Data Centers Construction and Spatial Planning Strategies: A Perspective of Developing New Quality Productive Forces

XU Su, ZHAO Min

Abstract: Data centers, as a critical form of new infrastructure, plays an important role in supporting national strategies and integrating real and digital economies. This paper examines data center layout and site selection from the perspective of new quality productive forces, focusing on their relationship with the development of new towns and districts. Data centers not only require substantial resources, such as electricity, water, and land, but also sustainable services and user accessibility. Hyper-scale centers favor low-cost, naturally cooler regions to minimize operational expenses, while medium and large centers prioritize proximity to markets to reduce latency. Small centers exhibit greater locational flexibility. Domestic and international case studies show a preference for city peripheries, influenced by factors such as user markets, geography, infrastructure, policies, and disaster resilience. New towns and new districts, as favored sites for data centers, align with site selection criteria, enhance regional functionality, and foster new quality productive forces, offering fresh opportunities to advance urban development.

Keywords: new quality productive forces; new infrastructure; data centers; new towns & districts; planning strategies

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New quality productive forces are driven by the deep application of new technologies and characterized by the rapid emergence of new industries, business forms, and models, thereby generating new social relations of production and institutional systems①. Their development is connected to urban planning through multiple mechanisms: spatial innovation is needed to provide strong territorial support, while innovation in digital-intelligent technologies can progressively foster new quality productive forces in urban districts[1-3]. Data centers form the core of the digital-economy industrial chain. They are both a key component of new infrastructure and a manifestation and supporting node of new quality productive forces, playing a critical role in the global innovation economy. As enterprise technologies are upgraded and artificial-intelligence research and applications deepen, big data as a new factor of production contributes increasingly to economic growth. Demand for high-performance computing is also expanding in smart government and urban management, further increasing the need for data centers. Worldwide, technology giants such as Microsoft, Google, and Amazon are investing tens of billions of dollars in new facilities. Elon Musk's company has likewise invested heavily in a 100,000-accelerator supercomputing center in Memphis and announced the launch of one of the world's most powerful AI training clusters.

China's strategic position in global data-center development will shape whether it can secure leadership in the artificial-intelligence era. National policy has evolved from supporting individual data centers, to establishing specialized institutions, and then to implementing systematic strategic planning, demonstrating the high priority attached to data-center construction. In July 2024, the Third Plenary Session of the 20th CPC Central Committee adopted the Decision of the CPC Central Committee on Further Deepening Reform Comprehensively to Advance Chinese Modernization, which called for establishing planning and standards systems for new infrastructure and improving mechanisms for its integrated use. Against this policy background, the spatial distribution and scientific planning of data centers have strategic importance. This paper analyzes their locational trends and site-selection factors and explores their relationship with the planning and development of new towns and districts. From a supply-side perspective, the aim is to optimize new relations of production and support high-quality development in new urban areas[4].

1 New Infrastructure: Infrastructure for New Quality Productive Forces

1.1 Characteristics of Data Centers as New Infrastructure

Infrastructure generally refers to the collection of essential services, public facilities, and physical systems that support society, including transport networks, electricity supply, and water systems. These facilities underpin everyday life and economic activity and are characterized by durability, capital intensity, publicness, and network effects. In the digital-intelligent era, scholars have proposed the concept of the "urban brain" as a basic component of urban infrastructure[5]. As new infrastructure for this era, data centers share the characteristics of conventional infrastructure but also have several distinctive features. First, they focus on information processing and technological applications, providing services that extend beyond conventional physical form. Second, rapid technological change requires continuous system upgrades at a pace far exceeding that of traditional infrastructure. Third, their operation depends on large quantities of electricity, and their energy and cooling requirements have substantial environmental impacts. Fourth, their functions depend heavily on stable, high-speed network connections, so network quality directly affects service performance and efficiency.

Data-center site selection also differs markedly from that of conventional infrastructure or ordinary firms because of complex service requirements and the involvement of multiple parties. As the core of digital infrastructure, data centers serve a broad client base, including governments and enterprises, and involve investors, constructors, operators, and model developers (Fig.1). The diversity of clients and their needs directly and indirectly influences functional configuration and site selection. Layout decisions must therefore satisfy the facility's own requirements for cost, environment, and technology while ensuring convenient access for both local and international users.

Fig.1 Key stakeholders involved in data center development and site selection

1.2 Data-Center Development and Proactive Government from the Perspective of New Quality Productive Forces

The development of new quality productive forces depends not only on effective market competition to drive technological innovation and efficiency gains, but also on timely support from a proactive government to overcome externalities and bottlenecks in new infrastructure[6]. The basic infrastructural nature of new infrastructure likewise means that government cannot avoid its ultimate responsibilities simply because development is highly marketized or privatized[7-8].

On the supply side, data centers have faced constraints on site selection and energy use in first-tier cities[9]. Although China has made substantial progress in digital infrastructure, mismatches between supply and demand remain. Megacities such as Shanghai and Beijing have repeatedly adjusted their data-center supply policies. This reflects both the challenge of constructing data centers under increasingly tight resource constraints and a deepening recognition among urban managers of their importance to technological, economic, and social development. A proactive government should use optimized distribution and site selection to resolve conflicts over spatial resources. Combining strategic public action with effective market mechanisms is essential to the sustainable development of the digital economy and new quality productive forces.

2 Data-Center Distribution and Site-Selection Criteria in China

2.1 Overview of Data-Center Distribution in China

In 2022, in response to strong computing demand in eastern China, together with energy-use constraints and high electricity costs, the National Development and Reform Commission and other departments launched the cross-regional "East Data, West Computing" project. It planned eight national computing hubs in the Beijing-Tianjin-Hebei region, the Yangtze River Delta, the Guangdong-Hong Kong-Macao Greater Bay Area, Chengdu-Chongqing, and other regions, as well as ten computing clusters including Zhangjiakou, Wuhu, and Horinger. Gui'an, Yangquan, Ulanqab, Zhongwei, and Karamay are also known as China's five principal data-center cities. In 2018, data centers were concentrated mainly in eastern coastal regions and core cities such as Beijing, Shanghai, Guangzhou, and their surrounding areas, with relatively few in central, western, and northern China[9]. More than 65% of current facilities are concentrated in the three major urban agglomerations, corresponding to the clustering of corporate headquarters, financial firms, and internet companies. By 2024, this concentration had become still more pronounced. Analysis of POI data at the end of September 2024, using the keywords "data center" and "big data center," shows that Guangdong, Beijing, Shanghai, and Jiangsu together accounted for more than one third of the national total (35.88%). At the city level, data centers are concentrated in first-tier cities and economically developed regions: twenty cities, including Beijing, Shanghai, Guangzhou, and Shenzhen, accounted for 38.14% of the national market, demonstrating a close relationship between data-center distribution and economic development (Tab.1).

Tab.1 Top 20 cities by number of data centers and their respective provinces

排名	城市	数据中心数量 / 个	所在省或直辖市	市场份额 / %	至最近地级市驻地中心的平均距离 / m
1	北京市	114	北京	8.61	19 275
2	上海市	102	上海	7.70	19 126
3	广州市	63	广东	4.76	20 287
4	深圳市	37	广东	2.79	15 772
5	武汉市	35	湖北	2.64	19 057
6	天津市	31	天津	2.34	23 155
7	重庆市	31	重庆	2.34	30 568
8	杭州市	28	浙江	2.11	20 050
9	东莞市	21	广东	1.59	17 028
10	苏州市	21	江苏	1.59	26 737
11	成都市	20	四川	1.51	22 405
12	廊坊市	18	河北	1.36	13 881
13	沈阳市	17	辽宁	1.28	10 228
14	郑州市	17	河南	1.28	19 906
15	佛山市	17	广东	1.28	17 095
16	张家口市	15	河北	1.13	54 935
17	青岛市	15	山东	1.13	33 286
18	大连市	15	辽宁	1.13	18 032
19	南京市	14	江苏	1.06	16 635
20	济南市	14	山东	1.06	20 511
	合计	645		48.69	21 898.45(平均)

注："至最近地级市驻地中心的平均距离/m" 由地级市范围内的数据中心POI至所在地级市驻地点估算得出

2.2 Site-Selection Criteria for Data Centers

Data-center distribution is a complex, multidimensional decision involving economic, environmental, technological, and social factors[10-11]. Once the broad regional pattern has been determined, site selection seeks to ensure long-term efficiency and sustainable operation through optimized resource use, cost control, and risk management.

2.2.1 Relevant Policies and Standards

A series of policy documents has addressed data-center planning and construction. In 2013, the Ministry of Industry and Information Technology issued the Guiding Opinions on the Layout of Data-Center Construction, requiring rational site selection, long-term planning, and sound distribution. Its Guiding Opinions on Further Strengthening Energy Conservation and Emissions Reduction in the Communications Industry specified that the power usage effectiveness (PUE) of new data centers should be below 1.4. In 2015, the Telecommunications Business Classification Catalogue (2015 Edition) incorporated data-center services into the IDC category and clarified market-entry requirements. The State Council's 2015 Action Outline for Promoting Big-Data Development called for integrating dispersed data-center resources to improve processing efficiency. In standardization, the national Standard for Design of Data Centers (GB 50174-2017) specifies detailed micro-level site requirements for electricity, telecommunications, and environmental conditions.

2.2.2 Site-Selection Criteria

Relevant studies suggest that data-center distribution should follow four principles: demand, cost, operating environment, and safety[12]. This article consolidates these into three main dimensions - demand orientation, cost orientation, and risk-management orientation - and uses them to explain site-selection criteria.

(1) Demand orientation. Demand orientation emphasizes the direct influence of market demand and technical requirements. Advances in information technology have raised expectations for data processing speed and efficiency, requiring data centers to be located near network backbones and major user clusters in order to reduce latency and improve response times. Fiber quality, network-service availability, and transmission capacity are also important, especially for applications processing highly time-sensitive data.

(2) Cost orientation. Cost orientation concerns the economic efficiency of both initial construction and long-term operation. Land and building materials influence initial costs, while electricity prices and reliability, climate, high-speed internet access, service availability, and transport accessibility affect long-term operating costs. Energy consumption, especially electricity use and cooling efficiency, is particularly important; natural cooling under suitable climatic conditions can substantially reduce energy demand. National and regional policies also shape costs. China's new-infrastructure policies may provide land, energy, and financial support; the United States and Europe use tax incentives or subsidies; and tax incentives have likewise supported data-center growth in India and other countries.

(3) Risk-management orientation. This dimension evaluates environmental and policy risks and is closely related to the disaster-recovery functions of data centers. Environmental risks include earthquakes, floods, and climate-related hazards. Site selection should also consider environmental quality and avoid heavily polluted areas. The stability of national and regional policies, the integrity of legal systems, and information-security policies are additional factors requiring careful management.

In summary, data-center site selection must integrate market access, natural conditions, infrastructure, energy supply, policy context, construction and operating costs, and risk control. Data centers generally favor areas with low electricity prices, adequate energy, a suitable climate, and low disaster risk. As cloud computing and big-data technologies expand and application scenarios diversify, the functions and scales of data centers will continue to evolve, making site-selection decisions increasingly complex.

2.2.3 Locational Preferences of Different Types of Data Centers

Data centers can be classified from several perspectives. By scale, they include hyperscale, large, and small or medium-sized facilities; by service target, they include national, internet, and enterprise data centers; and by operating model, they may be self-built or colocation facilities (Tab.2).

Tab.2 Classification of data centers and analysis of their sensitivity to different site selection factors

	类别	特征	需求导向	成本导向	风险管理导向
处理规模	超大型数据中心（HDC）	规模大于10 000个标准机架的数据中心	★	★★★	★★★
	大型数据中心（LDC）	规模介于3000—10 000个标准机架的数据中心	★★	★★	★★
	中小型数据中心（SME-DC）	规模小于3000个标准机架的数据中心	★★★	★	★★★
服务对象	国家数据中心（NDC）	由政府投资建设的公共服务数据中心	★	★★★	★★★
	互联网数据中心（IDC，也称托管数据中心）	由IDC服务商搭建，向客户提供互联网基础平台服务及各种增值服务的数据中心	★★	★★	★★
	企业数据中心（EDC，也称自建数据中心）	由企业或机构自建并所有，服务于企业或机构自身业务的数据中心，是一个企业数据存储、运算和交换的核心计算环境	★★★	★	★★★

注：星号数量越多，表示对该类因素越敏感

资料来源：作者根据数据中心分类参考中商产业研究院《2024年中国数据中心行业市场前景预测研究报告》整理

Hyperscale data centers are designed for enormous data volumes and high-performance computing. They are usually national facilities or are built and operated by cloud-service providers such as Amazon Web Services, Microsoft Azure, and Google Cloud. They represent the core technological capacity of a country or enterprise. Although relatively few in number, they are very large and highly sensitive to cost and risk. Climate and energy supply are therefore central considerations. They mainly store cold data and process tasks with low time sensitivity and are generally located where construction and computing costs are low, as in China's eight national computing hub nodes.

Large data centers are generally internet data centers that provide clients with internet platform services and other value-added services. Multiple clients share a facility and may lease racks, rooms, or other portions of the data center. The provider manages the physical infrastructure, including electricity, cooling, and security, while tenants manage their own equipment and data. In addition to energy supply and climate, proximity to service markets and clients is especially important. Large and medium-sized data centers primarily support cloud computing and are often located in core cities to reduce latency and draw on concentrations of skilled labor, as seen in Shanghai's Waigaoqiao data-center park and new facilities in Qingpu and Lingang.

Enterprises and institutions may also build and operate their own data centers, which are usually smaller. Such facilities are selected for security, control of data, specialized business needs, or reduced long-term leasing costs and are flexibly located within the organization or close to clients. Small and micro IDC facilities deployed at the network edge for applications with exceptionally high requirements for real-time performance and security are typically located in dense user areas to provide ultra-low latency and highly localized services, as with financial and banking data centers in Chinese cities (Fig.2).

Fig.2 The design of China telecom's Lingang data center i

注：一期占地119亩（约7.9 hm^2），介于超大型至大型规模之间，规划承载10万卡智算集群
资料来源：临港算力（上海）科技有限公司公众号

3 International Experience in Data-Center Development

3.1 Data-Center Development in the United States

The United States began developing data centers relatively early and has become a global leader in industry growth. Virginia, Texas, and California are its principal regions, followed by Illinois, Georgia, Nevada, and others, with facilities concentrated mainly in the West and Southeast. Ashburn, Virginia, has become the world's largest data-center cluster, hosting major facilities operated by Amazon Web Services, Microsoft, Google, Meta, and other technology firms.

The U.S. distribution pattern reflects the combined influence of market conditions, geography, infrastructure, fiscal policy, and other factors. Virginia and Texas have become major locations because of advanced infrastructure, relatively low energy costs, and tax incentives. Virginia, for example, offers both tax exemptions and energy-cost advantages, and qualifying data centers may receive tax relief for up to ten years. Ashburn is close to Washington, D.C., has ample electricity and advanced fiber infrastructure, and offers extensive suburban land at relatively low prices, with lower sensitivity to noise and other environmental impacts.

3.2 Data-Center Development in Japan

Despite geographic and energy constraints, Japan has become a globally competitive data-center location through tax incentives, highly developed communications networks, innovative disaster prevention, and low-cost cooling solutions. Facilities are concentrated mainly in Tokyo and Osaka, with Tokyo's Koto Ward and Chiba New Town emerging as major clusters.

Chiba New Town in Chiba Prefecture has an advantageous location, convenient transport, relatively flexible planning policies, and favorable land-supply conditions. It has therefore become an important data-center cluster in recent years (Fig.3). Its proximity to Tokyo provides access to Japan's largest market, while nearby rivers offer cooling water. Compared with inner-city facilities, Chiba New Town also offers better land conditions and more room for expansion.

Fig.3 Data centers in Chiba new town

4 Spatial Planning Strategies for Data-Center Development

The U.S. and Japanese cases show that data-center site-selection strategies must balance economic, environmental, land, infrastructure, and risk factors. In China, the United States, and Japan alike, data centers show a strong preference for locations around major cities and a close association with new towns and new districts. This pattern identifies an important direction for planning research and policy.

4.1 A New Function for New Towns and New Districts: Regional Reach and Support for New Quality Productive Forces

Since the beginning of the century, China has developed new towns and districts on a large scale, supporting rapid socioeconomic growth. Yet slow industrial development, extensive idle land, and low investment returns have left many such areas performing below expectations. As industrial growth and urban population expansion slow, existing new towns and districts need to reconsider their functional positioning and identify new sources of growth. The authors have previously examined the role of new towns under the conditions of the "space of flows" and urban networks, arguing that they should not only absorb excess population and industry from central cities but also become nodal cities with regional influence in selected professional fields[13].

Land resources in the central districts of China's megacities are increasingly scarce, requiring new mechanisms for resource allocation and spatial use[14]. As functional components of metropolitan regions, new towns and districts generally have more abundant land and infrastructure capacity and often benefit from development-zone policies. They are therefore well suited to accommodating new infrastructure such as data centers. Introducing these new functions through planning and construction can create strategic nodes that serve wider regions and support new quality productive forces.

Geographically, existing new towns, districts, and suburban settlements in megacities such as Beijing, Shanghai, Guangzhou, and Shenzhen, and in very large cities such as Nanjing, Hangzhou, Tianjin, and Wuhan, are suitable core locations for ordinary data centers. New urban areas in western regions such as Ningxia, Guizhou, and Inner Mongolia are more suitable for large cloud-computing centers specializing in cold-data storage or large-scale computation. Shanghai's Nanhui New Town, with strong land-supply conditions and advantages in market access, energy supply, and cooling systems, is particularly well suited to hyperscale and large data centers.

4.2 Data-Center Development and Local Development: Planning Interpretation and Institutional Innovation

4.2.1 Theoretical Interpretation of the Relationship between Digital Industry and Spatial Development

Planning scholarship offers multiple perspectives on the interaction between the information-technology-driven digital economy and place-based urbanization. In the early 1980s, some scholars argued that high-technology zones had limited effects on employment and could not be treated as a new driver of urbanization. By the 1990s, however, the development of Tsukuba Science City in Japan, Silicon Valley in the United States, and Zhongguancun and Zhangjiang in China demonstrated the important role of high-technology clusters in urbanization. Castells's theory of the space of flows and the work of Sassen and Soja on world-city networks likewise emphasized the role of information and communications technologies in the formation of global urban centers and in suburbanization. These studies provide a theoretical basis for understanding and anticipating the broader urban effects of data centers.

Other research argues that data-center development produces agglomeration effects and can promote clustering along high-technology industrial chains[15]. Areas with dense concentrations of data centers commonly receive upgrades in high-speed broadband, electricity supply, and other infrastructure, attracting technology firms and professional-service providers and generating new growth points in chip manufacturing, server production, network equipment, data storage, and related industries. The coordinated development of these advanced manufacturing sectors can in turn attract additional industries and services and accelerate industrial and talent clustering in artificial intelligence and big-data processing within new towns and districts.

4.2.2 Integrating Planning, Construction, and Governance

In practice, data centers must be more fully integrated with the planning, construction, and governance of new towns and districts, combining physical development with institutional innovation. Data centers and their transmission chains are typical objects in the space of flows, and their spatial production is highly distinctive. Because enormous value can be created through data storage, processing, and transmission, they should be classified as technological-industry land rather than research, office, or commercial land. At the same time, because their outputs are intangible, the value created for the host locality must be made visible through taxation and innovative factor-market design, thereby injecting vitality into the local economy[16].

Data centers may promote economic development in new towns and districts, but their high energy consumption and heat emissions also pose practical challenges to urban sustainability. Planning and construction should therefore be guided by sustainability and resilience and should employ green-building design, renewable energy, efficient cooling systems, and other environmental measures to reduce carbon footprints and support low-carbon urban development in the new era.

5 Conclusion

This study has examined the distribution and site selection of data centers as both expressions and supports of new quality productive forces. It finds that macro-level distribution is closely related to regional economic development, while micro-level site decisions are influenced by cost, energy use, policy, environment, and other factors, with different types of data centers showing different sensitivities. Data-center distributions in China, the United States, and Japan all reveal a preference for the peripheries of major cities. New towns and new districts are therefore suitable as principal spatial carriers.

This research connects digital intelligence with spatial planning, but its findings and arguments remain primarily conceptual. Analysis of the locational preferences and spatial effects of different types of data centers is based largely on qualitative judgment and lacks in-depth empirical testing. Future research should strengthen data collection and empirical analysis, especially by using big-data technologies for intelligent site-selection analysis[17-18]. This would allow more accurate assessment of sensitivity to different factors and a deeper understanding of the combined economic, social, and environmental impacts on host regions.

Notes

① The definition of “new quality productive forces” follows the website of the State Information Center: https://www.ndrc.gov.cn/wsdwhfz/202402/t20240206_1363980.html.

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