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The Disruptive Innovation Impact of Supply and Demand Matching in Digital Platforms Using Fuzzy-Set Qualitative Comparative Analysis Methodology: Evidence from China

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Abstract: Practice shows that digital platforms could enhance disruptive innovation. Given that digital platforms have always encountered imbalance problems, this study intended to explore which factor configurations could promote disruptive innovation sustainably from the perspective of supply and demand matching. This study constructed a theoretical framework referring to the TOE framework. Based on 25 questionnaires from China, the fuzzy-set qualitative comparative analysis (fsQCA) method was used to explore the configurations of disruptive innovations. This study found the following: (1) None of the five factors in the dimensions of technology, organization, or environment could constitute a necessary condition for enabling disruptive innovation alone. (2) There were four supply and demand matching configurations that could lead to highly disruptive innovation. Based on the homogeneous characteristics of the results, the four paths were divided into "technology-organization driven transition" types and "organization-environment collaborative transition" types. (3) Non-highly disruptive innovation included three specific configurations, all of which lacked the core conditions in technical and organizational dimensions, suggesting the importance of technical and organizational factors for disruptive innovation. This study provides guidance on supply and demand matching for platform enterprises to continuously create disruptive innovation. However, the data from China may limit the results' applicability to a more expansive setting.

Keywords: digital platform; supply demand matching; disruptive innovation; TOE; fsQCA

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1. Introduction

Disruptive innovation, initially put forward by Bower and Christensen in 1995, is an innovation form in which latecomer enterprises replace incumbent enterprises with existing technologies or technology combinations [1]. Tens of thousands of companies, such as GE, Tesla, and Siemens, have explored disruptive innovation for their rapid development [2]. It is not difficult to find that most of these enterprises have completed disruptive innovation using a digital platform, which is a complex ecosystem composed of digital tools, complementary modules, and a series of rules [3]. For example, MindSphere of Siemens disrupted the production mode of the manufacturing industry. The series of changes and disruptions initiated by digital platforms was called "Platform Revolution" by Parker et al. [4]. Furthermore, according to the research by Ozalp, a digital platform embedded in an ecosystem can sustainably realize value-added and disruptive innovation with technological iteration [5]. From this, it can be seen that digital platforms have become a popular means for enterprises to carry out disruptive innovation sustainably [6].

In the process of practice, disruptive innovation in digital platforms has encountered many barriers, especially the imbalance between supply and demand caused by diversified innovation demand and complex technology supply [7]. In order to promote disruptive innovation, platform owners have to carry out supply and demand matching, which is the management behavior of platform owners in coordinating the supply-driven driving effect and demand-pulling effect to maintain a high level of dynamic balance between supply and demand [8]. Meanwhile, the existing research has found the significant impact of platform architecture, platform organization, and environment on disruptive innovation. However, less research focuses on the coupling linkage effect of factors that could promote disruptive innovation from the perspective of supply and demand matching in digital platforms.

Therefore, this paper aims to explore the different paths for achieving disruptive innovation from the perspective of supply and demand matching in digital platforms based on configuration theory. Specifically, the research questions are as follows: (1) What disruptive innovation factors are necessary conditions from the perspective of supply and demand matching in digital platforms? (2) What configurations of sufficient conditions can promote disruptive innovation? (3) How do these configurations form disruptive innovation paths? To address these questions, fuzzy-set qualitative comparative analysis (fsQCA) was used to explore the configuration effect of disruptive innovation from the perspective of supply and demand matching in digital platforms. The digital platform of China was selected as the data source because China has rapidly developed digital platforms and spawned industrial internet platforms such as COSMOPlat of Haier, FusionPlant of Huawei, and INDICS of AVIC. These enterprise practices provided a data foundation for this paper.

The contributions of this paper are as follows: (1) This paper enriched the research circumstance of the fsQCA method, which was used to explore the factors of disruptive innovation in digital platforms. (2) Based on the theory of innovation by Schumpeter, this paper embeds supply and demand matching logic into the configuration effect of disruptive innovation in digital platforms. (3) This paper found different paths for achieving disruptive innovation based on the factors' relationships and their configuration effect.

The remainder of this paper is organized as follows: Section 2 provides a theoretical background on disruptive innovation, supply and demand matching in digital platforms, disruptive innovation factors, and factor relationships. Section 3 details the research method and data collection. Section 4 presents this study's results, including variable calibration and analysis of sufficiency. Section 5 presents a discussion of this study. Finally, Section 6 concludes this study and puts forward managerial implications.

2. Theoretical Background

2.1. Disruptive Innovation

The disruptive innovation theory proposed by Christensen based on the methodology of environmental and cost constraints is considered to be an important innovation pathway for enterprises to enhance their industry position and build their competitiveness [9]. Disruptive innovation has been gradually favored by enterprises and even national governments because of its unique "impact" effect. Disruptive innovation has become an innovative strategic approach for them to build their own competitive advantages [10]. As disruptive innovation is usually aimed at "undetected user needs", incumbent enterprises that are accustomed to meeting the major needs of mainstream customers are usually at a loss. On this basis, Danneels has argued that disruptive innovation can also meet the needs of high-end customers, which is innovation with a higher degree of technological mutation [11]. Govindarajan and Kopalle further explored the specific use of the post-measurement of disruptive innovation from the perspectives of demand and technology [12]. Furthermore, with the development of digital technology, research on disruptive innovation has gradually integrated the scenarios of digital platforms. The functional modules and robust algorithms of digital platforms can analyze user demand in different segmented markets, effectively solving the problem of innovation barriers [13]. Further, Mukhopadhyay and Whalley confirmed a disruptive platform and its impact on an ecosystem by focusing on the intersection of the platform and the disruptive innovation literature [14]. When investigating the reason for disruptive innovation, heterogeneous enterprises attracted by a platform can share and complement knowledge, thereby triggering changes in internal platforms and creating opportunities for disruptive innovation. In fact, complementors are bound to reach a unified value goal and build a reasonable ecosystem aiming to realize disruptive innovation [15].

2.2. Supply and Demand Matching in Digital Platforms

In digital platforms, the reusability, compatibility, and extensibility of digital platforms have become convenient conditions for platform innovation activities [16]. In order to promote supply and demand matching, platform owners usually manage to shape a balanced bilateral market (Figure 1). Based on user demand, platform owners will construct and govern a platform by supporting advanced information technology [17], and they connect suppliers and demanders around the digital platform. Then, the digital platform promotes the supplier to obtain adaptive demand information and the demander to obtain satisfactory delivery results by using the flow and transmission of data in the platform to break the "information island" phenomenon. Various factors such as information are redistributed in the process of supply and demand matching in digital platforms. This activity could promote disruptive innovation by reducing innovation costs and improving innovation efficiency [18]. In addition, the supply and demand sides of a digital platform can be converted into different scenarios [19]. For example, iOS consumers can transform into potential innovators by innovating applications sustainably.

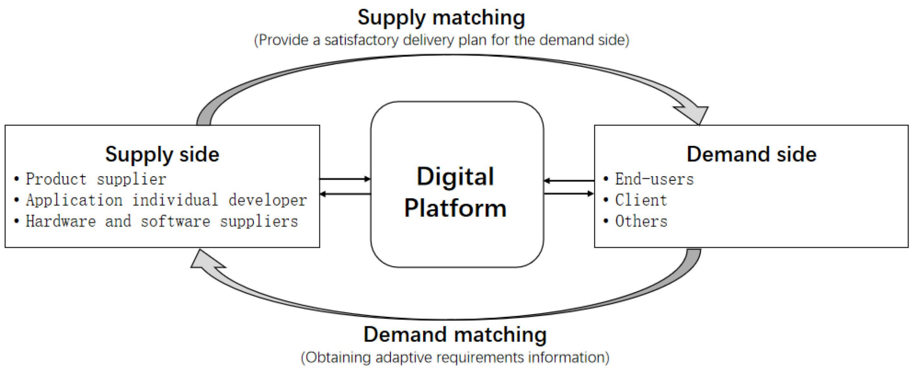

Figure 1. Supply and demand matching in digital platforms for disruptive innovation.

However, the following problems have emerged in the supply and demand matching of current digital platforms: (1) The demands of target customers tend to be fragmented, personalized, and varied, which are difficult to satisfy. (2) The supply of products, technologies, and solutions is insufficient. (3) A platform owner may fail to play the bridging and communication role in the process of supply and demand matching. Unfortunately, the current research on the supply and demand matching of digital platforms is mostly based on a micro perspective, such as algorithm design, case studies, etc. There are still gaps in the general theoretical laws based on medium-sized samples.

2.3. Disruptive Innovation Factors of Supply and Demand Matching in Digital Platforms

The TOE framework, founded by Tornatzky and Fleischer in 1990, is a theoretical framework used to analyze the factors of technology innovation from the dimensions of technology, organization, and environment [20]. The TOE framework has the features of systematicity, flexibility, and operability. Thus, it is always applied in various technical analysis fields in different situations. Li et al., confirmed that the decisive factors affecting innovation can all be categorized into the dimensions of technology, organization, and environment [21]. Due to the widespread applicability of the TOE framework, this paper dissects the factors of disruptive innovation in digital platforms using the TOE framework.

Technical Factors: Platform Technical Architecture

According to architecture theory, the technical architecture of a digital platform typically includes elements such as interfaces, functional modules, and hierarchical structures [22]. A layered modular technical architecture design is based on generally accepted standardized interfaces, which are the basis for strengthening the connections between people, machines, and things within the platform. Functional modules in platforms are usually divided into core functional modules and peripheral modules [23]. This not only effectively reduces complexity but also ensures the stability of the core functions of a platform [24]. There are loose relationships among hierarchical structures, and core functions and related modular services are provided using interfaces such as extensible code libraries. Further, the layered modular technical architecture of a digital platform reduces the barriers to sharing information between the supply and demand sides, which is an advantage for enterprises in improving innovation efficiency and effectiveness [25]. Therefore, a reasonable platform architecture design is the key to improving a platform's capability and innovation performance.

Organizational Factors: Organizational Flexibility and Network Externality

Compared with general innovation activities, disruptive innovation requires greater perceptions about market change, resource allocation ability, and responsiveness to demand. The flat structure, fuzzy boundaries, and decentralization management in digital platforms make their organization more flexible. As seen in the disruptive innovation research on the Predix platform of General Electric and the MindSphere platform of Siemens by Peteraf and Bergen [26], the organizational flexibility of digital platforms not only forms dynamic capabilities but also effectively promotes interactions between platform owners and complementors, which provides the possibility for disruptive innovation [27].

According to Freeman, "networking between autonomous firms will grow still more important" [28]. An innovation network with a digital platform as its core is composed of platform owners, core enterprises, and complementors [29]. Platform owners are usually committed to expanding the scale of their digital platform to obtain higher industry status, more partners, and more broadly shared resources. In this way, platform complementors can obtain higher value in innovation through collaboration, integration, and co-creation. Regarding the network externality of a platform, the more complementors a digital platform has on the same side (the supply side or the demand side), the higher the level of interaction and communication the digital platform could have. This can enhance network externality and enhance the value of disruptive innovation. Therefore, organizational flexibility and network externality are crucial to the innovation of digital platform participants.

Environment Factors: Internal Environment and External Environment in a Platform

Cenamor et al. [25] stated that a series of management designs such as those for digital platform operation and maintenance, relationship governance, and interaction mechanisms using modularization can overcome the service paradox and provide a good reference for improving innovation efficiency. From the perspective of the internal environment of a digital platform, excessive centralized control by a platform owner will lead to the exit of the platform's complementors. On the contrary, if digital platforms lack constraint rules such as an attraction mechanism, an incentive mechanism, and a punishment mechanism, it is difficult for complementors to form effective synergies. Therefore, identifying how to balance the relationship between innovators and realize effective governance is a major challenge for a platform owner. From the perspective of the external environment, industry development trends, policy environment, competition with potential stakeholders, and government subsidies are all factors that affect disruptive innovation in a digital platform [30].

2.4. Factor Relationships from the Perspective of Configuration

From the perspective of configuration, there is a logical correlation between the disruptive factors of technology, organization, and environment. For example, a reasonable platform technical architecture can dismantle bureaucratic organizations and form a layered modular technical organizational structure. This flat organization of the digital platform can reduce obstacles such as decision-making processes in disruptive innovation and enhance organizational flexibility in responding to changes in customer needs. In addition, technical architecture can effectively connect the complementors in a digital platform using information tools and build a unique innovation ecosystem around platform owners to promote the generation of network effects. Furthermore, a platform owner could adopt a series of governance measures to build an innovation ecosystem, forming a favorable internal environment for their platform. This well-developed innovation ecosystem can quickly respond to market changes, survive competition, and resist risks through cooperation, that is, the coupling linkage effect formed by the technical, organizational, and environmental factors plays an important role in promoting disruptive innovation.

According to configuration theory, different combinations of factors may produce the same results. For example, positive technological and organizational factors may work together to form highly disruptive innovation, while negative technological and organizational dimensions may also work together to form highly disruptive innovation. Previous scholars have confirmed the effects of a platform's technical architecture, organizational flexibility, network externality, internal environment, and external environment on disruptive innovation—in summary, previous scholars have confirmed the effects of numerous factors on disruptive innovation. However, we did not find any studies in the literature that successfully discussed the complex linkage among the factors of disruptive innovation, especially from the perspective of supply and demand matching in digital platforms. Thus, this paper constructs a theoretical model of disruptive innovation factors based on the TOE framework to explore the different combined effects of positive and negative factors in producing disruptive innovation (Figure 2).

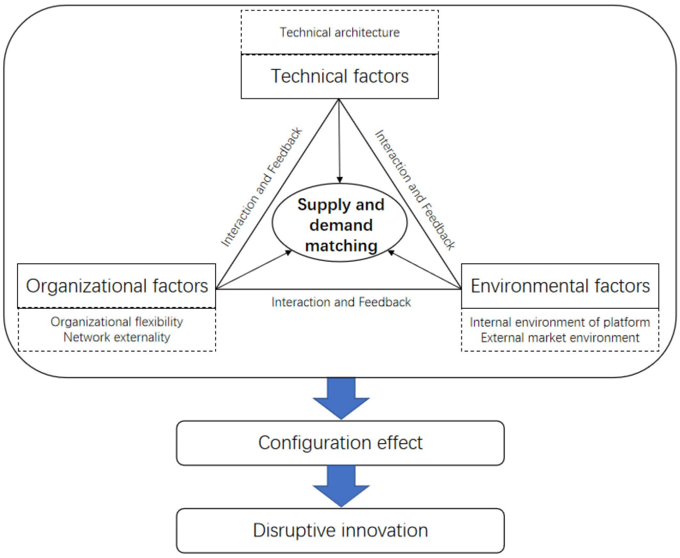

Figure 2. Theoretical framework.

3. Research Design

3.1. Fuzzy-Set Qualitative Comparative Analysis (fsQCA)

QCA is a case-based comparative analysis method that takes into account both configuration analysis and set thinking, and it combines certain advantages of qualitative and quantitative research approaches [31]. In recent years, the QCA method has been widely used in sociology, political science, management, and other fields. Fuzzy-set qualitative comparative analysis (fsQCA) can calibrate membership scores and set anchor points based on the actual and theoretical knowledge of researchers. Typically, factors are divided into sets and negation sets. Then, fsQCA is used to solve the partial membership problems in the sets, which is more advantageous for the study of causal complexity [32].

This study used the fsQCA methodology for the following two reasons. First, the factors of disruptive innovation are not single, but rather, they are the result of a configuration of multiple factors. Meanwhile, the fsQCA method is suitable for the study of medium sample sizes such as the one in this study. Thus, we explored how the configurations of the technology, organization, and environmental factors affected disruptive innovation in digital platforms from the perspective of supply and demand matching.

3.2. Data Collection

This paper refers to some authoritative lists such as the "2022 Cross-Industry and Cross-Domain Industrial Internet Platform List" published by the Ministry of Industry and Information Technology of the People's Republic of China to select 40 leading industrial internet platforms with outstanding innovation achievements as samples [33]. Using the key information tracking method, data were collected from technical and management personnel familiar with the development and governance of the above 40 industrial internet platforms using on-site form filling and emails.

First, questionnaires were collected from enterprises maintaining long-term cooperation with the research group, such as COSMOPlat of Haier. Meanwhile, we conducted on-site questionnaire surveys of the above platform enterprises at the 2022 Industrial Internet Conference. A total of 32 questionnaires were collected, of which 7 invalid questionnaires were excluded because the options selected in the questionnaires were the same or the questionnaires were not completely filled. The effective recovery rate of the questionnaires was 62.5%, and the information on the effective sample platforms is shown in Table 1.

Table 1. Typical platform samples.

Code	Platform	Platform Owner	Establish Time	Primary Involved Industries
A	COSMOPlat	Haier (Qingdao, China)	2015	Household appliances, agriculture, equipment, construction, transportation, etc.; a total of 12 industries
B	M·IoT	Midea (Foshan, China)	2018	Automotive parts, semiconductors, food, home building materials, etc.
C	FusionPlant	Huawei (Shenzhen, China)	2017	Steel, coking, mining, building materials, home appliances, automobile manufacturing, etc.
D	Kingdee Cloud	Kingdee (Shenzhen, China)	2019	Manufacturing, transportation, property, construction, etc.; a total of 12 major industries
E	Yonyou Cloud	Yonyou (Beijing, China)	2012	Metallurgy, machinery, automobile manufacturing, aerospace, etc.; a total of 21 industries
F	Root Cloud	Rootcloud technology Co., Ltd. (Beijing, China)	2016	Construction machinery, concrete, custom home, etc.; a total of 20 industries
G	WeMake	Tencent (Shenzhen, China)	2019	Equipment manufacturing, steel, tobacco, etc.; a total of 26 industries
H	supET	Alibaba Cloud (Hangzhou, China)	2017	Service, automobile manufacturing, steel, home appliances, chemical industry, toy manufacturing, etc.
I	TuringPlat	iFLYTEK (Hefei, Chian)	2015	Energy chemical industry, machinery manufacturing, etc.
...	......	......	......	......
Y	Kaiwu	Baidu (Beijing, China)	2021	Manufacturing, energy, electricity, etc.

3.3. Variable Measurement

In order to improve the reliability and validity of the questionnaire, the variable measurement in this study mainly referred to mature research results. The questionnaire used the Likert seven-point scale, with participants scoring items from 1 to 7 (1: totally disagree to 7: totally agree). This study followed established translation and reverse translation procedures to ensure the accurate translation of the questionnaire. The measurements of the variables are shown in Table 2.

Table 2. Conditional variable index definitions.

Dimension	Variable	Question
Technology	Technical architecture (TA)	1. Our digital platform is scalable to support open connections between our partners' systems and our systems. 2. Our digital platform is compatible with our partners' systems and is able to transmit, integrate, and process data. 3. Our digital platform consists of modular software components, most of which can be reused in other business applications.
Organization	Organizational flexibility (OF)	1. Cooperation between different enterprises, departments, and teams is a common practice. 2. It is easy and easy to change the connection of the entire supply chain. 3. Employee suggestions often play an important role in organizational decision-making and strategy formulation.
	Network externality (NE)	1. The platform gathers complementors with different complementary experiences, skills, and abilities from different fields. 2. The platform connects customers and suppliers through information networks. 3. Platform functions can be integrated and connected in real time. 4. Complementors in digital platforms have good credit and can establish long-term cooperative relations. 5. Platform complementors have access to the data network for sharing information such as production plans.
Environment	Internal environment of platform (IEP)	1. The platform has a unified value goal and a relaxed innovation atmosphere. 2. The platform has developed an equal cooperation policy to increase willingness to cooperate. 3. The platform can provide online services and management.
	External environment (EME)	1. The market environment of the platform is stable, and there is no rapid increase in the quantity of products/services or frequent changes in types. 2. Demand changes are stable, and there are fewer requirements for new products/services. 3. The market competition of the platform is not very fierce, and there are fewer strong competitors.
Disruptive innovation	Disruptive innovation performance (DIP)	1. During the past 5 years, new products/services launched in digital platforms were disruptive. 2. During the past 5 years, new products/services that were introduced by digital platforms were very attractive to different customer segments. 3. During the past 5 years, the new products/services launched in digital platforms usually satisfied the potential market demands. 4. The digital platform is leading in introducing disruptive product/service innovations. 5. Disruptive innovation in digital platforms has strengthened the mode of competition or changed the mode of innovation.

Technical factors: The driving factor in the technical dimension was platform architecture. A reasonable architecture design can combine the flexibility of modular architecture with the self-generation ability of hierarchical architecture. The interconnection of platform interfaces formed a loose coupling relationship between the core modules and the alternative modules. At the same time, digital technology had the characteristics of homogeneity, editability, and distribution, forming the reusability, compatibility, and extensibility characteristics of the digital platform [34]. On this basis, this paper referred to the mature scales used by Zhu et al. [35] and Anthony and Turnerdouglas [36].

Organizational factors: From an organizational perspective, the factors were divided into organizational flexibility and network externality. Flexible organizations can promote complementors to quickly respond to demands for innovation and form a competitive advantage of disruptive innovation. The scale of organizational flexibility referred to the scale proposed by Tiwana [29], Zhu et al. [35], and Alegre and Chiva [37]. Meanwhile, blurred organizational boundaries made the network externality of the platform gradually prominent, and the innovation paradigm also changed from the individual traditional model to an open innovation model. On this basis, the scale of network externality referred to the scale proposed by Tiwana [29], Flynn et al. [38], Golicic and Mentzer [39], and Frohlich and Westbrook [40].

Environment factors: For the internal environment, a unified value goal, complete regulations, and a relaxed innovation atmosphere on a platform can improve the efficiency and effectiveness of disruptive innovation. The scale for the internal environment of the platform was designed by referring to the scales proposed by Alegre et al. [37] and Zhu et al. [35]. The external environment in the digital platform, such as the dynamics and uncertainty in the external environment, the degree of competition, etc., could also provide important opportunities for disruptive innovation. In view of this, this study referred to the scales proposed by Jansen et al. [41].

Disruptive innovation: Given that disruptive innovation is difficult to discover and "disruptive" in nature, this study referred to the mature scales established by Subramaniam and Youndt and Govindarajan et al. to construct the measurement items of the enterprise disruptive innovation performance [42,43].

The questionnaire is shown in Table 2.

3.4. Variable Calibration

As fsQCA is a comparative analysis method based on the conditional configuration of a set membership analysis, it was necessary to convert the scores from the questionnaires into fuzzy set membership scores between zero and one. In order to ensure the objectivity of the analysis, this study set 95% as the anchor point of full membership and 5% as that of full non-membership by referring to the methods used by Andrew and Beynon [44], and it set the average value as the crossover point by referring to the method used by Fiss [45]. The specific calibration anchor points and case descriptive statistics are shown in Table 3.

Table 3. Calibration and descriptive statistics of the variables.

Dimension	Variable	Break Points			Descriptive Statistics			
		Full Membership	Crossover Point	Full Non-Membership	Average	SD	Min	Max
Technology	TA	6.67	5.44	3.67	5.44	0.950883	3.67	6.67
Organization	OF	6.23	4.74	3.67	4.74	0.713551	3.67	6.33
	NE	6.60	5.37	4.00	5.37	0.791313	4.00	6.33
Environment	IEP	6.33	4.87	4.00	4.87	0.705534	4.00	6.33
	EME	5.67	4.53	2.43	4.53	1.028483	2.33	5.67
Disruptive innovation	DIP	6.60	4.93	3.72	4.93	0.83346	3.60	6.60

4. Supply and Demand Matching Path Analysis of Disruptive Innovation in Digital Platforms

4.1. Analysis of Necessity

A necessity test needed to be conducted before the conditional configuration analysis, and the result is shown in Table 4. The consistency of all the variables was less than 0.9. This indicated that the set of five variables, including technical architecture, organizational flexibility, network externality, internal environment, and external environment, and their non-set were not necessary conditions for highly disruptive innovation performance and non-highly disruptive innovation performance. In other words, even if an enterprise had an antecedent mentioned herein, it was not necessarily able to achieve disruptive innovation. This statement is not only in line with the current enterprise practices but also with the "unexpected" feature of disruptive innovation proposed by Christensen.

Table 4. Result of the necessary condition analysis.

Dimension	Variable	DIP		~DIP	
		Consistency	Coverage	Consistency	Coverage
Technology	TA	0.854150	0.801310	0.528489	0.465793
	~TA	0.430566	0.492895	0.774566	0.833037
Organization	OF	0.738557	0.820690	0.526837	0.550000
	~OF	0.595035	0.572388	0.828241	0.748508
	NE	0.795190	0.816083	0.511974	0.493631
	~NE	0.506594	0.524920	0.809249	0.787781
Environment	IEP	0.579519	0.714833	0.513625	0.595215
	~IEP	0.671839	0.595189	0.753922	0.627491
	EME	0.573313	0.570656	0.732453	0.684942
	~EME	0.683476	0.731120	0.540875	0.543568

Note: "DIP", which is called highly disruptive innovation, indicates the set of DIP, and "~DIP", which is called non-highly disruptive innovation, indicates the negation set of DIP.

4.2. Analysis of Sufficiency

A conditional configuration analysis is the core of a fuzzy-set qualitative comparative analysis, and it aims to analyze the adequacy of configurations formed by different conditions for results. In this study, fs/QCA3.0 software was used for the conditional configuration analysis, and the configuration results were displayed directly and clearly with symbols [46]. In this study, 0.8 was used as the original consistency threshold, the PRI threshold was set to 0.7, and the case frequency was set to 1 in the analysis process. The specific results are shown in Table 5.

Table 5. Highly disruptive innovation and non-highly disruptive innovation configuration.

Dimension	Variable	DIP				~DIP		
		H1a	H1b	H2a	H2b	P1a	P1b	P1c
Technology	TA	●	●	·		⊗	⊗	⊗
Organization	OF	●	●		·	⊗		⊗
	NE		·	●	●	⊗	⊗	
Environment	IEP	⊗		●	●		·	⊗
	EME	⊗	⊗	⊗	⊗		⊗	●
Raw coverage		0.373933	0.454616	0.394104	0.369278	0.568126	0.316268	0.427746
Unique coverage		0.0411171	0.1218	0.0837859	0.0589604	0.0949628	0.020644	0.0412881
Solution coverage		0.727696				0.630058		
Solution consistency		0.947475				0.965823		

Note: "●" indicates the presence of a core condition, "⊗" indicates the absence of a core condition, "·" indicates that an auxiliary condition exists, and "⊗" indicates the absence of an auxiliary condition.

5. Discussion

5.1. Configuration Analysis of Highly Disruptive Innovation Performance

According to the results, there were four specific paths that could lead to a highly disruptive innovation performance. The coverage of the results was 0.727696, and the consistency was 0.947475, indicating that the configurations had high explanatory power and a high confidence level. According to the distribution of the core conditions in the technology, organization, and environment dimensions, the four paths leading to a highly disruptive innovation performance were divided into two types, and they were named "technology-organization driven transition" types (H1a and H1b) and "organization-environment collaborative transition" types (H2a and H2b).

(1) Technology–organization-driven transition path

In the H1a (TA*OF*~IEP*~EME) configuration, high-tech architecture and high organizational flexibility were the core conditions, and non-high internal environment and non-high external environment were the auxiliary conditions. Network externality had no impact on highly disruptive innovation. Platform owners built layered modular technical architectures that supported supply and demand matching in digital platforms and provided common interfaces for resource circulation. This formed a platform system bridged by the platform owners for interconnection between the supply and demand sides, which improved the matching degree between supply and demand. Furthermore, the layered modular technical architecture improved the organizational flexibility in the digital platform. Flexible organization departments and research teams with specialized divisions, which were loosely coupled, could carry out cross-enterprise, cross-department, and cross-functional team cooperation and coordination under the specific innovation demand. Driven by technical architecture and organizational flexibility, even if the internal and external environments were unstable, disruptive innovation could still be generated. Cases of the H1a configuration included the FusionPlant platform of Huawei, the WeMake platform of Tencent, and the supET platform of Alibaba Cloud. It was not difficult to find that these platform owners were all enterprises that were deeply engaged in the internet business in the 20th century. They took the lead in building digital platforms with technological advantages using strong technological accumulation and shaping flexible and flat organizational structures in organizational transformations. In this way, these platform owners integrated the technical resources of suppliers using open digital platforms to create platform ecosystems for disruptive innovation that met customer demands.

In the H1b (TA*OF*NE*~IEP) configuration, high-tech architecture and high organizational flexibility were the core conditions, and high network externality and non-high internal environment were the auxiliary conditions. Different from the H1a configuration, the auxiliary condition of the network externality in the H1b configuration played a catalytic role. Specifically, such a digital platform could gather enterprises, which constituted a complex network from the supply side or the demand side, including core enterprises, complementors, and other resource suppliers. Further, the more obvious the network externality of the supply and demand matching in a digital platform, the more likely an enterprise was to use network externality to obtain resources for achieving more disruptive innovation through secondary innovation. The Kingdee Cloud platform is an example of an H1b configuration. It was designed as a hierarchical architecture with multiple sub-platforms, including PaaS, SaaS, a software delivery layer, an enterprise e-commerce layer, a mobile office layer, and others. The group has subsidiaries responsible for different business modules which are able to respond to demand changes quickly and provide platform construction services, software services, and cloud services. There are more than 100 branches dealing mainly with marketing and service in the Kingdee Cloud platform. These branches can quickly match personalized and fragmented demands and obtain suitable technologies and solutions through algorithm-matching so as to enable core enterprises providing technical services to create "disruption" rapidly.

Viewpoint 1. *In the situation of a harsh environment in a digital platform, the technical architecture and organizational factors of supply and demand matching in a digital platform are crucial to disruptive innovation.*

(2) Organization–environment collaborative transition path

In the H2a (TA*NE*IEP*~EME) configuration, high-tech architecture was the auxiliary condition, and high network externality, high internal environment, and non-high external environment were the core conditions. Under this configuration, the digital platform had a well-designed technical architecture that facilitated supply and demand matching, but it did not directly constitute a key condition for disruptive innovation. This study found that technical architecture promoted the formation of a high network externality and a high internal environment under the H2a configuration. Furthermore, in the situation of a high network externality and a high internal environment, a digital platform could form a core capability. This capability was able to resist turbulence, demand changes, and face fierce market competition in an external environment, responding to demand quickly and matching technology supply to promote disruptive innovation. The cases under the H2a configuration included the COSMOPlat platform of Haier, M·IoT platform of Midea, and RootCloud platform. They were all built by industry leaders who took the lead in digital transformation and platform strategies. In contrast to the cases under the H1a configuration, the technical architectures of the digital platforms under the H2a configuration focused more on manufacturing processes and industrial mechanisms. Thus, they could form platform ecosystems that connect heterogeneous industrial enterprises and create good internal environments.

In the H2b (OF*NE*IEP*~EME) configuration, high organizational flexibility was the auxiliary condition, and high network externality, high internal environment, and non-high external environment were the core conditions. Under the H2b configuration, the technical architecture of a digital platform was not necessarily unreasonable, but enterprises usually no longer relied on technical architecture to promote the matching of supply and demand for achieving disruptive innovation. This not only led to higher requirements for organizational flexibility and network externality for supply and demand matching in a digital platform but also required the support of perfect governance. In addition, a dynamic environment and competition also became conditions for stimulating disruptive innovation. This study found that when the two organizational factors appeared together, there was an interaction between them. Organizational flexibility improved network externality by reducing the constraint generated by organizational inertia in the process of supply and demand matching. Conversely, the network externality improved the organizational flexibility of the digital platform through the coupled and coordinated relationship between the network nodes on the supply and demand sides. Usually, enterprises achieve more business model disruption through synergies between the organizational and environmental factors than they do through disruptive technical innovation. The Yonyou Cloud, which is under an H2b configuration, supports this view.

Viewpoint 2. *When the technical architecture did not appear as a core condition for supply and demand matching in a digital platform, the synergies between organizational factors and the internal environment could also enhance the disruptive innovation of supply and demand matching in a digital platform.*

5.2. Configuration Analysis of a Non-Highly Disruptive Innovation Performance

Three non-highly disruptive innovation configurations were found. First, P1a (~TA*~OF*~NE) showed that if a digital platform was without the core conditions of technical architecture and network externality and the auxiliary condition of organizational flexibility, it was difficult to complete the supply and demand matching for disruptive innovation. Second, P1b (~TA*~NE*IEP*~EME) showed that when technical architecture and network externality were absent as core conditions, as was the internal environment as the auxiliary condition, it was impossible to balance a two-sided market with a poor external environment for disruptive innovation. Finally, the P1c (~TA*~OF*~IEP*EME) configuration showed that in the absence of two core conditions, including technical architecture and organizational flexibility, and the auxiliary condition of the internal environment, even if the external environment was stable and peaceful, the supply and demand sides were difficult to match.

5.3. Robustness Test

Configuration robustness was tested on the configurations of highly disruptive innovation [47]. First, a robustness test was carried out according to the critical value used to change the variable scale, as proposed by Kim [48]. The critical values of full membership and full non-membership were changed to 90% and 10%, respectively, and the corresponding configuration results had no significant changes. Next, the PRI consistency was increased from 0.7 to 0.8, and the resulting configurations had no significant changes. Due to the limited number of cases involved in this study, the case frequency threshold could not be increased.

6. Conclusions and Practical Applications

6.1. Conclusions and Contributions

At present, identifying how to use digital platforms to realize innovation sustainably is one of the major challenges faced by enterprises. Previous studies have pointed out that the success of innovation in a digital platform relies on network externality based on information and interaction [4]. However, given the bilateral roles of supply drivers and demand drivers in digital platforms, the current research has not yet clearly answered the question of whether the factor of supply and demand matching in digital platforms can promote disruptive innovation sustainably. Therefore, this study constructed a theoretical framework of supply and demand matching for disruptive innovation in digital platforms based on the TOE framework by referring to platform theory, supply and demand matching theory, disruptive innovation theory, and modularization theory. Furthermore, the fsQCA method was used to analyze the effective questionnaires from 25 digital platforms in China and explore the varying impacts of different configuration paths of supply and demand matching in digital platforms on disruptive innovation.

The results showed that: (1) Using a necessity analysis, it was found that none of the five factors of supply and demand matching in digital platforms could independently constitute the necessary conditions for enabling disruptive innovation. (2) Four paths that produced highly disruptive innovation were found using a sufficient condition analysis, reflecting multiple methods of supply and demand matching in different digital platforms (Figure 3). Furthermore, the four paths were divided into two categories according to the core conditions. The first type was the "technology-organization driven transition" path. In situations with an unsatisfied supply and demand matching environment in a digital platform, the technical architecture and organizational factors were critical to the supply and demand matching in a digital platform for disruptive innovation. The second type was the "organization-environment collaborative transition" path. When the technical architecture was not the core condition for supply and demand matching in a digital platform, the synergy between the organizational factors and the internal environment could also promote supply and demand matching and contribute to disruptive innovation. (3) There were three configurations of non-highly disruptive innovation, all of which lacked technical and organizational factors as core conditions, reflecting the importance of these factors for disruptive innovation.

The theoretical contributions of this study are as follows: First, based on the TOE framework, this study constructed a theoretical framework of supply and demand matching for disruptive innovation referring to digital platforms, supply and demand matching, disruptive innovation, and modularization theories, and this enriched the theoretical research on disruptive innovation. Second, we explored the multiple concurrent factors of technical architecture, organizational flexibility, network externality, the internal environment, and the external environment from a configuration perspective using a specific situation in China. Third, this study enriched the application scenarios of the QCA method, which is more typical and pertinent to the exploration of supply and demand matching problems in digital platforms, and it provided some theoretical references and inspiration for the development of platform owners and complementors.

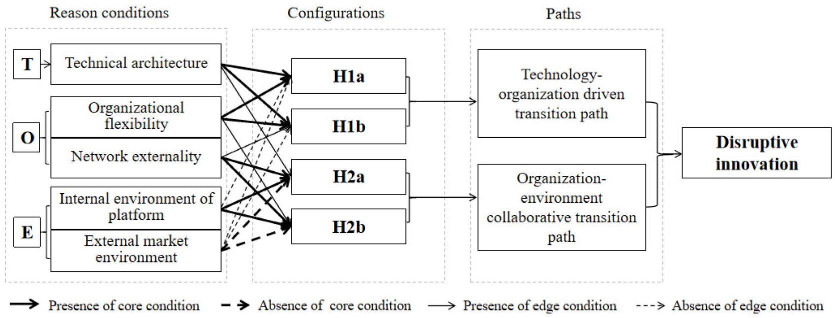

Figure 3. The paths of highly disruptive innovation based on the TOE framework.

6.2. Managerial Implications

Configuration thinking should be taken seriously because single factors fail to balance the supply and demand sides for achieving disruptive innovation sustainably. Platform owners and complementors should explore their development with consideration of the configuration effect of technology, organization, and environment.

First, a digital platform technical architecture suitable for supply and demand matching should be built. Among the four configurations of highly disruptive innovation, technical architecture appeared in three configurations. High technical architecture appeared as a core condition in H1a and H1b and as an auxiliary condition in H2a. At the same time, non-high technical architecture appeared as a core condition in the three configurations of non-highly disruptive innovation. It could be seen that technical architecture is crucial for disruptive innovation. To this end, in order to help core enterprises achieve disruptive innovation sustainably, a platform owner should design a layered modular platform architecture. A digital platform with a reasonable architecture design, interface standards, and reusable modules can further construct a disruptive innovation ecosystem, and based on the technical architecture, a demand insight and monitoring analysis system may be established to guide the research direction of disruptive innovation.

Second, organizational flexibility and network externality in digital platforms should be improved and utilized. Organizational factors as the core conditions exist in all highly disruptive innovation configurations. High organizational flexibility was a core condition in H1a and H1b, and high network externality was a core condition in H2a and H2b. Organizational factors were also missing as core conditions in all non-highly disruptive innovation configurations. It was not difficult to find that organizational factors are indispensable for achieving disruptive innovation. Therefore, platform owners should fully consider the role of organizational flexibility and network externality when conducting organizational structure and innovation network deployment. Furthermore, platform owners can shape flat organizational structures that facilitate supply and demand matching by reducing the levels of administrative management, and a special department for accurate supply and demand matching can be set up to guide core enterprises in completing disruptive innovation.

Third, attention should be paid to the synergies between the environment and organizations. In the highly disruptive innovation configurations, a high internal environment was a core condition in H2a and H2b, which appeared simultaneously with high network externality and a non-high external environment. This provides a new idea about supply and demand matching governance for disruptive innovation. On the one hand, platform owners can promote disruptive innovation using appropriate supply and demand matching governance measures such as providing financial support and assessing cooperative innovation performances for enterprises that successfully matched supply and demand. On the other hand, cross-industry and cross-domain cooperation can improve the platforms' abilities to cope with fierce competition and respond to external environments such as rapidly changing needs.

6.3. Limitations

There were some limitations to this study. First, this study was horizontal, focusing on how the supply and demand matching factors of digital platforms and their paths can help enterprises achieve disruptive innovation. In the future, typical cases can be used to explore the evolution process of disruptive innovation factors in digital platforms at different times. Second, the factors affecting disruptive innovation were not limited to the five variables in this study, and further research is needed in the future. Third, the samples selected in this study were all from industrial internet platforms. Whether the research conclusions are universal for consumer digital platforms needs to be further tested in future research.

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