

The Impact of Digital Business Environment on Regional Digital Innovation and Entrepreneurship Activity

-- Configuration Analysis based on Multi-Period QCA

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Abstract

In the era of digital economy, the digital business environment constitutes an integral component of the regional digital innovation and entrepreneurship ecosystem, serving as a significant driving force for regional digital innovation and entrepreneurial activities. This study establishes a multidimensional framework encompassing digital infrastructure, legal governance, administrative services, human capital, and market dynamics to evaluate digital business environments. Drawing upon ecosystem theory and utilizing multi-period fsQCA techniques, the research reveals configuration paths through which provincial digital business environments influence regional innovation and entrepreneurship activity in China (2013-2020). Key empirical findings include: (1) Identification of nine high-vitality configurations demonstrating policy-driven, market-oriented, and polycentric governance patterns. (2) Exposure of ten inhibitory mechanisms associated with institutional deficiencies and resource misallocation in non-high vitality scenarios. (3) Elucidation of a dynamic adaptation model following *institutional environment* → *resource allocation* → *market feedback* sequences, with vitality enhancement requiring tripartite coordination among policy frameworks, digital infrastructure, and talent ecosystems. This investigation transcends conventional linear analytical paradigms, advancing theoretical understanding of complex adaptive systems in digital innovation and entrepreneurship while offering practical insights for regional policy design.

Keywords

Digital Business Environment; Digital Innovation and Entrepreneurship Activity; Configuration Analysis; Multi-period fsQCA.

1. Introduction

The vigorous development of the digital economy is profoundly reshaping the global economic landscape, with digital innovation and entrepreneurship serving as its core driver and emerging as a key engine for high-quality regional economic development. However, significant disparities in digital innovation and entrepreneurship activity across regions persist, and the underlying causes urgently require in-depth investigation. In recent years, the digital business environment, as an institutional infrastructure for digital economic development, has increasingly become a focal point in academic research. Existing studies demonstrate that the digital business environment significantly impacts digital innovation and entrepreneurship activities through mechanisms such as optimizing resource allocation, reducing transaction costs, and stimulating market vitality (Xu et al., 2022; Gao, 2023) [1], [1]. Nevertheless, current research predominantly focuses on single-factor or linear relationships, lacking thorough

exploration of the multidimensional and synergistic effects of the digital business environment, with scant attention paid to its dynamic evolutionary characteristics (Liu & Huang, 2024) [2]. Furthermore, traditional statistical methods struggle to reveal the complex causal relationships between the digital business environment and innovation-entrepreneurship activity, limiting their capacity to provide policy recommendations with practical guidance.

To address these gaps, this study employs fuzzy-set Qualitative Comparative Analysis (fsQCA) to investigate how different dimensions of the digital business environment synergistically interact to influence regional digital innovation and entrepreneurship activity from a configurational perspective. Compared to conventional methods like regression analysis, fsQCA effectively identifies multiple concurrent causal relationships and reveals combinatorial effects of antecedent conditions (Ragin, 2008) [4]. Additionally, this research incorporates multi-period analysis to dynamically examine the evolutionary patterns of the digital business environment's impact on innovation-entrepreneurship vitality, thereby addressing the limitations of static perspectives in existing studies. The significance of this research lies in two aspects. Theoretically, it deepens the understanding of the complex relationship between the digital business environment and innovation-entrepreneurship activity, enriching research in the digital economy domain. Practically, it offers targeted policy recommendations for local governments to optimize the digital business environment and stimulate innovation-entrepreneurship activities, ultimately facilitating high-quality regional economic development.

2. Literature Review

(1) *Research on the Digital Business Environment*. As a critical engine driving high-quality economic development, the digital business environment has become a focal point for both academic and practical communities. Existing research primarily concentrates on conceptual definitions and component structures of the digital business environment. In a broad sense, the digital business environment refers to the aggregate of environmental factors influencing enterprise operations and innovation activities in the digital context. At the narrow level, two definitional approaches exist: Zhou (2022) emphasizes it as a fusion of "digital+" and traditional business environments [4], while Liu (2023) conceptualize it as a new business ecosystem adapted to digital economic transformations [6]. Scholarly efforts to measure and evaluate the digital business environment have adopted multidimensional frameworks, reflecting its diverse conceptual interpretations. Kshetri (2018) proposed a foundational framework encompassing dimensions such as online platform availability and cybersecurity regulations [7]. The OECD (2020), in its *Digital Economy Outlook*, developed an evaluation system centered on digital infrastructure, highlighting metrics like broadband penetration rates [8]. Schadep (2022) demonstrated that the maturity of digital infrastructure significantly enhances regional talent aggregation and collaborative network formation [9]. Prasetyo (2022) underscored the institutional safeguards provided by a rule-of-law environment for the digital economy [10], while Martins (2022) validated the efficiency gains in public services from optimized digital governance [11]. Xu et al. (2022) constructed a six-dimensional evaluation index system based on ecosystem theory [1], whereas Zhao et al. (2022) proposed a comprehensive framework with six primary dimensions and 21 secondary indicators [11]. Song et al. (2022) further synthesized four key dimensions: legalization, facilitation, marketization, and internationalization [13].

(2) *Research on the Activity Level of Digital Innovation and Entrepreneurship*. Existing research mainly focuses on the measurement of activity levels, and the measurement system for the activity level of digital innovation and entrepreneurship features a combination of traditional and emerging indicators. Ács et al. (2017) used the Global Entrepreneurship Monitor (GEM) indicators, including the early-stage entrepreneurial activity rate and other core parameters to

measure entrepreneurial activity [14]. The OECD (2019) adopted traditional innovation indicators such as the number of patent applications and the intensity of R&D investment [15]. With the development of the digital economy, Du (2020) constructed a comprehensive evaluation framework that includes the survival rate of new businesses [16]. Wang et al. (2025) established a dual-dimensional measurement system for digital innovation and entrepreneurship [17].

(3) *Research on the Mechanisms of Influence*. From both broad and narrow perspectives, academia generally agrees that the optimization of the digital business environment has a multidimensional supportive effect on digital innovation and entrepreneurship. In terms of revealing the mechanisms of their interaction, various methods have been employed by scholars to explore the pathways of influence. For instance, Xu et al. (2022) used utility value methods and barrier models to reveal key obstacle factors [1]. Efremova (2020) constructed a balanced development model of the business environment and entrepreneurial activity [18]. Gao (2023) established a two-way fixed effects model based on panel data, confirming the significant promotional effect of the optimization of the business environment on innovation and entrepreneurship performance [2]. In addition, the comprehensive use of methods such as bibliometric analysis [19], and structured questionnaires [20], provide a multidimensional perspective on revealing the mechanisms of action.

There are three limitations in existing research. First, there is a focus on conceptual and measurement studies, with weak research on mechanisms of action, especially the driving pathways of regional digital innovation and entrepreneurship are not clear. Second, on the methodological level, there is an emphasis on single-perspective quantitative or qualitative analysis, lacking systematic examination of configuration effects. Third, there is insufficient analysis of temporal dynamics, making it difficult to capture nonlinear interactive relationships between variables. Thus, this study plans to construct an analytical framework of *antecedent conditions - configuration pathways - outcome variables* and employ a multi-period qualitative comparative analysis method to systematically explore the dynamic impact mechanism of the synergy of digital business environment factors on the activity of regional digital innovation and entrepreneurship, providing a theoretical basis and policy insights for optimizing the construction of the digital business environment and stimulating regional innovation and entrepreneurial activity.

3. Research Design

3.1. Configuration Model Construction

3.1.1. Variable Measurement

(1) *Digital Business Environment*. There are numerous studies on the measurement of the digital business environment. For instance, Zhao et al. (2022) integrated a framework of digital infrastructure and technological elements to construct a comprehensive evaluation index system that includes 6 first-level indicators and 21 second-level indicators [11]. Xu et al. (2022) proposed an evaluation model based on ecosystem theory that covers six dimensions, including digital infrastructure, government regulation, and services [1]. The OECD (2020) emphasized the supporting role of digital infrastructure for business activities [8], while Kshetri (2002) focused on the regulatory effects of network regulations [7]. These studies are quite enlightening for understanding and evaluating the digital business environment, but there is no consensus on the focus of the connotation and the content of the indicators of the digital business environment.

Considering the continuous impact of the rapid development of the digital economy on the connotation and extension of the digital business environment, this study believes that the digital business environment refers to a collection of efficient, convenient, and transparent

operating environments provided to enterprises through digital technology, infrastructure, and policy frameworks. It is an extension and upgrade of the traditional business environment in the digital age, aimed at using digital technology to optimize the entire life cycle experience of enterprises from establishment to operation, and to enhance the efficiency and competitiveness of their economic activities. This study uses text analysis to collect and integrate various indicators that frequently appear in the evaluation literature, and after consultation and optimization by experts, it ultimately constructs a comprehensive evaluation index system for the digital business environment around five dimensions: digital infrastructure, digital legal environment, digital government environment, digital talent supply, and digital market environment (see Table 1).

Table 1. Evaluation Index System of Digital Business Environment in Chinese Provinces

Primary Indicator	Secondary Indicator	observation	Attribute
Digital infrastructure	Internet Application	Internet Penetration Rate	Positive
	Computer Usage	Computers per 100 People	Positive
	Mobile Phone Popularity	Mobile Phones per 100 People	Positive
Digital legal environment	Data Legislation	Data Legislation Index	Positive
	Data Judiciary	Data Judiciary Index	Positive
	Data Rights Protection	Data Protection Index	Positive
Digital government environment	Governance Capability	Government Digital Attention	Positive
	Governance Effectiveness	Provincial Government Service Coverage	Positive
	Online Services	Online Government Service Capability Index	Positive
Digital Talent supply	Service Labor Cost	Average Wage of Information Transmission, Software and IT Service Workers	Negative
	R&D Labor Cost	Average Wage of Scientific Research and Technical Service Workers	Negative
	Service Labor Quantity	Employment Proportion of Information Transmission, Software and IT Service Workers	Positive
	R&D Labor Quantity	Employment Proportion of Scientific Research and Technical Service Workers	Positive
Digital market environment	E-commerce Transactions	Proportion of E-commerce Transaction Enterprises	Positive
	Business Sales	E-commerce Sales Volume	Positive
	Financial Services	Digital Inclusive Finance Index	Positive
	Financial Technology	Financial Technology Index	Positive

(2) *Activity Level of Digital Innovation and Entrepreneurship*. In terms of measurement content, related measurement studies exist in two perspectives: categorical research and combined research. The former carries out measurement from the two dimensions of innovation activity and entrepreneurship activity separately. The latter adopts an integrated approach, measuring both innovation and entrepreneurship activity together. In terms of the complexity of measurement, these studies either use a single or a few indicators for calculation or employ a multi-indicator system for comprehensive evaluation. For instance, Du et al. (2020) [16]

respectively use early-stage entrepreneurial activity rate, number of patent applications, and digital platform project numbers for related activity level calculations. Ács et al. (2017) measured entrepreneurial activity with the core indicator of new business creation rate [14]. Liu (2024) constructed evaluation indicator systems for innovation activity and entrepreneurship activity separately, and then measured the activity level of innovation and entrepreneurship together as primary indicator dimensions [21].

Considering the differences in the scale of digital business environment development across regions, as well as the authority and continuity of data, this study uses the *Index of Regional Innovation and Entrepreneurship in Digital Economy in China (IRIEDEC)* to depict the activity level of digital innovation and entrepreneurship in various regions of China. This index is based on enterprise big data integrated by the Peking University Enterprise Big Data Research Center, and it statistically evaluates the innovation and entrepreneurship status of the digital economy in each region from six dimensions: new business establishment, foreign investment, venture capital, patents, trademarks, and software copyrights. This study uses the digital innovation and entrepreneurship index of each region to characterize the activity level of digital innovation and entrepreneurship (see Table 2).

Table 2. Digital Innovation and Entrepreneurship Index Indicators

Primary Indicator	Secondary Indicator	Weight
Number of Newly Established Enterprises	Number of Newly Registered Enterprises	0.2
Attraction of Foreign Investment	Number of New Foreign Legal Person Investments	0.15
Attraction of Venture Capital	Number of Enterprises with New Venture Capital Investment	0.25
Number of Patent Grants	Number of Newly Granted Invention Patents	0.125
	Number of Newly Disclosed Utility Model Patents	0.05
	Number of Newly Disclosed Design Patents	0.025
Number of Trademark Registrations	Number of Newly Registered Trademarks	0.1
Number of Software Copyright Registrations	Number of Newly Registered Software Copyrights	0.1

3.1.2. Mechanism Analysis

(1) *Empowering Mechanism of Digital Infrastructure Environment.* Digital infrastructure is the cornerstone of digital innovation and entrepreneurship, significantly reducing transaction costs by breaking down information barriers, spatial-temporal restrictions, and market segmentation, and broadening channels for opportunity identification and factor acquisition (Wang et al., 2024) [22]. Indicators such as internet coverage rate and mobile communication penetration rate represent the level of digital technology application in a region, while high-speed broadband and cloud computing platforms not only reduce business operating costs but also promote the flow of innovation elements, effectively lowering the threshold for entrepreneurship entry.

(2) *Safeguarding Mechanism of Digital Legal Environment.* A robust digital legal system provides institutional protection for innovation and entrepreneurship through the improvement of data legislation, optimization of judicial mechanisms, and protection of digital rights (Wang & Wang, 2022) [23]. Clear legal regulations can reduce compliance risks for market entities and enhance the stability of investor expectations.

(3) *Coordination Mechanism of Digital Government Environment.* The digital transformation of government reconstructs the business environment by enhancing governance capabilities and optimizing service efficiency. Indicators such as the digital coverage rate of government services and online handling capabilities reflect the maturity of the government environment.

An efficient government reduces transaction costs by breaking down institutional barriers, promoting the efficient allocation of factor resources. For example, the "one-stop online platform" significantly compresses the time limits for administrative processes such as business registration and tax declaration.

(4) *Driving Mechanism of Digital Talent Supply.* Human capital, as a core element of innovation, drives knowledge spillover and technology diffusion through spatial mobility (Liu 2024) [24]. The scale and salary level of information industry professionals reflect the quality of regional digital talent reserves. An ample supply of high-end talent not only provides technical support but also promotes industrial cross-integration. The talent training system built by universities and research institutions continuously supplies intellectual capital to the innovation and entrepreneurship ecosystem.

(5) *Incentive Mechanism of Digital Market Environment.* Dimensions such as the scale of e-commerce transactions and the penetration rate of digital finance constitute the market environment evaluation system. A mature market mechanism can regulate the behavior of digital economy entities and accelerate the market circulation of data elements. E-commerce platforms build new transaction spaces, and digital inclusive finance alleviates financing constraints for small and medium-sized enterprises, with both mechanisms working together to improve resource allocation efficiency.

3.1.3. Model Construction

The British ecologist Tansley first introduced the concept of *ecosystem* in 1935, which refers to individuals (whether biological or social) that do not exist in isolation but interact and depend on their environment. These interactions and dependencies are constantly changing and maintain a relatively stable dynamic equilibrium over a period of time [25]. Alderson proposed the concept of *organized behavior system* in 1957 and introduced ecological thought into the economic field. Subsequently, derivative ecosystem theories such as business ecosystem theory, innovation ecosystem theory, and talent ecosystem theory have been enriched and developed, providing a powerful tool for understanding and dealing with complex ecological and social issues. The concepts of openness, synergy, symbiosis, and evolution of ecosystems have been widely applied to various economic and social fields [26].

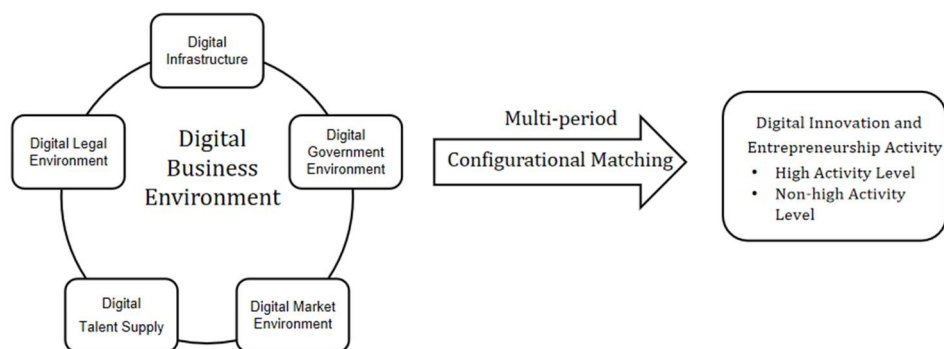


Figure 1. Configurational Impact Path Model of Digital Business Environment on the Activity Level of Digital Innovation and Entrepreneurship

Based on the analysis of mechanisms and ecosystem theory, this study views the digital business environment as a large ecosystem of digital innovation and entrepreneurship, where each dimension of the business environment is a number of subsystems. These subsystems interact and influence each other and have different effects on regional digital innovation and

entrepreneurial activities. To systematically and dynamically analyze these series of impact mechanisms, this study constructs a configurational impact path model of the digital business environment on the activity level of regional digital innovation and entrepreneurship (see Figure 1), and will use the multi-period fuzzy set qualitative comparative analysis method to deconstruct the differentiated coupling paths of digital business environment elements from the perspectives of high and non-high activity levels at different times, and to reveal their convergent effects on regional digital innovation and entrepreneurial activities.

3.2. Method Selection and Data Collection

(1) *Research Methods*. In terms of method selection, this study employs the multi-period fsQCA method for the research. Compared to the linear assumptions of traditional econometric models, the qualitative comparative analysis method can better capture the complex non-linear causal relationships between the digital business environment and the level of innovation and entrepreneurship activity (Ragin, 1980) [4]. However, early QCA research was mostly limited to static analysis within a single time cross-section, which made it difficult to capture the dynamic evolutionary characteristics of the research subjects. With the development of methodology, multi-period QCA has gradually become an important tool for analyzing temporal dynamics (Caren & Panofsky, 2005; Rihoux et al., 2013) [27, 28]. The fsQCA method adopted in this study has the following advantages: firstly, by analyzing the structural coupling of the preconditions of the digital business environment, it can deeply reveal the asymmetric causal effects produced by the synergistic action of multiple elements. Secondly, this method effectively avoids the mean regression bias problem in traditional regression analysis, making it more suitable for exploring the heterogeneity and dynamic characteristics of complex social phenomena. In terms of specific operations, this study draws on the time-slicing strategy proposed by Vis et al. (2013) [29], using the *Digital Business Indicators* released by the World Bank in 2017 as a time node, dividing the research period into two stages: 2013-2016 (T1) and 2017-2020 (T2), with the former representing the exploration period of the digital business environment evaluation index system and the latter representing the maturity period. This period division not only takes into account the key nodes in the development of the research question but also ensures the availability and comparability of the research data. Through the dynamic configuration comparison of the two periods, this study can effectively capture the path dependency characteristics and pattern transition phenomena in the evolution of the institutional environment, providing new theoretical insights into the co-evolution mechanism between the digital business environment and digital innovation and entrepreneurship activities.

(2) *Sample and Data*. This study takes the 31 provincial regions of China as the research object, with a research period spanning from 2013 to 2020. Data sources include the *China Statistical Yearbook*, *China E-Government Development Report*, *Digital Government Development Index Report*, *Big Data Blue Book: China Big Data Development Report* and the Peking University Open Research Data Platform.

4. Configuration Identification and Analysis

4.1. Data Processing and Calibration

Data Processing. In this study, the outcome variable of digital innovation and entrepreneurship activity directly uses the report data from the Peking University Open Research Data Platform. The digital business environment data is obtained by querying the corresponding yearbooks, and the weights of the digital business environment indicators for each province are calculated using the entropy method. Then, the data is aggregated layer by layer using the linear weighting

method, with the comprehensive evaluation value of the primary indicators ultimately serving as the numerical values for each antecedent condition.

(2) *Data Calibration*. Data calibration is an important step in qualitative comparative analysis, aiming to transform the original data of antecedent conditions and outcome variables into set membership scores within the range [0,1]. Referring to the approach of Vis et al. (2013) [29], this study introduces the temporal dimension into configuration analysis, using the World Bank's 2017 introduction of *Digital Business Indicators* as a temporal node, dividing the research period into 2013—2016 (Period 1) and 2017—2020 (Period 2), to explore the laws of change in conditions and configurations over time and their corresponding regional changes. Drawing on relevant literature, anchor points are set at 95% (full membership), 50% (crossing point), and 5% (no membership) to calibrate the antecedent conditions and outcome variables (see Table 3).

Table 3. Data Calibration

	Period 1			Period 2		
	Full Membership	Crossover Point	No Membership	Full Membership	Crossover Point	No Membership
Digital Infrastructure	0.077428237	0.027328768	0.008332034	0.092566598	0.043828681	0.024882737
Digital Legal Environment	0.090314237	0.023727893	0.001223752	0.181869705	0.079422085	0.021083645
Digital Government Environment	0.131850799	0.045654623	0.002853729	0.144810418	0.12626983	0.104888053
Digital Talent Supply	0.047784788	0.027114059	0.018310737	0.058874886	0.027173787	0.0178805
Digital Market Environment	0.1046935535	0.033150804	0.008430979	0.17739084	0.06023233	0.035305875
Digital Innovation and Entrepreneurship Activity	92.74193535	47.06744957	8.00586524	97.85924225	72.43401718	23.57771358

4.2. Univariate Necessity Analysis

Univariate necessity analysis is a method used in fuzzy-set Qualitative Comparative Analysis (fsQCA) to study the complex causal relationships between antecedent conditions and outcome variables. It is used to assess whether a single antecedent condition is a necessary condition for the outcome variable. A necessary condition refers to a condition that must be present when the outcome variable occurs, and can be assessed through two indicators: consistency and coverage. Consistency can be used to measure the necessity of the condition for the outcome; coverage can be used to measure the explanatory power of the condition for the outcome. Generally, when consistency is greater than 0.9 (and coverage reaches a certain level), the condition is considered necessary. This study conducts a necessity analysis for high and non-high innovation and entrepreneurship outcomes produced in Period 1 and Period 2, respectively. The calculation results of consistency and coverage for the two periods are shown in Tables 4 and 5.

Table 4. Univariate Necessity Analysis Results for Period 1

Antecedent Conditions		Outcome Variable			
		Period 1			
		High Innovation and Entrepreneurship Activity(zs)		Non-high Innovation and Entrepreneurship Activity(~zs)	
		Consistency	Coverage	Consistency	Coverage
jcsc	High Digital Infrastructure	0.653071	0.725543	0.538312	0.606990
~jcsc	Non-high Digital Infrastructure	0.646246	0.579678	0.756596	0.688807
fz	High Digital Legal Environment	0.782905	0.824294	0.470701	0.502994
~fz	Non-high Digital Legal Environment	0.527949	0.495652	0.835575	0.796186
zw	High Digital Government Environment	0.647546	0.666388	0.449408	0.469398
~zw	Non-high Digital Government Environment	0.484440	0.464330	0.680595	0.662149
rcgj	High Digital Talent Supply	0.545515	0.591653	0.650656	0.716237
~rcgj	Non-high Digital Talent Supply	0.738365	0.675582	0.629043	0.584160
sc	High Digital Market Environment	0.804696	0.863773	0.463657	0.505137
~sc	Non-high Digital Market Environment	0.538983	0.497518	0.874960	0.819721

Table 5. Univariate Necessity Analysis Results for Period 2

Antecedent Conditions		Outcome Variable			
		Period 2			
		High Innovation and Entrepreneurship Activity(zs)		Non-high Innovation and Entrepreneurship Activity(~zs)	
		Consistency	Coverage	Consistency	Coverage
jcsc	High Digital Infrastructure	0.615284	0.700028	0.592813	0.618750
~jcsc	Non-high Digital Infrastructure	0.664904	0.640281	0.712603	0.629530
fz	High Digital Legal Environment	0.797900	0.852599	0.472804	0.463484
~fz	Non-high Digital Legal Environment	0.497905	0.507262	0.849635	0.794102
zw	High Digital Government Environment	0.758918	0.788181	0.507846	0.483861
~zw	Non-high Digital Government Environment	0.503023	0.526988	0.777680	0.747432
rcgj	High Digital Talent Supply	0.546644	0.653408	0.605471	0.663943
~rcgj	Non-high Digital Talent Supply	0.718854	0.665117	0.683932	0.580534
sc	High Digital Market Environment	0.776128	0.918041	0.408080	0.442825
~sc	Non-high Digital Market Environment	0.528954	0.493437	0.924472	0.791161

According to Tables 4 and 5, it can be observed that in both Period 1 and Period 2, the consistency of individual antecedent conditions for the outcome of high digital innovation and entrepreneurship activity does not exceed 0.9. Similarly, for the outcome of non-high digital innovation and entrepreneurship activity, the consistency of each individual factor is below 0.9. Therefore, individual antecedent conditions do not constitute a necessary condition for digital innovation and entrepreneurship activity, meaning that digital innovation and entrepreneurship activities are influenced by the synergistic effects of multiple factors, necessitating further analysis of multi-factor configurations.

4.3. Multi-factor Sufficiency Analysis

The multi-factor sufficiency analysis in fsQCA is used to study how combinations of multiple antecedent conditions lead to the occurrence of the outcome variable. Unlike the univariate necessity analysis, sufficiency analysis focuses on whether the combination of antecedent conditions is sufficient to cause the outcome. Following the procedures of Du (2020) and Wang (2021) [16, 30], this paper sets the raw and PRI consistency thresholds at 0.8, and the case frequency threshold is chosen as 1. Core and peripheral conditions are identified through the analysis of intermediate and parsimonious solutions, and various configuration impact paths are refined and analyzed, with the results shown in Tables 6 and 7.

4.3.1. Impact Paths for High Innovation and Entrepreneurship Activity

There are a total of 9 configuration paths that trigger high innovation and entrepreneurship activity (as shown in Table 6), of which Period 1 includes 2 paths, and Period 2 includes 3 categories with 7 paths.

Table 6. Configuration Path of High Digital Innovation and Entrepreneurship Activity

Condition	S1	S2	H1a	H1b	H1c	H2a	H2b	H2c	H3
Digital Infrastructure	●		⊗			⊗			⊗
Digital Legal Environment	●	●	●	●	●		●		
Digital Government Environment		●						●	●
Digital Talent Supply	⊗	⊗		●				●	●
Digital Market Environment	●	●			●	●	●	●	
Original Coverage	0.424293	0.444442	0.528058	0.449212	0.69866	0.520481	0.69866	0.393082	0.30615
Unique Coverage	0.100585	0.120734	0.0306166	0.00400484	0.0989624	0.0332451	0.0989624	0.00819528	0.0129887
Consistency	0.917109	0.921809	0.868736	0.835928	0.933263	0.933677	0.933263	0.888815	0.823243
Overall Coverage	0.545028					0.832243			
Overall Consistency	0.91265					0.84026			

● =Presence of Core Condition(s) ⊗ =Absence of Core Condition(s) ● =Presence of Peripheral Condition(s) ⊗ =Absence of Peripheral Condition(s) Data Analysis from Table shows/indicates

(1) The configuration analysis of Period 1 (initial stage) shows that the joint optimization of digital infrastructure and institutional environment constitutes a key driving force. Path S1 (consistency=0.917) confirms that the combined effect of high-level digital infrastructure, legal environment, and market environment can effectively compensate for the shortage of talent supply, with an original coverage of 0.424, confirming the applicability of the technology-

institution co-evolution theory in the digital economy scenario. Path S2 (consistency=0.922) highlights the compensatory effect of the institutional environment, where the optimization of digital legal and government environments can produce a case explanation power of 0.444, which theoretically echoes the regulatory pillar role emphasized by institutional entrepreneurship theory. The consistency of the two paths reaches 0.913, with a total coverage of 0.545, confirming the foundational role of the institutional environment in the early stage of the digital economy.

(2) The configuration structure of Period 2 (mature stage) shows multi-dimensional driving characteristics, with 7 paths including 3 types of configurations (H1, H2, H3), where the legal environment and market environment serve as core elements in this stage. The pivotal role of the legal environment is highlighted in the H1 series paths, where its individual effect (H1a, consistency=0.869) and synergy with talent supply (H1b, 0.836) and market environment (H1c, 0.933) all reach the sufficiency threshold, confirming the innovation catalytic effect of adaptive regulation in dynamic institutional theory. The market environment then demonstrates strong explanatory power through the H2 series paths, where its individual effect (H2a, 0.934) and complementary effects with infrastructure (H2b, 0.933) and government environment (H2c, 0.889) validate the market pull mechanism in innovation ecosystem theory. It is worth noting that the H3 path (consistency=0.823) reveals the compensatory effect of talent supply and government environment, indicating that the marginal utility of human capital accumulation increases in the mature stage, which is consistent with expectations from endogenous growth theory.

(3) Temporal comparative analysis. Comparing the two periods, it is not difficult to find that the driving mechanism of digital innovation and entrepreneurship has shown a paradigm shift from *technology-institution dual-wheel drive* to *institution-market dominance*. The initial stage relies on the rigid support of infrastructure and institutional environment, while the mature stage evolves into flexible synergy of legal environment, market mechanisms, and talent elements. This finding expands the theoretical boundaries of the technology-organization-environment framework in the digital age. The research conclusion provides a theoretical basis for formulating differentiated digital innovation policies at different stages.

4.3.2. Impact Paths for Non-high Innovation and Entrepreneurship Activity

Based on asymmetry, for the analysis of non-high innovation and entrepreneurship activity, the original and PRI consistency thresholds are also set at 0.8, and the case frequency threshold is set at 1 (Zhang & Du, 2019) [31]. The multiple concurrent mechanisms of non-high digital innovation and entrepreneurship activity are shown in Table 7, identifying 10 inhibitory paths with temporal heterogeneity, with 5 paths each in Period 1 and Period 2. The consistency of the solutions is 0.876 and 0.794, respectively, with total coverage reaching 0.789 and 0.899, indicating that the configuration model has strong explanatory power for low-case scenarios.

(1) The inhibitory paths in Period 1 (initial stage) exhibit a *dominant lack of institutional environment* characteristic. Path S1 (consistency=0.881) shows that the absence of digital legal, government, and market environments leads to 64.35% of cases being unable to achieve high activity levels, with a unique coverage of 0.464, confirming the systemic constraints of the regulatory, normative, and cognitive--cultural pillars in institutional theory. It is worth noting that paths S2-S5 reveal the failure of single-element compensation mechanisms: neither well-developed infrastructure (S2, consistency=0.925) nor sufficient talent supply (S3, 0.911; S4-S5, 0.949) can compensate for the absence of an institutional environment, which theoretically echoes the foundational role of the institutional environment in innovation ecosystem theory. The configuration analysis indicates that in the initial stage, the *short board effect* of the institutional environment is significant, with a cumulative original coverage of 0.613, forming the core cause of non-high activity levels.

Table 7. Configuration Path of Non-high Innovation and Entrepreneurship Activity

Condition	S1	S2	S3	S4	S5	H1	H2	H3	H4	H5
Digital Infrastructure		●		⊗	⊗		⊗	●		
Digital Legal Environment	⊗	⊗	⊗			⊗				
Digital Government Environment	⊗			⊗	⊗		⊗	⊗		⊗
Digital Talent Supply			●	●	●				●	●
Digital Market Environment	⊗	⊗	⊗	⊗	⊗		⊗	⊗	⊗	
Original Coverage	0.613513	0.464025	0.557317	0.381044	0.381044	0.849635	0.611135	0.278953	0.579346	0.539551
Unique Coverage	0.464025	0.0286744	0.0233589	0.00960624	0.0960624	0.149151	0.0156753	0	0.0153551	0.00235975
Consistency	0.88092	0.925295	0.910756	0.948547	0.948547	0.794102	0.860438	0.754949	0.858828	0.821174
Overall Coverage	0.789481					0.898717				
Overall Consistency	0.875846					0.737769				

● =Presence of Core Condition(s) ⊗ =Absence of Core Condition(s) ● =Presence of Peripheral Condition(s) ⊗ =Absence of Peripheral Condition(s) Data Analysis from Table shows/indicates

(2) The inhibitory mechanism in Period 2 (mature stage) shifts to a *multi-element synergy failure* model. Path H1 (consistency=0.794) confirms that the absence of the legal environment alone explains 84.96% of low cases, with a unique coverage of 0.149 highlighting the continuous impact of adaptive regulation in dynamic institutional theory. Paths H2-H5 then reveal the boundaries of element substitution effects: neither infrastructure (H2, 0.860; H3, 0.755) nor talent supply (H4, 0.859; H5, 0.821) can compensate for the synergy absence of government and market environments, among which the absence of the market environment leads to an explanatory power of 57.93% of cases (path H4), confirming the irreplaceability of the market pull mechanism in innovation-driven theory. Data in Table 7 indicate that in the mature stage, the complementary needs between elements are enhanced, and it is difficult for a single element improvement to break through the inhibitory effect of the path.

(3) Temporal analysis. A comparative analysis between Period 1 and Period 2 shows that the formation mechanism of non-high digital innovation and entrepreneurship activity has stage-leaping characteristics: the initial stage is subject to the rigid constraints of the absolute absence of the institutional environment, while the mature stage is subject to the flexible constraints of multi-element synergy failure. This finding deepens the applicability of technology-institution co-evolution theory in inhibitory configurations, revealing that the digital innovation and entrepreneurship ecosystem has a *institutional foundation—element synergy* dual barrier mechanism, providing a theoretical basis for solving the innovation and entrepreneurship inhibition bottlenecks at different stages.

4.4. Robustness Test

In qualitative comparative analysis, the robustness test is an important step to ensure the reliability of research results. Existing studies have pointed out that robustness tests can be achieved by adjusting calibration thresholds, changing the minimum number of cases, raising consistency thresholds, or increasing sample size [32]. This study conducts a robustness test by raising the consistency threshold (from 0.8 to 0.85), and the results show that the analysis

results are consistent with the initial analysis, verifying the stability and reliability of the research results.

5. Conclusion and Implications

5.1. Research Conclusion

Taking the 31 provincial regions of China as an example, this study reveals the configurational heterogeneity and temporal dynamics of regional digital innovation and entrepreneurship driving mechanisms. The study found that: Period 1 relies on the collaborative effect of infrastructure and market environment elements, while Period 2 shifts to the complementary driving force of the legal and government environment, confirming the stage adaptability characteristics of the institutional complementarity theory. Cross-period analysis indicates that talent supply has a multi-dimensional regulatory effect, significantly moderated by the legal environment and infrastructure, highlighting the need for digital business environments to follow the policy adaptability principle of "technology-institution-talent" co-evolution.

5.2. Research Implications

Based on the multi-period fuzzy set qualitative comparative analysis method, this study systematically explores the multiple impact mechanisms and differentiated configurational paths of digital business environment on regional digital innovation and entrepreneurship activity. According to the configurational situations of various impact paths, focusing on the construction and optimization of the digital business environment, this paper has the following implications.

(1) *Multi-dimensional collaborative advancement.* Optimizing the digital business environment requires the construction of a government-led digital governance system and element supply mechanism, promoting market entities to implement digital transformation and quality upgrading, and simultaneously advancing social digital literacy projects to achieve collaborative governance among multiple stakeholders.

(2) *Dynamic adjustment and regional differentiated strategies.* Regional digital business environment governance should be based on the characteristics of the gradient of factor endowments, constructing adaptive institutional arrangements: the former focuses on institutional innovation and factor agglomeration to drive the allocation of innovative factors, while the latter needs to implement digital infrastructure gap-filling projects, bridge the digital access gap, and gradually cultivate the foundation of the digital entrepreneurship ecosystem.

(3) *Emphasize the core role of talent.* The introduction and training of digital talent require the construction of a three-dimensional institutional design of *policy incentives - livable ecology - growth channels*, relying on the industrial-academic-research collaborative innovation community to achieve knowledge spillover effects and drive regional digital factor level leap.

(4) *The dynamic and adaptive nature of policies.* The governance of the digital business environment needs to build an institutional framework that can adapt to technological development, achieving effective integration of institutional innovation and emerging technology application scenarios such as blockchain through dynamic policy supply mechanisms, enhancing the flexibility and governance effectiveness of the digital business environment system.

In summary, the optimization of the digital business environment needs to construct a multi-stakeholder co-governance ecology, driving the efficiency of digital innovation factor allocation through multi-level institutional innovation clusters and adaptive iterative mechanisms, achieving a leap in the level of the digital economy.

Acknowledgments

This research is supported by College Students' Innovation and Entrepreneurship Training Program of University of Science and Technology Liaoning. The project name is *The Impact of Digital Business Environment on Regional Digital Innovation and Entrepreneurship Activity-Configuration Analysis Based on Multi-Period Fuzzy-Set Qualitative Comparative Analysis*.

References

- [1] H. Xu, Z. Y. Zhu, H. C. Zhang et al: Theoretical Logic, Comparative Analysis and Policy Recommendations for Evaluating China's Digital Business Environment, *Economist*, Vol.12 (2022), p.106-115.
- [2] H. Gao: Research on the Impact Effect of Business Environment Optimization on the Level of Innovation and Entrepreneurship (MS., Qufu Normal University, China 2024), p.61.
- [3] D. Liu, Z. L. Huang: Urban Business Environment, Digital Transformation and Firm Innovation Output, *Journal Of Business Research*, Vol. 5 (2024), p.114-123.
- [4] C. C. Ragin: *Redesigning Social Inquiry: Fuzzy Sets and Beyond* (University of California Press, Berkeley 2008).
- [5] W. Zhou: Data Empowerment: Data Empowerment: The Theoretical Logic and Optimization Path of Digital Business Environment Construction, *Truth Seeking*, (2022) No.4, p.30-42+110.
- [6] Q. Liu: The Path of Administrative Legalization for Optimizing the Business Environment of the Digital Economy, *Social Science Journal*, (2023) No.2, p.57-67.
- [7] N. Kshetri: Digital Infrastructure and Economic Development: An Analytical Framework, *Journal of the Association for Information Science and Technology*, Vol. 69 (2018) No.7, p.875-887.
- [8] Information on: https://www.oecd.org/en/publications/oecd-digital-economy-outlook-2020_bb167041-en.html
- [9] P. Schade, M. C. Schuhmacher: Digital infrastructure and entrepreneurial action-formation: A multilevel study, *Journal of Business Venturing*, Vol.37 (2022) No.5, p.106-232.
- [10] E.H. Prasetyo: Legitimacy Building of Digital Platforms in the Informal Economy: Evidence From Indonesia, *Journal of Entrepreneurship in Emerging Economies*, Vol. 14 (2022) No.6, p.1168-1187.
- [11] J. Martins, L. G. Veiga: Digital government as a business facilitator, *Information Economics and Policy*, (2022) No.60, p.1-11.
- [12] H. M. Zhao, W. H. Wang: Construction and Empirical Study of Digital Business Environment Evaluation Index System, *Statistics and Decision*, (2022) No. 23, p.28-33.
- [13] Y.Q. Song, L.X. Men and X. Han: The Digital Business Environment: Conceptual Understanding, Governance Logic, and Optimization Path, *Public Governance Research*, Vol. 37(2025)No.1,p.73-85.
- [14] Z. J. Ács, L. Szerb and E. Autio: *Global entrepreneurship and development index 2017* (Springer, Germany 2017).
- [15] Information on:https://www.oecd.org/en/publications/oecd-digital-economy-outlook_f0b5c251-en.html
- [16] Y. Z. Du, Q. C. Liu and J. Q. Cheng: What Kind of Ecosystem for Doing Business Will Contribute to City-level High Entrepreneurial Activity? A Research Based on Institutional Configurations, *Management World*, Vol. 36 (2020) No.9, p.141-155.
- [17] Y. Wang, L. Guo: Research on the Impact of Digital Innovation and Entrepreneurship on the Development of New Quality Productive Forces, *Inquiry into Economic Issues*, (2025)No.1,p.37-49.
- [18] G. E. Zhulina, A. N. Efremova, S. E. Dykman, et al: The Role of Information Systems in Maintaining Interrelation between Marketing Activity and Quality Assurance Activity within the Company. (Atlantis Press, Netherlands 2020).

- [19] F. Y. Lan, S. Zhang: Current Status and Future Prospects of Business Environment Research: Bibliometric Analysis Based on CiteSpace, *Journal of Entrepreneurship in Science & Technology*, Vol. 37 (2024) No.11, p.185-191.
- [20] V. R. M. Martínez, D. T. C. J. Henríquez, C. J. D. N. Flores, et al: Business Environment, Attitudes and Entrepreneurial Intentions as Antecedents of Entrepreneurial Inclination among University Students, *Sustainability*, Vol.15 (2023) No.16.
- [21] M. Y. Liu: Digital Rural Construction, Innovation and Entrepreneurship Activity, and High-quality Integrated Development of Urban and Rural Areas, *Statistics and Decision*, Vol. 40 (2024) No.19, p.38-43.
- [22] Y. F. Wang, M. Shi, J. Liu, et al: Research on the Impact of New Infrastructure Construction on Regional Innovation and Entrepreneurship Activity, *Journal of Management*, Vol.21 (2024) No.5, p.711-720.
- [23] X. M. Wang, H. L. Wang: The Establishment and Improvement of Legal Risk Prevention Education Mechanism in Innovation and Entrepreneurship Education, *Legality Vision*, (2022) No.12, p.18-20.
- [24] Y. Liu: Research on the Influence of Talent Introduction Policy on Enterprises Innovation Efficiency. (Ph.D., Harbin University of Science and Technology, China 2024), p.226.
- [25] S. Trudgill, A. G. Tansley: The Use and Abuse of Vegetational Concepts and Terms, *Ecology*, Vol.16 (1935) No.3, p.284-307.
- [26] B. L. Hu, X. B. Hu, X. Y. Liu, et al: Research on Business Model Innovation in Business Ecosystems Based on the Perspective of Niche, *Journal of Information and Management*, Vol.6 (2021) No.Z1, p.53-64.
- [27] N. Caren, A. Panofsky: TQCA: A Technique for Adding Temporality to Qualitative Comparative Analysis, *Sociological Methods & Research*, Vol.34 (2005) No.2, p.147-172.
- [28] B. Rihoux, C. C. Ragin, S. Yamasaki, D. Bol: From Niche to Mainstream Method? A Comprehensive Mapping of QCA Applications in Journal Articles from 1984 to 2011, *Political Research Quarterly*, Vol.66 (2013) No.1, p.175-184.
- [29] B. Vis, J. Woldendorp and H. Keman: Examining Variation in Economic Performance Using Fuzzy-sets, *Quality & Quantity*, Vol.47 (2013) No.4, p.1971-1989.
- [30] Y. J. Wang, X. X. Sun, L. Jiang, et al: Multiple Concurrent Factor Analysis of Major Audit Failures in Listed Companies—Based on 22 Cases of Clear Set Qualitative Comparative Analysis, *Communication of Finance and Accounting*, (2021) No.13, p.118-122.
- [31] M. Zhang, Y. Z. Du: Qualitative Comparative Analysis (QCA) in Management and Organization Research: Position, Tactics, and Directions, *Journal of Management*, Vol. 16(2019) No.9, p.1312-1323.
- [32] L. Xu, M. L. Xi: Research on the Synergistic Effect and Mechanism of Medical and Nursing Policies from the Perspective of Policy Network: Based on fsQCA Empirical Analysis of 31 Provinces in China, *Scientific Management*, Vol. 43 (2023) No.3, p.79-86.