"Customized Spatial Demand for 'Industry-City Integration' Planning: A Case Study of Shanghai Lingang New City"

Zhou Ling, Li Fengqing, Huang Huang

Abstract: Based on the context of shrinking land finance and industrial chain innovation, this paper explores the transformation of spatial demands in suburban areas of China's large cities from "scale-based supply matching" to "customized demand guidance" in the framework of "industry-city integration" planning. Taking the Lingang New City area in Shanghai as a specific case, the paper reviews the development process of industry-city relations, focusing on "crowd profiling and value division." By using differentiated spatial demand as an entry point for optimizing the "industry, city, and people" spatial organization relationships, the paper analyzes the differentiated spatial demand characteristics formed by various groups' residential choices, commuting preferences, and industrial chain organization. The paper further proposes a demand-driven, refined "industry-city integration" planning strategy.

Keywords: Crowd profiling; Industrial value chain; Customized demand; Industry-city integration; Shanghai

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Author Information:
Zhou Ling, Deputy Director of the Planning and Design Department, Lingang Group, Senior Engineer, zhouling@shlingang.com
Li Fengqing, Associate Dean, Shanghai University Institute of Urban Renewal and Sustainable Development, Associate Professor
Huang Huang, Assistant Professor, School of Architecture and Urban Planning, Tongji University, Corresponding Author, hhuang@tongji.edu.cn

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1. The "Demand-Side" Shift in Industry-City Integration Planning

Since the 21st century, the rapid urbanization process in suburban areas of China’s large cities has been characterized by a supply-driven growth logic: local governments, relying on large-scale new town (district) planning—land development—industry and real estate investment—land-based fiscal revenue—new development project cycles, have achieved the accumulation and expansion of local finance and market capital. The supply-oriented land finance development model has objectively supported the rapid urbanization of suburban areas in large cities in China. While great achievements have been made, it has also increasingly faced systemic problems, such as oversupply of spatial products [1], accumulation of real estate debt [2-3], imbalance in industry-city relations and job-housing relations [4-5], and social spatial segregation [6-7]. Consequently, discussions on the “industry-city integration” strategy for new districts and towns have become an important academic topic in China’s planning research and practice in recent years.

Against the backdrop of global fluctuations and the construction of a new development pattern, the spatial organization logic of metropolitan areas in China has also begun to undergo profound changes: on one hand, the role of suburban areas, where industrial supply chains and innovation chains are concentrated, in supporting national strategies and regional development has become increasingly prominent. For example, the Lingang New City in Shanghai has gradually become an engine of international competitiveness, bringing together advanced manufacturing production, research and development, and logistics chains. On the other hand, many new suburban towns in China are transitioning to large-scale unmanned and unlit models, and the traditional urbanization understanding that "industrial development drives significant population growth in new towns" is gradually becoming disconnected from the reality of suburban new towns where advanced manufacturing industries are concentrated. These regions often also show spatial differentiation due to the organizational needs of the industrial value chain. Different value chain groups, such as production manufacturing, research and development innovation, headquarters management, and logistics services, exhibit significantly differentiated spatial demands.

With the establishment of the new framework for land and space development and protection, both the optimization of urban stock space and the expansion of new cities and new districts require more refined and guided planning. Suburban new cities need to not only maintain their attraction for population and industry but also achieve high-quality development and high-quality living by continuously optimizing job-housing relationships and upgrading living amenities. These new towns must adapt to the differentiated spatial needs of different industrial value chain segments and their workforce, leading to a more efficient, collaborative, and sustainable "industry-city-people" development model.

As China’s urbanization rate approaches 70%, entering a stage of high-quality development, the large-scale supply-driven land finance model can no longer continue. Suburban areas of large cities urgently need to transition the spatial product from the supply side to the demand side. In other words, how can effective demand bench marking and planning guidance be used to continually reduce commuting costs, improve livability and suitability for business, and achieve a more efficient and refined matching of spatial needs for industry and people? The "industry-city integration" spatial pattern plays an increasingly important role in the high-quality spatial development of urbanization in China during its "second half." This gives new significance and academic value to research on "industry-city integration" planning.

1.1. Review of the Evolution of Industry-City Integration Planning Research

A review of the relevant literature from the past decade reveals the evolving stages of industry-city integration planning research in China:

The 12th Five-Year Plan (2011–2015) period focused mainly on the concept and spatial policies of "industry-city integration" in the context of "spatial transformation." Research on "industry-city integration" began during this period, with the construction of new cities and the transformation of development zones. Studies during this time mainly addressed the matching of job-housing relationships, infrastructure, and other aspects of the industrialization and urbanization processes, as well as the analysis of the conceptual connotations of "industry-city integration" [8-10]. Researchers also proposed spatial planning strategies and policy recommendations for integrating industrial and residential functions through mixed land-use consolidation [11-15].

The 13th Five-Year Plan (2016–2020) period focused on exploring the new patterns of "industry-city integration" and multi-system support strategies. This included: establishing "industry-city integration units" and "industry-city integrated communities" based on reasonable commuting scales [16]; emphasizing the role of institutional mechanisms and management authority design in promoting industry-city integration during the development of new districts and new cities, and discussing key indicators [17]; supporting strategies for industry-city integration based on the spatial connections within industrial value chains, and promoting the simultaneous upgrading of industrial and urban spatial structures [4]. Some scholars [18] explored the life cycle of development zone transformation from the perspectives of development dynamics, industry, function, and spatial multi-systems, suggesting that the process of industry-city integration should be understood as a shift from "external policy promotion" to "internal driving force enhancement." In addition, new data sources such as mobile positioning were widely used in studies of job-housing spatial relationships, providing new technological tools for the construction of industry-city integration patterns [19-21].

The 14th Five-Year Plan (2021–Present) period, under the "People's City" construction concept, has seen research on industry-city integration focus more on the coordination and optimization mechanisms of the "industry, city, and people" multi-systems. From the mid-to-late stage of the 13th Five-Year Plan, some scholars [22] began reflecting on the "industry-heavy, people-light" issue in industrial parks from a human-centered perspective. Other research [23] noted that industrial and residential functions are developed based on different leading forces and logics, and that, in addition to focusing on the development and improvement of new urban functions, the government should also promote "people integration." Furthermore, some studies have proposed the coordination and linkage of multiple systems such as "industry, city, and people" [24], analyzing the spatial characteristics and strategies for optimizing industry-city integration from a "people, living, and work" overlapping perspective using multi-source data [25], and forming spatial optimization strategies based on the "people-industry" integrated development model, in line with spatial planning workflows and the national land space planning system [26].

1.2. New Issues in the New Context: From the Supply Side to the Demand Side of Spatial Provision

Overall, the evolution of planning research on "industry-city integration" reflects China's transformation from rapid urbanization centered on growth to high-quality urbanization centered

on people. This transformation began with the conceptualization and spatial policy discussions of "industry-city integration" in the context of development zone transformations, followed by the exploration of new patterns for "industry-city integration" and multi-system support, and more recently, the focus on the coordination and optimization strategies of the "industry, city, and people" systems under the global restructuring of industrial innovation chains. As a result, related research has continually evolved in response to the changing context of the times.

On the other hand, although planning concepts for "industry-city integration" based on people's needs are increasingly emphasized, there is still a lack of a clear research framework for the spatial organizational mechanisms of the "industry, city, and people" coordination. The "supply-side" planning approach of "providing urban living services for industries" has clearly constrained the progress of fine-tuned "industry-city integration" research and further optimization of spatial organizational strategies.

In reality, the development of industrial production, research and development (R&D), and urban service functions follows its own rules and different driving mechanisms and spatial demands [4,23,27]. It is precisely because of the differences in spatial demand preferences and spatial activity capabilities among different groups that "integration for the sake of integration" could potentially lead to a decline in the area's industrial and population attractiveness and the inefficient layout of public service facilities. Therefore, "industry-city integration" should not be simply understood as providing diverse urban living services for industrial areas through spatial supply organization, but rather as a process that requires full recognition of the division of labor within the industrial value chain, the differentiated spatial demand preferences of various groups in terms of housing choices and commuting, and the motivations of different driving forces behind industry and urban spaces. Only by considering these factors can planning guidance continuously optimize the multi-system relationships between industry, city, and people, achieving more accurate and effective allocation of spatial resources and public service facilities.

Based on the above judgment, research on "industry-city integration" planning needs to shift from the "supply-side" spatial production framework focused on the relationship between industry and city support during the land finance period, to the "demand-side" custom service development framework focused on the division of the industrial value chain and differentiated demand guidance for various groups in the era of high-quality development. This is the main issue addressed in this paper.

2. Constructing the Framework for "Industry-City Integration" Spatial Demand

The concept of "space production" originates from the works of French sociologist Henri Lefebvre [28], which introduced the "spatial turn" in Western social sciences. He interpreted space as the fundamental organizational form of all human social production and practical activities, and believed that human society would inevitably progress toward "complete urbanization" through the production of space [29]. Building on this, David Harvey [30] argued that the space carrying human social activities is like a commodity, becoming a tool for the expansion and reproduction of capital circulation. Space will, under "time-space compression," evolve from being heterogeneous to rapidly flattening.

In contrast to the logic of large-scale production of space under rapid capital circulation, the "demand-side" spatial customization framework discussed in this paper can be understood as a

transformation of spatial products from "scale-based supply" to "customized services" in the context of fiscal contraction in the new era. It also responds to the trend of suburban development in large cities shifting from a land finance path to a development path focused on industrial innovation and cultivating new productive forces. To a certain extent, "spatial customization services" still continue the logic of "capital circulation" in the expansion of space reproduction, further extending and evolving the theoretical connotation of "space production" in the era of refined spatial organization and customized spatial product supply.

Compared to the period of rapid urbanization, the spatial products provided by "customized services" can more accurately and effectively meet the differentiated needs of various groups for production and living in the new era, thereby further supporting the people-centered high-quality urbanization process.

Research on "spatial customization" from the demand side can be widely applied in urban internal optimization, community planning, new city construction, development zone transformation, and other planning optimization practices. It also lays a solid foundation for theoretical research. This paper only discusses the construction of the framework and its planning application in the study of "industry-city integration" in suburban areas of metropolitan cities in the new era. Industrial spaces have their own spatial organizational laws based on the division of the value chain, and spaces for industry, R&D, and integrated living services also have different development entities and driving mechanisms. Therefore, the study will attempt to build a multi-system spatial coordination framework of "industry, city, and people" based on differentiated demand among groups, incorporating the spatial organization laws of the industrial value chain and policies of different development entities, to provide new ideas for the construction of "industry-city integration" planning strategies in the new era (Figure 1). This framework specifically covers:

(1) Spatial Division of Labor in the Industrial Value Chain

The industrial value chain is the link that connects regional industrial development, upgrading, and the organization of industry-city spatial relations. The different stages in the value chain—such as R&D, production, and headquarters management—often have distinct location requirements, and in terms of spatial organization, they tend to form significant agglomeration relationships with research institutions, industrial zones, and central urban areas, respectively [31]. Some scholars divide the evolution of industrial zones into four main stages: factor agglomeration, industry leadership, innovation breakthrough, and industry-city integration [15]. According to the specialization and division of labor logic in the value chain and the guidance provided by different location needs, the organization of industry, city, and park spaces has become an important theoretical guide for the planning layout of industry-city integration [4].

(2) Segmentation of Population Types and Spatial Differentiation Optimization Logic

Based on the existing spatial layout of the value chain, this research suggests that studies on industry-city integration in the suburban areas of metropolitan cities in the new era should focus on people's spatial needs. The research should center on the development zones' transformation and new city construction, and build a "people-centered" spatial customization framework for daily production and living scenarios. Firstly, it is necessary to segment and identify the population types behind the spatial organization logic in the industrial chain division. On this basis, it is essential to deeply analyze the group-based differences in the "work-residence" spatial demand preferences and capacities (such as housing choice, commuting preferences, etc.) that

underlie the relationship between industry and the city. Based on this, targeted strategies for matching the industry, city, and population systems are proposed to further optimize the corresponding spatial organization logic.

(3) Spatial Policy Support Mechanisms Based on Different Development Entities

Industrial parks, R&D offices, urban real estate, and commercial service facility development have different developers and driving mechanisms. On the other hand, the management committees (and state-owned first-level development companies that control the related land) commonly established in new cities and development zones in China can explore spatial policies that are customized to meet demand, based on the division of labor in the industry and differentiated needs of the population. These policies can be formulated in line with industry and talent introduction policies at the overall level, further supporting the multi-system coordination of industry-city integration development from an institutional and systemic perspective.

The following section takes the Shanghai Lingang New City area as an example. Based on the evolution of the industry-city-population relationship over the past 20 years in the region, this paper will analyze the evolution of its population structure and the formation process of differentiated spatial demands. It will then propose planning guidance for the construction of an industry-city-population integrated spatial demand framework (Figure 1) for the new era's "industry-city-population" coordination in this area.

3. Lingang New City Industry, City, and Population Relations: Planning Vision and Real-world Evolution

Lingang (Nanhui) New City is located at the southeastern tip of Pudong New District in Shanghai, on the north shore of Hangzhou Bay. It is adjacent to the world’s largest container port, Yangshan Port, and is approximately 60 kilometers from downtown Shanghai. As one of the five key new cities for development during Shanghai's 14th Five-Year Plan, the area is managed by the Lingang New Area Management Committee of the China (Shanghai) Pilot Free Trade Zone. State-owned enterprises at both the city and district levels, such as Lingang Group, Port City Group, and Lingang Investment Control, lead the development of primary and secondary land and the operation of industrial investment and financing.

Over nearly two decades since the start of its planning and construction, the region has evolved from "port-driven city development, industry-led, and localized urbanization" to a relatively independent coastal integrated new city in the Yangtze River Delta, and then into a Free Trade Zone area that undertakes China's mission for global governance exploration in the new era. As such, the "industry, city, and population" relationship in Lingang New City has continuously evolved.

3.1 Industry, City, and Population Planning Vision (Early 21st Century)

Lingang New City was originally a suburban area of Shanghai. In 2004, the population of the area was about 152,000, with around 24,000 urban residents, concentrated mainly in the towns of Nicheng, Shuyuan, Luchao Port, and Wanxiang, with the rest being rural populations. In 2004, the first overall planning of Lingang New City outlined four functional zones within a 297 square kilometer area, with a planned population of 830,000 by 2020.

The key elements of the early planning regarding the industry-city relationship included:The main urban area of Dishui Lake was designated to accommodate the comprehensive residential and

service functions for advanced manufacturing industries, with a focus on housing 450,000 residents, with the northwest sector identified as the first area to be developed.The four old town areas were to be transformed into "urban communities," with all 230,000 residents of displaced households receiving residential services.

A new industrial and residential mixed-use area in the northern part of the main urban area, which aimed to gradually achieve the goal of "industry driving city, and city driving industry."

The functional zoning and sectoral layout in the early plan facilitated phased investment and construction. The main urban area, comprehensive zones, and industrial areas were included in the first phase of development. However, typical issues from China's new city construction were also evident, such as the large scale of the sectors, relatively single functions, oversized industry-city spatial scales, and the distance from the central urban area.

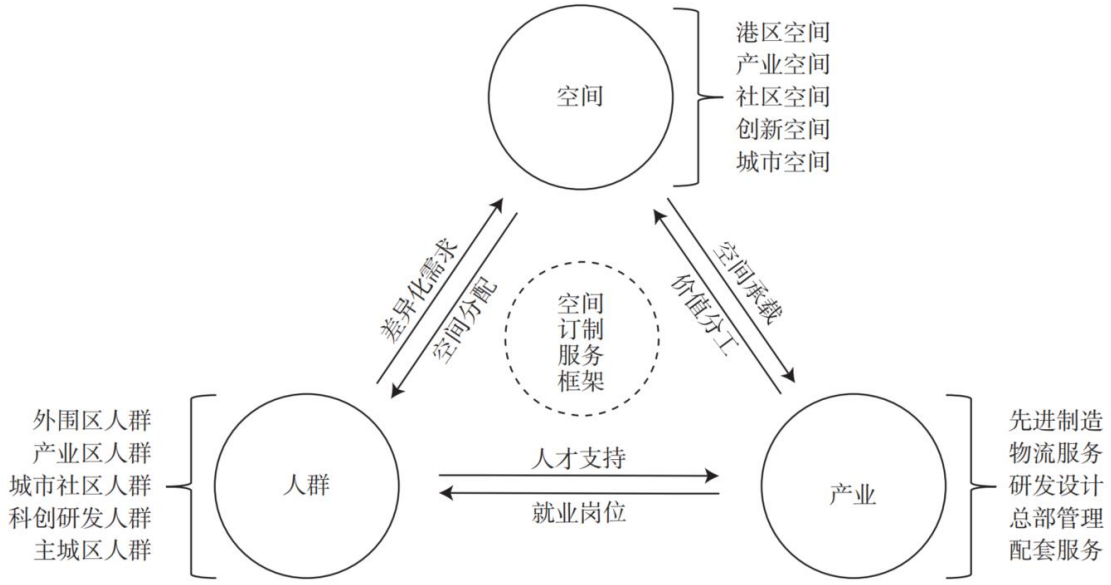

Fig.1 Framework of space customization through industry-city-people coordination toward industry-city integration: Lingang New City, Shanghai

3.2 Evolution of "Industry, City, and Population" Relationships: Realistic Scenarios (2004–2021)

3.2.1 Rapid Industrialization and Urbanization Period (2004–2010)

The 11th Five-Year Plan period marked the stage of rapid industrialization and the beginning of urban infrastructure in the Lingang New City area. During this period, the relationship between industry and the city exhibited characteristics such as industry-driven development, the introduction of major projects, and rural urbanization [25,32]. In 2008, the Fengxian Park was incorporated into Lingang, expanding the new city area to 315 square kilometers. During this time, the northern shore of Hangzhou Bay became an industrially-driven initial zone, attracting large-scale heavy equipment and logistics industries. The neighboring communities of Micheng and Luchao Port took on the bulk of rural relocation and the associated population for industrial zone support, resulting in rapid population growth.

On the other hand, the population growth in the Dishui Lake main urban area was slow. Due to its distance of over 50 km from downtown Shanghai and more than 20 km from the industrial zone, the northwest initial development area of the main urban district struggled with low real

estate demand. To drive population influx into the main urban area, the Shanghai municipal government established the Lingang University Town in the southwestern part of the main urban area and gradually moved campuses such as Shanghai Maritime University and Ocean University, in an attempt to boost population numbers and "stitch together" the spatial relationship between the industrial park and the main urban area, promoting integrated industry-city development. By 2010, the permanent population of the Lingang New City area was approximately 237,000, with only around 11,000 people in the main urban area, about 17,000 in the university town and research education zone, totaling around 28,000, accounting for only 12% of the permanent population. 43% of the population concentrated in the four "urban communities," mostly relocation residents. The remaining 41% still lived in peripheral rural areas, with around 4% residing in dormitories within the industrial zone. Overall, this phase exhibited characteristics of rapid industrialization driving local urbanization, with large-scale manufacturing industry introduction and the implantation of higher education institutions, a significant increase in urban community populations, and relatively weak population growth in the main urban area.

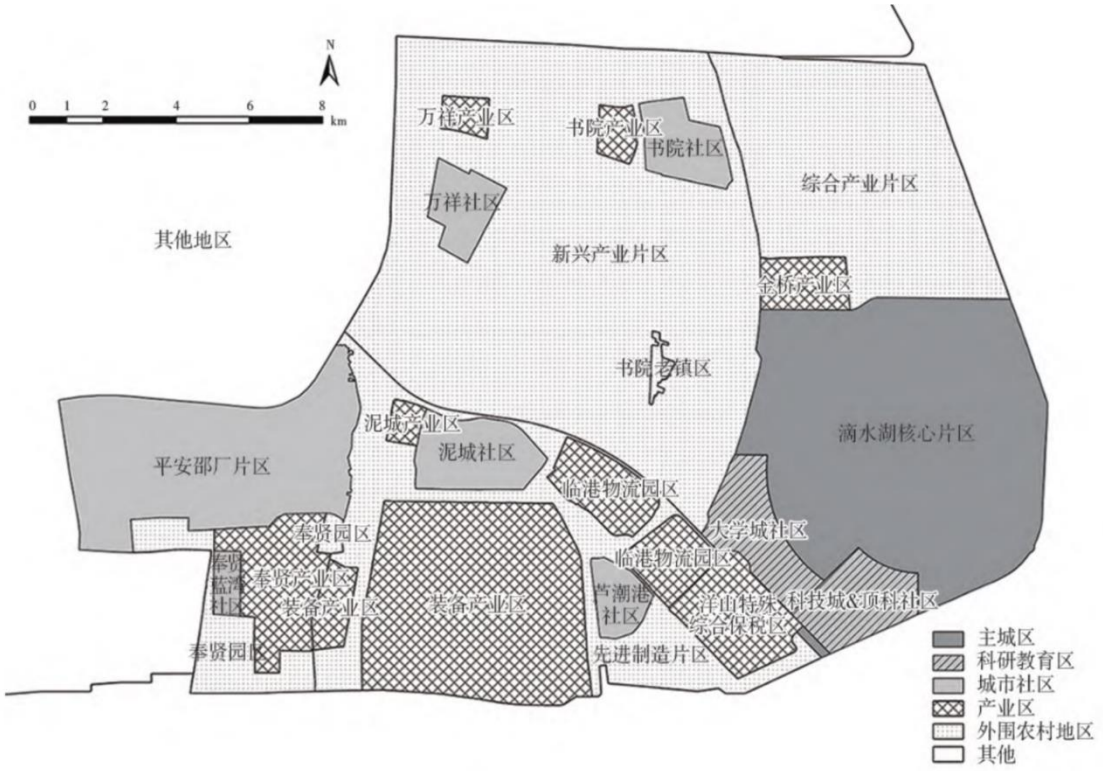

Fig.2 Spatial division of Lingang New City

Note: The Lingang New City area is divided into five spatial types: the Dishui Lake main urban area, the education and research area, urban communities, industrial zones, and peripheral rural areas. These spatial types have relatively clear spatial boundaries, and their inherent industrial types and population structures exhibit significant differences.

3.2.2 From "Comprehensive New City" to "Free Trade Zone New Area" (2011–2021)

In 2009, the State Council approved the integration of the original Nanhui District into the Pudong New Area. During the 12th and 13th Five-Year Plans, Lingang New City defined its development positioning as "a relatively independent node city in the Yangtze River Delta, a

coastal integrated new city," with the spatial area further expanding to 343 square kilometers. A differentiated relationship between "community + urban district" for industry-city integration gradually took shape. Especially with the establishment of the China (Shanghai) Free Trade Zone Lingang New Area in 2019, leading enterprises in the fields of new energy vehicles, integrated circuits, biomedicine, and artificial intelligence, such as Tesla and CATL, settled in the area, further reinforcing the demand for industry-related residential support. In response, the Michen community began building public rental housing under a "rent first, then purchase" model since the 13th Five-Year Plan, gradually constructing 2 million square meters of public rental housing, capable of accommodating about 65,000 people near the heavy equipment industrial zone. The population of urban communities like Michen further increased. By 2020, the permanent population of Lingang New City had reached 344,000, a 45% increase from the 6th National Census. The population growth primarily came from non-Shanghai residents. Among them, the four urban communities, such as Michen, saw a net increase of 82,000 people over the past decade, accounting for 47.8% of the total population in Lingang New City. In contrast, nearly half of the population in the Dishui Lake main urban area (10.3% of the total population) were from the research and education zone, and the population increase in the main urban area, excluding the university town, was only 16,000, clearly falling behind the planned expectations.

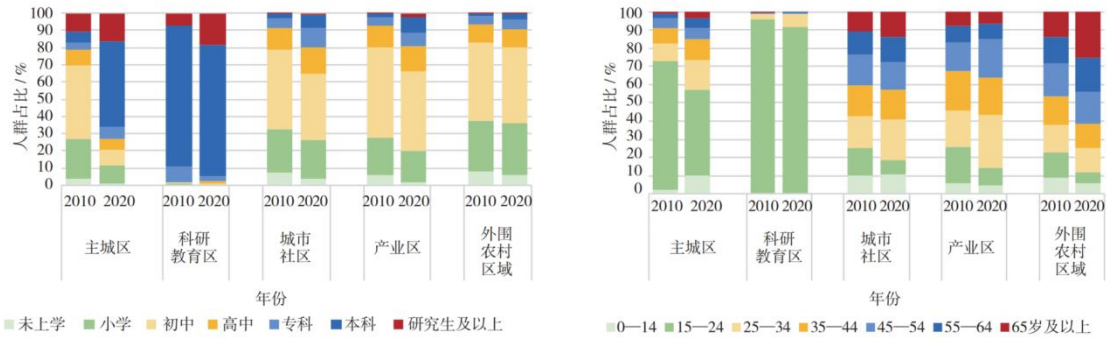

Figure 3: Differentiation in Educational Levels (left) and Age Structure of Population (right) by District from 2010 to 2020

Table 1: Evaluation Indicators for Population Profiles of Different Spatial Types

维度	编号	表征指标
年龄结构	1	15 岁以下少儿比例 / %
	2	25—45 岁青年劳动力比例 / %
	3	65 岁以上老年人口比例 / %
教育水平	4	小学及以下比例 / %
	5	大专以上比例 / %
住房水平	6	租赁商品房及廉租房比例
	7	购买商品房及二手房比例
收入水平	8	<8000 元月收入人群比例 / %
	9	>15 000 元月收入人群比例 / %

Data Sources: Age, education, and housing data are from the Seventh Population Census (2020) of the Lingang New City area; income levels are from mobile LBS income profile data (2020).

3.3 Evolutionary Characteristics of Population Structure and Regional Differentiation

Overall, the 20-year development process of the Lingang New City area reflects the characteristics of nearby urbanization driven by rapid industrialization, with a noticeable divergence from the early planning concepts regarding the relationship between industry, city, and population. The population structure in the region has gradually evolved from a suburban structure to that of an integrated new city, and the internal population structure within the new city has become increasingly differentiated into distinct segments.

In the early stages, the population of the Lingang New City area was primarily composed of residents from Shanghai's suburban towns and villages. In 2010, the proportion of the population aged 65 and above in the area was 15%, and the proportion of those with a bachelor's degree or higher was about 8%, the highest level of aging and the lowest level of higher education among the five new cities in Shanghai at that time. As the development of the university town and industrial zones led to the influx of a large population, the proportion of young and highly educated individuals gradually increased. Between 2010 and 2020, the proportion of incoming population in Lingang New City increased from the lowest 29.5% (below suburban districts) to 50.7%. The proportion of people with a bachelor's degree or higher increased from 12% to 22%, and the proportion of young people and highly educated individuals reached a higher level compared to the other four major new cities.

Within the Lingang New City area, the spatial distribution and evolution of population structure between 2010 and 2020 increasingly showed characteristics of regional differentiation (see Figure 2). Specifically:The research and education zone, which hosts multiple universities (including University Town, Science and Technology City, and Top Scientist Communities), had a noticeably higher proportion of individuals aged 25–44 and those with a bachelor's degree or higher than other areas.The main urban area also had a relatively high proportion of young, highly educated individuals, and showed a trend of an increasing proportion of people under the age of 14.The urban communities, while accommodating a significant number of local suburban residents and relocated populations, saw the greatest growth in the 25–34 age group, with a noticeable increase in people with high school education or higher.The population structure of the industrial zones evolved similarly, reflecting the youth-driven population transformation brought about by industrial development, gradually optimizing the population structure from being predominantly local residents.The peripheral rural areas exhibited an accelerated aging trend, as shown in Figure 3.

4. Differentiated Spatial Needs of the Population in Lingang New City and "Industry-City Integration" Customization Strategy

4.1 Analysis of Differentiated Spatial Needs of the Population

Based on the evolution of the industry-city relationship in Lingang New City and the differentiated population structure across various sectors, this section provides an in-depth analysis of the spatial needs of the population in each sector. This lays the foundation for developing a customized "industry-city integration" spatial planning strategy that aligns with the

"industry value chain division" and "differentiated population needs."

4.1.1 Population Profiles in Different Sectors

As mentioned earlier, the Lingang New City area can be divided into five spatial sectors: the main urban area around Dishui Lake, the education and research zone, the industrial zone, urban communities, and rural areas. These sectors exhibit significant differences in both population structure and industry composition. Using data from the 7th population census, the population profile of each sector can be expressed across four dimensions: age structure, education level, housing conditions, and income levels (Table 1). This enables a targeted analysis of the differentiated spatial needs of populations in each sector.

In terms of population age structure, the main urban area and industrial zone have the highest proportion of young people aged 15–45, reflecting a relatively young working population. The peripheral rural areas have the highest proportion of people aged over 65, indicating a prominent aging trend. In terms of education level, the main urban area and university town are significantly higher than the industrial zone and urban communities, while the rural areas have lower educational attainment. Regarding housing and income levels, the main urban area has relatively higher income levels, while urban communities have lower income levels but a higher proportion of residents who own or purchase commercial housing nearby. In contrast, the industrial zone primarily relies on rented housing to solve residential needs (Figure 4).

In addition to the population characteristics identified based on the "7th Population Census" residential affiliation, the study also notes a significant proportion of "dual-location" residents who work in Lingang and return to central Shanghai on weekends. Furthermore, there is a group of extreme commuters who travel over 40 km one-way for work in Lingang. Through tracking and analysis of mobile spatiotemporal location data and AI tags of demographic attributes, it is found that 91.6% of these commuters are under the age of 45, with nearly 60% belonging to the middle and high-income groups (monthly income above 8,000 yuan). Among them, around 22% earn more than 15,000 yuan per month.

4.1.2 Differentiated Commuting Preferences of the Population

In terms of differentiated commuting preferences between work and residence, based on 2020 mobile LBS big data, a total of 68,300 commuting samples involving the Lingang area were collected. Among these, 50.6% were internal commutes (both origin and destination within Lingang), while 49.4% were external commutes (either origin or destination in Lingang). Overall, the commuting distance exhibits a pattern of "short-distance internal commuting + long-distance external commuting." Among the samples, 39.9% commuted within 5 km, while 31% commuted over 30 km, showing clear characteristics of commuting at the two ends (Figure 5). The regions with the most frequent external commuting connections are other areas of Pudong and Fengxian District.

Within the Lingang area, the internal spatial connections are most closely linked between the heavy equipment industrial zone and the communities of Nicheng and Luchao Port, as well as between the Fengxian Industrial Park and the Ping'an community to its north. These connections are far stronger than those with the main urban area around Dishui Lake. With the completion of public rental housing and blue-collar dormitory projects within the heavy equipment industrial zone, the population in the industrial zone grew from 10,000 in 2010 to 23,000 by the end of 2020. This population is highly dependent on relatively stable employment positions within the industrial zone and the neighboring community support. For residents in the industrial zone and

urban communities, about 50% of commutes are within 5 km, further confirming the "industry + city" integration and nearby urbanization development path of the industrial zone and urban communities. (See Figure 6).

On the other hand, the main urban area around Dishui Lake primarily reflects commuting connections with the education and research zone, urban communities, and the surrounding rural areas. The number of job opportunities in the main urban area is far higher than the number of residents commuting outward, indicating that the main urban area provides many service-related job positions for these areas. Additionally, over a third of the population in the main urban area commutes over 30 km, with nearly 1/5 of extreme commuters traveling more than 50 km daily, covering a round-trip distance of over 100 km. Notably, areas such as Zhangjiang and Zhuqiao in Pudong are the primary destinations for commuting out of the main urban area, while also attracting residents from peripheral areas such as Huinan Town. The education and research zone, which is adjacent to the main urban area around Dishui Lake but spatially and demographically independent, gathers multiple universities and science and technology industrial parks. Its population is roughly equivalent to that of the main urban area, with a resident base primarily composed of university students and graduates. This zone features a mixed environment of study, life, and work, with daily commutes primarily within a short to medium range of 3–10 km. (See Figure 7).

4.1.3 Analysis of Differentiated Spatial Demands of the Population in Each Sector

Based on the demographic characteristics of each sector and the commuting distribution that reflects the daily spatial activity preferences of the "industry-city" integration, we can refine the differentiated spatial demands of the population in each spatial sector of Lingang New City.

The main urban area around Dishui Lake is a typical area for the influx of non-local populations, exhibiting the "three high" characteristics in terms of education level, income level, and extreme commuting proportion. Through in-depth interviews, two specific groups with differentiated spatial needs were identified according to their work-residence relationships: one group resides in the city but works in the main urban area of Dishui Lake. This group mainly includes civil servants, managers in enterprises and institutions, and university professors in the Lingang area. These workers typically seek high-quality housing and public service facilities in the city center or opt for long-distance commuting due to family reasons. The other group resides in the main urban area of Dishui Lake but commutes to the city for work. This population is generally younger, engaged in industries such as IT, scientific research, and production-oriented services. However, there is a limited supply of matching employment opportunities in Lingang New City, so this group mainly commutes to key science and technology innovation hubs such as Zhangjiang Science City in Pudong. The young population in the education and research sector has specific spatial needs for relatively low-cost, trendy consumption spaces such as popular food streets, as well as spaces for "industry-university-research" spillover incubation. How to address the housing, employment, and corresponding support needs for these specific groups and provide refined spatial products is an important issue to be explored in the "industry-city integration" planning strategy for this region.

On the other hand, the "industrial zone + urban community" model driven by advanced manufacturing is an important existing path for achieving "industry-city integration" in this area. The residents of towns, relocated residents, and blue-collar workers in the manufacturing sector have formed a scale effect in a short period of time, resulting in the population of the five urban

communities growing rapidly from 102,000 in 2010 to 164,000 in 2020. This population scale far exceeds that of the main urban area around Dishui Lake and has further driven the development of market support such as large commercial complexes, while also providing nearby public services for the elderly population in surrounding rural areas and promoting urban-rural integration. The life trajectories of blue-collar workers in the industrial zone are relatively simple, with a tendency to commute within a short to medium range (2.5–5 km) using shuttle buses, and they are highly dependent on public transportation for long-distance travel. In line with the trend of technological upgrading in advanced manufacturing in Lingang New City, the large-scale aggregation of blue-collar populations driven by advanced manufacturing is gradually becoming a thing of the past. In the future, this area still needs to further improve the level of urban community support, but it should not overly pursue the development intensity of industrial land and the proportion of supporting facilities. At the same time, attention should be paid to the daily commuting needs of technical research and senior management personnel traveling between Shanghai city center and the industrial zone. For these groups, higher standards of housing and stronger individual commuting capabilities are needed. Custom residential space allocation should be created in the main urban area around Dishui Lake, strengthening the connection between the industrial zone and the main urban area, and establishing a new "industry-city" linkage in the new era.

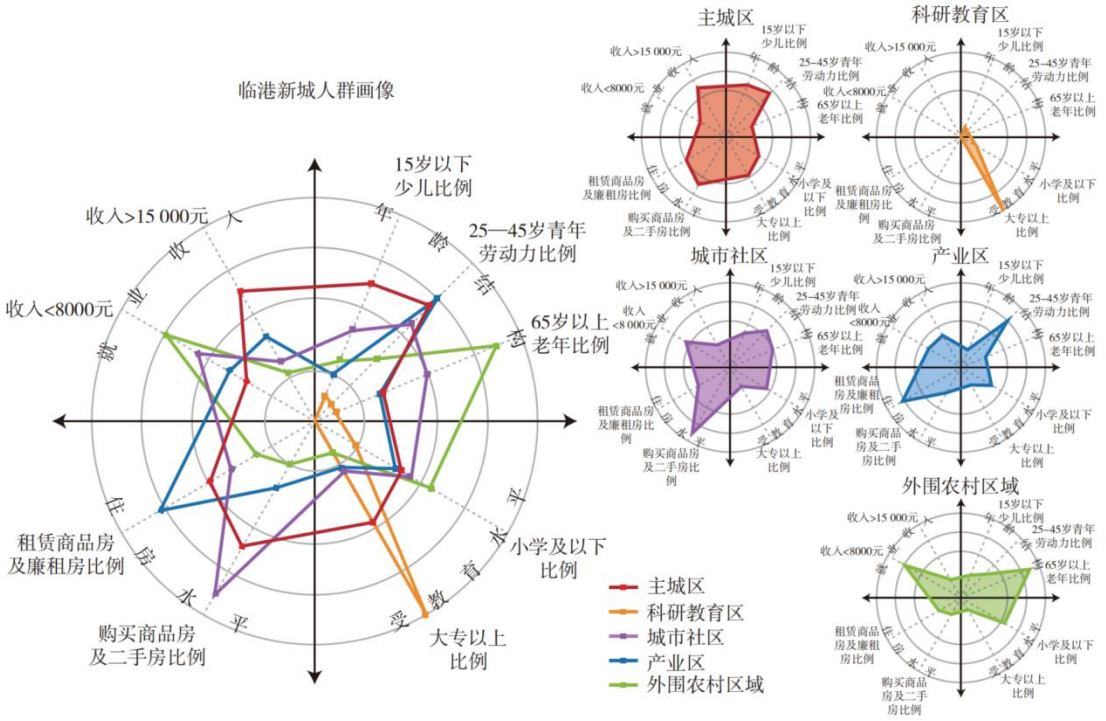

Fig.4 Features of social groups in five major spatial divisions

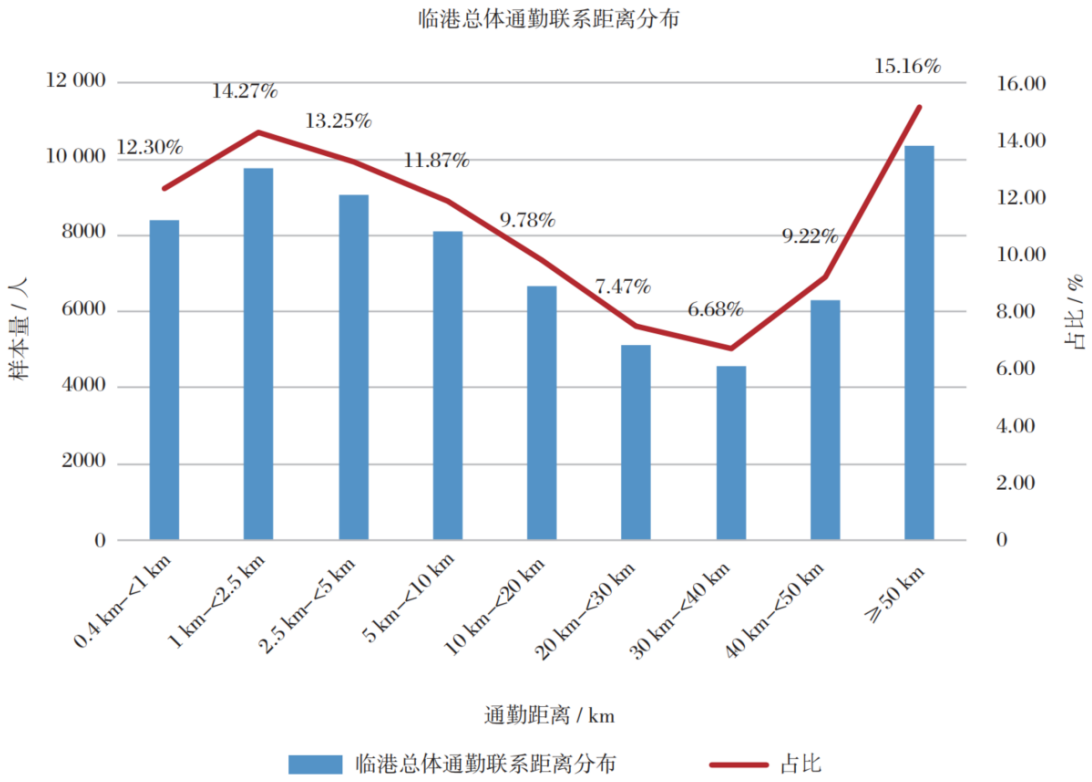

Fig.5 Analysis of commuting distance of Lingang (2020)

Data Source: Mobile LBS Income Profile Data (2020)

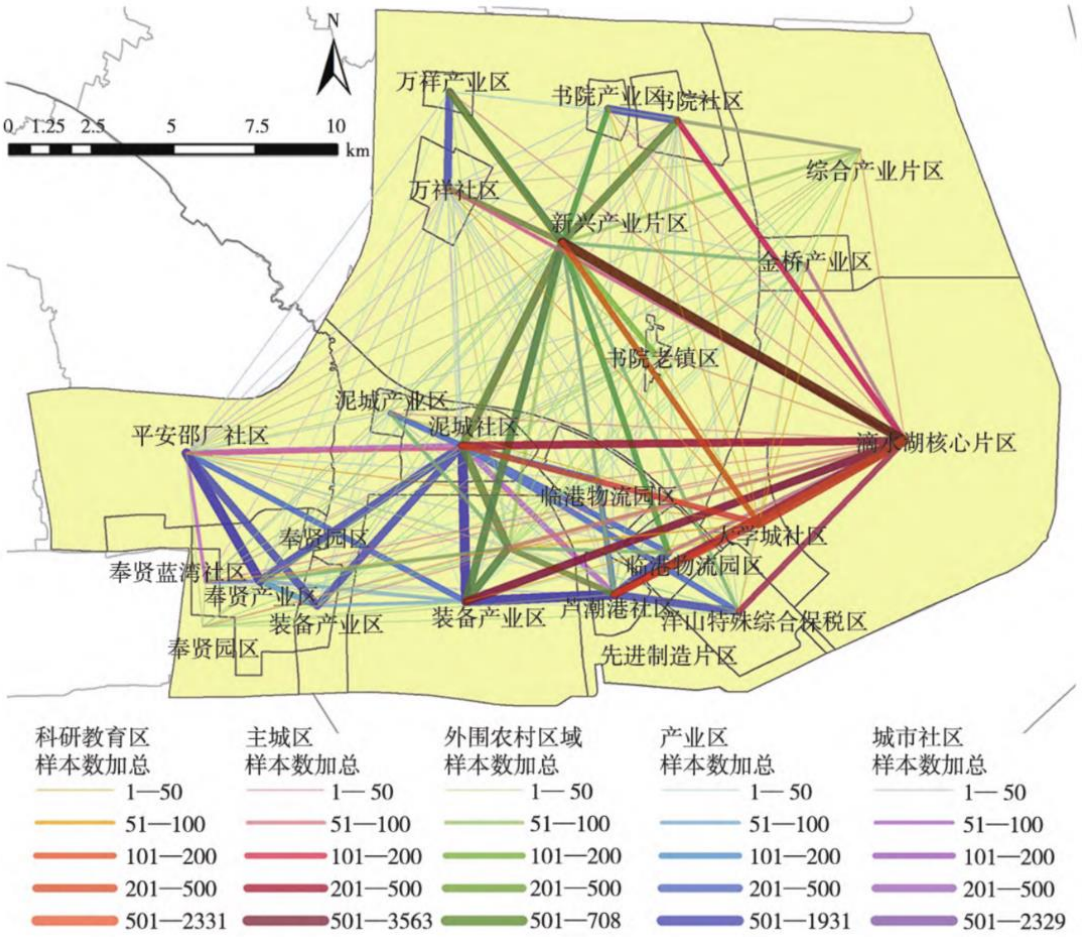

Fig.6 OD analysis of different spatial divisions in Lingang
Data Source: Mobile LBS Income Profile Data (2020)

4.2 Space Demand-Oriented "Industry-City Integration" Planning Customization Strategy

The following section further explores the "Industry-City Integration" strategy based on the division of the industrial value chain and the differentiated needs of various populations, within the overall framework of "Industry-City Integration" in the region.

4.2.1 Overall Level: Spatial Demand Guidance Framework for "Industry-City Integration" in Lingang New City

The space demand-oriented "Industry-City Integration" planning customization strategy must first be based on higher-level planning and the overall planning guidance for the Lingang New City area. This is achieved through the "Industry-City-People" spatial fine-tuning, differentiated cooperation, and spatial combination strategies to realize the strategic objectives for regional development, thereby avoiding a fragmented, project-driven approach that leads to spatial division.

The "Shanghai Metropolitan Area Spatial Coordination Plan" designates Lingang New City as a comprehensive global city and the first-tier "Industry-City Integration" free trade port city in the metropolitan area. The "Lingang New Area National Spatial Planning (2020-2035)" also positions the area as a central node for China’s domestic circulation, a strategic link for both domestic and international circulations, and an important part of Shanghai's global city core functions. From a trend perspective, the mid- to long-term goal for "Industry-City Integration" development in Lingang New City should be to realize its own "Industry-City Integration," systematically addressing the current issues of long-distance commuting, pendulum-type traffic, and declining weekend activity, which reflect the imbalance between work and residence.

Therefore, creating a comprehensive, independent new city and enhancing its rootedness and integration should become the primary task in developing the "Industry-City Integration" planning strategy for Lingang New City.As a suburban new city that has been under development for 20 years, Lingang New City has increasingly become a highland of international competitiveness in China’s advanced manufacturing industry. However, the comprehensive global city functions of this region still need improvement, especially with the policy advantages of the Free Trade Zone. The ability to allocate global resources and develop open economic functions, such as cross-border finance, trade, shipping, high-quality professional services, and innovation, is yet to be cultivated. High-level public service facilities also need improvement to effectively match the diverse spatial needs of talent and increase the region's attractiveness to skilled workers.On the other hand, the large-scale, single-function zones in the early planning of Lingang New City have intensified long-distance commuting. Under the logic of nearby urbanization, major sectors such as the main urban area of Dishui Lake, the research and education area, the industrial zone, and the urban communities are organized into spatial zones based on the division of labor in the industrial value chain, such as "R&D + services" and "production + supporting facilities." However, with the further development of the new area, there is a visible trend of integrating manufacturing with R&D, and production with living space. Data from the "Sixth Population Census" to the "Seventh Population Census" also show that the "Industry-City-People" interactive relationships between sectors in Lingang New City are becoming increasingly tight. The "Industry-City Integration" spatial strategy for the region needs

to not only meet the demands of the industrial value chain and the differentiated space needs of different populations but also further promote the effective interaction between sectors and enhance the combined effects of spatial development.

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4.2.2 Dishui Lake Main Urban Area—Research and Education Area Spatial Demand Customization Strategy

The planning positioning of the Dishui Lake main urban area complements the advantages of Shanghai’s central urban area, with a focus on strengthening global resource allocation capabilities. This area serves as the functional core for the region’s free trade and open services, positioned as a center for new trade, cross-border finance, headquarters economy, and shipping services. The research and education area, as a transformation platform for higher education and high-tech R&D incubation, is the area with the most concentrated resources at the forefront of the industrial value chain, such as R&D and testing, and has a population structure predominantly composed of younger students.

With the introduction of modern services and R&D industries, this area, with an expected permanent population of 640,000, is projected to attract 300,000 jobs. Currently, the area is characterized by high levels of education and income, with significant extreme commuting patterns, and a clear "amphibious" phenomenon where people live in one area and work in another. There remains a mismatch between the current employment opportunities and the level of supporting facilities.

Therefore, the space demand-oriented customization strategy needs to enhance the functional support provided by both productive and lifestyle services to the core area. The slow population influx into the main urban area is mainly due to the lack of large-scale modern services. Simply relying on the residential demand overflow from the industrial zone is not enough to support the scale of the main urban area. To address this, the planning has designated a central activity area within the main urban area. The customized planning strategy for this area needs to meet global city standards, accelerating the introduction of culture, exhibitions, leisure, entertainment, and innovation facilities to create a public activity center system from "Central Activity Area—Regional Center—Community Center" and strengthen the attractiveness to urban communities and industrial zones.To enhance services for productive services groups, the Dishui Lake main urban area should emphasize "attracting people with the city, and driving industry with people" (see Figure 8). This strategy includes: leveraging the two-port expressway hub area and the first ring around the lake to concentrate modern service industries, with the two-port expressway hub area developing into a multifunctional hub combining international transfer, duty-free shopping, and leisure; the financial bay area around the lake will focus on cross-border finance, trade, and professional services as a headquarters office zone. This will enhance the interaction between the main urban area and the industrial zone through the spatial organization of modern services—advanced manufacturing industries.Additionally, an international community, modeled after the Pudong Biyun community, will be built near the Dishui Lake area to further improve high-level public services, gradually transforming some high-income, highly educated, amphibious commuting populations into permanent residents. Along with rail transit station areas, high-quality, destination-oriented, high-energy services will be introduced, such as the construction of the "Ice and Snow Star" indoor ice and snow complex, the largest of its kind globally, linked to Metro Line 16. Expanding international capital and experience into the public service sector, the main urban area will speed up the introduction of city-level cultural and sports facilities, such as museums, libraries, performance centers, and sports arenas, along with international hospitals and schools, to attract international high-end talent to the area.

In strengthening services for the research and university population, the focus in the education and research area is on "nurturing industry through the city, retaining people through industry." The main strategies include: focusing on the support needs of startups and university populations, strengthening the integration of industry and education based on the existing university town, building national laboratories, attracting enterprise R&D headquarters, innovation centers, and technology R&D and transformation platforms, and enhancing foundational innovation capabilities with diverse incubation spaces and public laboratories; providing diverse housing products and maker spaces suitable for young scientists, leading scholars, and enterprise R&D personnel, and accelerating the construction of a "top scientist community" to build a talent reservoir that connects the "first kilometer" of innovation sources with the "last kilometer" of industrialization. This will create an industrial park, university district, and residential community model of "three-zone integration" for industry-city integration development.

4.2.3 Industry Area + Urban Community Space Demand Customization Strategy

The industrial area is the production and R&D cluster for strategic advanced manufacturing industries such as integrated circuits, artificial intelligence, biomedicine, and new energy vehicles in the Lingang New City area. It is also a major engine for population growth in the area over the past 20 years. The urban community, based on the original old town near the industrial area, has

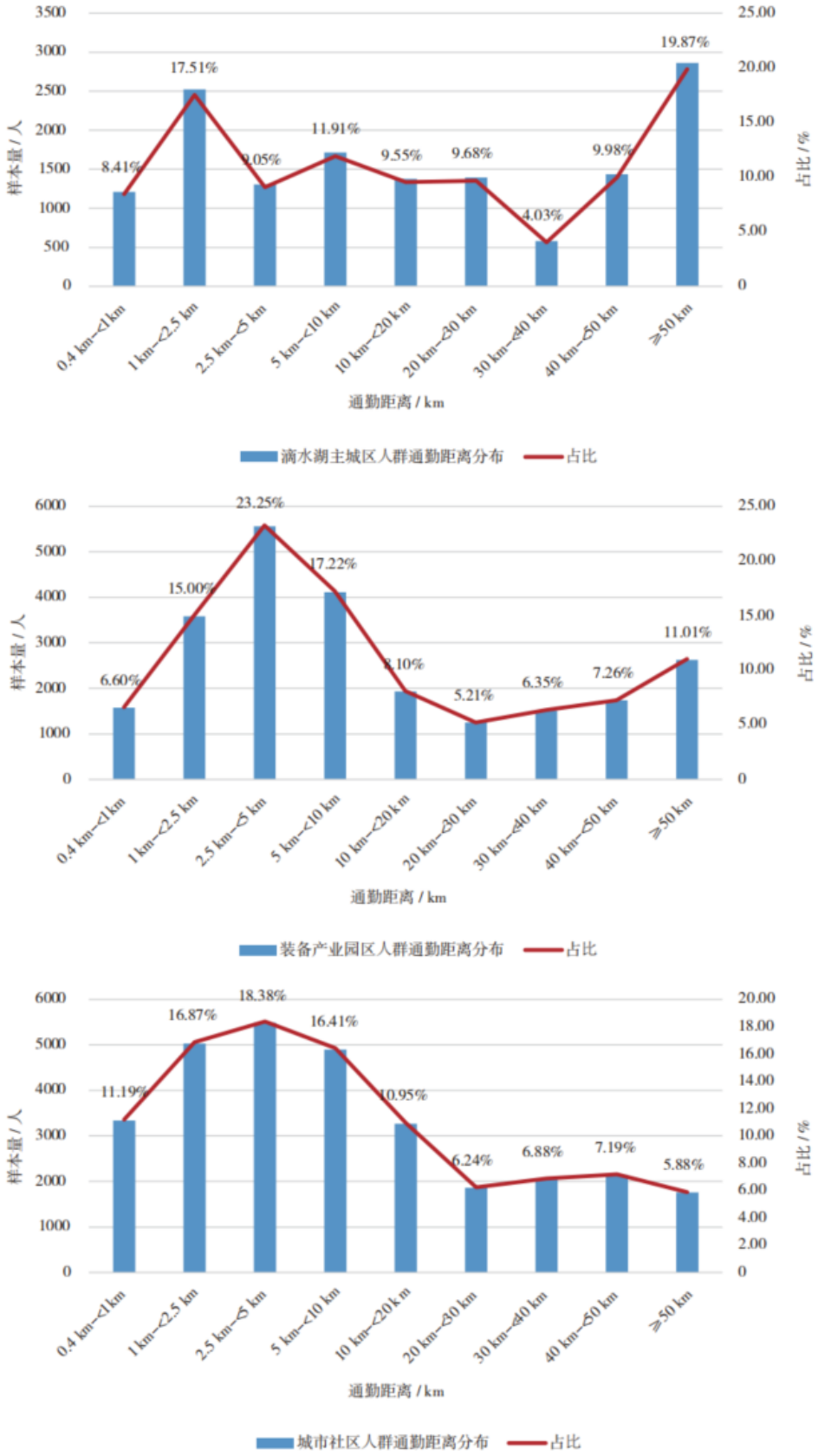

Fig.7 Spatial distribution of commuting distance: Dishui Lake downtown (top), Equipment Industrial Park (middle) and urban community (bottom)

Data Source: Mobile LBS Income Profiling Data (2020)

gradually formed an existing "industry-city integration" path of proximity between the industrial area and urban community. The "industry + living" proximity model in these areas has balanced the dual roles of introducing industrial population and resettling local residents, significantly improving the living support facilities in the region. As the industrial area further evolves toward intelligent manufacturing, the proportion of blue-collar jobs is gradually decreasing, while the share of high-tech and managerial populations is significantly increasing. This shift in the manufacturing-driven urbanization logic and the corresponding evolution of the living structure has created new demands for the industry-city support model.

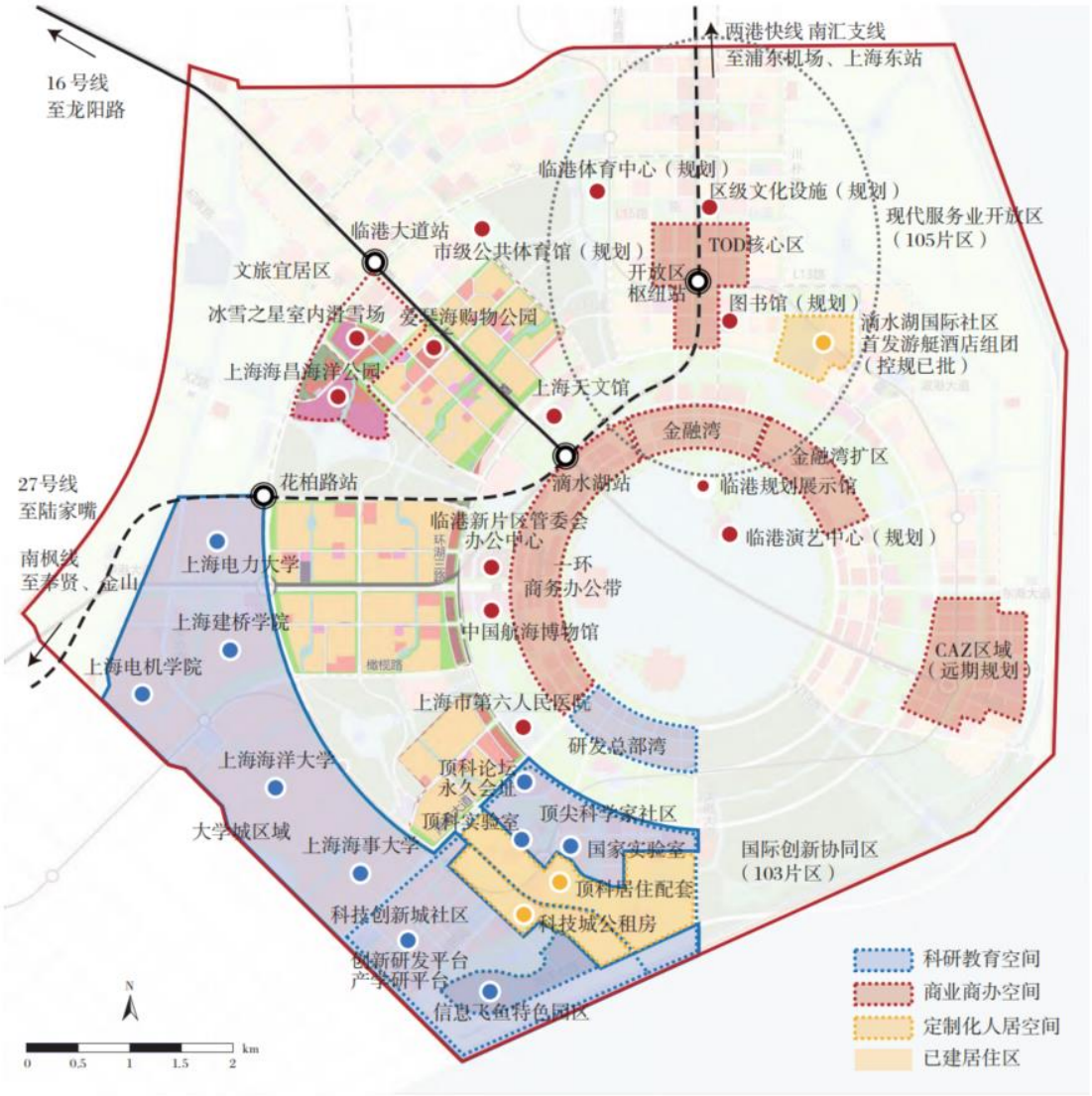

Fig.8 Key facilities and external transportation facility layout in the main urban area and scientific education area

The industry area-urban community "industry-city integration" space demand customization strategy mainly includes: further strengthening functions such as special comprehensive bonded areas, breakthroughs in key core technologies, and freight distribution hubs, while combining the trend of reducing labor scale per unit area under the unmanned and low-light manufacturing

processes in the production chain, gradually transforming the internal dormitory and cafeteria setup of heavy equipment companies from a decentralized model to a centralized support center model on the park platform. It emphasizes adding cultural and sports leisure facilities, embedding innovation services and living service areas, and concentrating on the construction of blue-collar apartments to improve the mixed-use functionality of industrial park land and form a new pattern of "industry-research integration, industry-city interaction" in a 50-square-kilometer industrial park.

In terms of the urban community, upgrading the existing community service centers at the transit hubs will provide better urban living services for blue-collar workers and technical R&D personnel. At the same time, more service industry job opportunities will be created for local residents and surrounding rural populations, enhancing the social network connections between the industrial population and the local urban and rural residents.

4.2.4 Coordinated Support Mechanism for "Industry-City Integration" Space Demand Customization Strategy

"Promote industry through ports and promote cities through industry" was the early concept of "industry-city integration" development in the Lingang New City area. To this end, industrial zones and the New City Administrative Committee were established. Later, after the adjustment of the Pudong-Nanhui district boundary and the merger of the two committees, a unified administrative management model was formed under the "Lingang Free Trade Zone New Area Administrative Committee."

Due to the decentralized decision-making characteristic of market forces entering industrial and residential support projects, the new area’s administrative committee needs to coordinate the relationship between the speed of population influx, structural distribution, the pace of infrastructure implementation, and land development progress from the outset. In particular, the committee needs to strengthen coordination among the three levels of government — the administrative committee, district, and town — and implement a multi-level financial support mechanism.

In response to the increasing demand for R&D and management personnel driven by the development of advanced manufacturing industries since the 14th Five-Year Plan, the administrative committee needs to establish more specific talent policy pilot programs based on financial element supply and reform autonomy. This would further enhance the attractiveness of target populations under the industrial development demands of the region. In 2023, the Shanghai People's Congress Standing Committee passed the "Decision on Promoting and Ensuring the Construction of the 'Five New Cities'," which clearly defined the need to further delegate powers, formulate differentiated population introduction and talent recruitment policies for new cities, strengthen the introduction and cultivation of urgently needed talents, outstanding young talents, and skilled professionals, and expand channels for introducing overseas talent. The population policies for the five new cities, compared to the entire city, mainly focus on areas such as "household registration conversion," residence points, and the introduction of graduates and talents.

Lingang New City, as a young and newly developed area, has the latest development timeline and is relatively farther from the central city. Its industrial development and population attraction require more targeted and preferential policy support, particularly in areas such as strategic industrial transformation and upgrading, R&D innovation incubation, and attracting high-quality

young talents. Innovations can be explored through financial support for key industries, the Lingang household registration system, and the Lingang property purchase restrictions.

5. Conclusion and Outlook

This paper, based on the logic of suburban urbanization in China’s large cities in the new era, as well as the development of industrial value chains and trends in population structure changes, provides an in-depth analysis of the evolution of the "industry, city, and people" relationships, the characteristics of population profiling, and their differentiated spatial product demands during the "industry-city integration" development phase of the Lingang New City area in Shanghai. Through the two main dimensions of "industrial value chain division" and "differentiated population needs," a "industry-city-people" spatial coordination framework is constructed, transitioning from the supply side to the demand side. This framework can be understood as the transformation of new-type urbanization spatial products in the new era, which are "people-centered," shifting from the "mass production" supply side to the "customized service" demand side. This transformation helps to more precisely and effectively match the industrial value chain divisions and differentiated population demands in suburban new cities, thus proposing corresponding "industry-city integration" spatial customization and planning guidance strategies, promoting higher-quality development of suburban new cities.

The planning and customization guidance research of the "spatial demand side" can be widely applied in urban connotation optimization, community planning, new city construction, and development zone transformation practices in the "post-land finance" era, and also provides a rich foundation for further theoretical research. This paper only discusses the construction of the framework and its planning application in the study of "industry-city integration" in suburban new cities in large metropolitan areas in the new era. In fact, under the guidance of the construction of a people-oriented city and new productive forces, real-world scenarios such as urban connotation optimization, the creation of 15-minute community life circles, and the transformation of new city developments can all be explored by focusing on the industrial value chain division and differentiated population needs. For example, different "15-minute life circles" in different regions with varying population age structures should have different facility types, scales, and densities. Spatial layout patterns should also reflect the differences in population demand. A "one-size-fits-all" or "radius and circle-drawing" approach to building a "complete community" not only misinterprets the concept of "age-friendly" communities but may also lead to a new round of huge public financial waste in the context of large-scale urban renewal investment. The discussion of the spatial demand-side customization planning framework and related topics in this paper is merely the beginning, and the combination of relevant fields with sociology, industrial economics, and urban big models is expected to become an important academic topic in spatial planning and urban renewal research.

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Notes

①Data source: "General Planning of Shanghai Lingang New City (2003-2020)."
②According to the "14th Five-Year Plan" for Lingang New City, by the end of 2025, three industrial clusters worth over one trillion yuan will be formed in new energy vehicles, integrated circuits, and high-end equipment manufacturing, along with several hundred billion yuan industry clusters in biomedicine, artificial intelligence, and civil aviation. The output value of the new energy vehicle industry alone surpassed 300 billion yuan in 2023. While the scale of leading industries continues to expand, the focus is also on accelerating the industrial value chain's division and layout in various spatial sectors, forming a complete industrial ecosystem.

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