Research on the formation mechanism of data value

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Abstract：Data elements contain great value, can directly participate in the process of production, exchange and distribution, and promote the input of other factors of production and empower other factors, this paper analyzes the data processing process from the perspective of life cycle, explores the value-added process in the process, and analyzes the value-added mechanism and value transfer mechanism. This paper analyzes the data processing process from the perspective of life cycle, explores the value-added process in the process, and analyzes the value-added mechanism and value transfer process. Finally, it puts forward the value formation mechanisms such as demand triggering mechanism and value transfer process. Finally, it puts forward the value formation mechanisms such as demand triggering mechanism, effectiveness enhancement mechanism, sharing triggering mechanism, benefit driving mechanism, policy leading mechanism, financial support mechanism, and the value of the value-added process in the process. Finally, it puts forward the value formation mechanisms such as demand triggering mechanism, effectiveness enhancement mechanism, sharing triggering mechanism, benefit driving mechanism, policy leading mechanism, financial support mechanism, technology guarantee mechanism, efficiency gathering mechanism, etc., to provide Theoretical references for the practical work of data value appreciation.

Keywords：data life cycle, data value, value formation mechanism, value appreciation

1 Introduction

In this increasingly data-driven era, data is no longer just a carrier of information; it has become a key economic asset and strategic resource. In many fields, from a driving force for innovation and growth to a basis for decision-making, data is increasingly becoming a leading, functional and key element in linking services to the domestic general cycle and the domestic and international double cycle. At the same time, with the development of big data processing technology, it can process more, more diversified and more effective data faster, which has contributed to the eruption of the blowout growth of data. Data is not only able to directly participate in the process of production, exchange and distribution to create new demand; differentiated from other traditional economic factors, it is able to empower other factors and generate a multiplier effect. Therefore, the continuous promotion of the strategic position of data factors, the state attaches more and more importance to data factors. in April 2020, the CPC Central Committee and the State Council issued the "Opinions on Building a More Perfect Institutional Mechanism for the Market-based Allocation of Factors", which further emphasized the important position of data factors, and explicitly proposed that data is the fifth major factor of production. in November 2021, the Ministry of Industry and Information Technology (MIIT) released the "14th Five-Year Plan for the Development of Big Data Industry", emphasizing the need to establish a data value system, enhance the role of factor allocation, accelerate the factorization of data, and cultivate new modes of data-driven industry-industry cooperation and collaborative innovation, etc.2022 In June 2022, the

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"Opinions of the CPC Central Committee and the State Council on Constructing a Data Base System and Giving Better Play to the Role of Data Factors In June 2022, the "Opinions of the CPC Central Committee and State Council on Building a Data Foundation System to Better Play the Role of Data Elements" proposed accelerating the construction of a data foundation system, with a focus on data property rights, circulation and trading, and revenue distribution.2022 In December 2022, the "Twenty Articles on Data" was released, which made a top-level design for the development of data elements, and called for the construction of the data foundation system.2023 In March 2023, the two sessions proposed the formation of a national data bureau, which would be responsible for Coordinating the construction of the data foundation system and the integration, sharing, development and utilization of data resources.

As a new type of production factor, the data factor has become a new engine of global growth and a new grip on international competition, and has permeated the entire process in all fields of the economy and society. In the context of the digital economy, data, as a core resource, urgently needs appropriate circulation channels to realize value mining. However, data is not equal to data assets, data must be organized in a reasonable, easy-to-use, secure and easy-to-understand way in order to inject effective value into other businesses to become data assets. Therefore, data needs to be processed throughout the whole life cycle of data collection, processing, analysis, transaction matching, and use before it finally reaches the final demand side, which involves different types of processing actions of multi-stakeholders on the data, which makes the data form different intermediate products at different stages, and have different values at the same time.

Since the moment of its birth, data has stepped into a complex cyclical process, in which it is supplied by producers, circulated through processing intermediaries, and finally applied by the demand side, with each step accompanied by the potential polarization of value. This paper aims to analyze the generation and growth mechanism of data value thoroughly from the perspective of life cycle, by systematically analyzing and summarizing the transformations and interactions in the three main phases of data supply, circulation and application, in order to reveal the key stakeholders in the data life cycle, and to explore how the data can progressively realize the gradient growth of value in the multidimensional space. Finally, the eight core analytical frameworks of demand triggering, efficiency enhancement, sharing triggering, benefit driving, policy leading, financial support, technology guarantee and efficiency gathering are used to decode the driving forces and mechanisms that drive the transformation of data from a raw state to a highly valuable asset. It provides practical references and guidelines for data management and strategy development.

2 Related Research

2.1 Research on value formation of data elements

The research on the value formation of data elements is mainly divided into three categories, one is to analyze the path of capitalization of data elements from the perspective of clear property rights; the second is to analyze the value formation from the perspective of data product evolution; and the third is to analyze the difficult problems in the process of stimulating the value of data elements.

Firstly，analyzing the value formation path of data elements from the perspective of property rights, it is believed that data first need to clarify property rights and determine the right to income before realizing data assetization, and then realize circulation and trading through market allocation, and realize multi-scenario application to stimulate the vitality of data to achieve the purpose of releasing value. Du

Qinghao[1] thinks that the process of capitalization of data elements is the process of data assets with clear ownership entering the market, operating, running and realizing value appreciation in the form of capital; He Wei[2] analyzes the three phases needed to comprehensively stimulate the value of data elements, i.e., resourcefulness to improve the quality of data, assetization to release the value of data, and capitalization to expand the value of data; Yin Ximing constructed a five-stage dynamic process of low-cost aggregation of data elements, standardization of rights, high-efficiency governance, assetization transaction and full-scene application based on the dynamic integration theory of data element valorization. Secondly, we analyze the value formation of data elements from the perspective of data product evolution, and form multi-level data products based on different processing depths and processing accuracy of data products, and the demand side obtains different types of products according to different demands for data products to realize the release of on-demand value. Hao Shouyi[3] added "information commodity" in the process of capital transformation of data products. Hao Shouyi adds the product stage of "information commodity" in the process of capital transformation of data products, i.e., the data evolution form is divided into "information - information products - information commodity - information capital", highlighting that the market is an important link in realizing the capitalization of data elements. Wang Zeyu et al.[4] analyzed the process of convergence, organization and processing of data elements according to specific production needs, and summarized the three value release paths of business continuity, digital decision-making and circulation empowerment for the release of value of data elements. Thirdly, they analyze the difficulties in the value formation process of data elements, which mainly include the rights allocation in data rights confirmation[5] , rights attributes and legal characteristics[6] , data property rights structure[7] , asset valuation and pricing mechanism[8] , value-based pricing strategy[9][10] , ethical issues in data transaction [11][12] , transaction model design[13] ; the design of benefit distribution rules[14] , and rights and interests issues in specific scenarios[15] .

2.2 Data element life cycle

The data element life cycle covers the entire process of data elements from collection, storage, use, sharing, archiving to disposal, in the areas of data management, information systems and data governance. It covers not only the physical existence of data, but also the planning, management, protection and value-added aspects of data to ensure that data are effectively utilized and maintained at all stages. Scholars' research on the value of data elements in relation to the life cycle mainly focuses on the construction of the life cycle model of data elements, and the classification and grading based on the value of data.

Firstly, research on the construction of data element life cycle model, at present, there are more classic data management life cycle models in the international arena, such as the DCC review life cycle model proposed by the UK Digital Review Center[16] , the data life cycle of UK Data Warehousing UKDA[17] , the DDI portfolio life cycle model proposed by the Data Documentation Initiative Consortium[18] , and the USGS scientific data life cycle model proposed by the US Geological Survey[19] , and so on. Although different types of organizations have proposed different data management lifecycle models, the models have convergence in terms of applicable objects, structured expressions, core constituent links, etc., indicating that the academia and the industry have reached a consensus to a certain extent during the exploration time process of data lifecycle management. Second, the value management of data elements based on different life cycle stages. Zhang Shaohua et al.[20] think that data have different values at different stages, and should be managed hierarchically based on the value of data in the life cycle, selecting the optimal data strategy according to the differences in the final application scenarios, and ensuring the continuity of the data value-added process. Zheng Daqing

et al.[21] believe that different decision-making mechanisms, incentives and constraints, and supervision mechanisms need to be implemented according to the value of different types of big data at different stages, so as to facilitate the acquisition of the maximum value in a simple, reliable, secure, and effective way.

Existing research on the data life cycle is mainly from the perspective of management and for the purpose of management services, and research on the value formation of data elements mainly focuses on the release of value in different forms of data. However, the value formation of data elements covers many processes, and there is no analysis that comprehensively analyzes the value formation process and mechanism of data from collection, processing, sharing, and application from the data element life cycle. Therefore, this paper refers to the data element life cycle model, constructs a data element life cycle oriented to the release of data value, and analyzes the value formation process and core mechanism in the process.

3 Data element life cycle analysis

The study of the life cycle of data elements is a comprehensive process study of the various stages of data generation, collection, processing, circulation and application. The comprehensive management and effective utilization of data has become an important research element in contemporary data management research.

3.1 Segmentation of the data element life cycle

The life cycle of data elements mainly consists of three stages, namely, data supply stage, data circulation stage, data application stage, as shown in Figure 1. Among them, the data supply stage includes data collection, data collation, data aggregation, data analysis, mainly data as a labor object, being tapped into the value and use of the value of the stage; data circulation to the stage including data evaluation, data trading, data regulation, data can be a smooth flow of security; data application stage includes data use and use of feedback, data as a tool of labor to play a driving role in the Data application stage includes data use and use feedback, data as a labor tool, play a driving role in the stage.

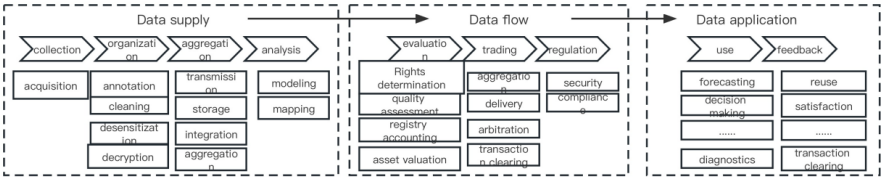

Fig. 1. Data element life cycle.

(1)Data supply phase

Firstly, data Acquisition. Data acquisition refers to the process of obtaining data from outside the system and inputting it into the system, and the granularity and timeliness of data acquisition will affect the embodiment of data value. The data collection strategy includes two kinds of strategies: one is the demand-oriented data collection strategy, i.e., when the application side, the business side or the management side puts forward the data demand, the data collection is carried out; the advantage of this approach is that it can minimize the cost of investment to meet the needs of all aspects, but it also restricts

the thinking of the data analysis, and it is often impossible to find the "accidental" data from data; the other is the data-driven-oriented data collection strategy. "The second is a data-driven data collection strategy, that is, any relevant data, as far as possible to collect, the advantage of this approach is that the value of the data is more earth mining, better service needs to provide the sex, but the disadvantage is that it is necessary to invest in more resources and costs of data collection, as well as the later processing and organizing, mining and other work. Data collection is the most important and basic part of the entire data life cycle, in which the collection of external data, all must be carried out under the framework of laws and regulations allowed.

Secondly, data organization. Data organization is a more complex processing process, which involves data standards, data cleaning, data quality, data desensitization, data decryption and other processes. The raw data collected needs to be cleaned, classified and pre-processed for subsequent analysis and utilization. The data organizing phase is critical to improving the quality and ease of use of the data. Common organizing tasks include eliminating redundancy, checking data consistency, completing missing values, and formatting data. Effective data organization ensures that the data can be properly understood and utilized in subsequent stages.

Thridly, data Aggregation. Data aggregation is the storage and aggregation of organized data. Divided into batch data and real-time streaming data in terms of timeliness or data form, and structured, semi-structured, and unstructured data in terms of structure, this stage involves integrating data from different sources and in different formats to form a unified, analyzable data set. Data aggregation helps to build a comprehensive view of the data, laying a solid foundation for in-depth analysis. Maintaining the relevance and context of the data during the aggregation process is key to ensuring the accuracy of the analysis.

Forthly, data Analysis. In the final part of data provisioning, the aggregated data is analyzed in depth by applying techniques such as statistics, data mining, and machine learning to reveal patterns, trends, and insights in the data. The work of data analysis includes building analytical models, testing hypotheses, and verifying model effects. The success of this phase directly affects the sex of the data's potential value into actual value.

(2)Data flow phase

Firstly, data Valuation. During the data circulation phase, it is critical to first identify the transaction value of the data. Data evaluation includes assessing factors such as the scarcity, accuracy, timeliness, completeness and relevance of the data. Through standardized evaluation guidelines, objective value benchmarks can be provided for the purchase and sale of data, ensuring a reasonable transfer of data ownership and use.

Secondly, data trading. The purchase and sale of data is realized through market or private transactions, and the data transaction link ensures the circulation of data and the diversity of access. For data marketplaces, it is critical to establish transaction rules, clarify transaction rights, and ensure transaction transparency and security. The main tasks involved in data trading include developing pricing strategies for data products, negotiating data use agreements and managing the data delivery process.

Thirdly, data regulation. The flow of data in the ecosystem needs to be subject to regulations and overseen by regulators. Data regulation includes protecting data privacy, ensuring data security, and preventing data misuse and market monopolization. Regulation not only ensures legal compliance of data flows, but also promotes the healthy development of the data flow market by providing a fair and transparent environment.

(3)Data application phase

Firstly, data use. Data usage is a direct way to realize the value of data. It involves applying data to a variety of practical business scenarios, such as decision support, product optimization, customer insights, predictive analytics, and so on. At this stage, important work elements include selecting appropriate data use cases, building data-driven solutions, monitoring the effectiveness of data-driven activities and continuously optimizing data use strategies.

Secondly, feedback on use. Evaluation and feedback on the effectiveness of data use can guide future data collection and processing activities, as well as data product improvements. Collecting user feedback, monitoring the business impact of the data solution, and conducting post-implementation effectiveness evaluations are the core elements of this phase. Through a continuous feedback loop, the value of data applications can be enhanced and the appreciation of data assets facilitated.

Each segment not only needs to accomplish specific tasks independently, but also needs to work together to contribute to the formation and appreciation of data value with a view of the entire data lifecycle. Such a continuous and integrated management perspective helps to understand how data can be transformed from simple numbers and characters into an asset of significant value to individuals, businesses and society.

3.2 Stakeholders in the data element life cycle

The data element life cycle is a process of multi-level integration and evolution of data, and the entire life cycle of data involves a total of three types of subjects, mainly including various types of data producers such as governments, research institutes, universities, enterprises, and individuals that provide data, various types of intermediaries at all levels of data processing such as data processors, data resource integrators, and transaction aggregators, and various types of data processing intermediaries at all levels of data processing such as governments, enterprises, education, finance, and scientific research. All kinds of data demand side to carry out data application.

The three types of subjects have different roles and points of interest at different stages of the data element life cycle, but there is a complex interdependence among them. Data producers need intermediaries to enhance the value of their data and find suitable markets; intermediaries rely on high-quality raw data to provide processed products and services to the demand side; and feedback from the demand side can facilitate improvements in data collection, processing and product development by producers and intermediaries. This interaction ultimately forms an ecosystem for the formation and enhancement of data value.

(1) Data producers

Data producers, including governments, research institutes, universities, enterprises, individuals, etc., are the starting point of the data life cycle. Such subjects provide raw data, and they are interested in the quality and quantity of the data, as this is directly related to the usability and potential value of the data. Governments are committed to enhancing transparency and public participation through open data; research institutes are concerned about the role of data in promoting scientific discovery; and enterprises value the importance of data in creating business value and maintaining competitive advantage.

This group of subjects is concerned that data remain accurate and that their original value is not diminished during subsequent processing and use, especially when the data relate to intellectual property and confidential information. At the same time, they require that the data be properly understood and applied, especially when it is used to guide policymaking or business strategy.

(2) Data processing intermediaries

Intermediaries such as data processors, resource integrators and deal aggregators constitute the transit and optimization part of the data life cycle. Their interest lies in increasing the market value of data through value-added processes such as data cleansing, integration, analysis and refinement, and trading platform services. The goal of such subjects is usually to improve data ease of use, accessibility and transaction fluency, thereby increasing the customer base and frequency of transactions and obtaining intermediary fees or service revenues.

Their interests intersect with those of data producers in maintaining data quality and integrity, and with those of the demand side in ensuring that data products and services match their needs. Intermediaries need to work closely with both the data producers and the demand side to ensure that the products and services they provide meet both the quality requirements of the supply side and the utilization criteria of the demand side.

(3) Data demand side

The data demand side, which includes government, business, education, finance, research and others, is concerned with how data can help them make better decisions, improve operational efficiency or drive innovation. They are at the tail end of the data lifecycle and are the driving force behind turning data into actions and outcomes. Benefit-wise, they seek data's operationalization, relevance, accuracy, and applicability to specific problems.

The needs of data demanders directly influence the direction of supply and the shape of processing services in the data market. Their feedback is key for producers and intermediaries to improve data products. At the same time, they are concerned about the legal, regulatory and ethical aspects of data transactions, as well as data security and privacy protection.

4 Data value formation mechanisms

4.1 The process of data value formation

The value of data is gradually released through a series of value-added activities that transform raw data into a core resource for end users. In each stage of the full life cycle of data, reasonable technology and management practices are important means and ways to enhance the value of data. The process of data value formation is shown in Figure 2.

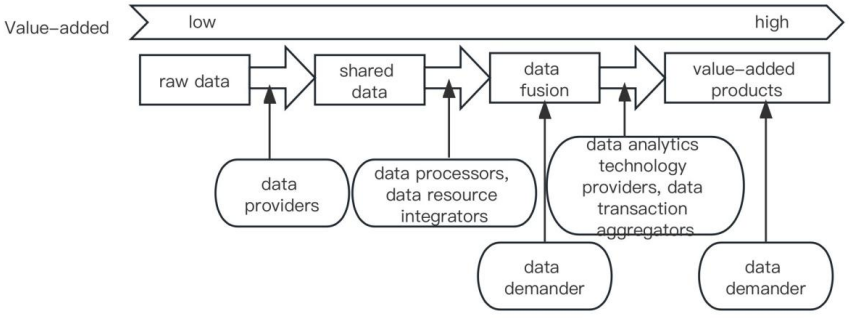

Fig. 2. The process of forming the value of data elements

(1) Data acquisition phase

In the data acquisition phase, data is collected and assembled as primary sources, the data involved here may be of low quality, may contain errors, missing values or inconsistencies, and the data may come from isolated sources, so they have relatively low value for direct application. Common acquisition methods include machine data collected by sensors, log data of user behavior on websites, public records, survey forms, etc.

Despite the limited value of the direct application of these raw data, the workload and complexity of the subsequent processing stage can be reduced through effective data management and quality control, such as ensuring a high standard of data collection processes and introducing initial data validation and filtering mechanisms. In addition, the breadth and comprehensiveness of the raw data can determine the subsequent potential depth and breadth of analysis at this stage, laying the foundation for further data value addition.

(2) Data Sharing Value Formation

After primary acquisition, data moves to the shared value formation stage. In this phase, data processors and resource integrators perform data cleansing (removing extraneous data, correcting errors), annotation (adding descriptive labels), desensitization (removing sensitive information), and declassification (complying with data protection regulations). As a result of this processing, the quality of the data is improved and it can be used for wider sharing and applications, thus increasing its value.

Data is made clearer, more accurate and easier to understand through cleansing and labeling. Desensitization and declassification ensure that data can be shared securely without invasion of privacy or violation of data protection regulations. This not only increases the credibility and applicability of the data, but also creates the conditions for it to be widely distributed, sold or further analyzed. Format standardization and quality control of data also make it a reliable decision-support tool, providing a basis for building trust among participants in the data market.

(3) Data fusion and value addition

After the data has been initially processed, it is further fused and value-added according to the specific needs of the demand side. In this process, data analytics technology providers combine multiple sources and types of data using advanced data analytics, data mining, machine learning, and artificial intelligence algorithms that translate into deep insights and solutions.

In the data fusion and value-added phase, data are transformed from the original "crude oil" state into tangible products that can directly facilitate decision-making, greatly enhancing the strategic and operational value of data. The application of customized data products and services can bring specific economic benefits, efficiency improvements or competitive advantages to end users (enterprises, governments, individuals, etc.), thus realizing the ultimate expression of data value. Comprehensive data applications and feedback loops also provide opportunities for data reinvention, when data can be used not only for current analysis and decision-making, but also to provide experience and information for future data generation and management.

4.2 Analysis of data value formation mechanism

The process of adding value to data contains many links, covering the three basic stages of data supply, data circulation and data application, as well as policy, technology, financial and human resources and other safeguard activities, which are interconnected and synergistic. Through the analysis of the data value-added process, the data value-added is achieved through a series of triggering mechanisms through these activities, specifically including: demand triggering mechanism, efficiency enhancement mechanism, sharing triggering mechanism, interest-driven mechanism, policy-led

mechanism, financial support mechanism, technology safeguard mechanism, and efficiency aggregation mechanism. The formation mechanism of data value is shown in Figure 3.

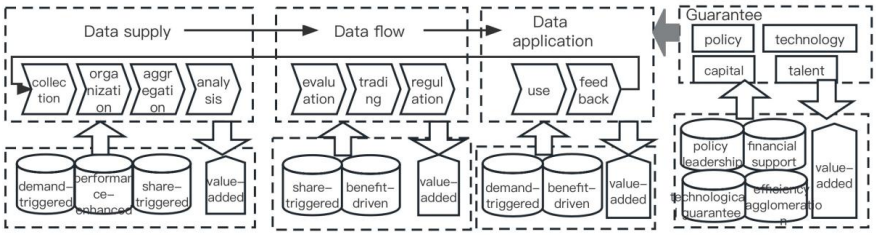

Fig. 3 Analysis of the formation mechanism of data value.

(1) Demand triggers

The demand trigger mechanism refers to the role of market demand in initiating the process of adding value to data. Demand-side data needs determine the direction of data supply and the depth of processing. For example, a company may seek specific consumer data to analyze and predict consumer behavior in order to meet the demand for personalized services. Demand triggers interact with other mechanisms in the marketplace. Explicit demand not only drives the process of data supply and flow, but also induces innovation in the technology assurance mechanism and optimization of the efficiency aggregation mechanism.

(2) Effectiveness enhancement mechanism

The effectiveness enhancement mechanism is concerned with increasing the value of data by optimizing data processing processes and improving data analysis capabilities. By adopting more efficient means of data storage, processing and analysis, the practical application of data can be improved. The effectiveness enhancement mechanism is closely linked to the technology guarantee mechanism, and technological progress can effectively enhance the effectiveness of data processing. At the same time, the financial support mechanism can also provide the necessary input for efficiency improvement.

(3) Shared Trigger Mechanisms

The establishment of a data-sharing mechanism can lead to the sharing and exchange of data between different organizations, which not only promotes the diversity and richness of data, but also improves the depth and breadth of data utilization. The sharing trigger mechanism and the policy leading mechanism support each other. Good policies can build a healthy data-sharing environment, which in turn triggers and promotes wider sharing of data.

(4) Benefit-driven mechanisms

The benefit-driven mechanism recognizes the economic drivers in the process of adding value to data. Producers, processors and demanders of data all participate in the supply, circulation and application of data based on the expectation that they will derive benefits from the data. The profit motive is the central force driving the flow and application of data, and is often combined with demand triggers and sharing triggers to influence the discovery and realization of data value.

(5) Policy Leadership Mechanisms

Policy-led mechanisms provide norms and directions for adding value to data by establishing relevant laws and regulations. For example, data protection laws and open data policies influence the boundaries of data application and sharing. Policy-led mechanisms can influence other mechanisms by incentivizing

or restricting certain behaviors, such as incentivizing technological innovation through financial support policies or influencing sharing triggers through data privacy policies.

(6) Financial support mechanisms

Funding is a necessity to drive value-add to data. At every stage, from data collection and processing to eventual application, funding is required to ensure continuity. Financial support mechanisms provide fuel for technology development, effectiveness enhancement and even policy implementation, and are directly linked to effectiveness enhancement mechanisms and technology assurance mechanisms.

(7) Technology Assurance Mechanism

The technical assurance mechanism supports the collection, storage, processing and analysis of data by providing the necessary technical means and platforms. This mechanism ensures that data can be transformed into value with efficiency and reliability. The Technology Assurance Mechanism provides direct support to the Effectiveness Enhancement Mechanism and is closely linked to the Sharing Trigger Mechanism, which enables the sharing and circulation of data.

(8) Efficiency Clustering Mechanisms

The efficiency clustering mechanism emphasizes the clustering of facilities, resources and talents through the construction of specialized and large-scale data-processing centers, thereby promoting the maximization of data value. The efficiency clustering mechanism is closely linked to the technology guarantee mechanism and the financial support mechanism, as technological innovation often requires the clustering of specific resources and funds, and also supports the profit-driven mechanism to maximize economic benefits.

5 Conclusion

The ultimate goal of research on data elements is to enable data to ultimately serve different scenarios, thousands of industries, technological progress and industrial development. Key issues such as data property rights, pricing, circulation, trading, compliance and security are being solved step by step. China has formed a national data bureau to coordinate the construction of a data base system and to coordinate data sharing and use.

This paper analyzes the process and mechanism of data value formation from the perspective of the full life cycle of data elements, and analyzes the analysis of stakeholders in the whole life cycle and key links from data collection, processing to final application, and analyzes the ways in which the potential value of data elements at each stage can be realized and added to with the efforts of stakeholders. Demand triggers supply, while policy and technology lead the release of data value like two wings; investment of funds and resources accelerates the value-added process; sharing and profit-driven fertile soil cultivate the sprout of innovation; and improved effectiveness and efficiency concentration explode the intrinsic potential of data into a powerful kinetic energy for practical application. The research in this paper emphasizes the position of the full life-cycle perspective as crucial to understanding and leveraging the value of data, and points out the interplay and importance of multidimensional triggering mechanisms in the whole process. These elements require us to think more deeply about how data management and utilization policies can inspire us to find innovative ways to maximize the potential value of data.

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