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Synergistic Mechanism of the High-Quality Development of the Urban Digital Economy from Blockchain Adoption Perspective—A Configuration Approach

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Abstract: Blockchain technology is suited to the high-quality development of the digital economy in addressing privacy and data security issues. This study explores the synergistic mechanism of the following six factors from three dimensions based on the Technology-Organization-Environment (TOE) framework theory with a fuzzy set qualitative comparative analysis (fs/QCA) method: technology, organization, and environment, namely, Blockchain service capability, Blockchain knowledge accumulation, government attention allocation, government funding support, industry carrying capacity and blockchain technology R&D environment, on the quality of the digital economy of 43 cities in China. The conclusions are as follows: (1) the absence of government funding regarding the blockchain domain is a condition contributing to the absence of high urban digital economy quality; (2) there are three driving configurations for the high-quality urban digital economy in the blockchain technology adoption perspective, which are as follows: knowledge-industry driven, government-service driven, and R&D-service driven; (3) there is one driving configuration for the absence of high urban digital economy quality, namely the knowledge-R&D-funding-inhibiting type. The relevant policy implications can provide theoretical references for local governments to develop the digital economy with the help of blockchain technology.

Keywords: blockchain; government attention allocation; digital economy; configuration approach

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1. Introduction

In recent years, with the rapid development of digital technologies such as blockchain, cloud computing, big data, and artificial intelligence, as well as their deep integration with various industries, the digital economy has penetrated all aspects of economic and social development, becoming a new engine for future economic growth and a new path for industrial transformation [1]. In 2019, the Chinese government stated their aim to "focus on promoting high-quality development and vigorously develop the digital economy" as the basic task and to "take blockchain as a breakthrough in independent innovation of core technology and accelerate the development of blockchain technology and industrial innovation", which sets the direction for the transformation of China's economic growth model [2]. Considering the important role played by the digital economy in the transformation of dynamic energy, promoting economic growth, and demonstrating national competitiveness, improving the quality of the digital economy is becoming a focal point for achieving high-quality economic development [3,4]. However, as a new economic form with digital knowledge and information as the key production factors, data privacy, and data security have become key to the high-quality development of the digital economy [5]. Based on its decentralization, distributed storage, asymmetric encryption, smart contracts, peer-to-peer information transmission, traceability, and other characteristics, blockchain technology is suited to the digital economy in terms of solutions to privacy and data security issues and is becoming an important technical foundation for the development of the digital economy [6]. Therefore, it is of great practical significance to explore the synergy between blockchain technology and the high-quality development of the digital economy.

The digital economy, as of the next stage of techno-economic paradigm change, is an advanced economic form based on a new generation of information technology and oriented to the optimal allocation of resources, emphasizing the mutual relationship between technology and the economy [7]. From the technical perspective, most existing studies focus on the exploration of the mechanism of digital technology for promoting the high-quality development of the digital economy, including the study of the mechanism of the role of digital technology in promoting digital industrialization [8], industrial digitization [9], and digital governance [10]. For blockchain technology, existing research mostly focuses on the application of blockchain technology in digital financial services [11], digital financial regulation [12], food safety traceability [13], digital cryptocurrency [14], etc. It is widely believed that blockchain technology is essentially a distributed database system and a new generation of Internet protocols involving various nodes that can automatically track all digital actions thereby creating a decentralized database to verify identity and disrupt traditional governance models with lower cost and higher efficiency [15]. At the logical level of equipping blockchain technology to improve the quality of the digital economy, Zutshi (2021) argues that blockchain technology can strengthen the resource allocation potential of the digital economy [16]. Based on the theoretical analysis framework of "macro-meso-micro", Kuang and Peng (2020) analyzed the theoretical logic of blockchain technology in promoting the development of the digital economy in terms of economic operation efficiency improvement, and industrial transformation and improvements, and enterprise business model innovation [17]. Relevant mechanistic research results lay the foundation for the application of blockchain technology in the digital economy.

However, from the perspective of the current analysis, the diffusion of innovation theory (DOI) shows that the diffusion of new technology undergoes three stages of "intention-adoption-programming" [18]. Previous studies related to blockchain technology mainly focus on the first stage (intention stage), and the few studies involving the perspective of blockchain technology adoption fail to address the issue of government attention and fund allocation in the process of blockchain technology adoption. Moreover, in terms of research methods, previous researchers mainly used traditional analysis methods, such as Wamba (2020), who empirically investigated the diffusion process of blockchain technology in supply chain management from the perspective of technology adoption using statistical regression [19].

Moreover, according to the theory of the Technology-Organization-Environment (TOE) framework, the adoption of blockchain technology is jointly influenced by multiple factors such as technology, organization, and environment, and different combinations of factors may produce the same results. It is necessary to systematically consider the synergistic effects of multiple factors in the process of blockchain technology adoption on the development of the digital economy. With regard to methods, traditional analysis methods focus on the net effect of a single factor and do not show good applicability in terms of exploring the synergistic effects of multiple factors, meaning that traditional analysis methods act in isolation or are only partially related and focus on a single causal relationship. The qualitative comparative analysis (QCA) method based on the configurational perspective can help to overcome the limitations of traditional methods by using set theory and Boolean operations to uncover the "configurational effects" of multiple factors and to explore the different ways to achieve the same effect and the relationship between each path.

In summary, based on the TOE framework theory, this study further extends its application in analyzing the combination of multiple factor relationships and reveals the complex mechanism of multiple factors linking to influence output. We propose an integrated analytical framework for analyzing the impact of blockchain technology adoption on the high-quality development of the urban digital economy from the perspective of blockchain technology adoption and introduce configuration thinking into the study of digital economy quality at the city level. This study takes 43 representative cities in China as samples and applies the fuzzy set qualitative comparative analysis (fs/QCA) method to extend the application area of the QCA method by analyzing the relationship between the set of elements involved in blockchain technology adoption at the technical, organizational and environmental levels in the studied cities and the set of digital economy quality, and uncovering the complex causal mechanism of multiple factors concurrently affecting the high-quality development of the urban digital economy. The key questions to be addressed in this study are as follows: which paths in the blockchain technology adoption process can lead to the generation of a high urban digital economy quality? Which paths in the blockchain adoption process inhibit the generation of a high digital urban economy quality? Do the necessary conditions exist for blockchain technology adoption to lead to a high urban digital economy quality?

The remainder of the paper is organized as follows. Section 2 provides a brief theoretical analysis. Section 3 briefly describes the research methods and data sources used in this study. Section 4 presents the empirical results and discussion. Section 5 reports some conclusions and provides further policy implications.

2. Theory

2.1. TOE Framework Theory

The TOE framework theory, first proposed by Tornatizky and Fleischer (1990) [20], is an extension of the theory of diffusion of innovation (DOI). It is essentially a comprehensive analytical framework based on technology application contexts and has been applied to many fields such as e-government, e-commerce, green technology, supply chain resilience, knowledge management diffusion, and organizational management [21]. Specifically, the TOE framework theory classifies the conditions that affect the application of technology into the following three categories: technical, organizational, and environmental conditions [22]. Technology conditions refer to the characteristics of the technology itself and its relationship to the organization, and focuses on whether the technology matches the structural characteristics of the organization, whether it is compatible with the organization's application capabilities, and whether it can bring potential benefits to the organization [23]. The impact of organizational conditions on technology adoption has also received extensive attention in empirical studies, which include many aspects such as the organizational size, the scope of operations, formal/informal institutional arrangements, communication mechanisms, and idle resources for standby savings [24]. Environmental conditions include aspects such as the market structure in which the organization is located and the regulatory policies of external governments [25].

2.2. Conceptional Model

The TOE framework has excellent applicability as it can be adapted to improve the effectiveness of the model according to the characteristics of the research area and the research object [26]. Moreover, the three dimensions of the TOE framework do not work independently, and the conditions of the three dimensions work together in some kind of linkage matching mode in specific scenarios. Based on this, this paper constructs a debugged and expanded TOE framework, combining the institutional context of the Chinese government and the specific practice scenarios of urban digital economy development, as shown in Figure 1.

2.2.1. Technology Conditions

Technology conditions concern whether the available technology matches the organization's structure, whether it is coordinated with the organization's application capabilities, and whether it increases the potential benefits to the organization [25]. According to the characteristics of blockchain technology itself and the specific problems faced in the development of the urban digital economy, the technical conditions specifically include two secondary indicators: blockchain service capability and blockchain knowledge accumulation.

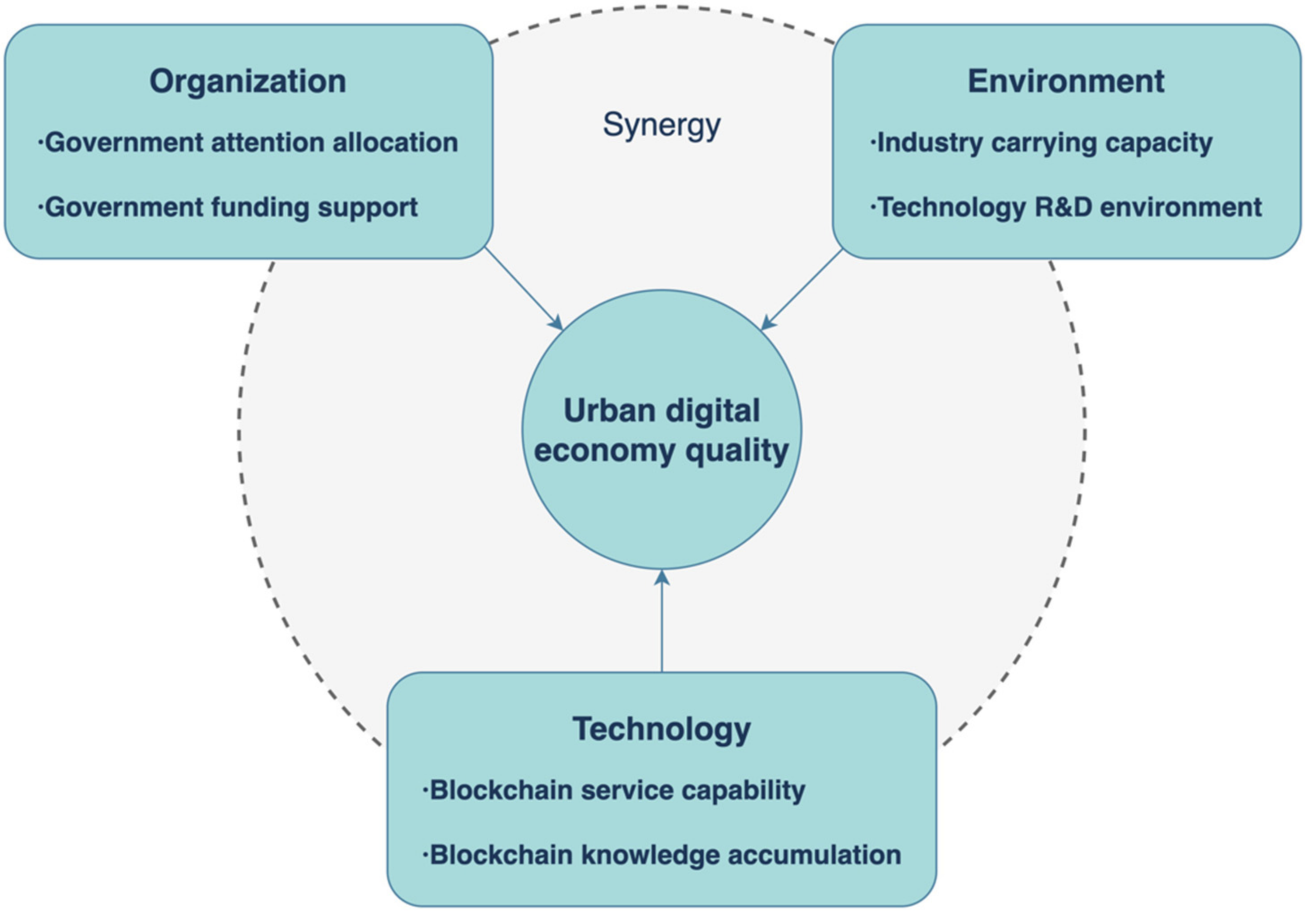

Figure 1. Configurational model of the quality-driven mechanism of the urban digital economy based on TOE framework.

In the interaction between technology and organizations, the adoption of technology affects the efficiency of management decisions and the operational management efficiency of the organization [27]. At the macro level, the adoption of blockchain technology can improve the operational efficiency of the urban digital economy by improving the information of market players, correcting market failures, regulating price discrimination and curbing market speculation with the help of a decentralized bookkeeping scheme [17]. At the mesoscopic level, it relies on the technical characteristics of distributed, tamper-proof, complete traceability, open programming and common maintenance to empower agriculture, manufacturing and traditional service industries to promote the transformation and upgrading of traditional industries, form a network system of shared credit governance with the characteristics of encrypted transactions and accelerate the process of rationalizing the structure of the financial industry [27,28]. At the micro-level, it promotes the flattening of enterprise organization, optimization of the enterprise management model, and innovation of the enterprise profit model to drive the digital transformation and upgrading of enterprises through value interconnection and other features [17,29]. It can be seen that the stronger the blockchain-service capability, in principle, the more significant the promotion of the urban digital economy will be.

2.2.2. Organization Conditions

Technology can recreate organizations, but it can also be influenced by the organization [25,30]. Organizational factors focus on whether the organization can choose an innovation strategy suitable for its development according to its characteristics. Researchers usually explore the factors affecting the application of technological innovation at the organizational and managerial levels, including the resource capacity of the organization, and the degree of centralization of the structure [31,32]. The finite rational decision theory suggests that the allocation of governmental attention to issues determines the choice of governmental behavior, and there is a logic of "governmental attention—governmental behavior choice" [33]. In this study, according to the degree of local government support for blockchain development and the strength of that support, the organizational conditions specifically include the following two secondary indicators: government attention allocation and government funding support. Combined with the Chinese context, the government's attention allocation to blockchain technology plays a facilitating role in the development of the digital economy through the corresponding institutional arrangements and policy support [25]. Moreover, blockchain technology as an emerging digital technology has a large capital demand from technology research and development to technology marketization, and the government's provision of funding support is crucial to the development of blockchain technology [34].

2.2.3. Environment Conditions

The influence of environmental factors on technology adoption is usually expressed as pressure or motivation [21], and specifically includes the following two secondary indicators: industry carrying capacity and technology R&D environment. For the blockchain industry, the city's industrial carrying capacity essentially refers to the maximum industrial scale that the city can effectively support in its current state, which not only demonstrates where the city currently is in the industrial development process, but also represents the city's current level of blockchain industrial development and its pressure due to industrial development [35,36]. As one of the basic technologies of the digital economy, blockchain technology plays a core supporting role in promoting the digital transformation of traditional industries and creating new industries and new business models through its characteristics of permeability, substitutability, and synergy [37]. Technology R&D is regarded as a major factor in the formation and accumulation of technological capabilities, and a major determinant of competitive advantage in high-tech industries [38]. As the forefront of the entire digital economy value chain, the technology R&D environment provides a solid foundation for blockchain technology innovation, which in turn promotes the formation and development of the digital economy.

In summary, the study of the impact of a single factor on the quality of the digital economy provides a basis for the selection of conditions for this study and a theoretical guide for discussing the quality development of the digital economy at the city level within the TOE framework. However, related studies have not revealed the complex interactions among the elements and their synergistic effects on the quality of the digital economy. The configuration approach focuses on the synergistic effects of multiple system elements on output and aims to uncover complex causal relationships such as asymmetry and equivalence between elements and output [39], which is suitable for analyzing the synergistic effects of technological, organizational, and environmental elements on the quality of the urban digital economy from the perspective of blockchain technology adoption. Based on this aim, this study introduces the QCA approach using the TOE framework to explore the complex causal mechanism of blockchain technology adoption affecting the high-quality urban development of the digital economy in China, for which the theoretical model is shown in Figure 1. That is, the way the six factors of blockchain service capability, blockchain knowledge accumulation, government attention allocation, government funding support, industry carrying capacity construction, and technology R&D environment synergistically link together to influence the quality of the urban digital economy in China.

3. Materials and Methods

3.1. QCA

Qualitative comparative analysis (QCA) is an ensemble analysis approach that aims to deconstruct the problem of causal complexity, using cases as causal conditions and focusing on the complex causal relationships between conditional configurations and outcomes, which considers that the factors influencing a given outcome are not independent but mostly interdependent [40–42]. On the one hand, the multidimensional and holistic characteristics of QCA expand the isolated perspective of the traditional quantitative regression analysis and provide a more ideal way to analyze the complex causality of interdependence among variables and their configurations affecting the results [43]. On the other hand, QCA can better answer the question of the asymmetry of causality, i.e., it answers the question that the causes that produce high and non-high quality are not the same [44].

The QCA method integrates the respective strengths of qualitative and quantitative analyses and is suitable for both small sample studies of up to 10 or 15 and large sample studies of 100 or more, as well as medium-sized sample studies of 10 or 15 to 50 [45]. Based on the case sample data of 43 cities in mainland China, this study explored the configuration influence and complex causality of blockchain service capability, blockchain technology knowledge reserve, government attention allocation, government funding support, industry carrying capacity, and the technology R&D environment in the high-quality development of the urban digital economy from the following three dimensions: technology, organization, and environment. The sample of 43 cases in this study is a medium-sized sample, which allows us to explore both the depth and uniqueness of the cases and the external validity. For medium-sized samples, the ideal number of conditional variables is generally between four and seven [41]; therefore, this study determined that six conditional variables met the requirements. Considering that the fuzzy set QCA (fs/QCA) is more suitable for dealing with contact variables, fs/QCA was used for the analysis in this study.

3.2. Sample and Data Collection

During the case collection process, cities that were listed in both the top 50 Chinese cities in terms of blockchain development level and the top 100 Chinese cities in terms of digital economy development in 2018 were selected. Combined with the administrative regions of China, this study covers all provincial administrative regions in mainland China as extensively as possible. The selected cases are all prefecture-level cities and can reflect the quality of the digital economy, meeting the homogeneity requirement of case selection. Moreover, from the geographical scope, this study covers 30 provincial-level administrative regions in mainland China, meaning that the condition and outcome variables of the case cities are more heterogeneous, thereby meeting the diversity requirement of case selection, and the finalized research sample contains 43 case cities as shown in Table 1. The descriptions of condition and outcome variables, data sources, and descriptive statistical analysis are detailed in Table 2.

3.3. Variables

3.3.1. Digital Economy Quality

Within the existing literature [46], the index is a frequently used indicator to measure the level of development of regional digital economy. The European Commission (2020) measures the level of digital economy development in EU countries in four dimensions, namely Connectivity, Human Capital, Use of Internet Services, and the Integration of Digital Technology to form the IDESI (International Digital Economy and Society Index) index [46]. The CAICT (2020) measures the digital economy development of selected Chinese cities in the following four dimensions: data and information technology infrastructure, urban services, urban governance, and industrial integration [2]. From the perspective of simplifying the research design and improving data precision, this study adopts the digital economy index data of sample cities in the 2019 China City Digital Economy Index White Paper to reflect the quality of the urban digital economy.

Table 1. List of sample cities.

	City	Administrative Level/Location		City	Administrative Level/Location		City	Administrative Level/Location
1	Beijing	A/North	16	Foshan	E/South	31	Zhuhai	E/South
2	Shenzhen	B+C/South	17	Wuxi	E/East	32	Taiyuan	D/East
3	Hangzhou	B+D/East	18	Suzhou	E/East	33	Shenyang	B+D/Southeast
4	Shanghai	A/East	19	Fuzhou	D/South	34	Lanzhou	D/Northwest
5	Guangzhou	B+D/South	20	Xiamen	B+C/South	35	Xuzhou	E/East
6	Chongqing	A/Southwest	21	Jinan	B+D/East	36	Quanzhou	E/South
7	Qingdao	B+C/East	22	Zhengzhou	D/Central	37	Nanchang	D/East
8	Nanjing	B+D/East	23	Ningbo	B+C/East	38	Xining	D/Northwest
9	Chengdu	B+D/Southwest	24	Ganzhou	E/East	39	Yinchuan	D/Northwest
10	Guiyang	D/Southwest	25	Harbin	B+D/Southeast	40	Nanning	D/South
11	Changsha	D/Central	26	Changchun	B+D/Southeast	41	Lasa	D/Northwest
12	Haikou	D/South	27	Dalian	B+C/Southeast	42	Huhehaote	D/East
13	Xian	B+D/Northwest	28	Hefei	D/East	43	Wulumuqi	D/Northwest
14	Wuhan	B+D/Central	29	Kunming	D/Southwest			
15	Tianjin	A/East	30	Shijiazhuang	D/East			

Note: A: Municipalities directly under the central government, B: Sub-provincial cities, C: Planned cities, D: Provincial capitals, E: Prefectural cities.

Table 2. Variable description and data sources.

Variables	Description	Units	Data Source
Blockchain service capability	Number of blockchain information service filings	Pcs	The official website of the Office of the Central Committee of the Communist Party of China for Network Security and Informatization
Blockchain knowledge accumulation	Blockchain Technology Patents	10,000 Pcs	Innojoy Patent Database
Government attention allocation	Number of blockchain industry policies	Pcs	China Blockchain Industry Business Model Innovation and Investment Opportunities In-depth Analysis Report
Government funding support	Number of Blockchain Industry Funds	Pcs	China Urban Blockchain Development Level Assessment Report
Industry carrying capacity	Number of Blockchain Industrial Parks	Pcs	China Urban Blockchain Development Level Assessment Report
Technology R&D Environment	Number of blockchain R&D institutions	Pcs	China Urban Blockchain Development Level Assessment Report
Digital Economy Quality	Digital Economy Index	%	White Paper on China's Urban Digital Economy Index

3.3.2. Blockchain Service Capability

The continuous development of blockchain technology services forms effective support for the digital economy. Following the literature [47], the blockchain service capability of each city was measured in terms of the number of blockchain information services in each city.

3.3.3. Blockchain Knowledge Accumulation

As a kind of knowledge resource, technical knowledge accumulation is the concentration of technology attached to enterprise products [48]. The patent is an important manifestation of technical knowledge accumulation, and existing studies usually use the number of patent applications to reflect the level of technical knowledge accumulation in a region. In line with the literature [49], this study adopts a number of blockchain-related patent applications to measure the level of blockchain technical knowledge accumulation in cities.

3.3.4. Government Attention Allocation

Local governments in China implement the central government's policy guidelines by issuing local implementations in line with the central government's guiding documents [50]. Scholars often use the time interval between policy implementation as a measure of government attention allocation. By referencing the literature [25], and drawing on the idea of clear sets, the allocation of each local government's attention to the development of blockchain technology was measured depending on whether each local government introduced institutional arrangements for blockchain technology within six months thereafter using 28 May 2018, the date of the speech disseminated by Chinese leaders proposing the development of blockchain technology, as the starting point in time.

3.3.5. Government Funding Support

As an important carrier combining the role of government and market mechanisms, the government industrial fund is an important policy tool used to increase the supply of venture capital and industrial investment capital and to guide social capital to invest in key areas and weak links of industry [51]. Government special industrial funds have a significant positive impact on the development of high-tech industries. Guided by the literature [52,53], the scale of government blockchain industrial funds in each region was adopted as an indicator to measure government funding support.

3.3.6. Industrial Carrying Capacity

The differences in geographic characteristics and industrial development logic have caused differences in regional industrial structures and affected the industrial carrying capacity of specific industries [36]. The degree of agglomeration of an industry can reflect the strength of the regional industrial carrying capacity [54]. The geographical agglomeration represented by industrial parks highly fits the development concept of industrial agglomeration. Following the literature [55], this study selected a number of blockchain industrial parks to measure the carrying of the blockchain industry in each region.

3.3.7. Technological R&D Environment

Technological innovation is an important source of the core competitiveness of enterprises [56]. The R&D institutions of enterprises, research institutes, and universities, as the main body of technology R&D and innovation, are an important part of the technology R&D environment; therefore, the number of research institutions influences the regional technology R&D environment to a certain extent. As an emerging digital technology, the specific form and embedding process of blockchain technology embedded into the digital economy is in continuous development, which requires theoretical and technical support from blockchain R&D institutions. Therefore, following the literature, this study adopted a number of blockchain R&D institutions to assess the strengths and weaknesses of the blockchain technology R&D environment [57].

3.4. Coding Cases' Set Memberships

As an ensemble analysis method, The QCA method reveals the causal complexity of social phenomena by exploring the ensemble relationships between conditions and outcomes [58]. In the set methodology, converting raw data into set membership scores is a necessary step for set analysis and operations, and the process of assigning membership scores to cases and conditions is known as variable calibration; however, uncalibrated data are uninterpretable and unrealistic [39]. Ragin (2008) argues that the specific locations of the three qualitative anchors should be determined based on theoretical knowledge and empirical evidence, and because of the lack of actionable theoretical and empirical guidance in the social sciences [42], the data were based on the cases themselves, which were calibrated using a direct calibration method to convert the data into fuzzy set membership scores, considering that the case cities in this study are relatively representative.

Specifically, (1) we adopted clear set calibration for government attention allocation, government funding support, industry carrying capacity, and the technology R&D environment, i.e., assigning a value of 1 to cities that have released blockchain industry support policies within six months, otherwise, assigning a value of 0; assigning a value of 1 to case cities that have set up blockchain industry funds, otherwise, assigning a value of 0; assigning a value of 1 to case cities that are planning blockchain industry parks, otherwise assigning a value of 0. Case cities that have set up special blockchain technology research institutions are assigned a value of 1, otherwise, it they are assigned a value of 0. (2) We adopted fuzzy set calibration for Blockchain service capability, Blockchain knowledge accumulation, and digital economy quality, and the three anchor points were set to the 75% quantile (fully affiliated), 50% quantile (intersection), and 25% quantile (fully unaffiliated) of the sample data [42]. The calibration information of the results and condition variables in this study are shown in Table 3.

Table 3. Fuzzy-set membership calibrations and sample description.

Variables	Fuzzy Set Calibrations			Measurement Description			
	Fully In	**Crossover**	**Fully Out**	**Mean**	**SD**	**Max**	**Min**
Blockchain service capability	14	5	1	22.72	54.54	309	0
Blockchain knowledge accumulation	81	18	4	114.84	278.36	1348	0
Government attention allocation	≥1	—	<1	0.84	1.93	9	0
Government funding support	≥1	—	<1	0.21	0.41	1	0
Industry Carrying Capacity	≥1	—	<1	0.60	1.03	5	0
Technology R&D Environment	≥1	—	<1	2	3.64	20	0
Digital economy quality	73	64.1	57.6	67.42	11.50	89.80	45.1

4. Results and Discussion

4.1. Necessity Analysis

When a factor outcome is always accompanied by a condition, such a condition is considered necessary for the outcome [39]. Consistency reflects the extent to which cases of the same condition configuration are subordinated to the same outcome and is an important measure of whether the condition is necessary. Following the literature [55], this study set the necessary condition consistency threshold at 0.9 and used the fsQCA3.0 software to conduct the necessary condition analysis for high digital economy quality and the absence of high digital economy quality, respectively. The results for this are shown in Table 4. For a high digital economy quality, none of the individual condition variables had a consistency level of higher than 0.9, so none of them constituted a necessary condition. For the absence of high digital economy quality, the consistency level for the absence of government funding support was 0.94, which constituted a necessary condition for the absence of high digital economy quality, indicating that lack of government funding support was a necessary condition leading to the creation of the absence of a high urban digital economy quality.

4.2. Configurations Sufficient for the High-Quality Digital Economy

A sufficiency analysis is used to identify the possible configurations consisting of multiple factors that lead to the focal outcomes. Following previous studies, this study set the consistency threshold for configuration analysis at 0.8 [59], the PRI consistency threshold at 0.7 [55], and the frequency threshold at 1 [60]. For the three solutions (complex, parsimonious, and intermediate) output by the fs/QCA3.0 software, following the method of previous studies [60], this study used the intermediate solution as the first solution and the parsimonious solution as the second solution in the reporting process. The results of the configuration analysis of the six factors are shown in Table 5, revealing the existence of three configurations that can lead to a high-quality urban digital economy (HQ1a, HQ1b, HQ1c, HQ1d, HQ2, HQ3).

Table 4. The necessity of conditions for high and non-high digital economy quality.

Condition Tested	High Quality		Absence of High Quality	
	Consistency	Coverage	Consistency	Coverage
Blockchain service capability	0.78	0.87	0.23	0.21
~Blockchain service capability	0.28	0.31	0.85	0.76
Blockchain knowledge accumulation	0.78	0.86	0.25	0.23
~Blockchain knowledge accumulation	0.30	0.33	0.85	0.75
Government attention allocation	0.47	0.80	0.14	0.19
~Government attention allocation	0.52	0.42	0.85	0.57
Government funding support	0.33	0.88	0.05	0.12
~Government funding support	0.66	0.46	0.94	0.54
Industry Carrying Capacity	0.56	0.83	0.14	0.16
~Industry Carrying Capacity	0.43	0.38	0.86	0.61
Technology R&D Environment	0.69	0.78	0.23	0.22
~Technology R&D Environment	0.30	0.33	0.76	0.67

Note: the notation "~" means the absence of the variable.

Table 5. Configurations sufficient analysis for the high quality of the urban digital economy.

	High-Quality Solution					
	HQ_{1a}	HQ_{1b}	HQ_{1c}	HQ_{1d}	HQ_2	HQ_3
Blockchain service capability	●	●		●	⬤	⬤
Blockchain knowledge accumulation	⬤	⬤	⬤	⬤		●
Government attention allocation		⊗	⊗	⊗	⬤	
Government funding support		⊗	⊗	●	⨂	⨂
Industry Carrying Capacity	⬤	⬤	⬤	⬤	⊗	⊗
Technology R&D Environment	●		●	⊗	⊗	⬤
Consistency	0.99	0.98	0.99	1	0.99	0.88
Raw coverage	0.40	0.08	0.16	0.02	0.03	0.16
Unique coverage	0.23	0.03	0.01	0.02	0.03	0.11
Overall consistency	0.96					
Overall coverage	0.64					

Note: Large, full black circle "⬤" (present) and large, cross open circle "⨂" (absence) represent core conditions. Small, full black "●" (present) and small, crossed open circles "⊗ " (absence) represent peripheral conditions.

Configuration HQ1 represents the knowledge-industry-driven path, which means that greater blockchain technology patents accumulation and a stronger blockchain industry carrying capacity can promote the generation of a high-quality urban digital economy. The configuration reflects the synergistic linkage of blockchain knowledge accumulation and the blockchain industry carrying capacity to drive the high-quality development of the urban digital economy. A technology patent is the basic guarantee to protect and stimulate innovation, and also an important bridge to transform innovation results into real productivity [56]. A higher accumulation degree of blockchain technology patents reflects a higher level of blockchain technology innovation in the city, and the high technology innovation ability further accelerates the transformation and upgrading of the regional blockchain industry, while the greater the construction of the blockchain industry carrying capacity, the stronger its ability to undertake the transformation and upgrading of blockchain industry, and the coupling effect of technology knowledge accumulation and industry carrying capacity construction promotes the generation of high-quality urban digital economies [61]. The typical city under this configuration is Shanghai. Shanghai, as the leader of blockchain development in China, has accomplished a high level of blockchain knowledge accumulation and strong blockchain technology innovation capabilities through layout in blockchain technology patents and has further consolidated blockchain technology innovation by planning blockchain industrial parks and innovation bases, while carrying blockchain industries, to realize the beneficial cycle of blockchain technology in helping digital economy development and promoting the generation of the high-quality urban digital economy.

Configuration HQ2 represents the government-service-driven path, which means that a higher government focus with a higher level of blockchain service capability can facilitate the generation of a high-quality urban digital economy. The configuration reflects the synergistic linkage of government attention allocation and blockchain technology service capabilities in driving the high-quality development of the urban digital economy. According to the behavior logic of "government attention—government behavior choice" [33], the high level of attention of local governments to blockchain technology and industry means blockchain technology is more closely connected with digital finance, digital government, digital healthcare, and other fields and leads to the deep integration of blockchain technology with various industries. This integration will facilitate the digital transformation of blockchain technology in traditional industries and promote the quality of the urban digital economy. The representative city under this configuration is Suzhou. The local government of Suzhou encourages information technology service enterprises represented by blockchain technology to become stronger and better, supports enterprises to develop markets, promotes industrial optimization and upgrading, and actively plays a guiding role in terms of financial funds to promote the high-quality development of the digital economy based on the software industry.

Configuration HQ3 represents the technology-R&D-driven path, which means that a better blockchain technology R&D environment and higher blockchain service capability can promote the development of the high-quality urban digital economy. The configuration reflects the synergistic linkage of the blockchain technology R&D environment and blockchain service capability to promote the high-quality development of the urban digital economy. Digital technology R&D is an important driving force of the digital economy, and as a fundamental digital technology, the strength of the blockchain technology R&D environment determines the level of development of blockchain technology in the region to a certain extent [62]. Meanwhile, all digital technologies are at a certain stage in the cycle of "R&D-application-marketing-R&D iteration", and the technology service capability provides an assessment of the marketability of the technology [63]. The excellent technology R&D environment promotes the development of blockchain technology. The higher blockchain service capability facilitates the marketization of blockchain technology, and the synergy between the blockchain technology R&D environment and technology service capability leads to the high-quality development of the urban digital economy. The representative city under this configuration is Tianjin. The local government of Tianjin supports universities and research institutes to carry out blockchain technology research and innovation and supports universities to build blockchain research and innovation platforms and research talent teams, creating a favorable R&D environment for blockchain technology research. Moreover, Tianjin seizes the opportunity of "One Belt, One Road" development, encourages enterprises to apply blockchain technology to more scenarios, rapidly builds blockchain application ecology, forms relevant application standards, expands business fields, and promotes the continuous and rapid development of enterprises, all of which represent strong Blockchain service capability.

4.3. Configurations Sufficient for the Absence of High-Quality Urban Digital Economy

Considering the causal asymmetry of the QCA approach (the conditions leading to the emergence and absence of outcomes are asymmetric), and to gain a comprehensive understanding of the mechanisms driving urban digital economy quality, this study then analyzed the configurations that lead to the absence of a high-quality urban digital economy. Following the literature [60], the calibration rule for the absence of a high digital economy quality is the opposite of high digital economy quality, i.e., the non-set of high digital economy quality is used. The results of the adequacy analysis of the absence of a high digital economy quality are detailed in Table 6, and one driving path of the absence of high urban digital economy quality (configuration AHQ1a, AHQ1b) is found by combining the core conditions of the six configurations.

Table 6. Configurations sufficient analysis for the absence of high-quality urban digital economy.

	Absence of a High-Quality Solution	
	AHQ_{1a}	**AHQ_{1b}**
Blockchain service capability	⊗	⊗
Blockchain knowledge accumulation	⨂	⨂
Government attention allocation		⊗
Government funding support	⨂	⨂
Industry Carrying Capacity	⊗	
Technology R&D Environment	⨂	⨂
Consistency	0.85	0.85
Raw coverage	0.62	0.58
Unique coverage	0.08	0.05
Overall consistency	0.86	
Overall coverage	0.67	

Note: Large, cross open circle "⨂" (absence) represents core conditions. Small, crossed open circles "⊗" (absence) represents peripheral conditions.

The configurations AHQ1a and AHQ1b represent the knowledge-R&D-funding inhibitory path, which means that weaker blockchain knowledge accumulation, poorer blockchain technology R&D environment, and less government funding support inhibit the generation of the high-quality urban digital economy. The insufficient accumulation of blockchain technology knowledge leads to a lack of motivation for blockchain technology innovation, which, coupled with a poor technology R&D environment, further weakens the city's blockchain technology innovation capability [48]. In addition, the failure of the government to establish a special blockchain industry fund to guide technological innovation has led to a serious lack of incentive for blockchain technological innovation and investment, thus inhibiting the generation of a high urban digital economy quality. A typical case under this driving path is Changchun, as Changchun has very few blockchain technology patent applications and lacks blockchain R&D institutions and government-led blockchain industry funds, resulting in a poorer level of blockchain technology innovation and industry development, inhibiting the generation of a high digital economy quality.

In addition, in terms of the influence of geographical characteristics on regional industrial development, Shanghai and Suzhou are located in the Yangtze River Delta city cluster, with a strong manufacturing base and deep accumulation in the new-generation information technology industry represented by blockchain, and their digital industry competitiveness is leading in China, which also contributes to the formation of a high-quality urban digital economy. Tianjin is located within the BeijingTianjin-Hebei metropolitan area and is an important port city in North China. While catering for the technology spillover from Beijing, Tianjin promoted the high-quality development of the digital economy by developing the ICT industry with the platform of Northern Big Data Exchange. Changchun is a non-high-quality representative case city located in the heavy industrial zone of Northeast China, which lacks the foundation for digital economy development, contributing to the predicament of the digital economy. Thus, it can be seen that geographical characteristics influence the development of the regional digital economy by affecting the regional industrial structure.

4.4. Robustness Test

We conducted two additional analyses to assess the robustness of the results. First, we re-performed the analysis with a higher consistency threshold of 0.85 [64]. In terms of the number of specific solutions, we observed slight changes, but the interpretation of the results remained unchanged. The results, overall, remained unchanged (see the footnote in Table 7 for a more detailed explanation). Second, we recalibrated with the 55th percentile of all conditions (blockchain service capability, blockchain knowledge accumulation, government attention allocation, government funding support, technology R&D environment, and technology carrying capacity) and outcomes (digital economy quality) as alternative intersections [65]. Again, the generated solutions remain similar, as do the interpretations of the results. The interpretation of the results, therefore, still holds (Table 8).

Table 7. Results of the robustness test with a higher consistency threshold.

.	$RTHQ_{1a}$	$RTHQ_{1b}$	$RTHQ_{1c}$	$RTHQ_{1d}$	$RTHQ_{2a}$	$RTHQ_{2b}$
Blockchain service capability	●	●		●	⬤	⬤
Blockchain knowledge accumulation	⬤	⬤	⬤	⬤		●
Government attention allocation		⊗	⊗	⊗	⬤	⬤
Government funding support		⊗	⊗	●	⨂	⨂
Industry Carrying Capacity	⬤	⬤	⬤	⬤	●	⊗
Technology R&D Environment	●		●	⊗	●	⊗
Consistency	0.99	0.98	0.99	1	1	0.98
Raw coverage	0.40	0.08	0.06	0.02	0.16	0.03
Unique coverage	0.23	0.03	0.01	0.02	0.04	0.03
Overall consistency			0.99			
Overall coverage			0.54			

Note: Large, full black circle "⬤" (present) and large, cross open circle "⨂" (absence) represent core conditions. Small, full black "●" (present) and small, crossed open circles "⊗" (absence) represent peripheral conditions. For high-quality solutions, RTHQ1a, RTHQ1b, RTHQ1c, and RTHQ1d, which can be represented by the knowledge-industry-driven path; RTHQ2a and RTHQ2b can be represented by the government-service-driven path.

Table 8. Results of the robustness test with alternative crossover points.

	$RTHQ_{1a}$	$RTHQ_{1b}$	$RTHQ_{1c}$	$RTHQ_{2a}$	$RTHQ_{2b}$
Blockchain service capability	●	●		⬤	⬤
Blockchain knowledge accumulation	⬤	⬤	⬤		●
Government attention allocation		⊗	⊗	⬤	⬤
Government funding support		⊗	⊗	⨂	⨂
Industry Carrying Capacity	⬤	⬤	⬤	⊗	⊗
Technology R&D Environment	●		●	⊗	⊗
Consistency	0.97	0.98	0.99	1	0.99
Raw coverage	0.43	0.09	0.07	0.18	0.03
Unique coverage	0.23	0.03	0.01	0.04	0.03
Overall consistency			0.99		
Overall coverage			0.54		

Note: Large, full black circle "⬤" (present) and large, cross open circle "⨂" (absence) represent core conditions. Small, full black " ●" (present) and small, crossed open circles "⊗" (absence) represent peripheral conditions. For high-quality solutions, RTHQ1a, RTHQ1b, RTHQ1c, and RTHQ1d, which can be represented by the knowledge-industry-driven path; RTHQ2a and RTHQ2b can be represented by the government-service-driven path.

5. Conclusions and Future Work

5.1. Conclusions

This study explored the synergistic influence mechanism of six factors from three dimensions based on the TOE framework theory with the fuzzy set QCA method: technology, organization, and environment, namely, blockchain service capability, blockchain knowledge accumulation, government attention allocation, government funding support, the industry carrying capacity and blockchain technology R&D environment, on the quality of the urban digital economy. The main findings are as follows: (1) the absence of government funding support is a necessary condition for the absence of high urban digital economy quality, indicating that weaker government funding support has stronger explanatory power for the absence of high urban digital economy quality; (2) there are three configurations for high urban digital economy quality, which are as follows: the knowledge-industry-driven path with sufficient blockchain knowledge accumulation and perfect industrial carrying capacity construction; the government-service-driven path with sufficient government attention and strong technical service capability; and the R&D-service-driven path with good blockchain technology R&D environment and strong technical service capability; (3) there is one configuration of the absence of high urban digital economy quality, namely the knowledge-R&D-funding inhibiting path that consists of a lower blockchain technology knowledge reserve, poorer blockchain technology R&D environment, and less government funding support.

5.2. Contributions

(1) This study enriched the theories related to digital economy quality and proposed a comprehensive analytical framework for the urban digital economy quality from the perspective of blockchain technology adoption. Compared with existing studies that focus on single-level causality [19], this study incorporated multiple factors into the same analytical framework and proposed an integrative analytical framework under the perspective of blockchain technology adoption, which lays a theoretical foundation for multiple factors to synergistically affect the urban digital economy quality.

(2) This study extended the applicability of the TOE framework theory through a configurational perspective and extended its application to explain the complexity of causal relationships. Previous studies on the TOE framework theory have been less concerned with the configurational effects between multiple factors [22]. This study empirically discussed the synergistic effects of six elements affecting the quality of the urban digital economy in three dimensions as emphasized by the TOE framework theory, with the help of the configuration perspective, extending the scope of application of the TOE framework theory to a certain extent.

(3) This study extends the applicability of the QCA approach to the study of digital economy quality at the city level and deepens the understanding of the complex causal mechanisms by which multiple factors influence the quality of the urban digital economy. At present, the QCA approach in digital economy research is mostly limited to the enterprise level [60], but this study extended the QCA approach to the city level, which not only identified the equivalent driving paths of high digital economy quality, but also explored the driving mechanisms of the absence of high digital economy quality from the perspective of causal asymmetry, and also broadened the application area of the QCA approach.

5.3. Implications

The findings of this study provide two policy implications for local governments to promote the high-quality development of the digital economy with the help of blockchain technology.

On the one hand, the government should combine the regional resource endowment and focus on the development of key core elements. The impact of blockchain technology adoption on the quality of the urban digital economy is influenced by the synergistic effects of various factors such as blockchain technology technical service capability, blockchain knowledge accumulation, government attention allocation, government funding support, industry carrying capacity, and the technology R&D environment. Moreover, there exist multiple paths for blockchain technology adoption to improve the quality of the urban high digital economy. Therefore, in the process of promoting digital economy development, the government should reasonably consider differences in regional resource endowments, combine the region's advantages, choose the driving paths that adapt to local development endowments, use configuration thinking to formulate targeted education, finance, industry, and public policies, take advantage of policy combinations, concentrate strong regional resources and develop key core elements.

On the other hand, the government should strengthen the available financial support for the blockchain industry. The absence of government funding support for the blockchain industry is a necessary condition that leads to the absence of high urban digital economy quality, indicating that the absence of government funding support for the blockchain industry inevitably leads to the absence of a high urban digital economy quality. Therefore, in terms of increasing the source of funds, the government should strengthen the financial support for the blockchain industry in various ways, such as by establishing a special fund for the blockchain industry, providing subsidies for blockchain technology innovation, and formulating tax incentives for the blockchain industry. In terms of reducing the cost of enterprises, the government should encourage the use of the technical license of national research institutions and the production support role of state-owned enterprises to reduce the cost of enterprises so as to mitigate the absence of a high digital economy quality.

5.4. Limitations and Future Work

There are some limitations in this study that need to be improved in future research. First, although this study analyzed the synergistic influence mechanism of blockchain technology service capacity, Blockchain knowledge accumulation, government attention allocation, government funding support, blockchain industry carrying capacity construction, and the blockchain technology R&D environment on the high-quality development of the urban digital economy from the perspective of blockchain technology adoption based on the TOE framework theory, the urban digital economy as a complex system is also influenced by factors such as blockchain technology management capacity, citizens' external demand and technology imitation in the process of blockchain technology adoption. Second, the empirical analysis of this study mainly explored the cross-sectional data among the 43 cases and did not consider the longitudinal data on the evolution of the sample over time. Subsequent studies can be conducted on the time vertical dimension for typical cases to examine the dynamic trends of the high-quality development of the urban digital economy over time. Third, in this study, in terms of variable measurement, the specific data were not precisely characterized for each variable due to the limitation of data availability, and follow-up studies should further strengthen the data integrity to improve the comprehensive and in-depth analysis of the impact mechanism on the high-quality development of the urban digital economy.

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