

The Impact of Multiple Institutions on Supply Chain Resilience: A Configurational Analysis Based on FsQCA

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Abstract. In the context of the globalization of the digital economy, supply and demand are increasing, exerting considerable strain on supply chains and necessitating enhanced supply chain resilience. Nevertheless, most current research emphasizes individual institutions' influence on supply chain resilience, neglecting the interplay among various institutional elements. This research utilizes pertinent indicators from Chinese provinces between 2014 and 2024, employing a two-dimensional framework that includes formal and informal institutions. It applies fuzzy-set qualitative comparative analysis (FsQCA) to examine the configurational conditions necessary for high supply chain resilience from a configurational viewpoint. The findings indicate: (1) four configurations contribute to elevated supply chain resilience: facility-led, facility-institution dual-drive, and facility-society-alliance-public joint-drive; (2) Investment in facilities is an essential prerequisite for achieving high supply chain resilience. The findings identify the institutional factors contributing to elevated supply network resilience, with the objective of offering recommendations for provinces to augment supply chain efficiency and bolster their capacity to manage emergencies.

Keywords: Supply Chain Resilience, Formal Institution, Informal Institution, FsQCA.

1. Introduction

Amidst the backdrop and trends of adjusting and reshaping the global landscape and dynamics, the stability and efficiency of supply chains have become a crucial topic of concern in international investment and trade. The "National Supply Chain Innovation and Application Development Report (2024)" released by the China Federation of Logistics and Purchasing, and the "Decision of the Central Committee of the Communist Party of China on Further Deepening Comprehensive Reforms and Advancing Chinese-style Modernization" emphasize "improving systems for enhancing the resilience and security level of industrial and supply chains." Zeng Xian Kui^[1], a scholar from the Chinese Academy of Social Sciences, stated that "enhancing the resilience and security level of industrial and supply chains is not only a requirement for building a new development pattern but also an inherent requirement for serving high-quality development." It highlights that improving the resilience and security of industrial and supply chains is essential to supporting high-quality development and creating a new development pattern. It can be seen that enhancing supply chain resilience has a significant impact on China's development and is a crucial factor for achieving high-quality development in developing countries. However, how to enhance supply chain resilience is a significant challenge faced by China and the world. Cohen, M and Cui, SL^[2] found that supply chains have different resilience requirements and ways to achieve resilience. According to existing research, they can generally be divided into two categories: formal institutions and informal institutions. Within formal institutions, these include regional trade^[3] which only solely examines options for subsidizing manufacturers. Nonetheless, more data should be given regarding the synergistic impact of systematic analysis methodologies when it addresses government subsidies, national policies^[4], and Man Cheri's^[5] policies on China. Within informal institutions, examples include Cullinane and Joan Barrett's proposal of Mindful Organizing's impact on supply chain resilience, which discusses the influence of supply chain norms, credibility, and manufacturer relationships on supply chain resilience. Kwon^[6] proposed the relationship between business performance and supply chain resilience and looks at the relationship between supply chain resilience and business success and the antecedent factors that

influence supply network resilience. However, there needs to be integration of how formal and informal institutions jointly affect supply chain resilience. Consequently, this work makes a modest contribution to the existing body of knowledge by combining formal and informal institutions to investigate their impact on supply chain resilience. The aim is to provide a more robust theoretical foundation for future supply chain management tactics and to offer constructive policy recommendations for enhancing supply chain resilience by examining the relationships between these institutions. This study offers theoretical support for China in developing a more flexible and secure supply chain system in the context of the current global environment and provides valuable insights for other developing countries.

2. Theoretical Background

2.1. The Impact of Formal Institutions on Supply Chain Resilience

Existing research confirms that the two formal institutions leading to supply chain resilience can be divided into facility investment and institutional guidance. The government helps strengthen the resilience of agricultural product green supply chains, proposing the primary tasks of ensuring market supply and protecting the environment. Meanwhile, government subsidies enhance the resilience of high-tech enterprise supply chains. Furthermore, Yan Jun and Liu Dan^[7] studied the role of government institutions in safeguarding supply chain disruption events in sudden situations, confirming the importance of government policies in ensuring the development of supply chain resilience. Therefore, this research categorizes formal institutions into government subsidies and facility investments. Government subsidies can be interpreted as investments in infrastructure and financial resources, where infrastructure investments encompass establishing comprehensive and extensive data pilot zones and enhancing logistics capabilities^[8].

2.2. The Impact of Informal Institutions on Supply Chain Resilience

Existing research has confirmed that the informal institutions contributing to supply chain resilience are categorized as external and internal factors. As Jun pointed out, unexpected events significantly impact the stability of e-commerce supply chains. Social capital encompasses resources enterprises obtain within the supply chain network through reputation, status, trust, and commitments. They are enabling interdependent relationships among supply chain enterprises. According to Ali, Imran, Nagalingam, and Sev^[9], most risks originate from internal supply chain factors that necessitate strong collaboration. Yang, JH, and Liu, YY^[10] proposed relationship management based on this theory. Coskun, AE suggested the moderating role of information sharing in sustainable supply chain management. Alliance relationships are evaluated through e-commerce data indicators, such as Wang, Yuyao^[11], who considered cross-border e-commerce empowerment as an influencing factor of supply chain resilience, studying its impact on enhancing corporate supply chain resilience. Meanwhile, Hsieh and Chia-Chun^[12] proposed that external factors like geopolitics and economic disruptions influence supply chain resilience through environmental risks. Therefore, informal institutions are divided into external and internal factors. External factors can be understood as environmental risks, public trust, and social norms, while internal factors include alliance relationships.

3. Research Method

The qualitative comparative analysis (FsQCA) method aims to reveal the causal relationship between configurational conditions and outcomes through case comparisons. The reasons for adopting the FsQCA method in this paper are as follows: Firstly, this study focuses on the impact of five antecedent conditions related to formal and informal institutions on supply chain resilience. These antecedent conditions are interdependent and have multiple concurrent effects on the outcomes. Compared to traditional statistical methods, FsQCA can uncover the complexity of the causal relationship between provincial supply chain resilience and institutions. Secondly, FsQCA uses

Boolean algebra unlike regression methods, which does not lead to omitted variable bias. Thirdly, this study collects data for each variable, and both conditional and outcome variables are continuous. Compared to csQCA and mvQCA methods, FsQCA can better address the issue of partial membership in continuous variables. Additionally, FsQCA considers the subtle impacts of changes in antecedent conditions on the outcomes, as shown in Figure 1.

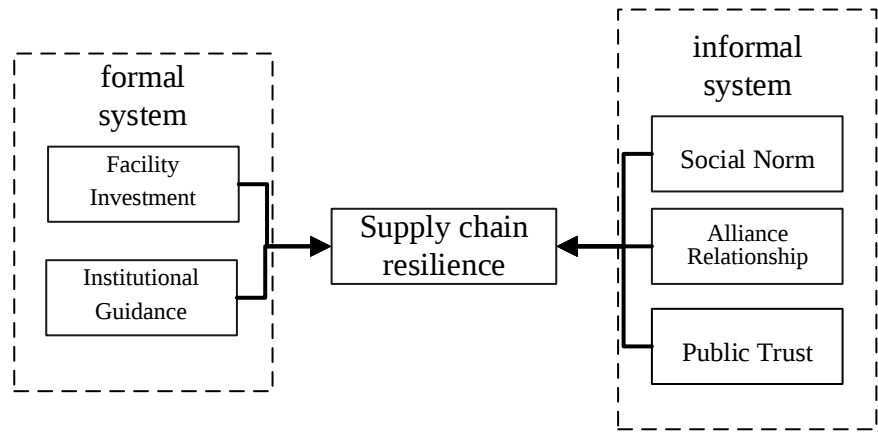


Figure 1: Configurational Model

3.1. Data Sources

The data sources for this paper are as follows:
(1) Measurement data for facility investment is derived from the "DID Data for 300 Prefecture-level Cities - National Big Data Comprehensive Pilot Zones (2000-2022)," which measures big data comprehensive pilot zones in 31 provinces and municipalities in China. (2) Measurement data for institutional guidance is sourced from PKULAW, which tallies the number of policy documents containing supply chain-related content for each province. (3) media responsibility and social trust data are measured using the Baidu Index. (4) Measurement data for alliance relationships is sourced from the Zhongli Database, including e-commerce data for various provinces.

3.2. Data Calibration

3.2.1 Evaluation Index System

Here is a chart showing the relationships between various factors, reference Table 1.

Table 1: Evaluation Index System for Supply Chain Resilience

Primary Index	Secondary Index	Index Explanation
Formal Institution	Facility Investment	Number of big data comprehensive pilot zones in each province
	Institutional Guidance	Number of policy documents containing supply chain-related content
Informal Institution	Social Norm	Frequency of media attention
	Alliance Relationship	E-commerce data
	Public Trust	Public Trust Public attention

3.2.2 Calibration

Calibration converts the original values of antecedent and outcome conditions into set membership scores. The direct calibration method calculates the values of the three calibration points for full membership, crossover point, and non-membership, which correspond to the original values' 95th

percentile, 50th percentile, and 5th percentile of the original values. The calibration results and descriptive statistics are shown in Table 2.

Table 2: Variable Calibration and Descriptive Analysis

Condition	Fuzzy Set Calibration			Descriptive Analysis				
	Non-membership	Crossover Point	Full Membership	Mean	Media	Std. Dev	Min	Max
Facility Investment	0.001	0.001	130.2	18.7	0.001	7.102	0.001	147
Institutional Guidance	0.6	9	31.6	10.967	9	1.552	0.001	40
Social Norm	499	8791	36100.8	12209	8896	1909.7	262	42951
Alliance Relationship	2266.6	33893.8	288366.6	61326.2	37128.31	14603.1	978.41	339075.9
Public Trust	22.6	140.5	301.2	151.67	141	12.655	13	360

4. Research Results

4.1. Necessity Analysis of Individual Conditions

Before conducting the fuzzy set truth table analysis, it is necessary to perform a necessity analysis of individual conditions. The results of the necessity analysis for high/non-high supply chain resilience are presented in Table 3. As shown in Table 3, the necessity levels of individual antecedent conditions influencing high/non-high supply chain resilience do not exceed 0.9; thus, they do not constitute necessary conditions.

Table 3: Necessity Analysis

Antecedent Conditions	High Supply Chain Resilience		Non-High Supply Chain Resilience	
	Consistency	Coverage	Consistency	Coverage
Facility Investment	0.93	0.61	0.78	0.84
~Facility Investment	0.75	0.68	0.64	0.94
Institutional Guidance	0.66	0.55	0.59	0.80
~Institutional Guidance	0.76	0.54	0.67	0.76
Social Norms	0.72	0.58	0.57	0.75
~Social Norms	0.69	0.50	0.68	0.79
Alliance Relationships	0.78	0.63	0.51	0.76
~Alliance Relationships	0.74	0.48	0.76	0.79
Public Trust	0.78	0.58	0.63	0.76
~Public Trust	0.69	0.53	0.65	0.82

Note: "~" represents the absence of a condition.

4.2. Configurational Analysis

This paper employs the FsQCA method to investigate the antecedent configurations of provincial supply chain resilience. The fuzzy-set Qualitative Comparative Analysis (FsQCA) method is appropriate for investigating the interactions among many conditional elements that lead to outcomes. It employs a comprehensive approach to analyze the mechanisms underlying complex issues arising from several simultaneous elements, addressing the shortcomings of conventional analytical techniques in assessing the synergistic impacts of various antecedent variables.

Following Ragin's approach, the frequency of sample cases in the combination is set at 1.5% of the total number of cases, i.e., the frequency threshold is set to 1 when constructing the truth table. Secondly, the original consistency threshold is set to 0.8, and the PRI consistency threshold is set to 0.7. Lastly, due to the lack of definitive theories and evidence regarding the direction of conditional influence on the outcome, this paper selects the "presence or absence" option for each condition during factual analysis. The FsQCA software generates complex, parsimonious, and intermediate solutions. This paper mainly reports the intermediate solutions and identifies conditions that appear in both the intermediate and parsimonious solutions as core conditions. In contrast, those only appearing in the intermediate solutions are identified as auxiliary conditions. Table 6 presents the configurational results, which include four high supply chain resilience configurations (S1, S2, S3, S4) and three non-high supply chain resilience configurations (NS1, NS2, NS3). The consistency levels of all configurations are more significant than 0.79, with overall solution consistencies of 0.884 and 0.792 and overall solution coverages of 0.794 and 0.748, indicating strong explanatory power.

Table 4: Configurations of Provincial Supply Chain Resilience Conditions

Antecedent Conditions	High Supply Chain Resilience				Non-High Supply Chain Resilience		
	S1	S2	S3	S4	NS1	NS2	NS3
Facility Investment	●	●	●	●	●	●	●
Institutional Guidance		●	●		●	●	
Social Norm	⊗	⊗	⊗	●	⊗	⊗	●
Alliance Relationships	⊗		⊗	●	●	⊗	●
Public Trust	⊗	⊗		●	⊗	●	●
Consistency	0.86	0.87	0.87	0.76	0.93	0.88	0.92
Raw Coverage	0.64	0.42	0.43	0.51	0.36	0.44	0.68
Unique Coverage	0.17	0.00	0.001	0.15	0.00	0.06	0.31
Overall Solution Consistency	0.79				0.88		
Overall Solution Coverage	0.79				0.75		

Note: ● represents the presence of a core condition, ● represents the presence of an auxiliary condition, ⊗ represents the absence of a core condition, ⊗ Representative auxiliary condition is missing, and a blank space indicates that a condition may or may not exist.

Configuration S1 indicates that high facility investment, non-high social norms, political alliances, and non-high public trust serve as the core conditions. This configuration suggests that regardless of whether a province's informal institutions possess social norms, alliance relations, or public trust capabilities, as long as the province can flexibly respond to emergencies and take effective facility investments in advance to cooperate, it can generate and maintain high supply chain resilience.

Provinces that exemplify this configuration include Guizhou, Heilongjiang, Shanxi, Guangxi Zhuang Autonomous Region, Tibet Autonomous Region, Xinjiang Uyghur Autonomous Region, Yunnan, Ningxia Hui Autonomous Region, Qinghai, Gansu, and Jilin. These provinces have relatively complete and sufficient measures in facility investment, which can enhance supply chain resilience.

Configuration S2 points to high facility investment, institutional guidance, non-high social norms, and non-high public trust as the core conditions. This configuration suggests that provinces with adequate facility investments and well-established institutional guidance within formal institutions can ensure resistance to supply chain risks.

A typical case illustrating this configuration is Guizhou Province, Tianjin, Guangxi Zhuang Autonomous Region, Jiangxi, Guangxi Zhuang Autonomous Region (mentioned again, possibly an error or emphasis), and Shaanxi. It is evident that these provinces not only have policies and systems capable of resolving various crises but can also quickly mobilize upstream and downstream resources through infrastructure during crises and formulate effective measures promptly.

Configurations S3 and S4 jointly indicate high facility investment, institutional guidance, non-high social norms, and non-high public trust as the core conditions.

This configuration suggests that provinces with informal institutions possessing alliance relations and public trust capabilities can help enhance supply chain resilience. As long as provinces can leverage public attention and cooperate with others through trust to resolve crises before emergencies, they can generate and maintain high supply chain resilience. Typical provinces for this configuration include Guizhou, Heilongjiang, Shanxi, Guangxi Zhuang Autonomous Region, Tibet Autonomous Region, Xinjiang Uyghur Autonomous Region, Yunnan, and Ningxia Hui Autonomous Region (partially repeated from earlier).

Configuration NS1 identifies high alliance relations, non-high public trust, and non-high social norms as the core conditions, with facility investment and institutional influence as marginal conditions. In the face of crises, provinces should prioritize alliance relations, respond rapidly, ensure prompt enhancement of risk prediction through alliance trust, and maintain a particular sensitivity to market environment changes. This can generate high supply chain resilience and maintain orderly supply chain operations.

Configuration NS2 highlights high public trust as the core condition, with facility investment, institutional influence, non-high alliance relations, and social norms as marginal conditions. (Note: There is some repetition in the description of NS2; it might be streamlined as "Configuration NS2 emphasizes high public trust as the core, with facility investment, institutional influence, and low alliance/social norms as marginal conditions.") During crises, enterprises can leverage public advantages, utilize public attention, enhance influence, increase sales channels, and rely on infrastructure and institutional strengths to resist supply chain fluctuations and maintain orderly operations.

Configuration NS3 identifies high alliance relations and public trust as the core conditions, with high facility investment and high social norms as marginal conditions. In crises, provinces can cooperate and respond rapidly with other provinces, ensuring prompt coordination. At the same time, provinces need a high level of public trust. They can generate high supply chain resilience and maintain orderly supply chain operations with facilities and norms in place.

Table 5: Typical Cases Corresponding to Configurations

Configuration	Configuration Naming	Typical Cases
S1	Facility-led	Guizhou Province, Heilongjiang Province, Shanxi Province, Guangxi Zhuang Autonomous Region, Tibet Autonomous Region, Xinjiang Uyghur Autonomous Region, Yunnan Province, Ningxia Hui Autonomous Region, Qinghai Province, Gansu Province, Jilin City
S2	Facility-Institution Dual-Drive	Guizhou Province, Tianjin, Guangxi Zhuang Autonomous Region
S3		Guizhou Province, Jiangxi Province, Guangxi Zhuang Autonomous Region, Shaanxi Province
S4	Facility-Society-Alliance Public Joint-Drive	Guangdong Province, Henan Province, Beijing, Shanghai, Liaoning Province, Hebei Province, Hunan Province, Hubei Province, Anhui Province, Shandong Province, Sichuan Province, Jiangsu Province, Fujian Province, Zhejiang Province
NS1	Alliance Relationship-led	Guizhou Province, Tianjin, Guangxi Zhuang Autonomous Region
NS2	Public Trust-led	Jiangxi Province, Guangxi Zhuang Autonomous Region, Shaanxi Province
NS3	Informal Institution-led	Guangdong Province, Henan Province, Beijing, Shanghai, Liaoning Province, Hebei Province, Hunan Province, Hubei Province, Anhui Province, Shandong Province, Sichuan Province, Jiangsu Province, Fujian Province, Zhejiang Province

5. Discussions

After analyzing six types of configurations and high versus non-high supply chain resilience in this study, this research has conducted a more profound analysis and interpretation of their deeper meanings. Next, this research will explain this study's contributions to current research.

Theoretical Contributions: This study provides theoretical contributions in multiple aspects. Firstly, by examining how different institutions affect supply chain resilience, this research has considered combining multiple institutions to study how they influence supply chain resilience. Through the interaction of formal and informal institutions, various factors are introduced. Six types of high and non-high supply chain resilience are combined, and this article offers new insights, hoping that future researchers can further investigate the impact of institutions on supply chain resilience. At the same time, this research anticipates driving the development of theory and the improvement of practical applications.

Practical contributions: This study provides practical suggestions for provinces to enhance their supply chain resilience. This research recommend that provinces prioritize the construction of comprehensive, extensive data pilot zones. This strengthens the development of emerging technologies in provinces and provides the necessary infrastructure for the supply chain, reducing the negative impact of supply chain disruptions. Simultaneously, attention should be paid to the influence of informal institutions to cope with shocks, such as the frequency of media attention, e-commerce data, and public attention, to study the constantly changing supply chain environment. Considering (S4), provinces should pay more attention to the joint impact of formal and informal institutions on supply chain resilience, enhancing supply chain resilience through both approaches.

6. Conclusions

This study provides practical suggestions for provinces to enhance their supply chain resilience. This research recommends that provinces prioritize the construction of comprehensive, extensive data pilot zones. This strengthens the development of emerging technologies in provinces and provides the necessary infrastructure for the supply chain, reducing the negative impact of supply chain disruptions. Simultaneously, attention should be paid to the influence of informal institutions to cope with shocks, such as the frequency of media attention, e-commerce data, and public attention, to study the constantly changing supply chain environment. Considering (S4), provinces should pay more attention to the joint impact of formal and informal institutions on supply chain resilience, enhancing supply chain resilience through both approaches.

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