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How Does the Business Environment Shape Digital–Green Synergy? A TOE-Based fsQCA of Chinese Cities

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Article

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How Does the Business Environment Shape Digital–Green Synergy? A TOE-Based fsQCA of Chinese Cities

Abstract： Digital–green synergy is essential for quality urban development and long-term sustainability.Previous work has focused on net effects of technological investments on the environmental performance. Few studies have considered how multiple aspects of the business environment play an important role in supporting digital–green synergy. Using TOE model we develop a configurational model to explain how business environment conditions jointly shape urban digital–green synergy. Using data from 272 prefecture-level cities in China, we apply fuzzy-set qualitative comparison analysis (fsQCA) to assess the necessity of individual conditions and find configurations of high levels of digital–green synergy.The results yield three main results. First, no single business environment condition can lead to high digital–green synergy.Rather, high digital–green synergy results from interdependence of multiple conditions. Second, five different configurations can lead to high digital–green synergy,which implies equifinality and complexity of the causal mechanism. Third, when the digital infrastructure is underdeveloped, strong legal protection, market dynamics and a supportive innovation environment can partially compensate technological constraints. This implies substitution between the institutional environment and the technological foundation.We find that there is no universally optimal route to urban digital–green synergy. Cities should identify conditions that constrain their digital and green transformation and choose different strategies according to their technological foundation, institutional capacity, and development stage. By extending the configuration logic of the TOE to urban digital–green development,we canunderstand how business environment conditions combine to produce equivalent development results and practical implications for cities in China and other regions facing similar development challenges.

Keywords: Digital–Green Synergy; Business Environment; TOE Framework; Urban Sustainability

1. Introduction

Digital–green synergy is becoming an important way to address the tension between urban growth and resource and environment constraints. It can also transform systemic development patterns (H. Lu et al., 2026; Zeng et al., 2025). By integrating digital technologies such as big data and artificial intelligence into energy management, industrial production, and public governance (Zhang et al., 2025; Zheng et al., 2026), cities can leverage digital technologies for information integration, intelligent coordination, innovation , resource allocation, energy efficiency, industrial restructuring, and environmental governance (Yan and Liu, 2025; Zheng et al., 2026). In turn, cities can reduce resource and environment costs while supporting economic growth .The digitalization and greenisation process is growing worldwide. According to Global Digital Trade Development Report 2025 by UNITTC, the global value of digital trade exports increased from US4.59 trillion 2020 to US7.23trillion 2024. This indicates that digital technologies are increasingly embedded in global production and trade systems, while energy systems are shifting towards renewable and low-carbon sources. According to the International Renewable Energy Agency Renewable Capacity Statistics 2026, global renewable capacity additions reached 692 gigawatts in 2025, a 15.5% year-on-year increase. Total installed renewable capacity increased to 5149 gigawatts. The digital economy expansion and rapid growth of renewable energy provide important foundations for digital–green synergy.Digitalization and green transformation can also be combined in parallel but not in the same way. Digital technologies can promote green transformation but also create additional resource and energy demands. According to the International Energy Agency, data centers consume around 485 terawatt hours of electricity in 2025, which is 1.5% of electricity demand in the world, and will double by 2030. The rapid expansion of data centers and clusters could therefore make digital infrastructure a significant source of energy consumption and carbon emissions. These developments show that digital–green synergy is neither automatic nor unconditional. A city can successfully integrate digitalization and green transformation under different conditions such as technological capability, industrial structure, organisation and institution. Of these conditions, the business environment may play a key role. As a key institutional setting shaping firm behavior, resource allocation and industrial transformation, the business environment may influence digitalization and green practices.

Some studies on digitalization and green transformation have developed in two directions. First, the effects of digitalization on green development are examined. Most studies argue that digitalization can improve energy efficiency and environmental governance by information integration, precise monitoring and intelligent decision making (Bai et al., 2025; He et al., 2024; Lu and Li, 2024; Xiao et al., 2025; Xu et al., 2024).Others argue that digitalization may also increase energy consumption and carbon emissions, produce energy rebound effect and constrain green transition (Ma and Zhang, 2025; Qian et al., 2025; Tu and He, 2026). These results suggest that environmental consequences of digitalization are complex and depend on how digital technologies are deployed. The second section focuses on the link between digitalization and green transformation, also known as digital–green synergy. Studies in this area have identified many drivers and effects of urban digital–green synergy such as urban agglomeration development (Liu and

Sun, 2026) and financial technology (Meng et al., 2025). Other studies have examined consequences of digital–green synergy such as new quality productive forces (Shan et al., 2025), reduced carbon emissions (Liu et al., 2025), innovation in key and core technologies (Zheng et al., 2026), and supply chain resilience(Zhang et al., 2026). Overall, existing studies have made significant progress in finding drivers and evaluating effects of digital–green synergy, and provide the basis for this paper.

The business environment has been a topic of much attention in studies of urban development and firm behavior. We know that better business environment can improve industrial-chain resilience (Zheng et al., 2025), improve firm resilience (Wang and Zhang, 2025), reduce government financing costs (Li et al., 2026), and increase the share of labor income (Lai et al., 2024), but we focus on general economic effects of business environment optimization, and less on how different business environment dimensions combine with other conditions to produce complex urban development outcomes. We therefore need a configurational view to study how these conditions combine to shape digital–green synergy.

Three limitations remain: First, the net effect of individual factors is limited. This is not enough to explain digital–green synergy as a configuration result of multiple conditions.In particular, the joint effects and alternative paths by which different conditions lead to similar results are not explored. Second, the role of business environment is rarely discussed in digital–green synergy research.In general, the role of business environment is treated as a general institutional indicator and its direct impact on urban development, firm innovation, or environmental performance is not investigated. This may obscure different roles of its dimensions. The business environment has many dimensions. Market conditions, government services, legal protection and innovation support are, among other things, market conditions, government services, legal protection, innovation support. The two dimensions can operate independently, strengthen one another or compensate weaknesses in other conditions. Third, limited studies have investigated how business environment conditions interact with technological, organizational, and government factors in urban digital–green synergy.

To address these issues we use fuzzy-set qualitative comparative analysis (fsQCA) to analyze how different dimensions of business combine with technological, organizational and environment conditions to promote urban digital–green synergy. We use TOE analysis to analyze multidimensional conditions in digital–green development. We analyze 272 prefecture-level cities in China in order to determine necessary conditions and causal conditions for high levels of digital–green synergy, and compare the paths to high and low levels of synergy. This paper provides three contributions. First, it broadens the research focus on urban digital–green synergy. Previous studies have focused on the effect of digitalization on green development, while the joint development of urban digitalization and green transformation has been relatively neglected. Cities are important transporters of technology application, industrial transformation, and environmental governance. Digitalization and green transformation are not separate processes at the urban level. They are interconnected systems, characterized by reinforcement, conflict and substantial variation between regions. By combining both processes into a single analytical framework, we provide new evidence on interaction and configurational differences between urban digitalization and green transformation. Second, we introduce multidimensional business environment into a single structure. In contrast to the traditional estimation of marginal effect of one factor, fsQCA allows us to identify multiple concurrent causal conditions, equivalent pathways and causal asymmetry, thereby explaining how different business environment dimensions together influence urban digital–green synergy, and extend research on economic effects of business environment beyond economic growth and firm performance.Specifically, we conceptualize business environment as a new institutional explanation of complex urban transformation and offer new institutional explanation of differences in digital–green synergy among cities. Third, we apply the TOE framework to urban digital–green transition: technological, organizational and environmental conditions may influence the digital–green synergy. It provides a systematic basis for selecting explanation conditions and addresses the fragmentation of factor selection found in some previous studies. By applying the TOE framework configurationally, we show how cities can achieve high digital–green synergy and under which conditions institutional strengths can compensate for technological limitations. The results are useful for Chinese cities and other regions facing similar challenges to combine digital transformation with green development.

2. Theoretical Background and Analytical Framework

2.1 The TOE Framework

Urban digital–green synergy is not a simple combination of digital technology and environmental governance, but rather a systemic transformation driven by multiple factors. On the one hand, digital technologies can support urban green transformation, information identification, real-time monitoring and process redesigning, improve resource use efficiency and environmental governance (Qin et al., 2024; B. Wu et al., 2025), Green development goals can redirect technological innovation towards energy management, clean production and low carbon governance, and new applications of digital technologies (S. Zheng et al., 2025).The integration of digitalization and green transformation requ

ires more than technological inputs. It also requires organizational resources (human capital and governance capacity) , external conditions (market competition and legal protection), etc. Urban digital–green synergies are result of intera ction between technological, organizational and environmental conditions.The TOE model provides a suitable mode l for studying these interactions. In particular, it proposes that technological innovations are adopted, applied and dist ributed jointly under conditions of technology, organisational capacities and environment (Alnoor et al., 2025; Bench is et al., 2025). We provide an unit for examining how technological resources, organizational capacities, and enviro nmental conditions jointly shape complex transformation outcomes (He et al., 2025; Luo et al., 2026).This logic allo ws us to apply TOE to urban digital–green synergy. In terms of technology we mean infrastructure and innovation vit ality, in terms of organization we mean human capital and governance capacity, in terms of environment we mean leg al environment and market vitality, thus allowing us to investigate both the roles of each of these conditions and how they promote urban digital–green synergy together.

2.1.1 Technological Dimension

The technological dimension captures material and knowledge underlying urban digital–green synergies.Achievi ng such synergies requires digital technologies to be applied to energy use, pollution control, industrial production an d public governance, and infrastructure for technological development, transmission and commercialization of innova tion outcomes (Shen et al., 2026; Wen et al., 2026). Lack of infrastructure may raise costs for adopting digital and gre en technologies, reduce interoperability across technological systems, and weaken the contribution of digitalization to green transformation.

(1) Infrastructure Conditions

Infrastructure conditions refers to basic facilities, production factors, and public services that support business o perations and technology development. These include water and electricity supply, land availability, information net works, and transportation (Biswas et al., 2022; Hu et al., 2026; Lu et al., 2026). Water, electricity, land and land are e ssential to the daily operations of firms and technological improvement and project implementation. Information net works collect, transmit, and process production and environmental data. Transportation systems facilitate the movem ent of products, equipment, professionals, knowledge and technologies. Together, these elements form the material b asis of urban digital and green transformation.

Stable supply of basic production factors reduces uncertainty in business operations and project implementation (Wang et al., 2023) ,and reduces additional costs caused by resource shortages and supply disruptions. Stability stren gthens firms' ability and willingness to invest long-term technologies. Proper land and energy allocation also support s data centers, renewable energy facilities and green factories. This enables the coordination of digital infrastructure a nd green production facilities. Under such conditions firms are better able to use digital technologies in energy manag ement, production, pollution control.Information networks are another important mechanism. High speed and reliable connectivity improves the collection, transmission and processing of production and environmental data (Yang and Zhang, 2025). Firms can use these data to monitor production activities, energy consumption, pollutant emissions, an d enable equipment optimization, production scheduling, energy allocation. For local governments, network infrastru cture allows the sharing of dispersed environmental information and data between departments, which improve energ y-intensive activities and highly polluting activities, support targeted regulation (Gong et al., 2026; Sun et al., 2024). Better information transmission reduces costs to obtain green technologies, market information and environmental sta ndards.Transportation infrastructure has a major role in factor mobility and knowledge dissemination. It reduces the c osts of personnel exchanges, equipment transportation and technical services. It also strengthens connections between firms, professionals, research institutions and external markets (Chen et al., 2025; He and Jia, 2026). Advanced equi pment, external knowledge, and innovative solutions can enter local markets faster. Interorganizational exchanges, de monstration effects, and collaborative innovation further accelerate the digital and green technologies integration. Th ey also promote their use in clean production, green logistics, low carbon transportation, and public governance.

(2) Innovation Vitality

Innovation vitality is the city's ability to generate knowledge, develop technologies, and commercialize innovati on results (S. Zheng et al., 2026).In this paper, it is represented in terms of R&D investment and patent output. R&D investment provides financial and knowledge resources to integrate digital and green technologies. Patent output is so metimes the accumulation of technological capabilities and codified innovation outcomes. Acknowledgements and re combinations are strengthened by supporting innovation (Li et al., 2024). Research and development investments allo w firms to use big data, artificial intelligence and Internet of Things to improve energy management, pollution detecti on and green manufacturing. These applications improve the visibility and control of production processes. They help firms to identify inefficiencies and environmental risks better.Knowledge accumulation and patent creation can redu ce the cost of innovation following a patent, and it can also spread technological achievements among firms and indu stries. When a city has a strong innovation base, digitalization is no longer limited to general information processing

or incremental process optimization, but embedded in green technology development, clean production and low-carb on governance.

2.1.2 Organizational Dimension

At the firm level, the organisational dimension of TOE usually refers to size, structure, and availability. When m oving to the urban level, city capacity is defined as the ability to mobilise human, information and public services res ources into development capability. In this context, urban digital–green synergy includes governments, firms, univers ities, research institutes and professional service organisations, which means that knowledge exchange and resource c oordination between these actors are required. Moreover, human capital and governance capacity determine how a cit y can organise such interaction.

(1) Human Capital

Human Capital cultivate and allocate professionals. They are also intellectual support for technological innovati on and industrial transformation (Li et al., 2024). Digital–green integration is knowledge intensive, technologically c omplex and interconnected. It requires skills in digital technology and environmental engineering, but also in busines s management, public governance and financial services. Strong human capital base improves the city's capacity to id entify, absorb and apply digital and green technologies. High skilled professionals help firms choose appropriate tech nologies, shorten learning and adjustment time of new equipment and technologies, and lower experiment costs. Prof essional exchanges between firms, researchers, universities and public agencies also facilitate the recombination of di gital and green knowledge. Such exchanges support intelligent energy management, digital environment monitoring, and green supply chain management. Professionals further contribute by operating equipment, optimizing production processes and improving organizational management, translating informational advantages of digital technologies int o tangible environmental results, namely lower energy consumption, higher efficiency and reduced pollutant emissio ns. Human capital affects both technology adoption and conversion of digital investment into green results.

(2) Governance Capacity

Governance capacity refers to the institutional and administrative conditions created by local governments throu gh public services, administrative processes, coordination of resources and restrictions on the exercise of administrati ve power. Urban digital–green synergies involve infrastructure construction, technological upgrading, environmental regulation, public data access and land/energy allocation. These activities involve many participants and require a lot of coordination between departments. Efficient, transparent and standard government services can reduce the instituti onal transaction costs faced by firms during digital/green transitions. Governance capacity promotes digital–green sy nergies by reducing administrative costs, resource coordination and predictable policy implementation. E-governmen t services can simplify project approval, policy applications, and access to public services, and can facilitate sharing o f government information and public data, thereby reducing firms' information acquisition and administrative compli ance costs (X. Chen et al., 2025). Strong government responsiveness and coordination can improve land, energy, capi tal, data and technology allocation. They support digital infrastructure projects and green technological upgrading. Tr ansparent and rule-based governance also reduces uncertainty in decisions, stabilizes firms' investment expectations and limits the use of resources from productive investment to nonproductive use. Firms can thus devote more resourc es to R&D, digital upgrading and green transformation.

2.1.3 Environmental Dimension

The environmental dimension reflects external institutional and market conditions surrounding urban digital–gre en transformation. Digital and green technologies are integrated not only on a city's technological and organizational strengths but also on property rights, contract enforcement, factor mobility, market competition, stable law regulates market behavior, reduces cooperation risks, supports data sharing, technology transactions, cross-organizational proje cts. Strong market vitality attracts capital, talent and professional services, and also promotes technology diffusion thr ough entrepreneurship, competition, openness.

(1) Legal Environment

The legal environment reflects a city's capacity to provide legal services, protect intellectual property rights, enf orce contracts, and maintain a stable social and commercial order. It can promote digital–green synergy through two principal mechanisms.

First, a good intellectual property protection and accessible legal services clarify ownership of patents, data and t echnological results and also define environmental responsibility. More clarity reduces the risk of technological infri ngement and collaboration between organizations and thus increases firms' incentive to conduct long-term research a nd collaboration (Han et al., 2025). Second, reliable contract enforcement and a stable commercial order constrain op portunistic behavior and reduce nonproductive transaction costs. Digital–green projects often involve sustained invest ment, data exchange, and benefit sharing among multiple actors. Legal predictability supports these long-term arrang ements and provides an institutional foundation for cooperation.

(2) Market Vitality

Market vitality reflects the extent to which market actors can enter and expand, obtain resources, participate in competition, and establish external connections. It promotes urban digital–green synergy through resource provision and demand creation. Acquiring financing and well-developed producer services can help firms achieve funding and professional difficulties for R&D, equipment acquisition, green technological upgrading, integrated digital–green solutions (S. Wu et al., 2025; Zhang et al., 2024). Financial institutions, consulting firms, technology intermediaries and other professional services help firms evaluate technologies, manage risks, and implement complex transformation projects. Entrepreneurship, market competition, openness and openness create demand for digital and green technologies. Competition pressure encourages firms to cut production costs, improve energy efficiency, and differentiate products through environmentally responsible practices. Entrepreneurship introduces new business models and technological solutions. Openness facilitates technological flow, capital and managerial knowledge. Together, these mechanisms promote technological diffusion through demonstration effects, supply chain collaboration and knowledge spillover.

2.1.4 Configurational Effects of TOE Conditions

The TOE framework explains technology adoption and its outcomes through the joint influence of technological, organizational, and environmental conditions. Following this multidimensional logic, this study conceptualizes urban digital–green synergy as a configurational outcome. Its emergence depends on how technological foundations, organizational capacities, and external environmental conditions interact. Infrastructure conditions and innovation vitality are the technological foundation. They provide physical carriers and knowledge resources for developing and applying digital and green technologies. Human capital and governance capacity are the organizational dimension. They shape cities ability to absorb technologies, coordinate resources, and deliver public services. Legal environment and market vitality are the environmental dimension. Intellectual property protection, contract enforcement, financing support, market competition influence firms' expected returns from innovation and willingness to make sustained investments. These conditions will likely complement each other and substitute each other. A strong technological foundation may lead to limited results without skilled professionals and governance. An organizational capacity may not sustain innovation without legal protection and market demand. Competition in the market and incentives require adequate technologies and coordination abilities before they can translate into higher energy efficiency and better environmental performance. At the same time, strengths in one dimension may partially compensate weaknesses in another. For example, strong legal environment, dynamic markets and well-functioning governance may reduce transaction costs and mobilize external resources when local infrastructure is underdeveloped. On the other hand, high infrastructure and high innovation vitality may enable digital–green transformation even when some institutional conditions are less favorable. These relations involve causal complexity, equifinality and asymmetry. No condition is expected to be sufficient or universally required for high digital–green synergy. Accordingly, we design a configuration of how business environment conditions shape urban digital–green synergy through two interrelated processes: resource allocation and innovation activity. The TOE dimensions are not isolated; rather different combinations of technological, organizational and environment conditions may produce similar levels of digital–green synergy. We theoretically base our analysis on fsQCA.

3.empirical design

3.1 Research methods

FsQCA is a qualitative and quantitative research method using set theory and Boolean algebra. Comparing the combinations of the condition combinations of different cases, the complex causal relation between multiple antecedent conditions and result variables is found.Unlike traditional regression analysis which focuses on the independent net effect of a single variable on the result variable, the linkage effect between multiple conditions can reveal complex phenomena. Urban digital green collaboration is the result of multiple conditions. Business environment elements like infrastructure, human capital, government services, legal guarantee, market vitality and innovation ability are not isolated from each other but are interdependent and synergistically influencing urban digital green collaboration. Depending on the resource endowment, development stage and institution, the conditions for different cities to achieve high-level digital green collaboration are not consistent, and one condition can change due to existence of other conditions. Therefore, one condition is not necessary condition for high-level digital green collaboration, and it is difficult to form sufficient conditions alone. Different antecedent conditions may form equivalent realization paths in different ways. Based on this situation, urban digital green collaboration has obvious causal complexity and path diversity, and it needs to investigate the joint impact of multiple business environment conditions from configuration perspective.

Based on this, we used the fsQCA method, taking urban digital green collaborative level as the result variable and infrastructure environment, human capital environment, government environment, law environment, market vitality environment and innovation environment as the six antecedents. From the configuration point of view, we investigated collaborative linkage and substitution relationship between different business environment dimensions and identifi

ed multiple realization path of high urban digital green collaborative level. Finally, we studied condition configuratio n leading to the level of digital green collaboration in non high cities to test causality of high digital green collaborati on formation mechanism and non high digital green collaboration formation.

3.2 research samples and data sources

The research samples are selected according to the city scope in the previous article, and the validity, availabilit y, and consistency of statistics are considered. First samples are selected and finally city cases are formed. Since the i mpact of urban business environment on collaborative development of digital and green has some conduction process and time lag, this paper uses the research design of lag period on time matching variables, which is, the urban busine ss environment data in 2023 is selected as the previous condition variable and the urban digital green collaborative le vel in 2024 as the result variable. The conditions variables are infrastructure environment, human capital environmen t, government environment, legal environment, market vitality environment and innovation environment. The base in dicator data are from China urban business environment database 2025 (Zhang et al., 2025). The result variable is th e urban number green collaborative level in 2024. Data obtained from public channels using Internet crawler technol ogy, and obtained after data cleaning, city matching and standardization.

3.2 variable description

3.2.1 result variable: Urban Digital Green collaborative level

In this paper, we take the urban digital green collaborative level as the result variable. Urban digital green collab oration is mutual empowerment, mutual promotion and coordinated evolution between urban digital development and green development. Digital infrastructure, digital technology application and digital industry can promote informatio n sharing and resource optimization, energy utilization efficiency and environmental governance improvement, techn ical support urban green low carbon development; Green development requires that digital technology can promote e nergy saving and carbon reduction, clean production and environmental governance, and urban digital development t o form greener low carbon development mode; Urban digital green cooperation emphasizes not only the superpositio n of digital level and green level, but the development matching degree and collaborative level between the two syste ms. In this paper, according to the number of digital and green word frequency constructed, urban digital developmen t level and green development level are calculated respectively, and urban digital green collaborative index is calculat ed using coupling collaborative degree model. Higher the index, the more the level of interaction and coordinated dev elopment between urban digitalization and greening is; In contrast, it indicates that there may be imbalance in develo pment, insufficient integration or low conversion efficiency between the two systems.

3.2.2 condition variable: business environment

Based on the current work (Zhang et al., 2025), and our own research situation , we measure the conditions of si x dimensions: infrastructure, human capital, government environment, legal environment, market vitality and innovat ion environment.The six conditions are measured not directly by one index, but by choosing two level indicators acco rding to the dimension names.The measurement method is as follows.

(1)Infrastructure.

The variable contains five indicators of water supply, power supply, land supply, network and transportation ser vice. The water supply measures water supply percentage ratio to population population, power supply percentage pe rcentage to population population of household registration population, supply area of commercial land percentage to population of household registration population, network percentage of households with Internet broadband access t o population resident population, transportation percentage of freight and passenger volume.

(2)Human capital.

Measured by the number of college students, it mainly reflects the scale of urban higher education talents and th e supply capacity of potential talents.

(3)The government environment.

The variable comprises five indicators: government care, government size, electronic service level, government i ntegrity, and ratio of fines and confiscations. The degree of government care measures the government care index, go vernment scale measures the ratio of general public budget expenditure to GDP, electronic service level measures the electronic service ability index, government integrity measures the government integrity index, confiscated income measures the ratio of taxes to taxes.

(4)The rule of law environment.

The variable consist of four indicators: administrative adjudication of patent disputes, 10 000 criminal cases, la w firms and contracts, the administrative adjudication of patent disputes being the ratio of number of patent infringe ment disputes to number of patent authorizations, criminal cases being a 10000 person problem of law (the ratio of nu mber of criminal cases to number of resident population), legal services being provided by number of law firms, and contract disputes being the ratio of number of contract disputes to GDP.

(5)Market vitality.

The variable contains four variables: financing level, leasing and business service industry development, trade dependence, foreign investment and foreign investment. Financement level is measured by the ratio of balance of deposits and loans of banks and banks to the registered population, development of leasing and business services is measured by the ratio of number of employees of related industries to the registered population, trade dependence is measured by the ratio of foreign economic and trade volume to GDP and foreign investment proportion is measured by the ratio of number of Hong Kong, Macao and Taiwan and foreign investment enterprises to the number of Industrial Enterprises above the indicated size.

(6)Innovation environment.

The variable comprises four components: number of patents, R&D investment, enterprise brand establishment and number of start-ups. Patent number measures the ratio of number of patent authorizations to household registration population, science and technology investment measures the ratio of science and technology expenditure to household registration population, enterprise brand establishment measures the ratio of number of trademark registrations to household registration population, number of entrepreneurial enterprises measures the number of enterprise registrations. This paper selects the basic indicators according to the meaning of each dimension and uses the entropy weight method to achieve objective power. Based on the information difference degree of each indicator, weights and weighted score of each indicator are calculated and the score of each indicator according to the same dimension sums up to obtain the whole level of six condition variables.

Table 1: Evaluation Index System for Business Environment in Chinese Cities

Indicator	Secondary Indicator	Measurement	Data Source
Infrastructure	Water Supply	Total water supply / Population with access to water	China Urban Construction Statistical Yearbook
	Electricity Supply	National electricity consumption / Registered population	China Economic Information Network
	Land Supply	Floor space of commercial buildings sold / Registered population	China City Statistical Yearbook
	Network	Number of internet broadband access subscribers / Registered population	China City Statistical Yearbook, China Economic Information Network
	Transport Services	Freight volume and Passenger volume	Statistical Bulletins of National Economic and Social Development of each city, China Economic Information Network
Human Environment	Human Capital	Number of university students	China City Statistical Yearbook
Government Environment	Government Care	Government Care Index	Report on the Business-Government Relations in Chinese Cities
	Government Size	General public budget expenditure / GDP	EPS Database
	E-service Level	E-service Capacity Index	"Report on the Government E-Service Capacity of China"
	Government Integrity	Government Integrity Index	"Report on the Government E-Service Capacity of China"
	Ratio of Penalty Income	Penalty income / Tax revenue	Financial reports of each city, Provincial statistical yearbooks
Legal Environment	Administrative Adjudication of Patent Disputes	Number of patent infringement dispute adjudications	China Judgments Online
	Patent Grants	Number of patent grants	China Judgments Online

	Criminal Cases per 10,000 People	Criminal cases / Registered population	China Judgments Online
	Law Firms	Number of law firms	Qichacha
	Contract Disputes	Number of contract disputes / GDP	China Judgments Online
	Financing Level	Deposits and loans scale of financial institutions / Registered population	China City Statistical Yearbook
	Leasing and Business Services	Number of employees in leasing and business services / Registered population	Provincial statistical yearbooks, EPS Database
Market Vitality	Trade Dependence	Foreign economic trade / GDP	China City Statistical Yearbook, China Economic Information Network
	Foreign Enterprise Ratio	Number of enterprises with foreign investment (from Hong Kong, Macao, Taiwan, and foreign direct investment) / Number of industrial enterprises above designated size	China City Statistical Yearbook, China Economic Information Network
	Patent Volume	Number of patent grants / Registered population	China City Statistical Yearbook
Innovation Environment	R&D Investment	Science and technology expenditure / Registered population	China City Statistical Yearbook
	Corporate Brand Establishment	Number of registered trademarks / Registered population	China Trademark Office (China Trademark Website)
	Number of Startups	Number of startups	Qichacha

4. Empirical Results and Analysis

4.1. Calibration of the Outcome and Antecedent Conditions

This study employs the direct calibration method to transform the raw data into fuzzy-set membership scores ranging from 0 to 1. The antecedent conditions include the infrastructure environment (X1), human capital environment (X2), administrative environment (X3), legal environment (X4), market vitality (X5), and innovation environment (X6). Following calibration methods from the fsQCA literature , we set three qualitative anchors for each variable : 95th , median, 5th（Ragin, C , 2008） . Cases with membership score equal to 0.5 cannot be marked as members or non-members of a set. Cases with score equal to 0.5 are adjusted to 0.01 in order to exclude them from the set-membership analysis. Table 1 shows the calibration anchors for the result and antecedent conditions.

Table 1. Calibration of Variables (N = 272)

Variable Name	Full Membership	Calibration	Crossover Point	Full Non-membership
Outcome Variable	Y	0.7491	0.5597	0.3162
Condition Variables	x1	0.0348	0.0158	0.0064
	x2	0.0328	0.0027	0.0004
	x3	0.0561	0.0213	0.0052
	x4	0.0449	0.0127	0.0047
	x5	0.0207	0.0084	0.004
	x6	0.0593	0.0084	0.0025

4.2. Necessity Analysis of Individual Conditions

Before calculating the configuration, we tested whether any single condition was needed to achieve high urban digital–green synergy. The results are shown in Table 2. These conditions were infrastructure environment (X1), human capital environment (X2), government environment (X3), legal environment (X4), market vitality (X5) and innovation environment (X6).Set-theoretically, a condition must exist when it is always present or almost always present whenever the result occurs.

We used fsQCA 3.0 to evaluate whether necessary is necessary or not. We considered necessity in terms of consistency and coverage. Consistent is the number of cases with the outcome that are a subset of cases with the condition. Coverage is the number of cases with the outcome-set that are covered by the condition. Following the standard QCA consistency threshold, a condition is necessary if its consistency score is equal or greater than 0.90.

The consistency scores for infrastructure environment (X1), human capital environment (X2), government environment (X3), legal environment (X4), market vitality (X5) and innovation environment (X6) are 0.90. The consistency scores for the absence of any condition are 0.90.Neither the presence nor the absence of any condition is required to achieve high urban digital–green synergy. These results indicate that high digital–green synergy is not attributed to any aspect of the business environment, but rather to a combination of multiple conditions. This results supports the use of configurational analysis to identify alternative combinations of conditions of high urban digital–green synergy.

Table 2. Necessity Analysis of Individual Conditions (N = 272)

Condition Variable	Y		~Y	
	Consistency	Coverage	Consistency	Coverage
X1	0.688	0.717	0.602	0.643
~X1	0.658	0.618	0.735	0.707
X2	0.645	0.767	0.544	0.663
~X2	0.717	0.606	0.808	0.7
X3	0.647	0.709	0.589	0.662
~X3	0.692	0.622	0.741	0.682
X4	0.644	0.722	0.563	0.647
~X4	0.685	0.605	0.758	0.686
X5	0.615	0.677	0.612	0.689
~X5	0.717	0.643	0.713	0.655
X6	0.628	0.748	0.529	0.646
~X6	0.703	0.593	0.794	0.686

4.3. Sufficiency Analysis of Causal Configurations

4.3.1. Configurations for High Digital–Green Synergy

(1) Institutional-Capacity Compensation

Human capital, legal environment, and innovation environment jointly support high digital–green synergy when market vitality is weak. These conditions compensate by strengthening technological capabilities, reducing institutional uncertainty, and matching digital technologies with green production needs. Harbin illustrates this pathway. Through digital transformation, Dongan Auto Engine increased the connectivity rate of key equipment to 70% and production efficiency by 30%, while reducing energy consumption. Harbin Electric Corporation established digital research and design platforms for clean energy equipment, while university technology-transfer activities supported intelligent manufacturing, energy savings, and emission reductions. Human capital enables firms to pursue digital transformation and green upgrading simultaneously; legal protection stabilizes investment expectations; and the innovation environment facilitates technology matching and commercialization. Together, these conditions allow digital capabilities and efficiency gains to support green development despite limited market vitality. The corresponding results are presented in Column 1 of Table 3.

(2) Resource-Endowment Coordination

This configuration combines infrastructure, human capital, government environment, and innovation environment. It has the highest raw coverage among the five configurations, indicating the broadest empirical relevance. Unlike Configuration 1, this pathway relies on complementary resource advantages connected through government coordination. Shanghai exemplifies this configuration. Its communication networks, computing facilities, and industrial Internet support cross-sector data flows, while universities and research institutes provide interdisciplinary talent. Government coordination reduces transaction costs through public data sharing, administrative approval reform, and interdepartmental collaboration. For example, Pudong's "one industry, one license" reform reduced approval times by nearly 90% and application materials by almost 70%. Shanghai's "AI + energy and carbon" platform also connects government management, enterprise services, green manufacturing, and talent recruitment. These arrangements translate infrastructure and knowledge resources into practical applications, creating a reinforcing cycle of infrastructure provision, talent support, government coordination, and innovation commercialization. The corresponding results are presented in Column 2 of Table 3.

(3) Market-Oriented Resource Endowment

Configuration 3 combines infrastructure, human capital, market vitality, and innovation environment. It differs from Configuration 2 in that market vitality serves as the coordinating force. Beijing illustrates this pathway through it

s developed digital infrastructure, concentrated research resources, and active technology market. Its universities and technology firms support innovation in artificial intelligence, big data, and cloud computing, while market demand encourages applications in traffic management, building energy management, and environmental monitoring. Infrastructure lowers technology application costs, human capital supports development and absorption, and the innovation environment facilitates experimentation and commercialization. Market vitality directs these resources toward productive applications through price signals, competition, and financing. Configurations 2 and 3 therefore demonstrate equifinality: similar resource endowments can support high digital–green synergy through either government coordination or market allocation, depending on local governance capacity and market structure. The corresponding results are presented in Column 3 of Table 3.

(4) Institutional–Market Substitution

This configuration shows how legal environment, market vitality, and innovation environment can jointly compensate for weak infrastructure by reducing transaction costs, improving resource allocation, and supporting technology adaptation. Ji'an exemplifies this pathway. Its administrative law enforcement relief measures and dispute resolution mechanisms reduce compliance costs and contractual uncertainty. Market competition encourages firms in its electronic information industry to upgrade production, while projects such as Xiajiang County's zero-carbon logistics platform connect digital applications with emissions reduction. Local innovation initiatives and high-tech enterprises further support technology absorption and diffusion across industrial clusters. This pathway suggests that resource-constrained cities can advance digital–green transformation through institutional improvements, competitive incentives, and the adaptation of external technologies. These mechanisms form a reinforcing cycle in which institutions activate competition, competition stimulates technological demand, and demand encourages innovation. The corresponding results are presented in Column 4 of Table 3.

(5) Soft-Environment Support

Configuration 5 combines human capital, government environment, legal environment, and market vitality, with infrastructure playing a supporting role. It suggests that strong local original innovation is not a prerequisite for high digital–green synergy. Shijiazhuang illustrates this configuration. Talent recruitment supports traditional industrial upgrading, while government planning and equipment investment subsidies facilitate technological transformation. Intellectual property protection and proportionate enforcement stabilize investment expectations and reduce compliance burdens. Market competition further encourages firms to adopt energy management and carbon-control technologies, as reflected in local smart factories and the city's electricity big data platform for pollution control. In this pathway, human capital strengthens technology absorption, government facilitates adoption, legal institutions reduce uncertainty, and market vitality stimulates demand. Their interaction enables cities to integrate mature digital and green technologies through adoption, adaptation, and diffusion. The corresponding results are presented in Column 5 of Table 3.

Table 3. Configuration Analysis Results (N = 272)

Condition Variable	n1	n2	n3	n4	n5
X1		●	●	⊗	●
X2	●	●	●		●
X3		●		●	●
X4	●			●	●
X5	⊗		●	●	●
X6	●	●	●	●	
Consistency	0.861	0.859	0.876	0.911	0.886
Coverage	0.352	0.427	0.355	0.214	0.303
Unique Coverage	0.024	0.025	0.024	0.018	0.017
Overall Consistency			0.85		
Overall Coverage			0.53		

4.3.2. Comparative Analysis of Configurational Pathways

The five pathways also differ substantially in their driving mechanisms. Configuration 1 is based on human capital, the legal environment and innovation environment. It shows a complementary mechanism between knowledge and skills from human capital, institutional safeguards from the rule of law and innovation system capability to translate

knowledge into practical applications. Configuration 2 is based on infrastructure, human capital, government service environment and innovation environment as core conditions. This pathway shows how government services coordina te resources among departments and reduce institutional transaction costs. Configuration 3 is based on market vitality replacing government service environment as core condition, so market competition plays a role in matching technol ogical supply with demand and facilitating the commercialization of technological achievements. Configuration 4 is driven by the legal environment, market vitality, and innovation environment. This implies that strong institutional an d market conditions can compensate for inadequate infrastructure. Configuration 5 combines human capital, governm ent service environment, legal environment and market vitality as conditions, while innovation environment does not play a role. This suggests cities can achieve digital–green synergies through introduction, absorption and diffusion of mature technologies rather than by locally generated original innovation. Some functional substitution and compensat ion relationships can be found among these configurations. First, government service environment and market vitality appear functionally equivalent under some conditions. Configurations 2 and 3 share three core conditions: infrastruct ure, human capital and innovation environment. Their main difference is that Configuration 2 includes government se rvice environment as a core condition and Configuration 3 includes market vitality. This suggests that government co ordination and market-based resource allocation may offer alternative solutions for digital–green synergy if the other core conditions are present. Second, infrastructure compensates with institutional and market conditions: infrastructur e is a core condition in Configurations 2 and 3, peripheral condition in Configuration 5 and core absent condition in Configuration 4.These differences indicate that infrastructure does not play the same role in cities. If the legal enviro nment, market vitality and innovation environment provide sufficient institutional and developmental support, they c ompensate for deficiencies in infrastructure. Third, the innovation environment could be replaced by a multidimensio nal combination of institutional and market conditions. It is a key condition in Configurations 1–4 but not a critical co ndition in Configurations 5: Digital–green synergy could arise from locally generated research and development brea kthroughs or from introduction, absorption, and diffusion of mature technologies. Third, market vitality is highly cont ext dependent. It is not absent from Configurations 1 but is present in Configurations 3–5. Market vitality is therefore not universally essential nor irrelevant, it depends on how it is combined with other technological, organisational and environment conditions.

Overall, we found that no single condition or fixed combination is responsible for high digital–green synergy, cit ies can follow multiple functionally equivalent paths, coordinating governments, market allocations, infrastructure, in novation capacity and institutional safeguards, and the resulting results show that urban digital–green synergy is caus ally complex. We conclude that weaknesses in one dimension may, under certain conditions, be offset by strengths in others.

4.3.3. Analysis of Configurational Pathways to Low Digital–Green Synergy

A sum of the five configurations of low digital–green synergy shows three general features: Soft constraints are more strong than infrastructure constraints; critical deficiencies overlap with related shortcomings; strength in one co ndition is rarely enough to compensate weaknesses in many other conditions. The first three configurations lack hum an capital (X2) and good legal environment (X4). This lack is also the absence of innovation environment (X6), infra structure (X1) or government service environment (X3) and market vitality (X5) depending on configuration. These p atterns suggest that the absence of human capital and legal protections is a major barrier to the digital–green synergy.

Lack of digital skills and green knowledge can limit the use of digital technologies in green production, energy c onservation, carbon reduction, and environmental governance. Lack of legal stability, property rights protection, and policy implementation. Lack of institutional stability can reduce firms' willingness and ability to invest in integrated digital and green innovation. Lack of innovation, infrastructure, government services or market vitality can exacerbat e these two key weaknesses.

The last two configurations show further that each of the conditions can only substitute for other conditions. Eve n if a city has a favorable human capital environment, this advantage might not translate into digital–green results if t he legal, government service, and innovation environments are not good enough. Even if a fairly good legal environm ent is good enough, it cannot independently lead to digital–green integration when human capital, government servic e, market vitality, and innovation support are not good enough.These results suggest that isolated strengths have limit ed compensatory capacity for low digital–green synergies.

Importantly, Infrastructure (X1) is only present in some cases and not a general characteristic of low digital–gre en synergy. This indicates that inadequate infrastructure is not the only, nor necessarily the main obstacle to coordina ted digital–green development. More fundamental obstacles may arise from lack of human capital, safeguards, gover nment services, market mechanisms, innovation systems.Infrastructure investment alone is unlikely to produce sustai ned improvements when the institutional and organizational environment is underdeveloped.

Low digital–green synergy is therefore more than a lack of digital/green resources. It is due to lack of effective o rganizational, institutional, market, and innovation tools connecting and changing the resources. Multiple deficiencies can reinforce each other, and improving only one condition alone is not enough to overcome the bottleneck. Cities sh ould instead combine Human Capital Development, Legal safeguards, Government Service Improvement, Market inc entives and Innovation Support in order to avoid mutually strengthening deficiencies and build complementary condit ions for digital and green development.

4.3.4. Comparative Analysis of Configurational Pathways

The five configurations reveal multiple pathways to high digital–green synergy, each involving distinct combina tions of core conditions. Configuration 1 combines human capital, legal protection and innovation capacity, highlight ing complementarities between skills, institutional safeguards and knowledge application. Configurations 2 and 3 sha re infrastructure, human capital and innovation capacity, but emphasize government services and market vitality, resp ectively, suggesting that government coordination and market allocation can serve as functional alternatives under th ese shared conditions. Configuration 4 combines legal protection, market vitality and innovation capacity despite the core absence of infrastructure, indicating that institutional and market strengths may compensate for infrastructure co nstraints. Configuration 5 emphasizes human capital, government services, legal protection and market vitality, with i nfrastructure playing a peripheral role and innovation capacity unspecified. This pathway is consistent with achieving synergy through technology absorption and diffusion, although the configuration alone does not establish this mecha nism. Overall, these findings demonstrate equifinality and contextual complementarity: high digital–green synergy ca n emerge through different configurations, with strengths in some dimensions potentially offsetting weaknesses in ot hers.

4.3.5. Analysis of Configurational Pathways to Low Digital–Green Synergy

The corresponding results are presented in Table 4. The five conditions of low digital–green synergy have three general properties: Soft constraints are stronger than infrastructure constraints, critical deficiencies overlap with relat ed shortcomings and strength in one condition is often inadequate to compensate for weaknesses in other conditions. The first three configurations have a shared lack of human capital (X2) and a solid legal environment (X4). The com mon lack of innovation environment (X6), infrastructure (X1) and government service environment (X3) and market vitality (X5) are either the same (or both) or the same (depending on configuration). These patterns suggest that the c ombination of human capital and legal safeguards is a major reason behind the digital–green synergy. Lack of profess ionals who have digital skills and green knowledge could inhibit use of digital technologies in green production, ener gy conservation, carbon reduction, and environmental governance. Lack of legal support could weaken regulatory sta bility, property rights protection, and policy implementation. Lack of stable legal environment could also hinder firm s' willingness and capacity to invest in integrated digital and green innovation. Lack of innovation, infrastructure, go vernment services, or market vitality can be compared to these two fundamental weaknesses. The last two configurati ons demonstrate that individual strengths have limited substitutability. Even if a city has a healthy human capital envi ronment, it may not translate into digital–green results if legal, government service, and innovation environments are inadequate.Similarly, a fairly good legal environment can not independently promote digital–green integration if hum an capital, government services, market vitality, and innovation support are not sufficient. These results suggest that i solated strengths have limited compensatory capacity in a low digital–green synergy configuration. Importantly, the l ack of infrastructure (X1) appears only in some configurations and is therefore not a general characteristic of low digi tal–green synergy. This suggests that lack of infrastructure is not the only, or necessarily the primary, obstacle to coor dinated digital and green development. More fundamental obstacles may arise from lack of human capital, institution al safeguards, government services, market mechanisms, and innovation systems. Infrastructure investment alone ma y not produce sustained improvements if institutional and organization environment is underdeveloped. Low digital–green synergy is more than just a lack of digital or green resources. It results mostly from lack of effective organizati onal, institutional, market, and innovation mechanisms linking and transforming digital and green resources. Multiple deficiencies can strengthen each other, improving one condition is generally not enough to overcome the bottleneck. Cities should instead adopt a coordinated approach which integrates human capital development, legal safeguards, go vernment service improvement, market incentives and innovation support.

Table 4. Configuration Analysis Results (N = 272)

Condition Variable	n1	n2	n3	n4	n5
X1		⊗			
X2	⊗	⊗	⊗	●	⊗

X3			⊗	⊗	⊗
X4	⊗	⊗	⊗	⊗	●
X5			⊗		⊗
X6	⊗			⊗	⊗
Consistency	0.796	0.806	0.850	0.868	0.836
Coverage	0.627	0.596	0.464	0.401	0.443
Unique Coverage	0.016	0.012	0.011	0.008	0.024
Overall Consistency			0.780		
Overall Coverage					

4.4. Robustness Analysis

To assess the robustness of the configurational results, this study performs two sensitivity tests by varying the truth-table parameters. The corresponding results are presented in Table 5-6. First, the raw consistency threshold is increased from 0.85 to 0.90. Second, the case-frequency threshold is raised from 1 to 2. The configurations obtained under these alternative specifications are in general consistent with the baseline results. The main configuration paths, core conditions and presence or absence of the conditions remain unchanged.This results suggest that the raw consistency and case frequency changes are not significant.

Table 5. Configuration Analysis Results (N = 272 , from 0.85 to 0.90)

Condition Variable	n1	n2	n3	n4	n5
X1	●	●	⊗	⊗	●
X2	●	●		●	●
X3	●	⊗	●	⊗	●
X4	⊗		●	●	●
X5		●	●	⊗	●
X6	●	●	●	●	⊗
Consistency	0.898	0.903	0.904	0.905	0.902
Coverage	0.280	0.232	0.236	0.222	0.297
Unique Coverage	0.049	0.028	0.015	0.022	0.046
Overall Consistency			0.867		
Overall Coverage			0.442		

Table 6. Configuration Analysis Results (N = 272 , case-frequency threshold is raised from 1 to 2)

Condition Variable	n1	n2	n3	n4
X1	●	●	●	
X2	●	●	●	●
X3	●			●
X4		●		●
X5			●	⊗
X6	●	●	●	●
Consistency	0.859	0.853	0.876	0.873
Coverage	0.427	0.426	0.355	0.321
Unique Coverage	0.019	0.015	0.009	0.013

Overall Consistenc y	0.844
Overall Coverage	0.496

5. Conclusions and Policy Implications

5.1. Conclusions

Drawing on the technology–organization–environment (TOE) framework, this study uses a sample of 272 prefec ture-level cities in China and applies fuzzy-set qualitative comparative analysis (fsQCA) to examine how six dimensi ons of the business environment jointly influence urban digital–green synergy. The principal conclusions are as follo ws.

First, high urban digital–green synergy is causally complex, conjunctually complicated and equifinal. The neces sity analysis shows that no single aspect of the business environment is necessary for high digital–green synergy, whi ch means that no single institutional or environmental factor is necessary. High digital–green synergy is based on effe ctive combination and interaction of multiple conditions.

Second, we identified five configurations of high digital–green synergy, consisting of three main pathways and t wo compensatory pathways. The first main pathway shows that human capital, legal protection and a supportive inno vation environment can compensate for lack of market vitality. The second pathway shows that, when infrastructure, human capital and innovation environment are well developed, either government coordination or market based resou rce allocation can be the central mechanism for digital–green synergy. Government efficiency and market vitality can therefore function as functional substitutability under specific resource conditions.

Third, compensatory pathways show cities can achieve high digital–green synergy even with disadvantages in s ome dimensions. Cities with weak infrastructure can compensate for lacks in physical and digital infrastructure by co mbination of legal protection, market vitality, and innovation capacity. If local innovation advantages are limited, joi nt effects of human capital, government efficiency, legal protection and market vitality can support high digital–gree n synergy.

Overall, we extend TOE to urban digital–green development. We show that digital–green synergies are not mere ly based on accumulation of technological, organizational, and environmental advantages, but rather on how well con ditions are aligned and combined. Different combinations can result in similar results, weaknesses in one condition m ay be offset by strengths in other conditions.

5.2. Policy Implications

Cities should pursue locally tailored pathways to digital–green synergy rather than replicate advanced-city mode ls. Resource-rich cities can strengthen key advantages, while those with more balanced endowments should coordinat e improvements across business environment dimensions. Where digital infrastructure is weak, stronger legal protecti on, market vitality and innovation capacity can partially offset infrastructure constraints by stabilizing expectations, i mproving resource allocation and aligning technologies with industrial needs. Government involvement should reflec t market maturity: less developed markets may require stronger coordination and public platform provision, whereas mature markets benefit from fair competition, reliable public services and targeted correction of market failures. The functional substitutability between government coordination and market vitality suggests that cities need an appropria te institutional mix rather than simultaneous maximization of both. Innovation policies should also reflect local capab ilities, with research-intensive cities advancing technological breakthroughs and commercialization, and resource-con strained cities prioritizing the absorption, adaptation and diffusion of mature technologies.

5.3. Research Limitations and Future Directions

This study has several limitations. First, although the cross-sectional data employ a temporal-lag design, reverse causality and omitted-variable bias cannot be completely excluded. Future research could combine longitudinal panel data with quasi-natural experimental methods to provide more robust evidence of causal relationships and examine h ow configurations evolve over time.

Second, the paper is focused on city configurations and does not directly investigate micro-level mechanisms by which firms transmit the effect of the business environment to digital–green synergy. Future studies could include en terprise survey data, interviews or case studies of firms' technology-adoption decisions, innovation strategies, and res ponses to institutional conditions.

Finally, differences in city size, resource use, industry structure and stage of regional development may affect st ability and applicability of the proposed configurations. Future work could conduct subgroup/cross region compariso ns with larger samples. This would help determine whether configurations differ among cities and would assess exter nal validity of conclusions.

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Data availability:

The data used in this study were obtained from "中国城市营商环境评估" (China Urban Business Environment Assessment), Version 4.0, by Sanbao Zhang, Zhixue Zhang, and Minxue Huang (2023), hosted on the Peking University Open Research Data Platform (https://doi.org/10.18170/DVN/9NJDWE). The authors do not have permission to publicly redistribute these third-party data. Researchers seeking access should consult the dataset page and follow the data provider's access procedures and applicable terms.