and revenue pricing. Cost pricing focuses on the collection, storage, processing, and maintenance costs of data, but it is difficult to reflect the potential value of data. Market pricing is based on the relationship between supply and demand in the market, but is constrained by the incompleteness of the data market and the problem of information asymmetry. Revenue pricing, which focuses on the economic benefits generated by the application of data, faces challenges to the fairness of value distribution. Recent studies have shown that these traditional methods need to be fully considered when applied to data elements, and a single method is difficult to fully present the value[3] of data.

On the other hand, the particularity of the platform economy has begun to draw attention to emerging data element pricing theories, such as the two-sided market theory and the marginal data value theory,

and MIT's 2021 study shows that the value of user data collected by platform enterprises averages between $3.8 and $12.5 per user per month, but the value distribution is very uneven. Data pricing theories in the platform economy also focus on the separate pricing of data usage rights and ownership, as well as multi-party value co-creation and distribution mechanisms. Research published in 2022 shows that data value assessment requires a multi-dimensional framework that takes into account the three dimensions of data quality, use value and social value simultaneously to ensure the comprehensiveness and fairness of pricing, thus providing a new research direction for data element pricing theory.

2.3. Limitations of Traditional Pricing Theories in the field of data elements

Traditional pricing theory faces multiple limitations when applied to data elements. First, since the marginal replication cost of data is nearly zero and its true cost is reflected in the initial acquisition and analysis processing of the data, marginal cost pricing theory is difficult to apply to data elements, which may seriously undervalue the data. Secondly, the assumption of a perfectly competitive market is significantly different from the actual data market, which has a considerable degree of monopoly and severe information asymmetry, making it difficult to form a so-called market-clearing price. Furthermore, the traditional linear pricing model is difficult to accurately reflect the value changes of data at different scales and combinations, which is determined by the nonlinear characteristics of data value. Most importantly, the traditional pricing theory fails to fully consider the privacy value and externalities of data, which are precisely important components of the value of data elements. With the advancement of the digital platform economy, The complexity and diversity of data value realization have become more prominent, and it is necessary to construct a theoretical framework[4] that is more in line with the characteristics of data elements.

3. Analysis of the Current Situation of Data Element Pricing Mechanism in the Digital Platform Economy

3.1. Comparison of Data Element Pricing Practices at Home and Abroad

Pricing practices in the international data element market have established a relatively complete and mature system. The United States uses a market-driven approach, and data service providers such as Bloomberg and FactSet use the form of subscription based on the quality, scarcity and application value of the data, as indicated in the report released by IDC in 2022, The data trading market in the US has exceeded $250 billion. The EU tends to integrate data value with social responsibility, setting data value assessment criteria in the GDPR framework to emphasize personal data control rights and promoting the free or low-cost opening of public data to build a pricing system that takes into account both market efficiency and social equity.

China's data element pricing practice is still in the exploratory stage compared to other countries. Data from the National Data Administration in 2023 indicates that China's data trading volume is approximately 32 billion yuan, while the figure in the United States is more than 55 times that of China, and the main way China promotes the development of pricing mechanisms is to establish regional data exchanges. For example, the Shanghai Data Exchange uses a dual-track pricing model of "data products + data services", while the Guiyang Big Data Exchange is trying to build a closed-loop system of "rights confirmation - evaluation - pricing - trading". However, compared with international practices, China's data pricing has problems such as inconsistent standards, imperfect evaluation systems, and imperfect price discovery mechanisms. There is a particular need to establish a more scientific and standardized pricing system to achieve efficient allocation and value release of data elements.

3.2. Major obstacles to market-based pricing of data elements

There are many obstacles to achieving market-based pricing of data elements. The first is the unclear definition of data property rights, especially the ambiguous boundaries of ownership of personal data,

enterprise data and public data, which leads to unclear rights and responsibilities of the trading parties, according to a survey conducted by the China Academy of Information and Communications Technology in 2023. More than 65 percent of enterprises consider unclear data ownership as the primary factor hindering data trading. Secondly, there is a lack of unified norms for data value assessment standards, significant differences in assessment methods used by various industries and platforms, and a lack of widely recognized value quantification tools, which makes it difficult for the market to construct a consistent price signal[5].

At the same time, there is a tension between the requirements of data security and privacy protection and value maximization, because overly strict privacy protection measures may reduce the value of data, while excessive commercial practices may infringe upon the rights of individuals. According to the China Digital Economy Development White Paper (2023), approximately 42% of potential data transactions end up due to compliance concerns, and the underdeveloped data element market is also a significant obstacle. There are widespread conditions such as single market players, imperfect transaction mechanisms, underdeveloped intermediary services, and an incomplete regulatory system. It is difficult to build a market trust mechanism, which further restricts the formation and improvement of market-based pricing mechanisms for data elements.

Figure 2. Analysis Framework of the main Obstacles to market-based pricing of data elements

3.3. Case Studies of Data Pricing on Typical Platforms

Alibaba's "Data Bank" model provides an innovative case for platform data pricing. This model cleans and integrates data from different industries and sources into tradable data products through standardized processes, and sets tiered pricing based on the industry coverage, update frequency, and application value of the data. According to public information, in 2021-2022, the price of Alibaba Data Bank's enterprise credit data products was 0.5-2 yuan per piece in the basic version and 5-15 yuan per piece in the advanced version, which enabled thousands of small and medium-sized enterprises to receive support for precise marketing and risk management, demonstrating the scenario-based differentiation[6] of data pricing.

Tencent's "Data Sharing Alliance" uses different pricing strategies to build multi-party data collaboration platforms for data value co-creation and sharing. This model does not directly price the data, but rather distribute revenue based on the value of the data contributed by each participant and the benefits brought by using the data. In 2022, when it cooperated in the field of financial risk control, The participating institutions contributed their own data to build a risk identification model, which increased the accuracy of risk identification by 23%. The incremental value generated was distributed based on contribution, demonstrating the multiplier effect of data value in collaboration.

Meituan's location data service demonstrated a data pricing strategy in vertical scenarios. Meituan packaged its accumulated POI (Point of Interest) data and user consumption trajectory data into different levels of API services and supplied them to merchants and developers on a pay-per-call pricing model. This business revenue exceeded 400 million yuan in 2022. These cases reveal the diverse characteristics of data pricing in the platform economy and show that the realization of data value is highly dependent on application scenarios and ecosystem cooperation.

4. The Theoretical Reconstruction path of Data Element Pricing Mechanism

4.1. Innovation in Data Element Value Assessment models

In the digital platform economy, due to the difficulty in accurately quantifying the value of data elements, innovating the value assessment model of data elements has become the first step in the reconstruction of the pricing mechanism. Based on the multi-dimensional characteristics of the intrinsic attribute value, use value and social value of data, this study proposes a "three-dimensional - nine-indicator" assessment model This model breaks down data value into technical dimensions (including accuracy, completeness, timeliness), application dimensions (including industry applicability, innovation potential, economic benefits), and risk dimensions (including privacy sensitivity, security level, compliance)[7]. According to the "White Paper on the Development of China's Digital Economy" released by the China Academy of Information and Communications Technology in 2023, the scale of China's data element market has reached 8.9 trillion yuan. However, only about 23% of data assets have undergone systematic value assessment, and the lack of uniform assessment standards has led to poor market transaction efficiency.

Based on this, the innovation of the value assessment model needs to introduce the data life cycle perspective to build a dynamic assessment mechanism, and in the specific operation, a weight dynamic adjustment system can be constructed by integrating the Analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation, based on the value changes of data in different application scenarios and different time points for real-time assessment, This innovative model not only takes into account the inherent characteristics of the data but also fully reflects the dynamic process of data value changes with the usage environment and over time, providing a more scientific value basis for the pricing of data elements in the digital platform economy.

4.2. Design of a multi-agent data pricing game mechanism

In the digital platform economy ecosystem, the realization of the value of data elements involves many subjects such as data providers, platform parties, data users, and regulatory authorities. Its pricing is bound to be the result of multi-party games. Based on cooperative game and non-cooperative game theories, a data pricing game mechanism that takes into account both efficiency and fairness can be designed. This mechanism includes two key levels: One is the contribution distribution model based on the Shapley value, which reasonably calculates the contribution of each subject to the data value creation, so that the benefit distribution and the value creation contribution are positively correlated. The other is the pricing strategy based on the incentive compatibility principle, which leads the participants to truthfully present their valuation and cost[8] of the data by designing an appropriate pricing architecture. According to the 2023 survey data of the National Data Administration, approximately 65% of the disputes in the pricing of data element transactions in China's digital platform economy are caused by differences in contribution recognition among multiple subjects, highlighting the urgent need for the design of multi-subject game mechanisms.

In the process of optimizing the game mechanism design, not only solutions to the problem of information asymmetry should be considered, but also a transparent contribution record and transaction history should be constructed through the use of technologies such as blockchain to reduce market failure caused by information asymmetry, and a pricing strategy with gradient should be planned. Set different prices based on the scale and purpose of data usage and the value it creates to meet the diverse needs of different entities. This game-playing mechanism design can not only reconcile the interests of multiple parties and enhance the efficiency of data transactions, but also promote fairness and vitality in the data element market and provide a micro basis[9] for the reconstruction of data pricing theory.

4.3. Reconstruction of pricing Theory based on clear data property rights

The prerequisite for reasonable pricing of data elements is clear and error-free data property rights, which is the fundamental work on which the pricing theory reconstruction relies. At present, China's

data property rights system is still incomplete, and the criteria for ownership division are not clear, making it difficult to precisely define the value of data. Based on the principle of "classification decentralization and hierarchical empowerment", this study proposes a two-dimensional ownership framework constructed based on data sources and value contributions, which includes three levels: original data rights, processed data rights, and derived data rights. The 2022 Global Data Asset Evaluation Report indicates that the efficiency of data market transactions can be increased by approximately 32% due to the clarification of the data property rights system, and pricing disputes can be reduced by nearly 45%, which is sufficient to demonstrate the importance of property rights clarification in the reconstruction of pricing theory.

Based on clear property rights, the reconfiguration of pricing theory should follow the principle of multiple realization of value, combining cost compensation, marginal utility and network externalities. For personal data, emphasis should be placed on the balance between privacy rights and data income rights. For enterprise data, emphasis should be placed on its production factor characteristics and commercial asset attributes. For public data, both[10] social benefits and market efficiency need to be taken into account. By building a multi-level pricing theory system to shape differentiated pricing models for different property rights subjects, various types of data, and different application scenarios to achieve precise quantification and reasonable allocation of data value and promote the sound development of the data element market in the digital platform economy.

4.4. Institutional guarantee system for data element pricing

To achieve the theoretical reconstruction of the data element pricing mechanism, the key lies in establishing a sound institutional guarantee system, which should include four interrelated subsystems. First, in terms of the legal and regulatory system, it is necessary to accelerate the completion of supporting regulations for top-level planning such as the Data Security Law and the Personal Information Protection Law, and clearly define the legal scope of data ownership transactions and pricing principles. Secondly, in terms of the market regulation system, a monitoring and evaluation mechanism for the data element market needs to be established to prevent data monopolies and unfair trading practices. Third, build a unified data classification and grading standard, quality evaluation standard and value assessment standard to promote the standardization of market pricing, and finally strengthen the social credit system by establishing a data trading credit evaluation mechanism to enhance the incentives for trustworthiness and the punishments[11] for untrustworthiness of market entities.

According to the "Digital Economy Development Monitoring and Evaluation Report" released by the National Development and Reform Commission in 2023, China scored 54.6 points (out of 100) for the degree of market-based allocation of data elements, which is a considerable gap from the average level of developed countries (72.3 points). Therefore, the construction of the institutional guarantee system should adhere to the principle of combining "delegation, regulation and service". It is necessary to allow the market to play a decisive role in the allocation of data element resources to promote the marketization of the pricing mechanism, and to strengthen the government's functions in rule-making, market regulation, and fair guarantee, with the improvement of the institutional guarantee system, It can create a stable and reliable external environment for the theoretical reconstruction of the data element pricing mechanism and drive the digital platform economy in a healthy and sustainable direction.

5. Conclusions

This study systematically explores the theoretical reconstruction of the pricing mechanism of data elements in the digital platform economy. Based on theoretical analysis and practical observation, the following conclusions are drawn:

Traditional economic pricing theories are difficult to apply effectively to data elements because data has special attributes such as non-competitiveness, externalities, and network effects, which require

the pricing mechanism to be restructured theoretically. Building a "three-dimensional-nine-indicator" evaluation model and integrating the technical value, application value and risk value of data can more comprehensively reflect the true value of data elements. Research shows that combining analytic hierarchy process (AHP) and fuzzy comprehensive evaluation methods to build a dynamic evaluation mechanism based on the data lifecycle can provide a scientific basis for data pricing.

The realization of the value of data elements is a complex process in which many subjects are involved, and the reconstruction of the pricing mechanism must be based on cooperative game and non-cooperative game theory to carefully design the benefit distribution mechanism that takes into account both efficiency and fairness. The contribution distribution model based on Shapley value proposed in the study And pricing strategies based on incentive compatibility can effectively regulate the interests of many subjects such as data providers, platforms and users, and promote the healthy development of the data element market.

Clear data property rights are the foundation of the reconfiguration of pricing theory. The two-dimensional ownership framework of "classified decentralization and hierarchical empowerment" constructed in this study distinguishes the rights of raw data, processed data, and derived data, providing institutional guarantees for the value assessment and reasonable pricing of various types of data. The study also found the clarification of the data property rights system. It can significantly enhance the efficiency of market transactions and reduce disputes in pricing.

A sound institutional guarantee system is the key support for the reconstruction of the data element pricing mechanism. The institutional system designed by the research covers four subsystems: laws and regulations, market supervision, technical standards, and social credit, which can create a favorable external environment for the market-based allocation of data elements.

As we carry out theoretical reconstruction of the pricing mechanism for data elements in the digital platform economy, it is necessary to advance it simultaneously from the following four dimensions: first, the innovation of the value assessment model; second, the design of the multi-agent game mechanism; third, the reshaping of the theoretical basis of property rights; fourth, the improvement of the institutional guarantee system. This theoretical reconstruction will not only help solve the academic problems of data element pricing, but also provide practical guidance for the development of China's digital economy, promote the effective realization and reasonable distribution of data element value, and provide solid support for the high-quality development of the digital platform economy.

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