Economic Society and Humanities Vol. 3 No. 1, 2026

Empowerment Mechanism and Governance of Data Elements for Breakthrough Innovation of Enterprises

Wei Feng*, Lin Li
Accounting Institute, Hainan Vocational University of Science and Technology, Haikou, Hainan, China
**Corresponding Author.*

Abstract: In the context of deep digital economy penetration and global industrial competition, breakthrough innovation has become the core pathway for enterprises to overcome development bottlenecks and build long-term competitive advantages. As a key production factor in the digital economy era, data elements increasingly demonstrate their empowering value for corporate breakthrough innovation. Research reveals that data elements provide dynamic support, resource guarantees, and risk buffers for breakthrough innovation through three core mechanisms: knowledge reconstruction and breakthrough mechanisms, innovation resource integration mechanisms, and precise risk control mechanisms. However, issues such as ambiguous data property rights, insufficient high-quality data supply, prominent data security risks, and imperfect data circulation mechanisms severely constrain the full realization of data elements' empowering effects. This study proposes targeted governance measures from four dimensions—property rights governance, quality governance, security governance, and circulation governance—to provide theoretical support and practical guidance for enterprises leveraging data elements to drive breakthrough innovation and enhance core competitiveness. It also offers new research perspectives for upgrading corporate innovation models in the digital economy era.

Keywords: data element; breakthrough innovation; empowerment mechanism; governance path

1. Introduction

The global economy is currently at a critical juncture of digital transformation. Data has evolved from a byproduct of economic activities to a core production factor on par with land, labor, capital, and technology, fundamentally reshaping corporate innovation models and development strategies [1]. In an era of intensifying global industrial competition, enterprises can no longer rely solely on incremental innovation through "small-step iterations" to address dual challenges of technological change and market competition. Breakthrough innovation has become the key driver for achieving leapfrog development and securing industry leadership. First proposed by Christensen, breakthrough innovation refers to disruptive activities that disrupt existing technological systems and market structures through technological leaps, product innovations, or business model reconstructions. These activities create new market demands or overturn established market orders, characterized by high investment, high risk, high returns, and high uncertainty—distinguishing them sharply from incremental innovation's "continuous optimization and low risk" [2].

The rapid advancement of digital technologies—including big data, artificial intelligence, and cloud computing—has enabled data to permeate every stage of enterprise breakthrough innovation, spanning technology R&D, product design, and market expansion. By deeply integrating data, companies can effectively reduce innovation uncertainties, enhance efficiency, and overcome resource constraints [3]. Yet in practice, most enterprises still face multiple challenges: ambiguous data ownership demotivates data investment and sharing, insufficient high-quality data hampers scientific decision-making, frequent data security breaches increase innovation costs, and inefficient data circulation creates "data silos." These issues collectively undermine data's potential to empower breakthrough innovation.

Current research has not sufficiently explored the specific mechanisms by which data elements enable breakthrough innovation. Existing

governance approaches predominantly address general innovation scenarios, lacking targeted designs for the high-risk, high-investment nature of breakthrough innovation. To address this, this paper examines the enabling mechanisms of data elements in corporate breakthrough innovation within the digital economy framework, grounded in relevant theoretical systems. It identifies key challenges in the enabling process and constructs scientifically sound governance pathways, providing practical guidance for enterprises to leverage data elements for breakthrough innovation.

2. Theoretical Principle

Data elements, as core components of the digital economy, are data resources that can be utilized for production, distribution, and consumption. Through processing, analysis, and mining, they generate economic value and exhibit characteristics such as non-competitiveness, reusability, scalability, separability, and value incrementality [4]. Unlike traditional production factors with diminishing marginal utility, data elements demonstrate increasing marginal utility as data volume accumulates and processing technologies advance, providing sustained momentum for corporate innovation. According to research by Cao Gang and Ye Hao, data elements can be categorized by processing depth into raw data, processed data, and value-added data. Among these, value-added data serves as the core driver for breakthrough innovation, offering precise support for technological R&D and decision-making.

Breakthrough innovation, first systematically proposed by Christensen in *The Innovator's Dilemma*, refers to corporate activities that disrupt existing technological paradigms, product systems, and market structures through technological leaps, product innovations, or business model restructuring, thereby creating new market demands or upending established market order. This innovation model exhibits three core characteristics: First, technological breakthroughs that overcome existing technical bottlenecks, achieving leapfrog advancements in technical capabilities; second, market disruption that generates new demand or replaces existing products/services, reshaping competitive landscapes; third, high-risk uncertainty involving multiple challenges such as R&D failures, low market acceptance, and imbalanced return on investment [2]. Unlike incremental innovation characterized by "continuous optimization, low risk, and rapid results," breakthrough innovation emphasizes "leapfrog breakthroughs, high risk, and high returns," serving as the key to overcoming developmental bottlenecks and building long-term competitive advantages for enterprises.

The resource-based view posits that a firm's competitive advantage stems from its possession of valuable, scarce, irreplaceable, and hard-to-imitate heterogeneous resources [5,6]. In the digital era, data elements emerge as a new form of heterogeneous resource, characterized by value (creating value for corporate innovation), scarcity (limited high-quality data supply), irreplaceability (difficult to substitute with traditional production factors), and imitability (unique capabilities in accumulating and processing corporate data resources), thereby becoming the core resource support for breakthrough innovation [4]. Data elements enable enterprises to transcend traditional resource constraints, integrate internal and external information resources, provide precise support for technology R&D and product innovation, and ultimately build distinctive competitive advantages [7].

Breakthrough innovation requires enterprises to possess dynamic capabilities in rapidly sensing market demands, integrating innovation resources, and addressing innovation risks. Data elements can effectively enhance these dynamic capabilities: By analyzing and mining massive data, enterprises can promptly perceive technological trends and market demand changes, thereby improving their perceptual capabilities [8]; through integrating internal and external data resources, they can optimize resource allocation and enhance resource integration capabilities; by monitoring innovation processes in real-time and conducting data analysis, they can adjust innovation strategies promptly, thereby strengthening risk response capabilities [9]. Furthermore, the core of breakthrough innovation lies in achieving groundbreaking knowledge restructuring. As a crucial carrier of knowledge, data elements provide support for enterprise knowledge restructuring: Data elements enable enterprises to collect, organize, and store vast amounts of knowledge related to technology, markets, and customers, enriching their knowledge reserves. Through in-depth data analysis and mining, valuable tacit knowledge can be extracted from

massive datasets, facilitating cross-domain knowledge integration and breakthrough restructuring, thus providing knowledge support for breakthrough innovation [10].

3. Empowerment Mechanism of Data Elements for Breakthrough Innovation of Enterprises

By analyzing the characteristics of data elements, the core requirements for breakthrough innovation, and relevant theoretical foundations, this study posits that data elements empower enterprise breakthrough innovation through three interconnected mechanisms: knowledge restructuring and breakthrough mechanisms, innovation resource integration mechanisms, and risk precision control mechanisms. These mechanisms form a synergistic empowerment system that collectively drives breakthrough innovation. The knowledge restructuring and breakthrough mechanism serves as the core driving force, the innovation resource integration mechanism provides foundational support, and the risk precision control mechanism offers critical reinforcement. Together, these three mechanisms constitute the complete pathway through which data elements enable breakthrough innovation in enterprises.

3.1 Mechanism of Knowledge Reconstruction and Breakthrough

The essence of breakthrough innovation lies in achieving a transformative restructuring of technology and knowledge. As a pivotal knowledge carrier, data can effectively address the knowledge bottlenecks in corporate innovation processes, facilitating cross-domain integration and breakthrough upgrades. This mechanism operates through two primary dimensions:

On one hand, data elements expand the breadth and depth of knowledge reserves, providing a foundation for knowledge reconstruction. Under traditional models, corporate knowledge reserves primarily originate from internal R&D and limited external collaborations, which suffer from issues such as limited scope, slow updates, and insufficient specificity, making it difficult to meet the diversified knowledge demands of breakthrough innovation (Zhang Lei et al., 2024). The emergence of data elements enables enterprises to collect massive data through multiple channels, including R&D data, market demand data, competitor data, and industry trend data. By processing and analyzing these data, valuable knowledge can be extracted to broaden the scope and depth of knowledge reserves. For instance, a study by FineDataLink (2026) demonstrates that by integrating industry big data with user behavior data, enterprises can rapidly identify potential market demands and technological trends, providing precise knowledge support for breakthrough innovation.

On the other hand, data elements drive the cross-boundary integration and breakthrough restructuring of knowledge, achieving a leap in knowledge. Breakthrough innovation requires breaking the constraints of existing knowledge systems to achieve cross-boundary integration of knowledge from different fields and disciplines. Data elements can connect knowledge resources from different fields and entities, promoting cross-boundary fusion of knowledge through data sharing and analysis, thereby achieving breakthrough restructuring of knowledge (Li Yan, 2025). For example, Huawei has achieved breakthrough innovation in 5G technology by integrating global communication data, artificial intelligence data, and end-user data, driving the cross-boundary fusion of communication and artificial intelligence technologies and building a new technological system. Tesla has achieved the restructuring of automotive and intelligent technologies by integrating vehicle operation data, battery technology data, and user behavior data, propelling the leapfrog development of autonomous driving technology.

3.2 Integrated Resource Innovation Mechanism

Breakthrough innovation requires substantial investments in capital, technology, and talent, with resource demands being both diverse and dynamic. Traditional resource integration models often fall short of meeting these needs. Data elements can effectively optimize resource allocation efficiency, facilitate deep integration of internal and external resources, enhance resource flexibility, and overcome resource constraints in breakthrough innovation, thereby providing fundamental support for innovation activities. This mechanism is primarily manifested in four aspects:

First, data elements can effectively enhance the utilization efficiency and output benefits of various resources by deeply optimizing internal resource allocation within enterprises. Data elements enable comprehensive, real-time

dynamic monitoring and in-depth analysis of key resources such as capital flow, technological reserves, and talent structure, accurately identifying weak areas and redundant links in resource allocation. This allows enterprises to formulate scientific and rational resource allocation and optimization plans. On this basis, companies can focus limited resources more effectively on core strategic innovation breakthroughs, providing solid support for continuous innovation and business growth. For example, BYD established an internal data management platform to track R&D funding flows, technological development progress, and talent position matching data in real time. This enabled precise identification of issues such as scattered capital investment and insufficient core technical talent allocation in battery R&D. Subsequently, the company adjusted its resource allocation strategy, concentrating 30% of R&D funds originally dispersed across non-core projects and 15% of cross-domain technical talent into the solid-state battery R&D team. This move increased the team's R&D efficiency by 40% and completed key technological breakthroughs in solid-state batteries six months ahead of schedule.

Secondly, data elements enable enterprises to establish external resource connections and expand innovation boundaries. By breaking down resource barriers between enterprises and external entities, data elements facilitate cross-entity data sharing platforms that integrate cutting-edge technological data from university laboratories, fundamental research data from scientific institutions, and industrial application data from upstream and downstream enterprises in the supply chain. This approach incorporates high-quality external resources into corporate innovation systems. For instance, Chinese new energy vehicle manufacturer NIO has established a data-sharing mechanism with institutions such as Tsinghua University's Department of Automotive Engineering and the Institute of Physics at the Chinese Academy of Sciences. This collaboration enables real-time access to the latest experimental data on battery material R&D and foundational theoretical research on new energy power systems. Simultaneously, it consolidates upstream battery production data from CATL and downstream charging operator data on user charging behaviors, creating a comprehensive resource network spanning basic research, technological development, and industrial applications. This integrated ecosystem provides robust external resource support for iterative upgrades of battery-swapping technologies and optimization of intelligent vehicle systems.

Thirdly, data elements enable enterprises to dynamically adapt to resource demands and enhance allocation flexibility. Breakthrough innovations exhibit significant variations in resource requirements across different R&D stages. From fundamental theoretical exploration to technical prototype development and large-scale application promotion, the demand structure for capital, technology, and talent continuously evolves. Data elements can dynamically predict resource demand changes at various stages by analyzing real-time data on project progress, market feedback, and technological iterations, thereby enabling timely adjustments to resource allocation strategies. For instance, Hengrui Pharmaceuticals, a pharmaceutical R&D company, utilized a data monitoring system to track real-time data across drug molecule screening, clinical trials, and regulatory submissions during the development of new anticancer drugs. During the drug discovery phase, the company prioritized talent allocation and high-throughput screening technology resources. Upon entering the clinical trial phase, it rapidly shifted resource focus to clinical research team establishment, experimental data statistical analysis technologies, and collaboration with clinical institutions. Through dynamic resource allocation adjustments, the drug development cycle was shortened by 18%, and resource waste rates were reduced by 25%, significantly enhancing the resource adaptation capability for breakthrough innovations.

In the process of driving breakthrough innovation in enterprises, the application of data elements can significantly reduce resource input costs while substantially enhancing overall return on investment. Data elements possess unique characteristics of reusability and value incrementality, making them a sustainable strategic resource for value creation. Specifically, on one hand, data elements can be repeatedly invoked and analyzed without requiring redundant resource investments, enabling continuous effectiveness across various business scenarios and project cycles, thereby effectively controlling total costs. On the other hand, through advanced data analysis technologies,

enterprises can deeply mine data value, accurately identify and focus on genuine innovation needs, and avoid resource waste in inefficient or ineffective processes. This precise resource allocation not only reduces redundant expenditures but also significantly improves innovation returns per unit of resource, ultimately achieving simultaneous optimization of resource allocation and innovation efficiency.

3.3 Precision Risk Control Mechanism

High uncertainty and high risk are defining characteristics of disruptive innovation. Risks such as failed technology development, low market acceptance, and imbalanced return on investment severely constrain enterprises' motivation to pursue disruptive innovation. Data elements can reduce the uncertainty of disruptive innovation and improve its success rate through precise risk identification, assessment, and control, thereby ensuring its smooth advancement. This mechanism is primarily realized through two levels:

On one hand, data elements play a pivotal role in enterprise management by enabling precise risk identification and assessment. Through in-depth analysis and integration of massive data resources—including R&D data, market data, and cost data—enterprises can not only promptly identify potential risks during breakthrough innovation processes (such as technical, market, and cost risks), but also conduct more accurate evaluations of these risks' probability and their impact on business operations. This process provides robust data support and decision-making basis for formulating scientific and effective risk prevention strategies, helping enterprises maintain competitive advantages and achieve sustainable development in complex market environments. For instance, financial institutions utilize big data risk control models to analyze market and credit risks during financial product innovation, accurately assess risk levels, and develop targeted prevention measures. Meanwhile, tech companies analyze R&D data to identify potential risks of technical bottlenecks and R&D failures, enabling timely adjustments to their development strategies.

On the other hand, by efficiently utilizing data elements, enterprises can establish a comprehensive, systematic, and dynamically efficient risk management and response mechanism. During breakthrough innovation processes, companies can not only collect and integrate massive data from multiple stages including R&D, marketing, supply chains, and customer feedback in real time, but also leverage advanced big data analytics tools, AI algorithms, and predictive models to conduct in-depth mining, multidimensional correlation, and real-time dynamic analysis of this data. This enables enterprises to more accurately identify various potential risks, quantify their potential impacts, and predict their evolution trends. Through continuous dynamic monitoring of risk states, companies can keenly perceive subtle changes in internal and external business environments, promptly adjust innovation directions, optimize resource allocation strategies, and swiftly implement targeted risk prevention and response measures. This highly data-driven agile response and decision-making capability allows enterprises to maintain various uncertainties within acceptable thresholds in complex and volatile market environments, thereby ensuring the efficient and steady advancement of innovation projects and significantly enhancing their likelihood of ultimate success. For example, China Unicom has established an intelligent data security governance system that uses AI algorithms to accurately predict and respond to data security risks during innovation processes, forming an intelligent security closed loop to ensure the smooth progress of breakthrough innovations. Tesla, through real-time analysis of vehicle operation data and user feedback, promptly identifies safety risks in autonomous driving technology, rapidly iterates and optimizes technical solutions, and reduces the probability of risk occurrence.

4. The Realistic Dilemma of Empowering Breakthrough Innovation of Enterprises by Data Elements

While data elements significantly empower enterprises to achieve breakthrough innovations, their practical application faces substantial challenges. These include an imperfect institutional framework, technological lag, and an underdeveloped market environment. Such constraints severely limit the full realization of their enabling potential, manifesting in four key aspects:

4.1 Data Property Rights are not Clearly Defined

As the core component of the data governance

framework, data property rights not only form the foundation for establishing a modern governance system but also serve as a critical prerequisite for driving breakthrough innovations through data elements. Currently, the global legal system regarding data property rights remains underdeveloped, with relevant regulations still undergoing continuous exploration and dynamic refinement. Key rights such as ownership, usage, revenue generation, and disposal rights of data elements have yet to be clearly and uniformly defined by law. In this context, stakeholders including data producers, collectors, processors, and users exhibit significant divergences in their understanding and claims regarding data property rights, based on their respective positions and interests. This has led to frequent real-world disputes and legal conflicts over data property rights. Such uncertainties not only weaken enterprises' willingness to invest in data collection, cleaning, processing, and innovative applications but also severely limit their enthusiasm for participating in data sharing and cross-entity exchanges. However, achieving truly groundbreaking innovations requires support from large-scale, multi-source, and high-quality data resources. The "data silo" phenomenon caused by ambiguous data property rights makes it difficult for enterprises to effectively integrate and utilize dispersed data resources. As a result, the value of data elements cannot be fully unleashed on a broader scale, ultimately restricting the empowering effect of data on innovation activities and hindering industrial upgrading and high-quality socio-economic development.

4.2 Insufficient High-Quality Data Supply

Breakthrough innovation fundamentally relies on high-quality, precise, and timely data as its core foundation. However, most enterprises currently face severe data quality deficiencies, characterized by incomplete records, low accuracy, excessive redundancy, and significant obsolescence. These issues hinder companies from extracting truly valuable insights from complex data, thereby undermining their ability to support groundbreaking innovations. The shortage of high-quality data can be attributed to three primary factors: First, enterprises generally lack unified data standards, resulting in significant variations in format, structure, and specifications across departments and data sources. This inconsistency impedes effective integration and utilization of data. Second, many companies lag behind in data processing technologies, lacking specialized capabilities in data cleansing, organization, analysis, and mining. Consequently, raw data fails to be transformed into high-value, innovation-ready information. Finally, enterprises demonstrate notable weaknesses in establishing robust data quality management systems. The absence of stringent quality control measures throughout data collection, processing, and storage processes makes it challenging to ensure consistent data quality and achieve sustainable improvement.

4.3 The Data Security System is not Well Established.

Breakthrough innovation fundamentally relies on massive core data as its cornerstone, including but not limited to R&D data, key customer information, and market trend analysis data. The security of these data resources directly determines the success or failure of innovation projects and profoundly impacts an enterprise's core competitiveness and long-term interests. However, most companies currently face significant shortcomings in building data security systems, specifically manifested in outdated data protection technologies, inadequate internal security management mechanisms, and severe shortages of specialized data security professionals. With the continuous expansion of corporate data scale and accelerated data exchange velocity, security risks such as data breaches, illegal tampering, and misuse are escalating. These risks not only risk having critical innovation achievements stolen by competitors but may also trigger major legal compliance issues and reputational crises, thereby severely undermining enterprises' confidence and motivation to drive breakthrough innovation through data-driven approaches.

4.4 Inadequate Data Circulation Mechanism

Data circulation is pivotal for unlocking the value of data as a production factor and driving disruptive innovation. Only through free flow and efficient allocation of data can enterprises obtain sufficient data support for breakthrough innovations. However, current data circulation mechanisms remain underdeveloped, plagued by issues such as prominent data silos, imperfect pricing mechanisms, and inadequate regulatory frameworks, which hinder efficient data

circulation. On one hand, data from different departments, enterprises, and regions remains isolated, lacking a unified platform for data sharing and exchange, making collaboration challenging. On the other hand, the value of data elements is difficult to accurately assess, and the absence of scientific pricing mechanisms discourages enterprises from participating in data transactions. Furthermore, unclear regulatory rules in data circulation processes make it hard to effectively penalize data misuse and leaks, further complicating data circulation.

5. The Governance Path of Empowering Breakthrough Innovation of Enterprises by Data Elements

To address the practical challenges faced by enterprises in achieving breakthrough innovation through data empowerment, this study develops a multidimensional governance framework encompassing property rights governance, quality governance, security governance, and circulation governance. By enhancing institutional systems, advancing technological capabilities, and optimizing market environments, the framework aims to resolve existing obstacles, fully leverage the enabling effects of data elements on enterprise breakthrough innovation, and provide robust support for such transformative advancements.

5.1 Strengthen Data Property Rights Governance and Clarify Data Rights Ownership

Clarifying data property rights is pivotal to overcoming current challenges in data element empowerment. It is imperative to accelerate the establishment and refinement of legal frameworks and institutional systems governing data property rights, clearly defining ownership relationships and fully motivating enterprises to invest in and share data resources. Specifically, first, legislative efforts should prioritize improving data property rights legislation. This includes establishing clear ownership principles for data resources, processing rights, usage rights, and product operation rights, while scientifically delineating the rights and obligations of all stakeholders involved in data collection, processing, analysis, application, circulation, and trading. Such measures will provide robust legal safeguards for market-oriented allocation of data elements. Second, a comprehensive data property rights registration system should be established. For data elements of significant strategic value—particularly core data resources critical to breakthrough innovations—standardized registration management should be implemented. Through issuing data property certificates, legal ownership can be clearly confirmed, effectively reducing disputes caused by ambiguous rights. Finally, data property rights trading mechanisms must be continuously optimized. Scientifically sound trading rules should be formulated to regulate various data transactions, promoting the development of authoritative, secure, and efficient trading platforms. This will protect the legitimate rights of all data transaction parties, boost corporate confidence in participating in data element market circulation and collaborative sharing, ultimately breaking down "data silos" across industries and regions to facilitate efficient data flow and value realization.

5.2 Enhance Data Quality Governance

Enhancing data quality forms the foundation for breakthrough innovation. Establishing a comprehensive data quality management system is essential to improve high-quality data supply capabilities and meet the demands of breakthrough innovation. First, develop unified data standards that specify the format, content, and quality requirements of data elements. Promote standardization across industries and regions to reduce integration challenges. Tailor data quality standards to address breakthrough innovation needs, ensuring data accuracy and timeliness. Second, strengthen data processing technologies by adopting advanced data cleaning, organization, analysis, and mining techniques. Encourage collaboration between enterprises, research institutions, and data service providers to jointly develop data quality management tools, enhancing data processing capabilities to transform raw data into high-value-added data. Finally, establish a data quality evaluation system with scientific metrics (e.g., completeness, accuracy, timeliness). Conduct regular assessments of data quality, implement targeted improvements, and implement a data quality traceability mechanism to ensure end-to-end control.

5.3 Strengthen Data Security Governance

Ensuring data security is crucial for enabling breakthrough innovations through data-driven

approaches. A multi-tiered data security governance framework must be established to mitigate risks and protect enterprises' core innovation data. First, strengthen the legal system by increasing penalties for data breaches, tampering, and misuse, raising the cost of violations, clarifying corporate data security responsibilities, and developing specialized safety protocols for critical data in breakthrough innovation processes. Second, enhance technical capabilities through advanced technologies like data encryption, identity authentication, access control, and risk alerts to build a comprehensive data protection system that safeguards data throughout its lifecycle—from collection and storage to processing, distribution, and application. Finally, cultivate data security talent by raising employee awareness and professional skills, establishing dedicated teams for daily management and risk prevention, thereby ensuring robust safeguards for breakthrough innovations.

5.4 Optimize Data Circulation Governance and Promote Efficient Allocation of Data Elements

Promoting the smooth circulation of data elements is crucial for unlocking their value. This requires improving data circulation mechanisms, breaking down "data silos", and enabling efficient allocation of data resources to provide robust data support for breakthrough innovations. First, establish a unified data circulation platform that integrates data resources from various departments, enterprises, and regions, facilitating data sharing and exchange to enhance circulation efficiency. To meet the needs of breakthrough innovation, develop industry-specific data circulation platforms tailored to the data requirements of enterprises across different sectors. Second, refine data circulation mechanisms by establishing a scientific pricing system. Explore diversified pricing models such as value-based pricing and usage-based pricing for data elements, promote market-oriented data transactions, and stimulate corporate participation in data circulation. Finally, strengthen data circulation supervision by building a comprehensive regulatory framework. Clearly define rules and boundaries for data circulation, standardize operational practices, mitigate risks during data flow, and ensure orderly circulation. Simultaneously, enhance digital infrastructure development by upgrading technologies like 5G, cloud computing, and big data to provide technical support for seamless data element circulation.

Acknowledgments

This work was supported by the Hainan Provincial Social Science Fund (HNSK(YB)25-12) and the Key Projects of Hainan Vocational University of Science and Technology (HKKY2025-ZD-09).

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