Urban Dynamic Spaces: The Transformation from Growth Doctrine to Structuralism

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Abstract. As urbanization continues to deepen, urban development is facing new challenges in its sources of momentum and profound changes in spatial organization. Under the traditional growth-doctrine model, cities relied primarily on rapid industrialization, rapid urbanization, and the extended momentum of real estate development; their dynamic spaces were mainly expressed through new towns and new districts. As cities enter an era of structuralism led by urban renewal, however, both urban dynamics and their spatial carriers are undergoing fundamental transformation. From a historical-comparative perspective, and in light of strategic planning practices at different stages, this paper argues that urban dynamic spaces are a key factor shaping planning transformation. In the new era, the main sources of urban development momentum include innovation driven by changes in modes of production, consumption and cultural momentum generated by changes in lifestyles, and network momentum enabled by information-technology transformation. The new dynamic spaces corresponding to these functions, together with the growth laws of their built environments, will exert a major influence on urban spatial development.

Keywords: urban dynamics; urban dynamic spaces; growth doctrine; structuralism.

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1 Introduction: New Dynamics of Urban Development

A growing number of recent studies [1-3] have reviewed and summarized the achievements and challenges of nearly four decades of urban planning and construction in China. A central concern in these discussions is whether past development models and logics remain applicable to the future. The authors have previously examined development models at different stages from the perspectives of “growth doctrine” and “structuralism,” but did not further elaborate on a core variable within those models: the urban development dynamic space. Over the nearly forty years following reform and opening-up, rapid urbanization and rapid industrialization constituted the two core driving forces of Chinese cities. Rapid urbanization concentrated population in cities, expanded labor markets, and stimulated the real estate sector. Statistics show that from 1978 to 2023, China’s urbanization rate rose from 18% to 66%, the urban population increased from 170 million to 930 million, and per capita housing floor area expanded from 6.7 m2 to about 40 m2, with a net increase of roughly 36 billion m2 in residential building area. Rapid industrialization brought industrial agglomeration, improved production efficiency, and became a powerful engine of urban economic growth: over forty-five years, national gross industrial output rose from RMB 162.2 billion to RMB 39.9 trillion.

The combined force of rapid urbanization and industrialization drove the expansion of urban scale and promoted the widespread preparation of urban plans centered on spatial enlargement. In academic discussions, this approach is commonly described as growth-oriented planning. Yet with the second half of urbanization now underway, a downward economic cycle, weakening demographic dividends, industrial overcapacity, and resource-environment constraints have converged. The traditional dynamic model is becoming increasingly difficult to sustain. Allocation of land resources is shifting from outward expansion

toward a stock-based era, and urban internal renewal has become an effective path for optimizing space, realizing value, and promoting capital circulation. Urban development is entering a window of transition from growth doctrine to structuralism, making the study of new dynamics and dynamic spaces increasingly important for urban planning.

This importance lies in two aspects. First, once a misjudgment of urban dynamics or an inefficient spatial form takes shape, large-scale investment becomes difficult to recover and later readjustment becomes more costly. Second, a systematic research framework for urban dynamic spaces has not yet been established. Existing theoretical support remains insufficient for planning practice, identification methods, and the evolutionary laws of dynamic spaces, and therefore cannot adequately support their scientific planning, construction, and governance. Re-examining the sources of urban development momentum and the planning and design of dynamic spaces has thus become a major issue at the present stage.

Based on domestic and international theoretical foundations concerning urban dynamic spaces, this paper undertakes two tasks. First, it reviews and summarizes a series of important Chinese urban planning practices over the past thirty years, identifying different formation mechanisms of urban dynamic spaces in the periods of growth doctrine and structuralism. Second, drawing on research into the laws of dynamic spaces using multiple-source big data, it explores how innovative spatial planning supply, grounded in scientific logic, can identify and continuously activate new urban dynamics and dynamic spaces. Through a comparative study of theory and practice, the paper examines new sources of momentum and their operational laws, renews and deepens understanding of urban dynamics and spatial organization mechanisms, and aims to provide urban planners and researchers with new perspectives and tools to address insufficient urban momentum and promote more vibrant, efficient, and sustainable development [4-5].

2 Literature Review on Urban Dynamic Spaces

Urban Dynamics was formally proposed by Forrester in the 1960s as an extension of system dynamics to urban systems [6]. It was among the first approaches to view the city as an integrated system and to explore the dynamic relationships among major factors such as population, housing stock, number of enterprises, tax rates, and urban attractiveness [7]. One important branch of urban dynamics links urban momentum with urban space, giving rise to the study of urban dynamic spaces. Closely related to this is research in economic geography on the spatial agglomeration of economic activity. With the increasing availability and application of diverse data, big-data-based studies of urban vitality have also become widespread. Broadly speaking, current research on urban dynamic spaces is concentrated in three streams: urban research derived from system dynamics, economic geography, and big-data-based studies of urban vitality.

2.1 Urban Research Perspective: Emphasis on Judging Urban Dynamic Mechanisms

The urban research perspective encompasses various schools that study the formation, development trends, and functions of cities. Many scholars [8-12] have extended the concept of urban dynamics, originally discussed in economics, from urban economy and population growth to spatial expansion. They define urban development dynamics in terms of outward expansion of built-up areas, internal spatial reorganization, continuous and rapid urbanization and economic growth, and changes in land use and land cover (Table 1). Zhang Tingwei [8] argues that changes in urban space result from the combined effects of policy forces, economic forces, and social forces. Wu Zhiqiang et al. [12] and Hamdy et al. [9], who focus more on the driving mechanisms behind changes in spatial layout, emphasize basic factors such as foreign investment,

transport accessibility, planned location, service facilities, and natural environment. Although their emphases differ, the analytical logic of economy, society, and environment is relatively clear.

This school also pays close attention to the relationship between urban dynamics and comprehensive urban competitiveness. Huang Yaping [13], for instance, proposes that urban dynamics integrate the development momentum of urban economy, population and society, and environment. Ma Li et al. [14] and Wang Xiaoguang et al. [15] construct multi-level indicator systems from perspectives such as endogenous and exogenous forces, market and government, and further examine the dynamic influence of resource-environment foundations, production and consumption vitality, soft and hard inputs in technological innovation and infrastructure, and policy orientations such as trade and finance.

Table 1. Theoretical review of urban dynamic mechanisms from the perspective of urban studies

Scholar / source	Connotation of urban dynamics	Dynamic mechanisms and driving factors
Zhang Tingwei [8]	Outward expansion of built-up areas and internal spatial reorganization	Government force, market force, and community force
Hamdy O., et al. [9]	Changes in land use and land cover	Transport accessibility, planned location, service facilities, and natural environment
De la Luz Hernández-Flores M., et al. [33]	Urbanization and processes that change or affect landscape	Social welfare, population growth rate, immigration share, school-age population, employment in secondary and tertiary sectors, and distance to quarries, schools, urban areas, and roads
Ma Haitao, et al. [11]	Population growth, land expansion, economic development, and social development	Government-driven forces, including industrial parks and preferential policies and total fixed-asset investment; market forces, including enterprises, self-raised investment, financial-market vitality, and retail sales; technology; foreign trade; external transport; and external policy conditions
Wu Zhiqiang [12]	Land use	Foreign investment, transport accessibility, planned location, service facilities, natural environment, and other basic factors
Huang Yaping [13]	Urban construction goals that achieve optimal comprehensive benefits and coordinated development	Diffusion of technology and information, population migration, capital flows, control-center functions, natural population growth, and development of economic factors related to production, life, and infrastructure
Ma Li, et al. [14]	Urban growth	Human capital, innovation and R&D capacity, vitality of domestic enterprises, domestic consumption capacity, natural environmental support, and social environmental support
Wang Xiaoguang, et al. [15]	Urban economic vitality	Agglomeration capacity, innovation capacity, market vitality, resilience, economic development outcomes, and radiation

		capacity
JLL City Momentum Index 2019	Sustained rapid urbanization and economic growth	Economic development momentum, including economic output, air connectivity, retail sales, corporate headquarters, and foreign direct investment; social development momentum, including population; and commercial real estate momentum, including absorption, rents, offices, retail, hotels, investment transactions, and market transparency

2.2 Economic Geography Perspective: Spatial Agglomeration Laws of Economic Activity

Economic geography primarily studies the spatial agglomeration laws of economic activity. Research on the mutually reinforcing relationship between economic growth and industrial agglomeration is, in essence, an exploration of the coupling between urban dynamics and space.

This judgment was advanced by Martin et al. [16] and Baldwin et al. [17]. Marshall's theory of external economies, the industrial location theory associated with Weber and others [18], Fujita et al.'s theories of economic agglomeration and regional development [19], Brulhart et al.'s empirical research on Europe [20], and domestic studies on the Yangtze River Delta and coastal urban belts [21-24] all reveal a positive relationship between economic development and the degree of industrial agglomeration. In other words, the dynamic spaces formed by agglomeration economies significantly promote labor productivity and improve urban development efficiency.

As societies move from the industrial to the post-industrial stage, economic development represented by the knowledge economy displays similar characteristics. Research on dynamics supported by the agglomeration of innovation, culture, and related factors has become a new focus. Romer argues that firms, seeking increasing returns to scale generated by innovation, tend to invest in regions where innovation is active, causing economic growth to concentrate in innovation-intensive areas [25]. Domestic studies on innovation agglomeration spaces [26-29], including research on regional innovation linkage networks and empirical analyses of the innovation pattern of the Yangtze River Delta, also show close connections between regional and urban economic development and the clustering of innovation factors. Innovation dynamic spaces formed by the agglomeration of universities, research institutions, and knowledge-based industries possess strong internal and external network linkages as well as capacities for knowledge sharing. Chen Jianjun et al. [30], through an empirical analysis of 222 Chinese cities, proposed a theoretical framework for producer-service agglomeration and emphasized the role of information levels in driving agglomeration spaces. Cultural and creative industries have also rapidly become an important feature of national and regional economic development [31]. Jiang Ling et al. [32] find that the agglomeration of cultural and creative industries generally produces positive effects, such as resource sharing, cost reduction, and enhanced innovation.

2.3 Urban Vitality Perspective: Distribution Characteristics and Formation Mechanisms

As urban big data reflecting residents' activities have accumulated, some studies of urban dynamics have turned toward human agglomeration as the core indicator and have focused on "urban vitality," using data such as Baidu heat maps and Weibo check-ins. Scholars such as Huang et al. [34], Zhou et al. [35], and Yu et al. [36] have used overall economic and social performance [37-40], or facilities such as cafés, small restaurants, and cultural elements, as criteria for evaluating urban vitality. The theoretical source of these studies largely comes from Jane Jacobs's notion of neighborhood vitality: urban vitality is understood as the expression of rich activities and good places for everyday life, dependent on the social construction of human gathering.

On the basis of vitality evaluation, some scholars further examine how characteristics of urban spatial form help create diverse and vibrant urban life. Guided by the 5D theory of the built environment, these studies focus on the extent to which the built environment, functional form, and related factors influence vitality as represented by human agglomeration. As spatiotemporal big data have become more available, and because such data have advantages over statistical data in spatially mapping urban activities, modeling and quantitative analyses have proliferated. They allow fine-grained analysis across different time periods (workdays, nights, and weekends) and spaces (historic districts, waterfront areas, streets, and others). For example, Li et al. [41] use spatial regression models (OLS, Moran's I, and GTWR) to explore how density, design, diversity, and accessibility affect vitality in Shenzhen across different time periods. Xuan Wei et al. [42] use an OSR model and geographically weighted regression to examine how residential population, functional businesses, urban environment, and transport design affect the spatial distribution of vitality in Hefei. Wang Bo et al. [43] analyze and predict Guangzhou's "multi-node" vitality pattern from the perspectives of location, functional mix, and density. Overall, most findings focus on judging the influence of specific factors and offering suggestions for optimizing stock space, which gives them strong relevance for urban renewal.

2.4 Limitations of Existing Research on Urban Dynamic Spaces

Although the three streams of urban research, economic geography, and urban vitality have made significant progress in studying urban dynamic spaces, limitations remain. Urban research focuses more on indicators and conceptual definitions related to urban dynamics. Economic geography tends to examine relationships among cities rather than taking the city itself as the object. Urban vitality research more often provides data portraits and descriptions of current conditions. A shared deficiency is the lack of research on urban dynamic spaces from the perspective of urban planning practice. Put differently, research on dynamic spaces remains disconnected from concrete planning work and therefore cannot effectively guide practice.

On this basis, and especially from the standpoint of urban planning practice, this study reviews urban strategic planning over the past thirty years. From the perspective of professional planners, it conducts a comparative study of urban dynamic spaces and analyzes planning practices in several megacities and superlarge cities. It explores how urban dynamics and dynamic spaces have been planned at different stages and clarifies their key influence on planning.

3 Transformation of Urban Dynamic Spaces from a Planning Practice Perspective: A Structuralist View

Looking back at Chinese practice in the study of urban development dynamics and dynamic spaces, China's urban development is currently at a critical stage of transition from large-scale expansion to urban renewal. This transition is evident on multiple levels. Two questions are frequently raised: What are the new dynamics of urban development? Where are the new spaces of urban development? Taken together, these questions ask where the urban dynamic spaces of the new era are located.

The authors attempt to answer this question from two perspectives. First, how have urban planning practitioners responded since reform and opening-up? Second, can general laws be refined and summarized behind specific practices? In the article Planning Demands and Practical Innovation at the Current Stage [44], the authors discussed growth doctrine and structuralism (Table 2). The present paper continues this line of inquiry.

During the growth-doctrine period, urban development was primarily shaped by broad external environmental forces. Generally, the main dynamics of this period were rapid urbanization, rapid industrialization, and the extended momentum of real estate development. They were expressed as rapid

economic growth, rapid population growth, and massive demand for real estate. Many planning practices took the form of planning and constructing new towns and new districts, and spatial leapfrog development became a major planning method.

In the structuralist period, the three traditional forces have become difficult to sustain. Rapid industrialization has shifted toward an innovation-driven stage. Rapid urbanization has entered its second half, with far fewer people entering cities; some cities have even begun to shrink. Real estate has also entered a new model, with “housing is for living in, not for speculation” becoming the main orientation. Most importantly, cities have entered an era of urban renewal - a structuralist stage marked by “stable total quantity and structural adjustment.” The core dynamics of this stage are concentrated in new quality productive forces. These include innovation led by changes in modes of production, consumption and culture led by changes in lifestyles, and networked development led by information-technology transformation. Changes in urban development dynamics will in turn profoundly influence urban dynamic spaces and urban spatial structure.

Table 2. Comparison between growth doctrine and structuralism in urban development and planning

Item	Growth doctrine	Structuralism
Cyclical characteristics	Long-, medium-, and short-term cycles move in the same direction	Long-, medium-, and short-term cycles conflict with one another
Main logic	Synchronized cycles and total growth	Cyclical fluctuation and structural evolution
Development dynamics	Dominated by industrialization, urbanization, and real estate	Driven by innovation, consumption, culture, and networked development
Development opportunities	Opportunities are sought through changes in total quantity	Opportunities are sought through structural change
Planning demand	New towns and new districts; leapfrog urban growth	Urban renewal, urban networking, and polycentric spatial structures
Representative planning cases	Harbin Songbei New District Development Plan (1996); Fuzhou Urban Master Plan (2011-2020); Beijing Urban Spatial Development	Wuhan 2049 Urban Development Strategy; Hangzhou 2050 Urban Development Strategy; Shanghai 2035 Urban Master Plan; Guangzhou 2049 Urban Development Strategy

	Strategy (2003)

3.1 Planning Practice in the Growth-Doctrine Stage

3.1.1 Sources of momentum: rapid urbanization and industrialization

During the growth-doctrine period (1990-2015), the economic cycle in which cities operated was generally on an upward trajectory, and globalization as a whole was favorable. Domestic cities relied mainly on industrial development and population inflow as core driving forces. Growth in total scale pushed cities to adjust their existing spatial patterns and actively plan new towns, new districts, and development zones (Table 3).

Table 3. Urban dynamics and dynamic-space development concepts in city planning during the growth-dominated period

City	Urban functional positioning	Urban spatial structure
Harbin	An important manufacturing center, trade center, financial center, transport hub, and famous science, technology, and cultural city in Northeast Asia	Cross-river development, with priority given to building Songbei New Town
Fuzhou	A national historic and cultural city and the political center of Fujian Province; a regional center and gateway city in the northern West Coast Economic Zone of the Taiwan Strait; an important port city on China's southeast coast	Eastward and southward development, following the river toward the sea, with priority given to building the Nantai Island subcenter and a coastal new town
Beijing	Capital of a major country, world city, cultural city, and livable city	A double-cross, dual-city, multi-core structure, with priority given to building Yongle New Town

3.1.2 Demand and supply of dynamic spaces: new town expansion and new center building

In the face of rapid urbanization and industrialization, the relatively constrained space of old urban areas and traditional construction methods could no longer meet development demands. New town expansion therefore became a central planning proposition. Planning focused on multi-center structural organization and new town construction models, providing spatial support for existing or forthcoming industrial and population growth.

Before Guangzhou's 2000 urban strategy attracted broad academic attention, the China Academy of Urban Planning and Design had already launched the Harbin Songbei New District Development Plan in 1996. At that time, globalization was beginning to accelerate, cooperation in Northeast Asia was expanding, and many Japanese and Korean enterprises were locating in the region. Around these opportunities for geopolitical cooperation, together with the demands generated by urbanization and industrialization, the plan proposed that Harbin should "cross the river and move northward" by developing Songbei New District. Through the construction of an administrative center, a border-trade development zone, and an external transport hub, the plan supported the goal of building Harbin into an important international economic and trade city in Northeast Asia. This was a typical new district development model.

The Beijing Urban Spatial Development Strategy, prepared from 2003 onward, was based on the city's positioning as "the capital of a major country, a world city, a cultural city, and a livable city." It proposed relieving overly concentrated functions in the central city and planning a relatively large Yongle New Town along the Beijing-Tianjin corridor. In the 2016 version of Beijing's master plan, this was later adjusted into the Tongzhou City Subcenter. The internal logic nevertheless remained the same: to arrange new towns on the periphery in order to guide orderly urban development.

3.1.3 Outcomes and reflections

Overall, after more than two decades of development, a group of new towns and new districts with clear industrial positioning, complete infrastructure, and relatively mature service functions have gradually developed into urban subcenters or specialized new towns. They have effectively supported demand for urban growth and demonstrated the value of urban dynamic spaces. Yet as the momentum of urbanization and industrialization weakens, many new towns and districts that were built too rapidly have become typical areas where land urbanization outpaced population urbanization and where inefficient urban land is concentrated. They have thus become priority areas requiring adjustment and optimization. This indicates that the demand logic of urban development dynamics and their corresponding dynamic spaces has already changed and must be adjusted in a timely manner.

3.2 Planning Practice in the Structuralist Stage

3.2.1 Sources of momentum: diversified industrial factors

The economic development of a country or city is shaped by both the economic cycle and by whether it is an economy being chased by others. The former refers to whether economic development is at a peak or trough; the latter affects the factors that drive economic development - whether a city is following a general industrialization path or has become an innovation-driven economy that others seek to catch up with. At present, China's economy is shaped by conflicting long-, medium-, and short-term cycles, creating a more complex economic environment. It is also shifting from follower-type industrialization toward innovation-driven, leading-type new industrialization. Development dynamics and models are therefore becoming more complex. At the same time, after China's urbanization rate exceeded 66%, the real-estate-driven growth rate of cities has also slowed significantly. Overall, industrialization, urbanization, real estate, and urban spatial development are all undergoing structural adjustment.

3.2.2 Demand and supply of dynamic spaces: formation of specialized and differentiated dynamic districts

Facing a complex and changing environment, the 2015 Central Urban Work Conference emphasized that urban development should follow the principle of "one respect and five coordinations." The focus of a new round of planning shifted toward adjustments in functional positioning and spatial structure. The authors have therefore proposed that urban development is transforming from growth doctrine to structuralism.

There have been many new technical breakthroughs in defining urban functional positioning. On the one hand, planning has been influenced by global city theory and value segment theory. On the other hand, it increasingly emphasizes a city's position in global and regional networks, especially its control capacity and influence. For example, Shanghai proposed the goal of becoming an "excellent global city," while Wuhan proposed the goal of becoming a "national central city."

As cities shift from growth doctrine to structuralism, spatial restructuring has also become a key focus of strategic urban planning. Shanghai was among the first to emphasize zero growth in land use. Its spatial development policy was expressed as "central radiation, two wings taking flight, new towns exerting force, and north-south transformation." In the authors' work on Shanghai's spatial development during the 14th

Five-Year Plan period, further emphasis was placed on key dynamic spaces, namely “key areas” and “potential areas” (Table 4).

Table 4. Planning concepts of urban dynamics and dynamic spaces in selected city plans during the structuralist period

City	Urban functional positioning	Urban spatial structure
Shanghai	An excellent global city; economic center, financial center, shipping center, trade center, and science and technology innovation center	Central radiation, two wings taking flight, new towns exerting force, and north-south transformation
Hangzhou	A world-renowned city with distinctive charm and extraordinary appeal; a historic and cultural city, a city of innovation vitality, and a capital of ecological civilization	Ten innovation circles, ten charm circles, and an alliance of clustered urban groups
Wuhan	A more competitive and more sustainable world city, strengthening four major functions: innovation center, financial center, trade center, and high-end manufacturing center	An efficiently connected main urban area (the three towns of Wuhan) and four peripheral clusters with clear functions: Greater Optics Valley, Greater Auto City, Greater Lin-gang, and Greater Airport; three axes in coordination and a dual-main, four-subcenter structure
Guangzhou	International trade center, national advanced manufacturing base, national comprehensive gateway, and an important carrier of the international science and technology innovation center	Southward expansion toward the two oceans, eastward advance along the two rivers, quality upgrading of the old city, and demonstration by polar nodes

3.2.3 Outcomes and reflections

In general, the shift from planning in the growth-doctrine period to planning in the structuralist period is centered on the transformation of urban development dynamics and the redefinition of dynamic spaces. Urban development dynamics now place greater emphasis on planning a city’s control capacity and influence within global and regional networks, as well as on functional positioning that promotes urban development. Many megacities and superlarge cities now attach great importance to innovation functions and the development of the real economy, particularly the leading role of chain-owner enterprises in supply chains. They also emphasize transport hub functions, producer services, trade, and cultural functions.

These functions and spaces are related through matching, coupling, and mutual reinforcement. The combination of dynamic factors and space should therefore be optimized; forms that match function and space should be emphasized; and corresponding infrastructure support networks and factor allocation should be provided. New urban dynamic spaces differ from the traditional primary-center/subcenter structure. Their functions are not merely to provide supporting services to surrounding urban areas, but to embody a city’s core functions in global competition. Further uncovering the laws of dynamic spaces, constructing a new urban center system, and forming a more resilient dynamic system are among the key tasks through which urban planning can play a guiding role.

4 Further Research on the Laws of Dynamic Spaces Based on Multi-source Big Data

Wu Zhiqiang et al. [45] note that multi-source, heterogeneous, and complex urban data can reveal characteristics and laws that are difficult to perceive through human observation alone. Accordingly, this paper proposes an analytical model based on multi-source urban big data to examine the operational mechanisms of urban dynamic spaces. Around this model, the paper explores three issues. First, it examines

the configuration of dynamic-space factors and identifies the core elements that influence the development of dynamic spaces. Second, it uses quantitative clustering and machine-learning algorithms to identify dynamic spaces precisely. Third, it conducts a coupling analysis between identified dynamic spaces and the built environment to examine how the built environment affects dynamic spaces, thereby supporting more scientific planning and design.

Shanghai is selected as the case city for this exploratory research. The main technical approach (Figure 1) is as follows. Building on the preceding analysis of current trends in urban development dynamics, the study first selects five emerging urban dynamics for investigation. In combination with the main productive-force factors of economic development, and around the three core elements of productive forces - talent, enterprises, and facilities - it constructs a dynamic evaluation system. Unsupervised machine learning is then used to preliminarily identify dynamic spaces, that is, areas of factor agglomeration. Second, semi-supervised machine learning is used to analyze the core factors influencing the formation of urban dynamic spaces and to determine the classification of different types of urban dynamic spaces. Finally, through a coupling analysis between built-environment morphology and the distribution of urban dynamic spaces, the study judges which spatial forms are more strongly associated with different types of dynamic spaces.

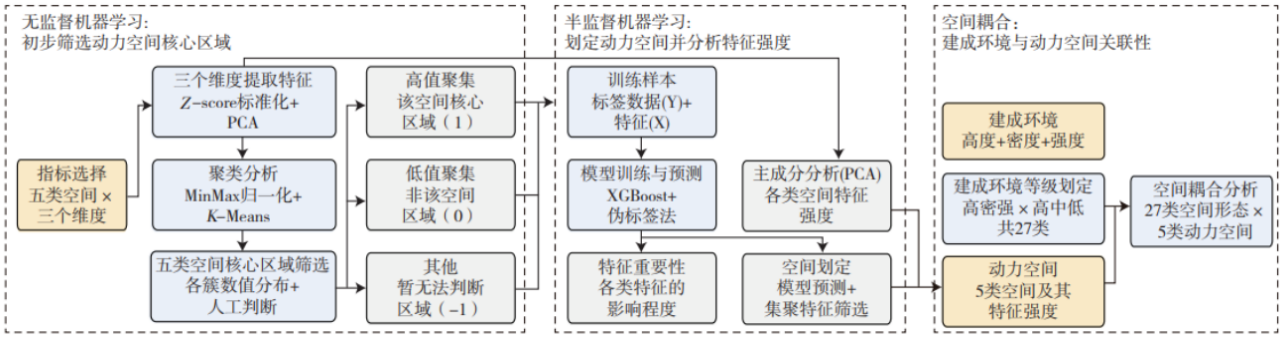

Figure 1. Research framework and technical flow chart for dynamic spaces

Figure 1 presents the technical workflow used in this study. It begins with indicator selection for five types of space across three dimensions, applies Z-score standardization and principal component analysis, uses clustering analysis and K-means normalization for unsupervised screening of core dynamic-space areas, then employs XGBoost and pseudo-label methods for semi-supervised learning, prediction, feature-importance analysis, and spatial delineation. The final step couples the five types of dynamic spaces with 27 built-environment categories derived from height, density, and intensity.

4.1 Factor Configuration of Dynamic Spaces

In identifying dynamic spaces, the study first focuses on their core elements. It constructs an evaluation indicator table around three dimensions - talent, enterprises, and facilities (Table 5). A fishnet dataset covering all of Shanghai at a 200 m grid scale is then established, and all data in the indicator table are linked to the grid, forming a dataset for five types of dynamic spaces in Shanghai across three dimensions.

Based on the constructed dataset, all elements of the five types of dynamic spaces are first subjected to dimensionality reduction and clustering to generate continuous numerical results for dynamic-space identification. During model construction, the study focuses on the influence of different factors in order to determine the core factor configuration of each type of dynamic space.

The preliminary analysis of Shanghai shows that factors related to talent have a significant influence on the formation of dynamic spaces, much stronger than enterprise and facility factors. Agglomeration of

employed population is often accompanied by agglomeration of related industries, and the productivity and innovative capacity of talent are the core driving forces for the formation and development of dynamic spaces. As people with professional skills and capabilities continue to gather, and as the industries they serve develop and upgrade, the energy level and competitiveness of dynamic spaces will rise markedly (Figure 2).

Table 5. Core indicators for identifying dynamic spaces

Type of dynamic space	Dimension	Indicators
Commercial agglomeration area	Talent agglomeration	Workers in catering; workers in hotels; shopping-scene foot traffic; hotel-scene foot traffic; beauty-service-scene foot traffic; food-scene foot traffic; parent-child-scene foot traffic; sports and fitness-scene foot traffic
Commercial agglomeration area	Enterprise agglomeration	Wholesale and retail enterprises; accommodation and catering enterprises
Commercial agglomeration area	Facility agglomeration	Wholesale and retail facility points; commercial and business-service facility points
High-end manufacturing agglomeration area	Talent agglomeration	Factory blue-collar workers
High-end manufacturing agglomeration area	Enterprise agglomeration	Manufacturing enterprises
High-end manufacturing agglomeration area	Facility agglomeration	Scientific research and technical-service facility points
Producer-service agglomeration area	Talent agglomeration	Financial workers; office-building white-collar workers; highly educated employed population; financial-scene foot traffic
Producer-service agglomeration area	Enterprise agglomeration	Information transmission, software and information-technology service enterprises; financial enterprises; leasing and business-service enterprises; scientific research and technical-service enterprises
Producer-service agglomeration area	Facility agglomeration	Finance and insurance facility points; scientific research and technical-service facility points; commercial and business-service facility points
Hub area	Talent agglomeration	Transport-facility-scene foot traffic
Hub area	Enterprise agglomeration	Transport, warehousing, and postal enterprises
Hub area	Facility agglomeration	Transport and warehousing facility points
Cultural and creative industry agglomeration area	Talent agglomeration	Entertainment-industry workers; scenic-area workers; leisure-and-entertainment-scene foot traffic; tourist-attraction-scene foot traffic; sports and fitness-scene foot traffic
Cultural and creative industry agglomeration area	Enterprise agglomeration	Culture, sports, and entertainment enterprises
Cultural and creative industry agglomeration area	Facility agglomeration	Sports and leisure facility points

商业集聚区		高端制造集聚区		生产性服务业集聚区		枢纽地区		文化创意产业集聚区	
特征	影响程度	特征	影响程度	特征	影响程度	特征	影响程度	特征	影响程度
美食场景客流	0.315 826	工厂蓝领工人	0.844 698	高学历就业人口	0.279 261	交通设施场景客流	0.417 686	休闲娱乐场景客流	0.231 478
批发和零售业企业	0.071 107	制造业企业	0.107 397	租赁和商务服务业企业	0.208 094	交通运输、仓储和邮政业	0.365 105	娱乐行业工作人员	0.182 888
总就业人口	0.067 808	POI科研及技术服务	0.047 004	金融	0.103 065	科学研究和技术服务业企业	0.094 523	POI运动、休闲	0.155 643
餐饮行业工作人员	0.052 175	总就业人口	0.000 361	写字楼白领	0.07 1960	金融业企业	0.012 633	文化、体育和娱乐业企业	0.105 731
住宿和餐饮业企业	0.046 815	科学研究和技术服务业企业	0.00 017	总就业人口	0.038 002	住宿和餐饮业企业	0.011 566	美食场景客流	0.090 923

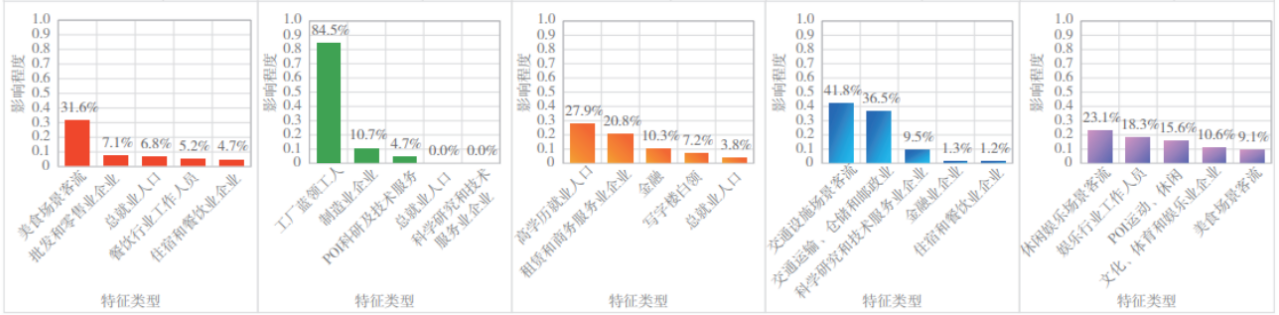

Figure 2. Top five features of the XGBoost model for five types of urban dynamic spaces in Shanghai

Figure 2 compares feature importance across five types of dynamic spaces in Shanghai. For commercial agglomeration areas, food-scene foot traffic is the most important feature. For high-end manufacturing agglomeration areas, factory blue-collar workers dominate the model. For producer-service agglomeration areas, highly educated employed population and leasing/business-service enterprises are prominent. For hub areas, transport-facility-scene foot traffic and transport, warehousing, and postal enterprises are decisive. For cultural and creative industry agglomeration areas, leisure-and-entertainment-scene foot traffic and entertainment-industry workers are among the leading features.

4.2 Precise Identification of Dynamic Spaces

After the preliminary identification of five types of dynamic spaces, the study further considers spatial continuity and territorial functionality. Thresholds are defined separately for different types of dynamic spaces to clarify their spatial distribution. In Shanghai, approximately 58.16 km2 of commercial agglomeration dynamic space is identified, accounting for about 0.76% of the city's area. Producer-service dynamic space covers about 46.72 km2, or around 0.60% of Shanghai. High-end manufacturing dynamic space covers approximately 215.36 km2, or about 2.8% of the city.

After a preliminary evaluation of the five types of urban dynamic spaces in Shanghai, the study overlays them and finds that many areas have composite functions. This is especially true in the central city, where many areas are compound dynamic spaces, such as commercial composite areas, producer-service composite areas, and cultural and creative composite areas. By contrast, high-end manufacturing spaces are relatively more concentrated on the urban periphery (Figure 3).

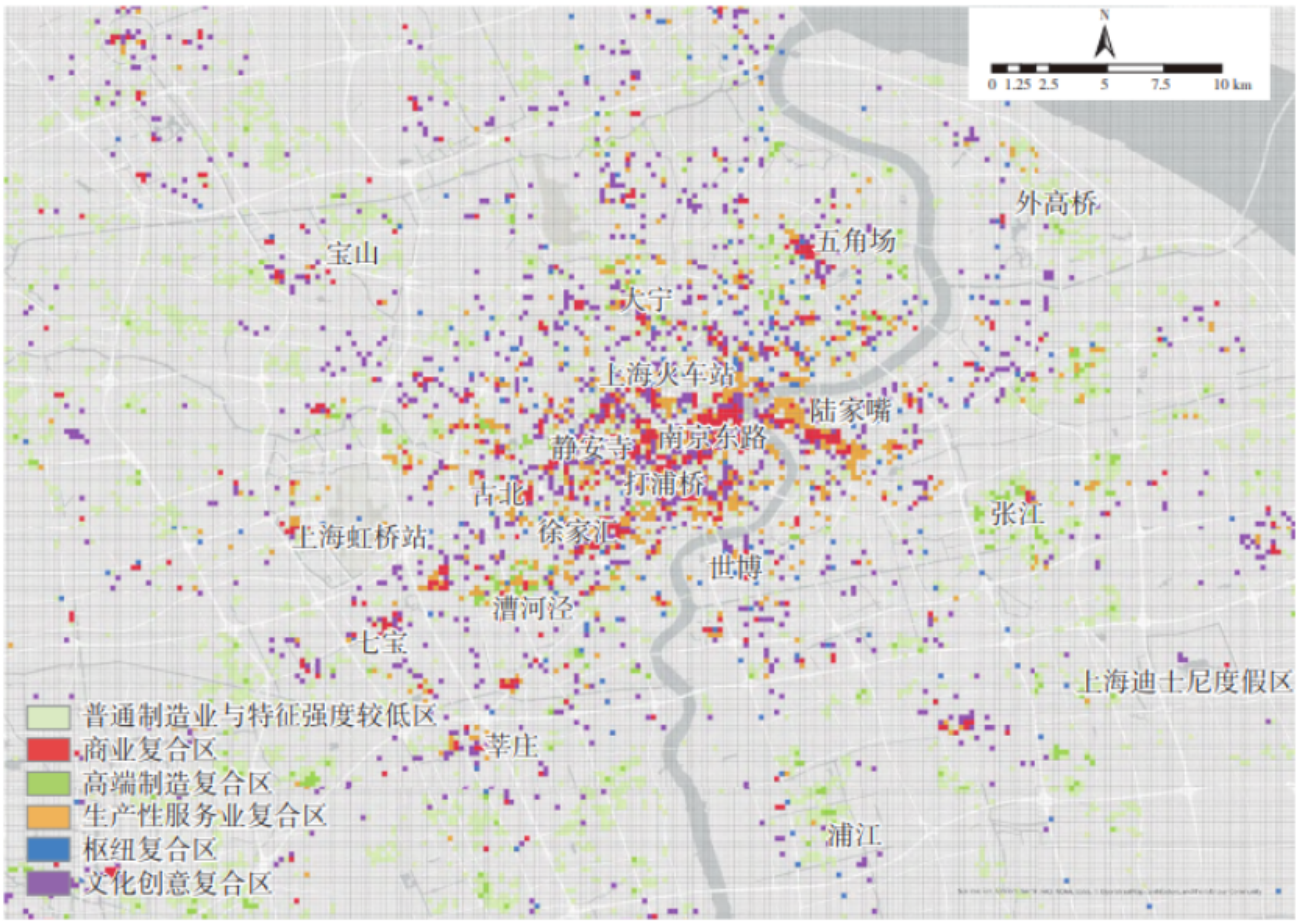

Figure 3. Spatial distribution characteristics of five types of composite dynamic spaces in Shanghai

Figure 3 shows the distribution of five composite dynamic spaces in Shanghai, including commercial, high-end manufacturing, producer-service, hub, and cultural-creative composites. It highlights the concentration of multiple dynamic functions in the central city and identifies named areas such as Lujiazui, Jing'an Temple, Nanjing East Road, Xujiahui, Hongqiao Railway Station, Zhangjiang, Wujiaochang, Baoshan, Daning, Waigaoqiao, Qibao, and Shanghai Disney Resort.

4.3 Coupling Relationship between Dynamic Spaces and the Built Environment

To better plan and build dynamic spaces, this paper examines the coupling relationship between dynamic spaces and the built environment after identifying the former. Although the built environment is a broad field, this study simplifies the analytical logic by adopting a "height-density-intensity" evaluation system [46-48] as the main criterion for assessing the built environment. Different built-environment types are identified through clustering based on height, density, and intensity, and then matched with the identified dynamic spaces. This coupling analysis reveals the built-environment characteristics of different types of dynamic spaces.

The study clusters built-environment height, density, and intensity into high, medium, and low levels, forming 27 spatial forms. These are then coupled with five types of dynamic spaces to analyze the built-form laws of different dynamic spaces (Figure 4). Preliminary findings show that cultural-industry dynamic spaces, which often rely on historic districts or old industrial areas as distinctive spatial carriers, usually correspond to medium- or low-level building height, intensity, and density. Commercial dynamic spaces have more universal characteristics across the city and display relatively even distribution across built-environment

types. Producer-service dynamic spaces are significantly associated with medium- and high-intensity built environments. Their high-density enterprise agglomeration, convenient transport networks, and rich talent resources provide strong support for the development of producer services.

In practice, existing regulatory detailed planning systems tend to use built-environment indicators such as floor area ratio, building height, and development intensity mainly to control the form of newly built areas. They lack sufficient consideration of dynamic matching. As a result, the demand for urban dynamics and the supply of space are often poorly connected; construction and operation fall short of planning expectations; and many spaces fail to achieve healthy operation and value appreciation. Introducing the idea of dynamic planning and adjusting spatial layout and facility provision in response to changes in dynamic-space development can effectively ensure coordinated development between the built environment and dynamic spaces. Of course, using height, density, and intensity to represent the built environment has limitations. Future research should enrich built-environment indicators in order to deepen analysis of the coupling laws between the two.

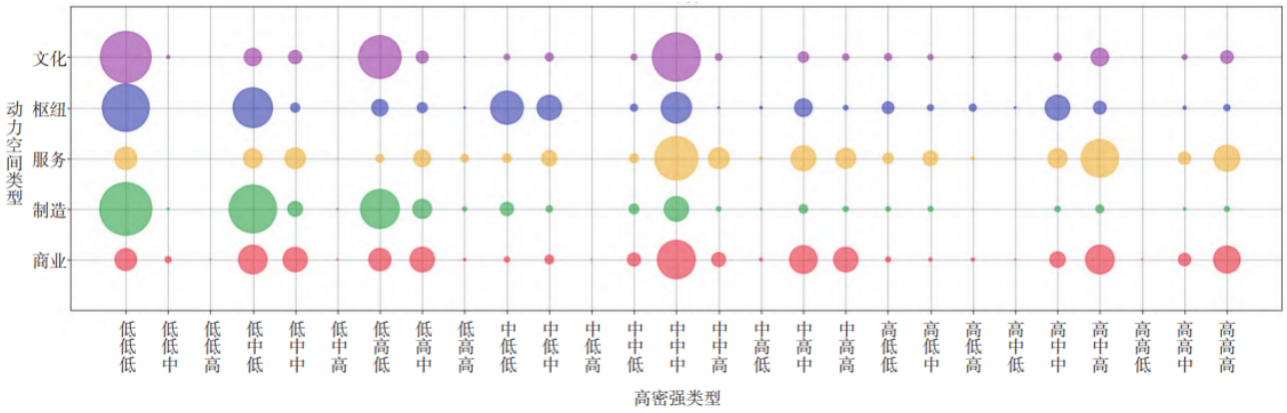

Figure 4. Distribution of five types of dynamic spaces in Shanghai within 27 categories of height-density-intensity built environments

Figure 4 compares the distribution of cultural, hub, service, manufacturing, and commercial dynamic spaces across 27 built-environment categories formed by high, medium, and low combinations of height, density, and intensity. It suggests that different dynamic spaces correspond to distinct built-form profiles rather than to a single universal development model.

5 Conclusion

As urbanization deepens, urban development faces new challenges in its sources of momentum and new spatial transformations. This also places new demands on the development of the planning discipline, requiring systematic reflection from both theory and practice to guide future work. The traditional growth-doctrine model relied mainly on rapid industrialization, rapid urbanization, and real estate as its driving forces, and urban spatial development primarily took the form of new urban areas and development zones on the urban periphery.

As cities gradually transform from growth doctrine toward structuralism, the original “three drivers” of urban development are becoming difficult to sustain. Industrial upgrading and adjustment are shifting toward multiple endogenous dynamics led by new quality productive forces, including innovation, services, and culture. These emerging dynamics are also seeking new spatial points of coupling and are gradually

becoming important nodes of urban dynamic spaces in the new era. They will have a major influence on urban spatial structure, the direction of urban renewal, and planning for urban opportunity spaces.

By judging the staged transition from growth doctrine to structuralism, and by exploring the theory, practice, and built-environment growth laws of urban dynamic spaces, this paper aims to provide new perspectives and tools for urban planners and researchers. The framework proposed here remains preliminary; it is hoped that colleagues interested in this field will continue to advance the study of dynamic spaces together.

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