# THE DEVELOPMENT OF SMART CITIES IN CHINA: AN ANALYSIS OF POLICY FRAMEWORK, DIGITAL ECONOMY DEVELOPMENT, AND PRACTICAL APPLICATIONS

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**Abstract**

Unprecedented urbanization in China has placed increasing pressure on urban governance, infrastructure, resource use, and environmental sustainability. In response, smart city development has been elevated to a national strategy aimed at strengthening urban resilience and ensuring sustainable growth. This study examines China's smart city trajectory through a four-dimensional framework: national policy design, digital economy evolution, application scenarios, and implementation challenges, drawing on official policy documents and statistical data. The findings show that China's smart city model is driven by a top-down, multi-level governance system combining central coordination with local implementation. A diverse ecosystem has emerged, led by government actors and supported by state-owned and private enterprises, research institutions, and the public. The expansion of the digital economy is closely linked to early policy experimentation in Special Economic Zones, direct-administered municipalities, and coastal cities, forming a "point-to-area" diffusion pattern. However, key challenges remain, including gaps in top-level design, data fragmentation, weak coordination mechanisms, and unresolved issues of data ethics and cybersecurity. By comparing China's experience with international practices, the study highlights governance dynamics, institutional foundations, and trade-offs shaping scalable smart city development.

**Key words:** smart cities, urban governance, policy frameworks, digital economy, practical applications, sustainable development.

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# РОЗВИТОК РОЗУМНИХ МІСТ У КИТАЇ: АНАЛІЗ ПОЛІТИКИ РАМОК, РОЗВИТКУ ЦИФРОВОЇ ЕКОНОМІКИ ТА ПРАКТИЧНИХ ЗАСТОСУВАНЬ

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**Анотація**

Безпрецедентна урбанізація в Китаї посилила тиск на міське управління, інфраструктуру, використання ресурсів та екологічну сталість. У відповідь розвиток «розумних міст» було піднесено до рівня національної стратегії, спрямованої на зміцнення міської стійкості та забезпечення сталого зростання. У цьому дослідженні розглядається траєкторія розвитку розумних міст у Китаї крізь чотиривимірну рамку: проєктування національної політики, еволюцію цифрової економіки, сценарії застосування та виклики впровадження, з опорою на офіційні політичні документи та статистичні дані. Результати показують, що модель розумного міста в Китаї визначається ієрархічною системою багаторівневого управління «згори вниз», яка поєднує централізовану координацію з локальною імплементацією. Сформувалася різноманітна екосистема, очолювана державними структурами та підтримувана державними й приватними підприємствами, науковими установами та громадськістю. Розширення цифрової економіки тісно пов'язане з ранніми політичними експериментами у спеціальних економічних зонах, містах центрального підпорядкування та прибережних містах, формуючи модель дифузії «від точки до території». Водночас зберігаються ключові виклики, зокрема прогалини у стратегічному проєктуванні, фрагментація даних, слабкі механізми координації, а також невирішені питання етики даних і кібербезпеки. Порівнюючи досвід Китаю з міжнародними практиками, дослідження висвітлює управлінські динаміки, інституційні засади та компроміси, що формують масштабований розвиток розумних міст.

**Ключові слова:** розумні міста, міське управління, політичні рамки, цифрова економіка, практичні застосування, сталий розвиток.

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## Introduction

According to data from the United Nations and the World Bank, the global urban population increased from approximately 1.02 billion in 1960 to over 4.61 billion in 2023 (Nations, n.d.; WorldBank, n.d.). During the same time, the global urbanization rate rose from 33.6% to 57.0%, reflecting a sustained global trend toward urban concentration (*Statista - The Statistics Portal*, n.d.). The United Nations' *World Urbanization Prospects 2018* predicts that by 2050, the global urbanization rate will likely reach 68.4%, with nearly 70% of the world's population living in cities (He et al., 2021; Herath & Mittal, 2022; Lai et al., 2020; Liu et al., 2019; O'Dwyer et al., 2019; Ullah et al., 2020). Rapid population growth and urbanization exert tremendous pressure on urban management, infrastructure capacity, resource utilization, and environmental sustainability (Qian et al., 2021; Yao et al., 2020). Moreover, the rapid and unregulated expansion of urbanization has resulted in industrial structure homogenization, inefficient land use, and environmental pollution, undermining the intended goals of urbanization development and hindering sustainable urban development (Ariken et al., 2020; Zeng et al., 2022).

To address emerging urban challenges and promote long-term sustainable urban development, the concept of "smart cities" was first introduced by the International Business Machines (IBM) in late 2008 as a global strategic vision (Qin & Qi, 2021; Yue et al., 2024; Zhou et al., 2021). The core principle of this concept is to use new technology to connect the physical resource elements and public services in the city to realize intelligent operation and maintenance (Yue et al., 2022). Building on this foundational idea, countries around the world have actively promoted smart city initiatives, each adopting distinct strategies tailored to their national contexts. Notable examples include the *Smart Nation 2025* in Singapore (Foong et al., 2024), *New York City 2050* in USA (Keeler & Bernstein, 2021), *Tokyo 2040* in Japan*, Seoul Vision 2030* in South Korea (Wang et al., 2020), *Smart London Plan* in UK (Bibri & Krogstie, 2020), and *European Data Strategy* in EU (Franke & Gailhofer, 2021). IBM's early smart city framework made a significant contribution to the development of smart cities in China by offering foundational conceptual models and initiating pilot demonstrations that informed subsequent national strategies. Building upon these foundations, China has progressively localized the concept into a state-led paradigm centered on technological innovation, industrial upgrading, and the strategic optimization of urban resources (Wang et al., 2022). After more than a decade of development, China has achieved notable progress in advancing smart cities across multiple urban sectors (Singh et al., 2022). This progress reflects an integrated approach that simultaneously enhances urban governance, industrial transformation, public service delivery, and environmental sustainability (Liu & Wan, 2025). Most importantly, smart cities play a critical role in times of crisis by enabling rapid, technology-driven responses and enhancing urban resilience. Their capacity for multidimensional data integration has proven essential for facilitating coordinated action, efficient resource allocation, and adaptive

governance under high-stress conditions. One particularly memorable case demonstrates this capacity. During the COVID-19 pandemic, smart cities in China played a pivotal role in prevention and control efforts (Chen et al., 2021; Kuzior et al., 2022; Yang & Chong, 2021). By leveraging digital infrastructures – including health code systems (Sun & Wang, 2022; Yu, 2024; Zhang, 2022), big data surveillance platforms (Fallatah & Adekola, 2024; Jiao et al., 2023), telemedicine services (Feng et al., 2024; Mirasghari et al., 2024), intelligent logistics (Liu & Zhao, 2024), and emergency operation centers (Asgary et al., 2024) – cities established integrated digital ecosystems for crisis management. These systems enabled real-time monitoring, data-informed decision-making, and uninterrupted delivery of key public services, showcasing the institutional flexibility and technological resilience of smart urban governance (Sharifi et al., 2024). In contrast, traditional urban systems revealed critical limitations in responding effectively to large-scale public health emergencies. Furthermore, China's smart city infrastructure ensured functional continuity, supported economic recovery, and accelerated the long-term embedding of digital systems in urban governance.

Since the launch of China's reform and opening-up policy in 1978, the country's urbanization rate has risen markedly – from 19.72% to 64.72% by 2021 (Cui et al., 2023) – triggering profound shifts in urban governance and spatial organization (Jiang et al., 2022). To address the challenges arising from rapid urbanization, China is actively promoting smart city strategic as a national initiative of transitioning from an extensive, high-speed expansion model to a quality-oriented approach that emphasizes inclusiveness, sustainability, and balanced socioeconomic development (Han et al., 2023; Shelton et al., 2015). This transformation has been largely driven by the integration of next-generation information and communication technologies (ICTs), including the Internet of Things (IoT), big data, cloud computing, blockchain, 5G technology, and artificial intelligence (AI) (Mishra et al., 2023). These technologies support data-informed decision-making and facilitate precision urban governance (Kumar et al., 2020). The development of smart cities in China has been shaped by a strategic framework driven by strong central government leadership, primarily implemented through a top-down governance approach (Cardullo & Kitchin, 2019; Dameri et al., 2019). This model is characterized by government-led, centralized coordination, and collaborative participation from state-owned enterprises and private-owned enterprises (SOEs/POEs), academia and research think tanks (ARTTs), and the public. By the end of 2019, 100% of sub-provincial cities and above, as well as 95% of prefecture-level cities, had proposed or were actively working on establishing smart cities. This widespread implementation has led to spatially clustered patterns of smart city development, driven by population agglomeration, economic output, strategic location, and disparities in local fiscal capacity. Geographically, five major smart city clusters have emerged: the Beijing-Tianjin-Hebei region (Xu et al., 2023), the Yangtze River Delta (Chang et al., 2022), the Guangdong-Hong Kong-Macao Greater Bay Area (Hong et al., 2023), the Middle Yangtze River region (Lee et al., 2024), and the Chengdu-Chongqing economic zone

(Li et al., 2025). Furthermore, according to the statistics of the *2023 The Group of Twenty (G20) Smart City Ranking*, Beijing, Chongqing, Shanghai, and Shenzhen are among the top 10 percent of all smart cities in the G20.

To comprehensively examine the developmental trajectory and governance logic of smart cities in China, this study adopts a four-dimensional analytical framework encompassing: the national policy framework, the evolution of the digital economy, real-world application scenarios, and key implementation challenges. First, the study systematically reviews major strategic plans and policy documents issued from 2012 to 2024, highlighting the top-down institutional logic and shifting structural priorities that have guided China's smart city development. Particular attention is given to the role of the "Five-Year Plan (FYP)" in institutionalizing and systematizing digital urban governance. A comparative assessment with policy frameworks in Singapore, the United States, and the European Union further underscores the distinctiveness of the Chinese model. Second, the research investigates the drivers behind China's rapid and high-quality digital economy growth, emphasizing endogenous innovation, institutional incentives, and technology spillovers – particularly within Special Economic Zones (SEZs) and Direct-Administered Municipalities (DAMs), and coastal cities. This dimension is further substantiated by a quantitative analysis of digital economy spanning 2012 to 2023. Third, the study investigates how China's multilevel governance structure – characterized by top-down coordination and local implementation – along with a collaborative ecosystem of governments, SOEs/POEs, ARTTs, and the public, has shaped smart city implementation across diverse urban contexts. Finally, the analysis identifies key challenges including data fragmentation, regional disparities in digital capacity, cybersecurity vulnerabilities, and insufficient citizen engagement. This study draws upon a diverse range of sources – including policy documents and statistical data from PRC government agencies, the National Bureau of Statistics, Deloitte China, and EO Intelligence – which offer not only authoritative information but also complementary perspectives spanning institutional, economic, and industrial dimensions. The integration of these multifaceted sources enhances the analytical rigor of the research and enables a more nuanced understanding of China's smart city transformation.

Ultimately, the study seeks to contribute both theoretically and practically – by deepening academic understanding of China's smart city development and providing actionable insights for policymakers and urban practitioners aiming to design scalable, adaptive, and digitally integrated urban strategies on a global scale.

## National policy framework analysis

The successful implementation of smart city initiatives depends not only on technological advancements in ICTs, but also on strong policy support and institutional capacity. In China, the evolution of smart city development over the past fifteen years has unfolded through several

distinct stages, beginning with conceptual introduction, moving toward pilot experimentation, progressing to large-scale construction, and ultimately advancing into a phase of deep integration characterized by cross-sectoral coordination and data-driven governance (Liao & Chen, 2022; Shan et al., 2021). To guide and coordinate these developments, the Chinese government has issued a series of national policies that define strategic priorities, promote top-level design, and support technological and institutional innovation. Representative national policies are summarized in Table 1. Since 2009, the policy framework has expanded in parallel with rapid urbanization, demographic pressures, and the growing demand for digital public services. These policies form a structured support system that has facilitated China's transition toward intelligent, sustainable, and resilient urban development.

This policy effort is further reinforced through a centralized governance framework that ensures strategic coherence, hierarchical accountability, and consistent implementation across administrative levels. The General Office of the CPC Central Committee and the State Council function as top-level decision-makers, formulating national strategies for smart city development. Relevant ministries act as implementers, each assigned with specific sectoral responsibilities: (1) the Ministry of Housing and Urban-Rural Development (MOHURD) oversees urban planning and spatial layouts; (2) the Ministry of Industry and Information Technology (MIIT) promotes industrial digitalization and smart manufacturing; (3) the State Bureau of Surveying and Mapping develops GIS and big data infrastructures; (4) the Ministry of Science and Technology (MOST) supports R&D and innovation ecosystems; (5) the National Development and Reform Commission (NDRC) steers socio-economic restructuring; and (6) the Ministry of Transport (MOT) pilots intelligent mobility and autonomous driving. Together, these institutions form a comprehensive policy ecosystem that strengthens resource coordination, expands digital infrastructure, supports balanced urbanization, and fosters environmentally sustainable growth. This institutional architecture has laid a solid foundation for the continued development of green, low-carbon, and digitally empowered smart cities across China.

Building upon this centralized governance structure, China's FYPs have played a pivotal role in institutionalizing smart city development by setting strategic priorities, allocating resources, and ensuring policy continuity across administrative levels (Ge et al., 2024; Hu et al., 2025). Although FYPs are overarching national development strategies, they have consistently incorporated smart city initiatives into broader efforts to promote urban modernization, digital governance, and innovation-led growth. As shown in Table 1, the evolution of China's smart city policy corresponds closely to the trajectories of the 12th, 13th, and 14th FYPs, each marking an increasingly institutionalized and integrated stage of development. During the 12th FYP period (2011–2015), smart cities were introduced as a strategic concept aimed at improving urban planning and public administration through the application of modern ICTs. The *National Smart City Pilot Program* launched in 2012 established the initial groundwork by encouraging

the integration of information resources and the coordination of application systems. Subsequent documents, such as the *National New-type Urbanization Plan* and the *Guiding Opinions on Promoting the Healthy Development of Smart Cities* issued in 2014, reinforced this direction by emphasizing next-generation ICTs – including IoT, big data, cloud computing, blockchain, 5G technology, and AI – as enablers of socioeconomic modernization. These policies collectively facilitated broad experimentation and enhanced institutional awareness among local governments.

***Table 1. National policies supporting the development of smart cities in China***

| Policy name | Release year | Main content |
|---|---|---|
| *National Smart City Pilot Program* | 2012 | Proposed leveraging modern science and technology to enhance urban planning, construction, and management by integrating information resources and coordinating application systems. |
| *National New-type Urbanization Plan (2014–2020)* | 2014 | Aimed to coordinate the utilization of material, information, and intellectual resources to promote the integration of next-generation ICTs – such as IoT, cloud computing, and big data – into urban economic and social development. |
| *Guiding Opinions on Promoting the Healthy Development of Smart Cities* | 2014 | Introduced a national-level framework emphasizing government leadership, multi-stakeholder collaboration, technological innovation, and data-driven development. |
| *The 13th Five-Year Plan for National Informatization Plan* | 2016 | Advocated for advancing smart city construction through the development and application of next-generation ICTs, including big data, cloud computing, and IoT. |
| *Guiding Opinions on Accelerating the Development of New Urban Infrastructure* | 2020 | Proposed building a new-type smart city with emphasis on data sharing, intelligent governance, and digital public services. |
| *Plan for the Overall Layout of Building a Digital China* | 2023 | Introduced the "2522" framework to promote deep integration of digital infrastructure, data systems, digital technologies, and economic and social systems. |

The 13th FYP period (2016–2020) marked the transition from exploratory pilots to structured implementation. The *13th Five-Year Plan for National Informatization* issued in 2016 formally embedded smart city development into China's national digital governance agenda. During this period, smart cities expanded into areas such as public service delivery, urban management, and industrial upgrading. The *Guiding Opinions on Accelerating the Development of New Urban Infrastructure* released in 2020 further signaled a shift toward data-driven urban governance by promoting intelligent public services, data sharing, and the construction of integrated digital infrastructures. These developments reflected a broader national effort to transition from traditional infrastructure investment to digital and intelligent urban systems. Under the ongoing 14th FYP (2021–2025), smart city development has entered a stage of deep integration and systemic convergence. The *Plan for the Overall Layout of Building a Digital China* issued in 2023 introduced the "2522" framework, which calls for

comprehensive integration of digital infrastructure, data systems, digital technologies, and economic governance mechanisms. In this phase, smart cities are positioned not as isolated technological projects but as strategic platforms underpinning cross-sectoral modernization, intergovernmental coordination, and national digital transformation.

Taken together, these evolving policies demonstrate a clear developmental trajectory: from initial pilot experimentation, to structured institutionalization, and ultimately to intelligent, integrated urban governance. Rather than treating smart cities as discrete or experimental initiatives, China has increasingly embedded them into long-term national strategies aimed at enabling sustainable, inclusive, and innovation-driven urban development.

To align with global trends in digital transformation and urban innovation, numerous countries and regions have formulated smart city strategies tailored to their unique institutional, social, and economic contexts. This study further presents a set of representative policy frameworks from Singapore, the United States, and the European Union for comparative analysis, as outlined in Table 2. A comparison of the entries in Tables 1 and 2 reveals distinct strategic priorities and governance approaches among China, Singapore, the United States, and the European Union. China adopts a top-down, state-led model that emphasizes strong central coordination, top-level design, cross-sectoral integration, and localized implementation, thereby establishing a unified and highly efficient policy advancement mechanism. Singapore adopts a data-driven and citizen-centric governance model that prioritizes transparency, participatory decision-making, and high-quality public service delivery. This approach is led by institutions such as the Smart Nation and Digital Government Group (SNDGG), GovTech, and the Ministry of Digital Development and Information (MDDI). The United States follows a bottom-up, market-oriented framework, wherein state governments, SOEs/POEs, and ARTTs act as the primary engines of technological experimentation and commercialization. Federal agencies such as the Department of Energy (DOE), the National Institute of Standards and Technology (NIST), and the Department of Transportation (DOT) provide strategic funding and regulatory support. Meanwhile, the European Union promotes a model centered on cross-border collaboration and sustainable development. Institutions such as DG CONNECT and the European Innovation Partnership on Smart Cities and Communities (EIP-SCC) play a key role in advancing green digital infrastructure, policy harmonization, and regional integration. Against this comparative backdrop, the distinctive strength of China's model lies not only in its capacity for rapid policy response and robust platform integration, but also in its well-established mechanisms for government–SOE/POE collaboration. Under strong state coordination, leading technology firms such as Huawei, Alibaba, and Tencent play pivotal roles in infrastructure deployment, platform development, and international cooperation. This synergistic public–private alignment enhances China's system integration capabilities and expands its global influence in the digital domain.

These divergent pathways illustrate how smart city development is shaped by national governance architectures and political cultures. In China's case, centralized leadership has enabled rapid mobilization of resources, uniform implementation standards, and close alignment with long-term development plans. Other models, however, highlight the value of institutional flexibility, multi-level coordination, and dynamic innovation ecosystems in enabling adaptive urban transformation. Overall, this comparative perspective underscores both the diversity of global smart city paradigms and the strategic effectiveness of China's centrally coordinated model in facilitating large-scale, integrated, and forward-looking urban development.

***Table 2. National-level policies supporting the development of smart cities among Singapore, the United States, and the European Union***

| Country | Policy name | Release year | Main content |
|---|---|---|---|
| Singapore | *Smart Nation 2025* | 2014 | A national strategy to build a smart nation through data-driven approaches and technological innovation, focusing on transportation, healthcare, e-government, and financial technology. |
| | *Digital Government Blueprint* | 2018 | Increasing government service efficiency through digital technology while promoting data sharing and open governance. |
| | *Smart Mobility 2030* | 2019 | Improving urban traffic efficiency through intelligent transportation technology while promoting autonomous driving and shared mobility. |
| | *Smart Health Initiative* | 2020 | Enhancing the efficiency of medical services through digital technology while promoting telemedicine and health data analytics. |
| | *Green Smart City Initiative* | 2021 | Promoting sustainable development through green and smart technologies, focusing on key areas such as smart energy, green buildings, and environmental protection. |
| USA | *Smart Cities Challenge* | 2015 | Funding for cities to develop smart city projects through competitive programs, focusing on key areas such as smart transportation, energy management, and public safety. |
| | *Strategy for American Innovation* | 2015 | Driving economic growth through technological innovation, with smart cities as a key focus area, emphasizing support for the Internet of Things, big data, and artificial intelligence. |
| | *Smart Cities Act* | 2017 | Supporting smart city projects through federal funding, focusing on key areas such as smart infrastructure, data sharing, and urban governance. |
| | *Smart Transportation Initiative* | 2018 | Enhancing urban traffic efficiency through intelligent transportation technology while promoting |

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|---|---|---|---|
| | | | autonomous driving and intelligent traffic management systems. |
| | *Smart Energy Initiative* | 2019 | Improving energy efficiency and promoting smart energy management through smart grid systems and renewable energy technologies. |
| EU | *European Innovation Partnership on Smart Cities and Communities* | 2012 | Advancing smart city development through cross-border cooperation, focusing on key areas such as smart energy, green buildings, and sustainable transportation. |
| | *European Green Deal* | 2019 | Promoting sustainable development through green and smart technologies, with smart cities as a key focus area, emphasizing support for smart energy and environmental protection. |
| | *European Data Strategy* | 2020 | Enhancing smart city development through data sharing and technological innovation, focusing on key areas such as data governance, artificial intelligence, and the Internet of Things. |
| | *European Smart Mobility Initiative* | 2020 | Improving urban traffic efficiency through intelligent transportation technology while promoting autonomous driving and shared mobility. |
| | *European Smart Energy Initiative* | 2021 | Enhancing energy efficiency and advancing smart energy management through smart grid systems and renewable energy technologies. |

## Digital economy analysis

Since the launch of the reform and opening-up policy in 1978, China has progressively established a market-oriented development model that underpinned decades of rapid economic growth. Within this broader national strategy, SEZs, DAMs, and coastal cities were designated as institutional platforms to pilot policy reforms, attract foreign investment, and facilitate integration with global markets. These regions have since played a pivotal role in fostering industrial agglomeration, technological upgrading, and innovation-driven growth, as illustrated in Fig. 1. China's accession to the World Trade Organization (WTO) in 2001 significantly deepened its integration into the global economy, catalyzing a transition from labor-intensive manufacturing to higher value-added segments of global value chains (GVCs). Bolstered by state-led industrial policies, technological advancement, demographic dividends, foreign direct investment, and large-scale infrastructure expansion (Xu & Xu, 2023; Zhang et al., 2021), China overtook Japan in 2010 to become the world's second-largest economy after the United States. As the marginal returns of factor-driven growth declined, China pivoted toward a path of high-quality development centered on digitalization transformation.

In this transformation, the digital economy is neither positioned as a standalone sector detached from the real economy nor narrowly defined as a subset of the service economy. Rather, it is conceptualized as a cross-sectoral and embedded economic formation, structurally

underpinned by two interrelated and mutually reinforcing processes: digital industrialization and industrial digitalization. Digital industrialization refers to the emergence of a technology-driven industrial system centered on ICTs, software platforms, data resources, and digital infrastructure – providing the core technological foundation for economy-wide digital transformation. In contrast, industrial digitalization denotes the deep integration of digital technologies into traditional industries – particularly manufacturing and services – through the reconfiguration of production processes and value chain architectures, thereby substantially enhancing total factor productivity (TFP). Within this framework, the digital economy does not replace the real economy; instead, it reinforces their integration by enabling synergistic development between advanced manufacturing and digital services via platform-based technological ecosystems, ultimately serving as a critical engine of innovation-driven growth.

From a theoretical standpoint, this transformation exemplifies the cumulative dynamics of endogenous growth. As articulated by Romer (1990), long-term economic expansion is propelled by knowledge accumulation, human capital externalities, and technological spillovers (Yuan & Zhang, 2024; Chandra, 2022). Rather than remaining locked into static comparative advantages within GVCs, China has harnessed institutional learning, technology absorption, and indigenous innovation to move beyond its historical trajectory of low-end assembly. The interplay between policy frameworks and technological diffusion has consequently given rise to a distinctive model of institutionally embedded endogenous growth. Spatially, the evolution of China's digital economy has followed a markedly uneven trajectory, characterized by a pattern of core concentration, secondary agglomeration, and gradient diffusion. In the early stages of reform, economic growth was predominantly concentrated in SEZs, DAMs, and coastal cities. With the maturation of industrial structures and the expansion of digital infrastructure, five major regional clusters have emerged through the progressive diffusion of development momentum: the Beijing–Tianjin–Hebei region, the Yangtze River Delta, the Guangdong–Hong Kong–Macau Greater Bay Area, the Middle Yangtze River region, and the Chengdu–Chongqing economic zone. Leveraging institutional advantages, talent agglomeration, and advanced platform ecosystems, these regions have evolved into strategic anchors for smart city development and digital industrial clustering. Therefore, through the implementation of smart city initiatives, these regions have progressively evolved into leading hubs of digital innovation, catalyzing the rise of globally competitive, platform-based industries and technology enterprises such as Alibaba (Hangzhou), Tencent and Huawei (both based in Shenzhen). Building on this foundation, spatial diffusion has been driven by industrial spillovers and institutional demonstration effects emanating from core regions, gradually extending the digital economy's reach into inland and less-developed provinces in the northwest and northeast. This process has fostered a multi-tiered diffusion network in which mega-cities function as national growth poles and provincial capitals act as regional hubs – thereby enhancing interregional connectivity and contributing to the formation of a polycentric development pattern.

In sum, the rapid rise and spatial diffusion of China's digital economy is not a coincidental development, but the product of dynamic interactions among market forces, state-led coordination, institutional experimentation, and endogenous technological advancement. Rooted in an "institutional geography" shaped by SEZs, DAMs, and coastal cities, China's digital economy has evolved through the strategic consolidation of five major regional clusters and the deployment of scalable governance models. This evolution marks a historic transition from path-dependent, factor-driven growth toward innovation-led development. As a key spatial mechanism of this transformation, smart cities have not only enhanced urban resilience and governance capacity, but have also functioned as strategic platforms for regional integration and new-type urbanization.

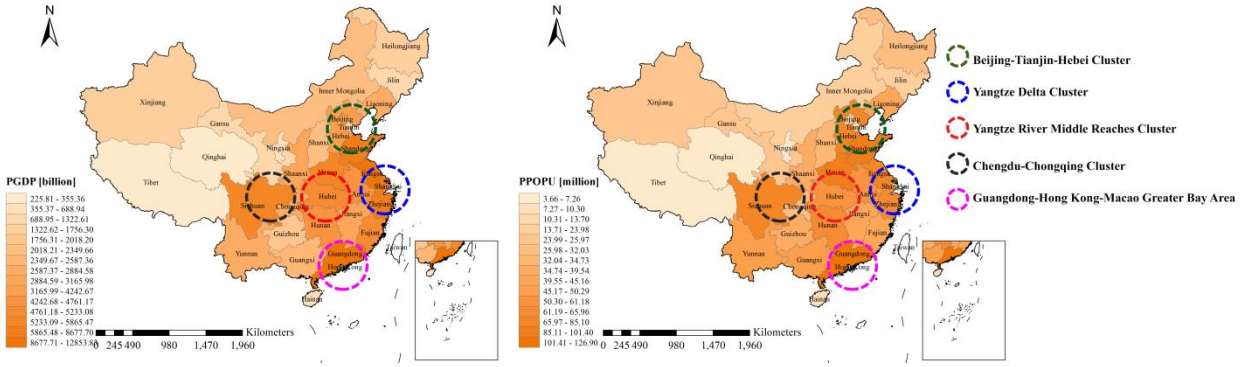


**Figure 1. Geographic layout of five leading smart city clusters in China, with corresponding provincial GDP (left) and population distribution (right)**

This study presents an in-depth analysis of the evolution of China's digital economy based on robust statistical evidence. Between 2012 and 2023, the digital economy experienced sustained growth, expanding from USD 1.58 trillion to USD 7.63 trillion – a 3.8-fold increase over eleven years, as shown in Fig. 2 (left). Over this period, the internal composition of the digital economy underwent a notable shift: the ratio of digital industrialization to industrial digitalization changed from approximately 3:7 in 2012 to 2:8 in 2023 (Fig. 2, right), reflecting a deeper integration of digital technologies into traditional sectors. By 2023, driven by continuous breakthroughs in ICTs – including IoT, big data, cloud computing, blockchain, 5G, and artificial intelligence – the digital economy had reached USD 7.63 trillion, accounting for 42.8% of China's GDP. Its contribution to GDP rose to 66.45%, marking an increase of USD 0.52 trillion from 2022 and a year-on-year growth of 1.3 percentage points. In nominal terms, the digital economy expanded by 7.39% year-on-year, outpacing overall GDP growth by 2.76 percentage points. In 2023, digital industrialization accounted for 18.7% of the digital economy, while industrial digitalization contributed 81.3%, underscoring the ongoing and intensifying integration between digital technologies and the real economy. Penetration rates of the digital economy in China's primary, secondary, and tertiary industries reached 10.78%, 25.03%, and 45.63%, respectively – representing increases of 0.32, 1.03, and 0.91 percentage points from the previous year. Notably, for the first time, the penetration rate in the secondary industry

surpassed that of the tertiary sector, signaling a structural shift toward digitally enabled manufacturing and industrial services. After more than three decades of development and full-scale integration into the global internet landscape, China has emerged as the world's largest digital consumer market, with 1.09 billion internet users as of 2023. Online retail sales reached USD 2.18 trillion, maintaining China's global leadership for the 11th consecutive year. Moreover, the scale of mobile payments has increased 239-fold since 2012. Artificial intelligence is now fostering new momentum in economic and societal transformation, reshaping both production systems and lifestyles across the country.

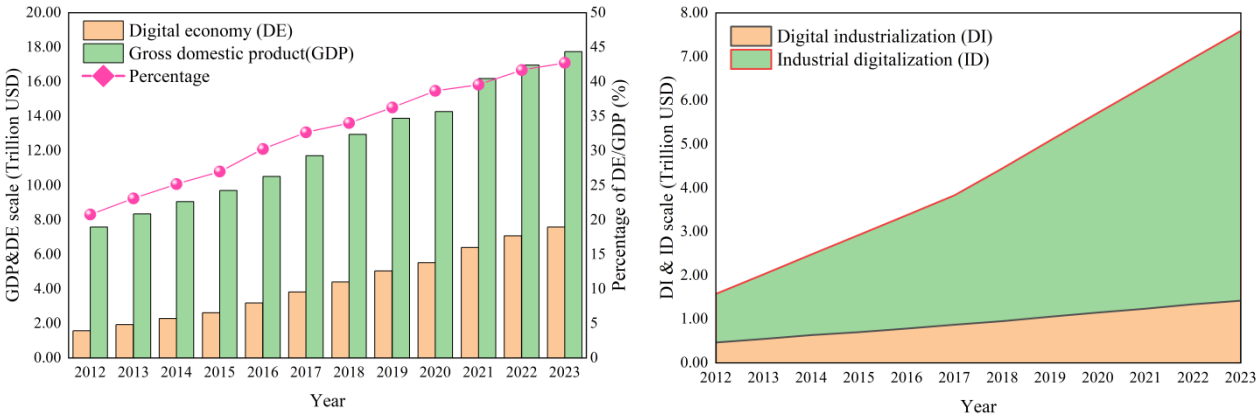


**Figure2. The digital economy in China from 2012 to 2023: digital economy (left) and digital industrialization and industrial digitalization (right)**

In the policy guidelines for the 15th FYP (2026–2030), China has pledged to accelerate the construction of a Digital China, enhance the foundational institutional framework that treats data as a key factor of production, and fully implement the "AI+" strategy. Looking forward, by deepening the integration between the digital and real economies, China seeks to modernize its industrial system and governance capacity – providing long-term momentum and structural support for the advancement of Chinese-style modernization.

## Practical application of smart city strategies

China's smart city strategy emerged as a response to the governance pressures and developmental bottlenecks driven by rapid urbanization. To meet the demands for improved administrative efficiency, optimized resource allocation, and enhanced public services, the central government has elevated smart cities to a strategic pillar of national development. Since the 12th Five-Year Plan, the concept has been systematically integrated into China's broader development agenda and advanced through successive national policy frameworks (see Table 1). Far beyond a technological undertaking, the smart city initiative represents a comprehensive effort to modernize state governance capacity and address persistent urban challenges such as traffic congestion, environmental stress, resource constraints, and demographic aging. This study further maps smart city application domains to China's evolving policy objectives, stages

of urbanization, and digital transformation indicators. It argues that the strategy not only facilitates the digitalization of urban governance but also serves as a key driver of new-type urbanization, productivity gains, and regional equity – highlighting the distinctive synergy between centralized policy coordination and digital empowerment in the Chinese context.

China's smart city strategy is embedded in a top-down, multi-level governance framework that spans central, provincial, municipal, and grassroots tiers. This vertically integrated structure ensures strong policy transmission and institutional coherence across all administrative levels. At the apex, the central government defines strategic objectives and regulatory frameworks, establishing unified direction and boundaries. Provincial governments serve as intermediaries, coordinating cross-regional implementation and mobilizing institutional resources. Municipal authorities are tasked with executing smart city initiatives, while grassroots administrations focus on service delivery and neighborhood-level digital transformation. This dynamic governance architecture – characterized by centralized standard-setting and localized responsiveness – has given rise to a distinctively Chinese model of smart urban governance: strategically guided, collaboratively implemented, and flexibly adapted to local conditions. In parallel with this vertical structure, China has cultivated a horizontally integrated smart city ecosystem under unified national leadership, as illustrated in Fig. 3. This ecosystem brings together four key actors: government, SOEs/POEs, ARTTs, and the public. Within this collaborative framework, the government assumes responsibility for strategic planning and the allocation of public resources; SOEs/POEs deliver digital infrastructure and spearhead innovations at the application layer; ARTTs contribute theoretical insights and cultivate human capital; and the public engages through mechanisms of co-creation and consultative governance. To institutionalize these interactions, collective intelligence and collaboration (CIC) mechanisms facilitate linkages between government and ARTTs, promoting evidence-based policymaking. Industry–university–research collaboration (IURC) connects ARTTs with SOEs/POEs to accelerate technological innovation. Crowdsourcing and co-creation platforms foster dynamic interaction between SOEs/POEs and the public, enabling user-driven innovation, while participatory governance channels strengthen the interface between government and the public, enhancing responsiveness and inclusivity. While government and SOEs/POEs jointly lead the direct implementation of smart city initiatives, ARTTs and the public contribute through indirect yet indispensable collaborative roles. Together, these vertically and horizontally integrated linkages form a resilient, multi-actor governance architecture that underpins China's systemic transition from fragmented pilot experiments to institutionalized digital governance.

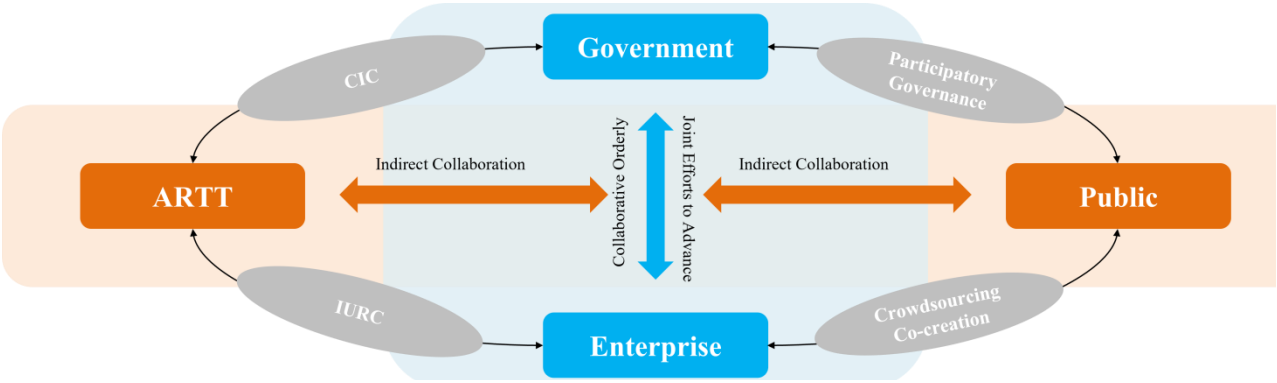


**Figure 3. Development and application of smart city strategies in China: ecosystem framework (left) and functional structure with application scenarios (right)**

Beyond the institutional framework of top-down, multi-level governance, the advancement of smart cities in China is further propelled by the active participation of SOEs/POEs. These actors not only catalyze technological innovation but also provide the foundational digital infrastructure that undergirds urban digitalization. Their coordinated efforts – spanning SOEs (e.g., China Mobile, China Telecom, China Unicom, China Broadnet) and POEs (e.g., Huawei, ZTE, Alibaba, Tencent), and foreign technology providers (e.g., NVIDIA, Intel) – have shaped a multilayered industrial ecosystem that enables end-to-end smart city functionality. As illustrated in Fig. 4, this ecosystem is systematically organized into four interdependent layers that reflect a progression from physical sensing to intelligent service delivery. The Perception Layer captures real-time environmental and operational data through sensors, cameras, and edge devices. The Transport Layer transmits this data securely and efficiently via advanced communication networks such as 5G and IoT. Building upon these foundations, the Processing Layer utilizes cloud computing, big data analytics, AI, and cybersecurity systems to transform raw data into actionable intelligence. Finally, the Application Layer translates this intelligence into integrated smart services across domains including mobility, public administration, emergency response, and environmental governance. Collectively, this layered architecture bridges physical infrastructure with digital intelligence, enabling China to pursue a model of smart urbanism that is scalable, adaptive, and strategically coordinated. Crucially, this enterprise-driven technological framework is both enabled and shaped by China's state-led governance logic. Under the sustained guidance of top-level design and the expansion of multi-actor coordination mechanisms, China's smart city strategy has followed a path of progressive institutional evolution. Early national initiatives such as "Broadband China" and "Internet +" prioritized infrastructure expansion and network connectivity. These laid the groundwork for more recent programs – including "New Urbanization" and "City Brain" – that focus on intelligent governance, service integration, and urban-rural synergy. This strategic progression marks a broader shift from infrastructure-centric deployment to governance-oriented restructuring, highlighting the state's path-dependent, adaptive, and incremental approach to building a digitally empowered society.


**Figure 4. Industrial landscape of smart cities in China. Sourced from the EO Intelligence**

Since smart city development was formally elevated to a national strategic priority during the 12th FYP period, China has consistently advanced institutional innovation and large-scale implementation in this domain, gradually positioning itself as a global leader in smart urban governance. According to Deloitte's global statistics on smart city initiatives, China currently leads the world, with its pilot projects accounting for approximately 48% of all smart cities under construction worldwide. The European Union ranks second with 23.6%, followed by India (11.0%), the United States (7.0%), Oceania (5.0%), and Japan, South Korea, and Canada, each contributing 2.0%. These figures highlight not only China's dominant position in the global smart city landscape but also the scale and ambition underpinning its nationwide digital transformation agenda. Initiatives such as "City Brain," "One-Stop Government Services," and "Grid-Based Governance" have been widely implemented, enabling key sectors such as digital government, smart healthcare, smart education, smart transportation, and others. The COVID-19 pandemic underscored the strategic value of smart city systems in crisis response and public health governance. In China, the rapid deployment of ICTs – including IoT, big data, cloud computing, blockchain, 5G technology, and AI – enabled efficient epidemiological tracing, real-time monitoring of population mobility, and the provision of contactless public services. Smart surveillance systems equipped with facial recognition and thermal imaging were widely implemented to support temperature screening and movement tracking. The "health code" mechanism, which integrated individual travel histories and testing information, provided an effective basis for differentiated risk control and the orderly resumption of economic activities. E-government platforms, exemplified by "One-Stop Government Services," ensured the continuity of essential public services during lockdown periods, while autonomous vehicles and drones played a critical role in delivering supplies within restricted areas. Together, these highly

integrated digital systems substantially enhanced urban governance resilience and adaptive capacity, while minimizing disruptions to social functioning. China's experience demonstrates that smart city infrastructure can be effectively transformed into a flexible and efficient public emergency response system.

## Key challenges

Despite notable achievements in recent years, China's smart city strategy is now entering a critical phase of structural transition – shifting from fragmented pilot experimentation to the pursuit of integrated, scalable, and citizen-centered systems. However, this transition faces persistent challenges at both institutional and operational levels.

First, the limitations of top-level design remain a fundamental bottleneck. In many cities, strategic goals are articulated in abstract terms without clear technical roadmaps or enforcement mechanisms. This has resulted in fragmented system architectures and poor platform interoperability, impeding the seamless integration of smart services. Second, systemic data fragmentation continues to obstruct data-driven governance. Siloed systems, inconsistent standards, and closed interfaces prevent the vertical and horizontal flow of information across administrative levels and departments. Even in advanced cities such as Shenzhen, digital infrastructure suffers from redundant platform construction and limited cross-platform communication. Third, governance coordination mechanisms remain underdeveloped. Effective smart city development requires collaborative engagement among governments, SOEs/POEs, ARTTs, and the public. However, resource asymmetries, fragmented accountability, and misaligned institutional logics often hinder cooperation. Fiscal constraints further amplify these issues, especially in central and western regions, where infrastructure is frequently overbuilt but underfunded in operation and maintenance – resulting in idle systems and technological obsolescence. At the same time, ethical and data security concerns have become increasingly salient. Applications such as facial recognition, health codes, and social credit systems have triggered public concern over algorithmic bias, privacy intrusion, and data misuse. These concerns are exacerbated by the lack of robust regulatory and ethical frameworks. Moreover, public participation mechanisms remain limited, particularly in less-developed areas, where digital literacy and civic trust are relatively low. Finally, performance evaluation pressures have led some local governments to favor KPI-oriented "image projects" over meaningful, citizen-centric services. This results in superficial digitalization and erodes public confidence in smart governance.

Addressing these multidimensional challenges requires a paradigm shift in strategic thinking and governance practice. Key priorities include enhancing policy-practice feedback loops, standardizing technical protocols to enable platform interoperability, transitioning from project-based to performance-based fiscal models, and institutionalizing inclusive governance mechanisms that prioritize public engagement and digital ethics. Only through such systemic

reforms can China's smart city strategy evolve into a more sustainable, adaptive, and participatory model of urban transformation.

## Conclusions

This study has provided a comprehensive examination of the evolution and implementation of China's smart city strategy, focusing on national policy frameworks, the development of the digital economy, practical applications, and key challenges. The findings reveal that since the 12th FYP, smart cities have been formally incorporated into China's national development agenda and have continued to expand under the 14th FYP.

Compared with policy models in countries such as Singapore, the United States, and the European Union, China's approach is characterized by a centrally coordinated, locally implemented, top-down institutional structure. This centralized governance model has facilitated rapid deployment of infrastructure and institutional integration. Furthermore, the rapid development of China's digital economy is not solely attributable to national policies, but also to the technological spillovers emerging from SEZs, ADMs, coastal cities. In practice, the implementation of smart city strategies has benefited from a multi-level governance system that enables coordinated interaction among governments, SOEs/POEs, ARTTs, and the public, forming a diversified innovation ecosystem. Nonetheless, several structural challenges persist. These include mismatches between top-down design and local needs, fragmented data governance, limited cross-sectoral collaboration, financial sustainability issues, and growing concerns over technological ethics and public trust. These challenges are spatially differentiated and reflect regional disparities in institutional innovation and local autonomy. In contrast to the market-driven and bottom-up experimentation seen in the United States, or the regulatory and citizen-centric model in the European Union, China's approach – while highly efficient – may constrain grassroots innovation and civic engagement in some contexts.

Looking forward, China's smart city development must shift from an emphasis on scale and speed to one on quality and sustainability. This requires enhancing local autonomy and policy flexibility within the existing centralized framework, improving performance-based fiscal mechanisms, promoting data interoperability standards, and embedding ethical and participatory governance mechanisms. In this context, the Chinese experience not only offers a viable state-led model for other developing economies but also contributes a valuable comparative case to the global discourse on smart city development – balancing institutional efficiency with the need for adaptability and inclusiveness.

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**Conflict of interest**

The author declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

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