

Postprint: A Study on the Coopetition Relationship of County-Level Cities in the Hexi Corridor Based on Niche Theory

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Abstract

Based on niche theory, this study employs urban comprehensive development level and niche breadth to reflect the degree of resource occupation and utilization of each city within its community, and evaluates the competitive-cooperative relationships among 20 county-level cities in the Hexi Corridor through cluster analysis and ecosystem structure classification. The results indicate that between 2001 and 2013, the comprehensive development levels of all cities in the Hexi Corridor improved to varying degrees, while urban niches also exhibited varying degrees of fluctuation; the comprehensive development level values demonstrated a highly positive correlation with niche breadth, suggesting that the degree of resource occupation and utilization among cities is closely linked and mutually reinforcing. The niches of Jiayuguan City and Jinchuan District consistently ranked at the forefront among the 20 county-level cities in the Hexi Corridor, classified as Type I cities; Liangzhou District, Suzhou District, and Ganzhou District as Type II cities; Aksai County, Yumen City, Dunhuang City, and Subei County as Type III cities; and the remaining 11 cities as Type IV. On this basis, and by integrating theories of niche differentiation, expansion, and collaborative development, corresponding basic competitive-cooperative development strategies were proposed according to urban ecosystem structure.

Full Text

Preamble

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Ecological Niche-Based Competition and Cooperation Relationships Among County-Level Cities in Hexi Corridor

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Abstract

Based on ecological niche theory, this study employs urban comprehensive development level and niche breadth to reflect the degree of resource occupation and utilization by each city within its urban community. Through cluster analysis and ecosystem structural division, the competition and cooperation relationships among 20 county-level cities in the Hexi Corridor were evaluated. The results indicate that: (1) From 2001 to 2013, all cities in the Hexi Corridor exhibited varying degrees of improvement in comprehensive development levels, with urban ecological niches showing corresponding fluctuations. (2) A highly positive correlation exists between comprehensive development level values and niche breadth, demonstrating that resource occupation and utilization are closely interconnected. (3) Jiayuguan City and Jinchuan District consistently rank at the forefront among the 20 county-level cities in the Hexi Corridor. Suzhou District and Ganzhou District constitute Tier II, Dunhuang City and Subei County form Tier III, and the remaining 11 cities comprise Tier IV. Drawing upon theories such as niche displacement and coordinated development, and according to urban ecosystem structure, corresponding basic competition-cooperation development strategies are proposed to provide theoretical guidance for the coordinated and sustainable development of urban clusters in the Hexi Corridor.

Keywords: niche theory; urban comprehensive development level; niche breadth; competition-cooperation strategy

Introduction

Cities serve as crucial carriers of modern social and economic development, and their growth fundamentally depends on the acquisition, accumulation, and utilization of various resources. When resource availability within a region satisfies the development needs of its cities, intercity relationships manifest as synergy; when resources become insufficient, competition or mutual exclusion emerges. Similar to natural ecosystems, modern cities can be viewed as special life forms possessing ecological wisdom, exhibiting competitive succession phenomena akin to forestry ecosystems. The ecological niche concept and its theory have evolved over nearly a century, with applications extending beyond ecology into urban geography, urban economics, and other fields, providing important guidance for research on environmental adaptability and competition mechanisms.

Domestic and international research on ecological niche theory in urban studies has focused primarily on two aspects: first, the conceptual definition of urban niche and theoretical application. For instance, Peng et al. systematically reviewed the development of niche concepts, dividing ecological niche theory into three developmental stages and four major academic schools. Niu et al. proposed concepts of cultivated land ecological units and cultivated land niche, constructing an ecological niche suitability evaluation model for sustainable cultivated land use. Hu et al. emphasized the importance of ecological niche theory in urban research, arguing that niche changes can reflect urban characteristics and development patterns. Ding et al. applied niche theory to analyze competition and evolution among different functional modules of urban ecology. Luo et al. introduced niche and state theory into urban-rural interface studies, analyzing the shaping effects of ecological niche on spatial expansion. Han et al. used niche theory to analyze driving factors of urban population agglomeration. Chen et al. established a social-natural complex ecosystem niche evaluation index system, providing a new perspective for related research. Jia et al. applied a coupled projection pursuit model to evaluate complex ecosystem niches, analyzing trends in Sichuan Province. Meng et al. employed ecological niche theory and spatial autocorrelation methods to measure and analyze spatiotemporal differences in niches of the Tianshan North Slope urban agglomeration. Tian et al. evaluated the suitability of rural settlements using complex niche, enriching applications in different fields.

Second, research has examined ecological niche theory and urban competition mechanisms. Chen et al. applied urban competitive niche theory to urban competition strategy research, reinterpreting strategies from an ecological wisdom perspective. Wang et al. analyzed the role of ecological niche theory in urban competition research using the Central Plains urban agglomeration as an example. Peng et al. constructed a framework for judging tourism city competition relationships using niche overlap theory and niche state theory. Sun et al. built a three-dimensional indicator system (performance, potential, environment) using ecological niche theory to evaluate tourism competitiveness in the Shandong Peninsula Blue Economic Zone. Cheng et al. constructed a cultural tourism creative industry competitiveness evaluation index system from an ecological niche perspective. Recent international research includes Sengers et al., who explored the internal mechanisms of successful urban transportation transformation from a niche development perspective, and Pallante et al., who studied how niche development changes promote farmers' livelihoods and agricultural biodiversity.

Domestic ecological niche measurement indicators primarily include niche breadth, niche overlap, niche volume, niche dimension, and niche similarity proportion. Theoretical research mainly involves calculating species ecological niches to study interspecies competition relationships. Urban niche competition involves cities competing for high-quality resources and expanding the scope of obtainable resources. Niche overlap index can serve as an important indicator characterizing intercity competition relationships. However, niche overlap does not necessarily accompany competition: if resources are abundant, two

cities can jointly utilize the same resources without harming each other' s development.

From a phytocoenology perspective, viewing modern cities as life forms with ecological wisdom reveals that cities require corresponding resource support to maintain survival. Therefore, it is necessary to clarify cities' degree of resource occupation. Whether cities can achieve sustainable development within the same community largely depends on their competition-cooperation relationships, specifically manifested as the degree of resource utilization. This study uses urban comprehensive development level to reflect resource occupation degree and niche breadth to characterize resource utilization degree. Through cluster analysis and ecosystem structural division, competition-cooperation relationships among Hexi Corridor county-level cities are clarified, and realistic competition-cooperation strategies are proposed based on ecological niche theory to provide theoretical suggestions for coordinated and sustainable development of Hexi Corridor urban clusters. The innovation lies in constructing urban ecosystem types and network structures, graphically representing niche relationships among cities, which visually demonstrates each city' s position and relationships within the ecosystem, surpassing previous numerical representations.

1 Study Area Overview

The Hexi Corridor is located in northwestern Gansu Province, named for its position between the Qilian Mountains and northern corridor mountains with low-lying terrain. It stretches approximately 1,000 km east-west, with administrative boundaries between 37°17' -42°48' N and 92°12' -103°48' E. The region includes 20 county-level cities under the jurisdiction of Wuwei, Jiuquan, and Jiayuguan, belonging to three independent endorheic basins: the Shiyang River, Heihe River, and Shule River systems. The total land area is 239,560 km², with a total population of 4.8502 million, including 1.8221 million non-agricultural residents (23.93% of Gansu' s non-agricultural population). GDP per capita is ¥18,676.64, 62.47% of Gansu' s average. Transportation and ecological infrastructure are gradually improving, and integration is accelerating, making the Hexi Corridor one of Northwest China' s most development-potential regions. As an ancient golden passage for East-West cultural exchange, the implementation of western development strategies and new Silk Road Economic Belt construction will further promote oasis economic development and urban prosperity.

[Figure 1: see original paper] Location map of study area

2 Urban Comprehensive Development Level Indicator System

Based on the multidimensional hypervolume definition of ecological niche theory, and fully considering the resource acquisition potential and capacity of Hexi Corridor county-level cities, this study adopts comprehensive dimensional

indicators to objectively reflect resource occupation levels. Following principles of comprehensiveness and data availability, an indicator system was constructed including three primary indicators: Resources and Environment (A1), Economic Conditions (A2), and Society and Security (A3), comprising 23 specific indicators. Data were sourced from the Gansu Development Yearbook, Gansu Construction Statistical Yearbook, and socio-economic statistical bulletins. Missing data for individual years were interpolated using software. The indicator system is shown in Table 1.

The index system of urban comprehensive development level

3 Urban Comprehensive Development Level

Factor analysis was employed to calculate the comprehensive development level of Hexi Corridor county-level cities. Before analysis, Bartlett's sphericity test was conducted on the global data, yielding a KMO value of 0.757 and significance probability of 0.000, rejecting the sphericity hypothesis and indicating that selected variables were not independent, making them suitable for factor analysis. SPSS 16.0 software performed factor analysis using the principal component method with eigenvalues greater than 1, extracting six common factors that retained most original information (76.910% cumulative variance contribution), greatly reducing data complexity. The varimax method orthogonally rotated the factor loading matrix. Principal component weights were calculated using the formula $F_a = c_a / \sum c_a$, where c_a is the component contribution rate. Table 2 shows the principal component extraction and weights.

Since factor analysis produced negative comprehensive strength scores, data were transformed to positive values using the min-max normalization method, which linearly transforms the original data column into a new one. City j 's comprehensive score was calculated as: $S_j = \sum (S_{aj} \times F_a)$, where S_{aj} is city j 's score on principal component F_a , and F_a is the component weight. Table 3 presents the normalized comprehensive development level values for Hexi Corridor county-level cities.

Principal component extraction and weights of urban comprehensive development level

The urban comprehensive development level of county areas of Hexi Corridor

4 Urban Niche Breadth

Ecological niche breadth indicates the degree of resource utilization by a species. Urban niche breadth expresses the interactive relationship between a city and its resources, environmental space characteristics, and urban nature, reflecting utilization of various resources within the community. Larger niche breadth indicates more extensive utilization of natural, economic, and social elements, stronger competitiveness, and greater ecological function within the urban community.

Drawing on the niche state-potential model, this study uses urban comprehensive development level to represent the “state” (current niche breadth) and the change rate of comprehensive development level over time to represent the “potential” (future niche breadth). The calculation formula is:

$$N_i = \frac{S_i + A_i P_i}{S_j + A_j P_j}$$

where N_i is city i 's niche breadth; S_i and P_i are city i 's state and potential; S_j and P_j are city j 's state and potential; and A_i and A_j are dimensional conversion coefficients. This study uses each city's comprehensive development level results for 2001, 2005, 2009, and 2013 as the state metric, and the average growth rate from 2001-2013 as the potential metric. With a 3-year interval, the dimensional conversion coefficient is 0.25.

Using SPSS 16.0 software with squared Euclidean distance as the interval scale, hierarchical cluster analysis with between-groups linkage was performed on the 20 Hexi Corridor county-level cities based on niche breadth values. Table 4 presents the niche breadth values, and Figure 3 shows the 2013 clustering results, dividing cities into four categories based on resource utilization status and stability.

The niche breadth of county areas of Hexi Corridor

5 Evaluation Results

5.1 Comprehensive Analysis

From 2001 to 2013, all Hexi Corridor county-level cities showed varying degrees of improvement in comprehensive development levels, with urban ecological niches experiencing corresponding fluctuations. In 2013, Jiayuguan City and Jinchuan District had the highest comprehensive development values (2.444 and 2.160 respectively), significantly exceeding other cities. Suzhou District (1.870), Ganzhou District (1.814), and Liangzhou District (1.772) ranked between 1.0-2.0, while the remaining cities were below 1.0. Jiayuguan's development level was 16.66 times that of Yongchang County, which had the lowest per capita GDP. Jiayuguan and Jinchuan are industrial cities with strong economic foundations and locational advantages (2014 industrial output values of ¥23.069 billion and ¥14.250 billion respectively). Suzhou and Ganzhou districts, as prefecture-level city jurisdictions, also show relatively high development levels. Dunhuang City leverages its rich tourism resources (2014 tourism revenue of ¥4.805 billion, 48.29% of GDP), while Yumen City has transformed from a resource-depleted city to an important energy base with abundant wind power resources.

Urban niche breadth values also showed varying changes. Shandan County's niche breadth expanded continuously, while Aksai County's compressed. Others fluctuated. Jiayuguan (0.122), Jinchuan (0.106), Suzhou (0.104), Ganzhou

(0.090), and Dunhuang (0.091) had the largest niche breadths, indicating strong competitive advantages and development potential. The correlation between comprehensive development level and niche breadth was highly positive (correlation coefficients > 0.8 all years), demonstrating close linkage between resource occupation and utilization.

5.2 Cluster Analysis

2013 clustering results categorized Jiayuguan City as Tier I (niche breadth 0.122), with Suzhou and Ganzhou districts as Tier II (0.104, 0.090), Dunhuang as Tier III (0.091), and remaining cities as Tier IV (niche values 0.065, 0.061, 0.060, etc.). The 2001-2013 average clustering showed Jiayuguan and Jinchuan as Tier I (0.106, 0.100), Suzhou, Ganzhou, and Dunhuang as Tier II (0.080, 0.073, 0.070), and 15 other cities as Tier III-IV with lower niche values.

[Figure 2: see original paper] The relationship between urban comprehensive development level and niche breadth

[Figure 3: see original paper] The ordinal scale and cluster analysis pedigree of urban niche in 2013

[Figure 4: see original paper] The ordinal scale and cluster analysis pedigree of urban niche in 2001-2013

5.3 Ecosystem Structure

Based on cities' positions and functions within the urban community, and using niche values as criteria, Hexi Corridor urban clusters can be classified into dominant, sub-dominant, and companion species. Jiayuguan City and Jinchuan District, possessing abundant capital, technology, and other survival resources, function as dominant cities with strong agglomeration and radiation capacities. Suzhou and Ganzhou districts have weaker capacities as sub-dominant species, while remaining cities are companion species.

Considering geographical locations, development levels, niche sizes, and potential, a hierarchical network structure can be formed with Jiayuguan and Jinchuan as core cities, Suzhou and Ganzhou as node cities, and other cities as network cities, creating a dual-core, three-node development axis. Core cities should diffuse their advantages to promote regional development, node cities should leverage historical and economic foundations to create distinctive urban characteristics, and network cities should exploit comparative advantages (Dunhuang's tourism, Aksai and Sunan's ethnic cultures, Yumen's new energy) to enhance competitiveness through cooperation with core and node cities.

[Figure 5: see original paper] The urban ecosystem types of Hexi Corridor

[Figure 6: see original paper] The network structure of Hexi Corridor

6 Co-opetition Strategies

Based on cluster results and ecosystem structure analysis, and utilizing ecological niche theory concepts of species separation/coexistence and generalization/specialization, differentiated strategies are proposed:

Jiayuguan City and Jinchuan District: As industrial cities ranking highest in development and niche breadth, they should adopt: - Niche expansion strategies: Rational resource exploitation and environmental management - Coordinated development strategies: Leverage core positions to integrate surrounding resources and maximize regional benefits through city linkage

Suzhou and Ganzhou Districts: As prefecture-level city jurisdictions with moderate niche breadth, they should adopt: - Niche separation strategies: Develop unique cultural resources and economic advantages to achieve differentiation from higher-niche cities - Coordinated development strategies: Establish strategic alliances for complementary product systems and enhanced competitiveness

Dunhuang, Aksai, and similar cities: With lower rankings but distinctive features, they should adopt: - Niche separation and specialization strategies: Dunhuang should strengthen its competitive advantage as a historical cultural city with rich tourism resources - Niche expansion strategies: Exploit unique potentials and advantages - Coordinated development strategies: Leverage locational advantages to strengthen exchanges with core and node cities

7 Conclusion

From 2001 to 2013, Hexi Corridor cities showed varying improvements in comprehensive development levels, with ecological niches fluctuating accordingly. The highly positive correlation between development level and niche breadth (correlation coefficients > 0.8) demonstrates close linkage between resource occupation and utilization. Cluster results show Jiayuguan and Jinchuan consistently leading, followed by Suzhou and Ganzhou as Tier II, Dunhuang and Subei as Tier III, and 11 cities as Tier IV. Based on ecosystem structure analysis, corresponding co-opetition strategies are proposed: Jiayuguan and Jinchuan should play radiating roles; Suzhou and Ganzhou should develop synergistically; other cities should adopt niche separation and specialization. Under regional policies and development opportunities, intercity co-opetition relationships will become increasingly complex. Ecological niche theory provides a new research approach, though future studies must incorporate complex and variable influencing factors to develop a comprehensive urban ecological niche theoretical system.

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