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The Impact of Smart City Construction on Path Dependence in Resource-Based Cities of Different Types

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ABSTRACT

This paper examines how smart city construction affects the path dependence of resource-based cities. Such cities currently suffer from an imbalanced industrial structure, and smart city initiatives offer a window of opportunity for their transformation. The paper reviews the origins of the smart city idea, the state of domestic and international research, and the literature connecting the two fields; it then characterises path dependence in resource-based cities and specifies the transmission mechanisms through which smart city construction acts upon it. Drawing on the cases of Yangquan in Shanxi Province and Daqing in Heilongjiang Province, the study identifies success factors—most notably top-level design and the development of distinctive industries anchored in local resource endowments—alongside persistent weaknesses in funding security, data integration and talent matching. The findings suggest that smart city construction can help resource-based cities break out of path dependence, but only if these weaknesses are addressed. Future research may probe the underlying mechanisms at the micro level and broaden its geographical scope, thereby offering theoretical and practical guidance for resource-based cities seeking high-quality transformation through smart city development.

KEYWORDS

Smart City; Resource-based City; Path Dependence; Transformation and Upgrading.

1. INTRODUCTION

Since the beginning of the twenty-first century, the widespread deployment of a new generation of information and communication technologies—the Internet of Things (IoT), cloud computing, big data and artificial intelligence (AI)—has set off a worldwide wave of ICT revolution, and smart city pilot programmes have become a major trend in global urban development [1]. Drawing on three-dimensional modelling, digital twins, the metaverse and other advanced technologies, smart cities pursue digital, intelligent and sustainable urban development [2], reshaping urban operating models and functional structures from the delivery of public services through to the upgrading of traditional industries.

Resource-based cities form a distinctive category in China. They are typically endowed with natural resources far more abundantly than non-resource-based cities, and their local economies depend heavily on resource industries centred on the extraction and processing of forests, minerals and other natural resources. Development economics has long held that resource abundance is a blessing for such cities: it underpins their initial capital accumulation and enables a qualitative leap in economic development. Yet an over-reliance on resource extraction and processing skews the industrial structure and ultimately traps the local economy in a vicious circle [3].

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2. RESEARCH BACKGROUND AND SIGNIFICANCE

In 2013, the State Council issued the National Plan for the Sustainable Development of Resource-Based Cities in order to advance their transformation. In 2022, the report of the 20th National Congress of the Communist Party of China highlighted the urgency of promoting coordinated regional development and accelerating the transformation of resource-based cities. In 2023, then Premier Li Keqiang stressed in the Government Work Report the need to support the economic transformation of resource regions as soon as possible. Chinese resource-based cities are currently grappling with excessive dependence on natural resources, structural imbalance and severe environmental pollution, and are therefore under strong pressure to transform. Smart city construction, as an institutional arrangement, offers a promising remedy for the high resource dependence and the difficulty of industrial transformation that afflict these cities.

Against this backdrop, investigating how smart city construction affects path dependence in resource-based cities is of considerable practical and scholarly value [4]. Practically, it can help such cities escape the constraints of traditional path dependence: by introducing the innovative concepts and technological applications embedded in smart city construction, they can optimise resource allocation, cultivate new growth drivers and diversify their industrial base, thereby strengthening overall competitiveness, improving the ecological environment, safeguarding residents' quality of life and shifting from single-resource dependence towards sustainable development.

From a scholarly perspective, research on smart city construction and the transformation of resource-based cities, though extensive, has rarely focused specifically on how smart city construction shapes path dependence in these cities [5]. This study enriches the theoretical literature on urban economic geography and offers a new perspective and empirical basis for subsequent work on urban development paths and coordinated regional economies, contributing to a more complete theoretical account of urban transformation and sustainable development.

3. LITERATURE REVIEW

3.1. The Origins of the Smart City

In the 1990s, the developed countries suffered from an acute "urban disease" that seriously undermined urban governance and healthy development. In pursuit of long-term social stability and a sound economic cycle, new models such as New Urbanism and smart growth emerged, and the outline of the smart city began to take shape, with the aim of embedding hardware and software based on advanced information and communication technology (ICT) into urban planning. Entering the twenty-first century, the widespread application of a new generation of ICTs—the IoT, cloud computing, big data and AI—triggered a global ICT revolution, and smart city pilot programmes proliferated [6].

The global financial crisis of 2008 prompted a rethinking of the sustainability of urban economies and societies. It was at this juncture that IBM proposed the "smart planet" concept in search of a new direction for innovation in the information technology industry [7]. The concept met with an immediate response and was extended to the urban scale, as the United States, Canada, the European Union, the Republic of Korea, Singapore and other countries and regions successively launched smart city initiatives.

China's smart city strategy dates from November 2012, when the Ministry of Housing and Urban-Rural Development (MOHURD) issued the Notice on Launching National Smart City Pilot Work, making smart cities an important pathway for improving urban development quality and modernising urban governance. MOHURD subsequently released national pilot lists for three consecutive years—

2012, 2013 and 2014—covering prefecture-level cities, districts and counties, and townships, thereby initiating a multi-level and comprehensive exploration of smart city practice in China.

3.2. The State of Research at Home and Abroad

Many international scholars regard the smart city as akin to the intelligent city, the digital city, the information city and the virtual city. Washburn et al. [8] define the smart city as the use of cloud computing, the IoT and other new-generation information technologies to make a city's critical infrastructure more intelligent and efficient. Edward J. Jepson Jr. and May M. Edwards [9] combined smart urban development with ecological construction, analysing how smart growth models contribute to greater ecological sustainability. Kogan et al. [10] argue that innovation is the soul of the smart city, whose construction requires not only hardware innovation but also changes in the soft environment, such as urban management models and forms of social participation. Sharif et al. [11] point out that the use of ICTs and related technologies raises levels of risk, particularly risks relating to security, privacy and safety.

Domestic scholars understand the smart city in broadly similar terms. Wu Xibo and Yang Zaigao [12] regard high-end information technology as the core of the smart city, arguing that the interconnection and sharing of urban information reshapes the spatial relationships among government, enterprises and citizens.

Li Deren et al. [13] insist that smart city construction cannot be discussed apart from digital technology and that close attention should be paid to the widespread use of the IoT, which constitutes a virtual platform on which "everything can be done on the web". Zhang Bingxuan and Zhou Tao [14] argue that smart governance does not, as expected, comprehensively promote urban development; on the contrary, it intensifies economic path dependence, social polarisation and segregation, raises the risk of privacy breaches and further fragments social governance. Wu Zhiqiang, He Rui et al. [15] provide a comprehensive analysis of intelligent scenario practices worldwide and propose a definition of the urban intelligent scenario characterised by two features: technological empowerment and spatial embedding.

3.3. Research on the Relationship between Smart Cities and Resource Dependence in Resource-Based Cities

Fu and Zhou [16] were the first to link smart cities with resource-based cities. On the basis of theoretical analysis, they argue that smart city pilot construction can benefit urban management, infrastructure and environmental protection, and that smart technologies can drive industrial restructuring and sustainable development in resource-based cities. Wang Yihua and Jin Haiming [17] contend that smart cities can effectively promote industrial transformation in resource-based cities and that the widespread application of information technology during pilot construction is the key to both the growth of emerging smart industries and the upgrading of traditional ones; accordingly, government should take the lead in building an industrial system for the smart transformation of resource-based cities while pursuing independent innovation and emphasising talent development strategies in institutional arrangements. Yue Yang and Sun Duguang [18], taking the traditional resource-based city of Ma'anshan as a case, argue theoretically that building a smart city on the foundation of the IoT industrial chain is an important opportunity for resource-based cities to establish sustainable science and technology industries. To date, however, no systematic research exists on the relationship between smart cities and resource dependence in resource-based cities, and work on the relationship between smart cities and resource-based cities more generally remains at an early stage.

4. ANALYTICAL FRAMEWORK AND THEORETICAL BASIS

4.1. Path Dependence in Resource-Based Cities

Resource-based cities have long developed around a specific resource industry. During resource exploitation, infrastructure, human capital and technological inputs have all been concentrated in that industry, giving rise to a large and rigid industrial system. The industrial chain is insufficiently extended: most resource-based cities have focused on extraction and initial processing, neglecting forward and backward linkages and failing to tap the potential of deep processing and related supporting industries [19].

Because the resource industry delivered relatively stable returns over a long period, urban administrators and enterprises have tended to channel funds into expanding reproduction in the existing industry while neglecting R&D and innovation in new technologies and processes. The skill base is correspondingly narrow: the talent attracted and trained by resource industries is concentrated in extraction- and processing-related fields, leaving little reserve of diversified technical expertise.

In some resource-based cities, policy orientation has become rigid, with national or local policies long favouring the resource industry—from development planning and tax incentives to industrial support—thereby reinforcing its dominant position. Because some of these cities evolved through a pattern of "enterprise before city", and in some cases even experienced an early fusion of government and enterprise, the division of responsibilities between urban administrative bodies and enterprise management has remained blurred, and this institutional inertia has persisted.

4.2. Transmission Mechanisms through which Smart City Construction Affects Path Dependence

(1) By virtue of its strong technological innovation capacity, smart city construction provides powerful support for resource-based cities in fostering emerging industries and upgrading traditional ones.

In terms of nurturing emerging industries, advanced technologies such as the IoT, big data and AI have given rise to new business forms including smart energy, smart logistics and digital cultural tourism. The introduction of IoT technology and the establishment of smart energy management systems enable real-time monitoring and precise control across coal extraction, transport, processing and sales, improving energy efficiency and, on that basis, opening up new business areas such as the development and application of new energy [20].

In terms of upgrading traditional industries, smart construction drives traditional resource industries towards high-end and intelligent development [21]. Big data analytics can be applied to data on mineral reserves, ore grade and mining difficulty, thereby optimising mining plans and improving extraction efficiency and recovery rates. AI, in turn, automates ore dressing and smelting processes, improving product quality and production safety.

Smart city construction also creates numerous opportunities and models for industrial convergence in resource-based cities, with the integration of manufacturing and services being particularly typical. On the one hand, manufacturing is transformed into service-oriented manufacturing by incorporating smart service elements. In the production of Shaanxi Jiahe Industrial Equipment Co., Ltd. in Yulin, for example, the introduction of a remote operation and maintenance system, supported by IoT technology that monitors equipment status in real time, provides early fault warnings and arranges remote or on-site maintenance by technicians, thereby extending the traditional product sales model into a "product plus service" model and enhancing both value added and customer satisfaction. On the other hand, services are penetrating manufacturing ever more deeply. The smart logistics industry, for instance, uses big data and AI to plan transport routes intelligently, raising transport efficiency

and reducing logistics costs while providing manufacturers with precise supply chain management services, seamlessly connecting production and logistics and fostering industrial coordination.

(2) Smart city construction generates strong demand for advanced technologies, which substantially stimulates the innovation vitality of enterprises and research institutions and constitutes an important driver of technological innovation.

To meet the intelligent and digital requirements of smart city construction, enterprises must continuously introduce and integrate emerging information technologies such as the IoT, big data and AI into their production, operations and services [22]. In building smart energy management systems, for example, enterprises deploy smart electricity and water meters together with IoT technology to collect energy-use data, apply big data analytics to identify energy-saving potential and use AI to allocate and regulate energy intelligently. This demand for technology application drives enterprises to invest continuously in R&D, improving and innovating relevant technologies in order to raise energy efficiency, reduce consumption and strengthen their competitive position in smart city construction, thereby raising the technological innovation level of the industry as a whole.

The many domains and complex technological requirements of smart city construction also provide research institutions with a broad and valuable research agenda. Focusing on key technical challenges—such as how to achieve efficient interconnection between different information systems and how to ensure the secure storage and privacy protection of massive data volumes—research institutions actively undertake research projects and pool talent and resources for technological breakthroughs. Governments, for their part, often issue policies encouraging technological innovation during smart city construction, such as establishing special research funds and granting tax incentives to innovative enterprises.

It follows that technological innovation plays a crucial role in enabling resource-based cities to break out of path dependence, through several key mechanisms. First, in terms of raising production efficiency, technological innovation introduces advanced production processes, equipment and management practices, thereby optimising the production chains of traditional industries in resource-based cities. Second, technological innovation facilitates the development of new products and expands the industrial boundaries of these cities. Chenzhou in Hunan Province, well known as the "home of non-ferrous metals", previously concentrated on ore extraction and simple processing with low value added; through innovation that introduces new materials R&D and deep-processing techniques, metal minerals can be further processed into high-performance new materials, precision components and other high value-added products that meet market demand in different fields. Third, technological innovation can drive the development of related supporting industries, forming a complete industrial chain and enhancing the stability and risk resistance of the urban industrial system. Driven by innovation in smart logistics technology, for example, resource-based cities can build efficient distribution networks around their leading industries, attracting logistics, warehousing and packaging firms to cluster locally and further improving the industrial ecosystem [23].

(3) Smart city construction creates multifaceted and pressing demands for institutional innovation, spanning government management systems, policies and regulations, and market mechanisms.

Traditional urban management tends to follow a compartmentalised, function-based model in which data and information are held separately by individual departments, creating obstacles to communication and coordination [24]. Smart city construction, by contrast, emphasises interconnectivity and collaborative operation among urban elements, requiring departmental silos to be dismantled and cross-departmental data sharing and business coordination to be achieved. Smart traffic management, for instance, may involve data exchange and joint decision-making among transport, public security and urban planning departments, which requires government to innovate its management system by establishing a unified coordinating body or platform, clarifying each department's responsibilities and authority in smart city construction and promoting the efficient flow and integration of information.

As new technologies and applications proliferate in smart city construction, the existing policy and regulatory framework has revealed numerous gaps and inadequacies [25]. Take data sharing: massive volumes of urban data involve personal privacy, commercial secrets and national security, yet legislation governing the collection, storage, use and sharing of data remains incomplete. On the one hand, data must be shared within a lawful and compliant framework so that its value can be fully realised in support of smart city applications; on the other, the rights and interests of the parties concerned must be strictly protected. In addition, emerging smart industries such as autonomous driving and drone delivery require corresponding market access standards and regulatory policies to ensure their safe and orderly development.

Innovation is equally needed in market mechanisms. Smart city construction requires substantial capital investment, technological R&D and enterprise participation, yet the market currently suffers from inefficient resource allocation and inadequate incentive mechanisms. Some small and medium-sized technology firms, despite possessing innovative technologies and ideas, struggle to participate in smart city projects for lack of funding and policy support, while some large enterprises may exploit their dominant position to form monopolies, which is detrimental to full competition and sustained technological innovation. Market mechanisms should therefore be reformed through diversified investment and financing channels, improved tendering systems and reasonable industrial subsidy policies, so as to attract more social capital and enterprises into smart city construction, foster a sound market ecosystem and promote the healthy and sustainable development of smart cities [26].

5. CASE ANALYSIS

5.1. Smart City Practices in Typical Resource-Based Cities

5.1.1. Smart City Initiatives and Outcomes in Yangquan, Shanxi Province

Yangquan in Shanxi Province, the largest anthracite production base and a major energy and heavy chemical base in China, is a typical resource-based city. In recent years it has actively pursued smart city construction with notable results.

In smart energy management, Yangquan has built the first prefecture-level smart energy data centre in the province. Construction began in June 2020 and the centre was officially put into operation in December 2021. It focuses on aggregating, monitoring and analysing energy data—coal, oil, electricity, gas and heat—from relevant local public institutions and enterprises, and has developed thirteen big-data application scenarios in four categories (energy transition, environmental protection and emission reduction, services for people's livelihoods, and social governance), including an online monitoring platform for key energy consumers, an analytical screening tool for suspected "scattered, disorderly and polluting" enterprises, and a public service platform for electric vehicle charging facilities. Nine of these scenarios are now fully operational. The centre produces analytical reports on a weekly or monthly basis, providing strong data support for government decision-making and enterprise production.

In 2023, key energy-consuming enterprises in Yangquan with comprehensive energy consumption exceeding 5,000 tonnes of standard coal equivalent used the online monitoring and analysis services provided by the data centre to identify anomalous energy consumption in production in a timely manner, successfully averting several energy consumption spikes. By adjusting production schedules and process flows in good time, they effectively reduced energy consumption per unit of output, cutting annual carbon emissions by approximately 20% and saving about RMB 5 million in annual energy costs.

By the end of August 2024, the centre had received 5.99 million records uploaded by enterprise-end system devices, 140,000 records of external data provided by government and 32.65 million records of power data from the data middle platform, amounting to 38.78 million records and 854 GB of data.

In 2024, 84 key energy-using units with annual comprehensive energy consumption above 5,000 tonnes of standard coal equivalent were connected, 539 warnings were issued to enterprises exceeding limits, and 152 warnings were generated for abnormal production conditions such as sudden energy consumption spikes, enabling online management of total enterprise energy consumption.

By deploying large numbers of sensors on roads, vehicles and other objects, Yangquan uses IoT technology to collect and transmit real-time information on traffic volumes and road conditions. Big data analytics are then applied to these large traffic datasets to identify patterns across different times of day and road sections, and AI is used for intelligent traffic signal control and congestion early warning. These measures have effectively eased urban traffic pressure, improved transport efficiency and made daily travel more convenient for residents.

Yangquan is actively promoting the deep integration of the traditional energy industry with modern information technology. It has gradually introduced intelligent mining equipment and established smart mine management systems, enabling real-time monitoring and precise control of coal extraction, which has not only improved mining efficiency and reduced labour costs and safety risks but also raised recovery rates. At the same time, Yangquan is actively cultivating emerging industries: drawing on its resource advantages and platforms such as the smart energy data centre, it has attracted enterprises engaged in energy big data and the development and utilisation of new energy, gradually broadening its industrial base and improving its industrial structure.

5.1.2. Distinctive Features and Experience of Smart City Construction in Daqing, Heilongjiang Province

Daqing in Heilongjiang Province, a city that grew up with and prospered from oil, likewise faces resource depletion, ecological degradation and economic decline, and has developed its own distinctive approach and successful experience in smart city construction.

Building on its petroleum resources, Daqing draws on local resource advantages to develop distinctive smart industries and actively explores a path of integrated development between the petroleum industry and digital technologies. At some oil production crews in the Daqing Oilfield, digital and intelligent transformation pilots have enabled the remote automatic collection, transmission, analysis and management of data, and technologies such as radar video surveillance and drone inspection are used for real-time management of oil and water wells. At the injection end, manual data recording and stratified testing have gradually given way to automatic collection of wellhead data and remote control of downhole water injection; at the production end, manual dynamometer measurements, pressure testing and liquid volume measurement have gradually been replaced by automatic collection and wireless transmission of production data. Platform-based data management has thus been realised and work efficiency greatly improved.

Daqing has also produced local enterprises such as Sitech Technology, founded in Daqing, which has grown steadily in the integrated application of digital creative industries and exports its products to 65 countries and regions. By upgrading its digital information management platform, the company has significantly reduced R&D costs and markedly improved production efficiency, making it a representative case of industrial upgrading driven by smart technology. It has also helped Daqing's digital economy exceed RMB 100 billion for two consecutive years, with more than one thousand enterprises active in digital economy-related fields spanning service outsourcing, e-commerce, industrial internet, oilfield service software and information services.

In promoting technological innovation and talent development, the Daqing municipal government works in partnership with enterprises such as China Unicom as well as universities and research institutions. On the one hand, it has issued policies encouraging enterprises to increase investment in technological innovation, established special research funds and granted tax incentives to innovative enterprises, attracting numerous firms to participate in R&D related to smart cities. The "Digital Daqing" project developed with China Unicom focuses on two core areas—digital urban governance

and digital industry development—and aims to raise the level of digitalisation in urban management, public security, traffic control and emergency command. On the other hand, drawing on local universities and research institutions, Daqing has introduced programmes and courses related to smart city construction to train technical talent suited to local needs, while actively recruiting high-end talent from outside, thereby providing solid intellectual support for the city's smart development.

Daqing has built the Digital Daqing Centre, the first prefecture-level smart city operations and command centre in Northeast China and the nerve centre of the city's smart management and digital transformation. Its architecture—"one cloud, one database, one map, one network, one middle platform, one brain, a set of screens and one city well governed"—takes "one cloud", "one database" and "one map" as the core computing and data support, "one network" and "one middle platform" as the core transmission and integration links, and "one brain" and "a set of screens" as the vehicle for digital urban governance, ultimately achieving the goal of governing the city well. The 12345 government service centre on the second floor of the centre provides round-the-clock service to citizens through combined online and offline channels, with on-site, online and cloud-based emergency response mechanisms that efficiently connect frontline hotline intake with back-office processing, making it the "general customer service desk" for government services, the "general hub" for government-citizen interaction and the "general aggregation point" for data governance.

5.2. Comparison of the Cases and Implications

A comparison of the smart city models of Yangquan in Shanxi and Daqing in Heilongjiang allows us to identify the following success factors and remaining problems, which offer lessons for smart city construction in other resource-based cities.

5.2.1. Success Factors

Emphasis on top-level design. Yangquan has built the province's first prefecture-level smart energy data centre, jointly constructed and operated by multiple departments, which aggregates, monitors and analyses energy data across the city and provides strong support for government decision-making and enterprise production. Daqing has developed the "Digital Daqing" project around the two cores of digital urban governance and digital industry development, establishing a systematic and scientific construction architecture and planning the direction and pathway of the city's smart transformation as a whole, thus laying the foundation for the orderly advancement of smart city construction.

Developing distinctive industries based on resource advantages. As an energy and heavy chemical base, Yangquan draws on its coal resources to make traditional coal enterprises smarter and to raise extraction efficiency and recovery rates; relying on the smart energy data centre, it cultivates emerging industries and improves its industrial structure. Daqing builds on its petroleum resources, pursuing digital transformation at oil production crews, nurturing local enterprises and strengthening its digital economy. Both cities attach importance to scientific and technological talent in order to raise the intelligence of urban governance and services.

Strengthening technological innovation and talent support. In smart city construction, the Daqing municipal government mobilises enterprises, universities and research institutions. Through policies, special research funds and tax incentives it encourages enterprises to engage in technological R&D; drawing on local educational resources it offers relevant programmes and courses to train local talent while recruiting high-end talent from outside, thus consolidating the intellectual foundations of smart development. Yangquan likewise emphasises technological support, actively applying big data, the IoT and other new technologies in smart energy management and intelligent transport. Enterprises and research institutions work together to explore innovative application models and raise the city's level of intelligence, while attention is paid to attracting and cultivating professional talent to ensure the smooth progress of smart projects.

Enhancing the intelligence of urban governance. Daqing has built the Digital Daqing Centre, which provides multiple services through an integrated "one chessboard" system, pioneers a coordinated command model and strengthens safety precautions. Its 12345 government service centre combines online and offline channels and operates around the clock, raising the intelligence of urban governance. Yangquan focuses on intelligent transport, deploying sensors to collect and analyse traffic information and alleviate congestion, and applies smart tools in energy management and other domains to optimise governance and improve residents' quality of life.

5.2.2. Remaining Weaknesses

Many smart city projects require substantial funding, and long-term stable financial support is difficult to secure; projects with long payback periods are prone to delays in construction, operation and maintenance owing to funding shortfalls. The integration of massive data volumes is hampered by inconsistent data standards and incompatible interfaces across departments and systems, which impedes circulation and sharing, while data security risks are high and the task of preventing leaks and tampering is formidable. Given the rapid pace of IT renewal, existing talent faces skills obsolescence, competition for talent recruitment is intense, and matching and training talent has become difficult. As for industrial coordination, traditional and emerging industries in both cities remain loosely connected in terms of industrial chain linkages, resource sharing and collaborative innovation, so the synergy between industries has not been fully realised.

5.3. Implications for Other Resource-Based Cities

Strengthen top-level planning. Before embarking on smart city construction, other resource-based cities should formulate comprehensive and scientifically grounded top-level designs that take account of their resource endowments, industrial foundations and urban development strategies. They should define clear objectives, priority areas and implementation steps, avoid blind imitation and ensure that smart projects advance in an orderly way around core urban needs so as to generate synergies.

Adapt measures to local conditions. Cities should explore smart industry development paths suited to their own advantageous resources. Cities rich in coal, for example, may draw on Yangquan's experience in smart energy management and the cultivation of energy-related emerging industries, while oil-based cities may refer to Daqing's approach of pursuing digital transformation and developing its digital economy on the basis of the petroleum industry. By tapping the potential of distinctive resources and building differentiated smart city models, cities can convert resource advantages into industrial and economic advantages.

Increase innovation drivers and talent security. Cities should increase investment in and support for technological innovation, issue preferential policies encouraging enterprises to undertake R&D and innovative applications, build industry-academia-research cooperation platforms and promote the commercialisation of research outcomes. At the same time, they should attach importance to talent development and recruitment, optimise the allocation of educational resources in line with the technical requirements of smart city construction, offer relevant programmes and courses to train local talent, and attract outside talent through a favourable policy environment and career opportunities, thereby providing sustained momentum for smart urban development.

Improve data governance and security safeguards. Cities should establish sound institutions and standards for data management in advance, unify data formats and standardise interfaces, and strengthen mechanisms for data integration and sharing across departments. They should also heighten awareness of data security and adopt advanced technical and managerial measures—such as encryption, access control and security auditing—to protect urban data assets and create a healthy and stable digital environment for smart city construction.

Promote industrial convergence. Cities should foster coordination and integration among industries, promote the deep integration of traditional resource industries with modern services and emerging

industries, build complete industrial chains and use industrial convergence to generate new business forms and models. This will enhance the overall competitiveness of the urban economy, help resource-based cities escape dependence on a single resource and enable sustainable, high-quality development.

6. CONCLUSION AND OUTLOOK

Although this study offers a relatively in-depth case analysis of how smart city construction affects path dependence in resource-based cities, it has limitations imposed by various factors, and future research could further investigate the underlying mechanisms at the micro level. The analysis is conducted mainly at the macro and meso levels, examining the effects of smart city construction on resource-based cities as a whole and on different types of such cities; it pays relatively little attention to micro-level actors such as enterprises and communities—their behavioural changes, response mechanisms and specific problems in this process. Future work could focus on micro-level actors through field surveys and case studies: for instance, examining how a traditional manufacturing enterprise in a resource-based city uses smart technologies to restructure its production processes, expand its markets and adjust its workforce, or studying how community residents' habits change during the diffusion of smart life services and how their awareness of and participation in urban transformation evolve, thereby providing firmer micro-level support for macro-level conclusions.

The scope of research could also be broadened. First, comparative studies of resource-based cities in different countries and regions could be added, especially those differing substantially from Chinese cities in smart city models, resource endowments and institutional and cultural contexts; cross-national comparison would help distil more general and universally applicable patterns and lessons, offering Chinese resource-based cities a broader international perspective and points of reference. Second, as new resource types continue to be developed and new urban development challenges emerge, future research could incorporate additional types of emerging resource-based cities and new influencing factors, making the analysis more timely and forward-looking and continuing to provide valuable theoretical reference and practical guidance for resource-based cities pursuing high-quality transformation through smart city construction.

REFERENCES

[1] Zhu, J., Gianoli, A., Noori, N., de Jong, M., & Edelenbos, J. (2024). How different can smart cities be? A typology of smart cities in China. Cities, 149, 104992. https://doi.org/10.1016/j.cities.2024.104992.

[2] Caselli, B., Pellicelli, G., Rossetti, S., & Zazzi, M. (2022). How are medium-sized cities implementing their smart city governance? Experiences from the Emilia-Romagna region. Sustainability, 14(23), 15300. https://doi.org/10.3390/su142315300.

[3] Miao, C. H., Hu, Z. Q., Geng, F. J., & Miao, J. M. (2018). Characteristics of economic evolution and influencing factors of resource-dependent cities in China: The role of path dependence, vulnerability and path creation. Geographical Research, 37(7), 1268–1281. https://doi.org/10.11821/dlyj201807002. [In Chinese]

[4] Liu, X. (2023). A study on the impact of smart city pilot construction on resource dependence in resource-based cities (Master's thesis). Hunan University, Changsha, China. https://doi.org/10.27135/d.cnki.ghudu.2023.000517. [In Chinese]

[5] Wang, Y. H., & Jin, H. M. (2017). An analysis of industrial structure upgrading paths in resource-based cities from the perspective of smart cities. Daqing Social Sciences, (6), 51–56. https://doi.org/10.3969/j.issn.1002-2341.2017.06.017. [In Chinese]

[6] Giffinger, R. (2015). Smart city concepts: Chances and risks of energy efficient urban development. In Proceedings of the International Conference on Smart Cities and Green ICT Systems (SMARTGREENS) (pp. 3–16). Lisbon, Portugal: IEEE.

[7] Nakano, S., & Washizu, A. (2021). Will smart cities enhance the social capital of residents? The importance of smart neighborhood management. Cities, 115, 103244. https://doi.org/10.1016/j.cities.2021.103244.

[8] Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E. (2009). Helping CIOs understand “smart city” initiatives. Forrester Research, 17(2), 1–17.

[9] Jepson, E. J., & Edwards, M. M. (2010). How possible is sustainable urban development? An analysis of planners’ perceptions about new urbanism, smart growth and the ecological city. Planning Practice & Research, 25(4), 417–437.

[10] Kogan, N., & Lee, K. J. (2014). Exploratory research on the success factors and challenges of smart city projects. Asia Pacific Journal of Information Systems, 24(2), 141–189.

[11] Al Sharif, R., & Pokharel, S. (2021). Risk analysis with the Dempster-Shafer theory for smart city planning: The case of Qatar. Electronics, 10(24), 3080. https://doi.org/10.3390/electronics10243080.

[12] Wu, X. B., & Yang, Z. G. (2010). The concept of smart city and future urban development. Urban Development Studies, 17(11), 56–60, 40. [In Chinese]

[13] Li, D. R., Yao, Y., & Shao, Z. F. (2012). The concept, supporting technologies and applications of smart city. Journal of Engineering Studies, 4(4), 313–323. https://doi.org/10.3724/SP.J.1224.2012.00313. [In Chinese]

[14] Zhang, B. X., & Zhou, T. (2016). Can smartness bring governance? Critical reflections on the smart city construction boom under the new normal. Wuhan University Journal (Philosophy & Social Sciences), 69(1), 21–31. https://doi.org/10.14086/j.cnki.wujss.2016.01.003. [In Chinese]

[15] Wu, Z. Q., He, R., Chen, Z. Y., Zhu, Y. M., Teng, Y. W., Yang, X. Y., & Jiang, L. M. (2024). iSpace: Conceptual exploration and urban planning practices from 246 global cases. Urban Planning Forum, (5), 12–17. https://doi.org/10.16361/j.upf.202405002. [In Chinese]

[16] Fu, B., & Zhou, C. Y. (2013). Smart city—A new mentality for resource-based cities' sustainable development. Advanced Materials Research, 748, 1130–1134. https://doi.org/10.4028/www.scientific.net/AMR.748.1130.

[17] Wang, Y. H., & Jin, H. M. (2017). Analysis of the industrial structure upgrading path of resource-based cities from the perspective of smart cities. Daqing Social Sciences, (6), 51–56. [In Chinese]

[18] Yue, Y., & Sun, D. G. (2017). Feasibility study on the transformation of resource-based cities to smart cities: Reflections based on the case of Ma'anshan. Journal of Anhui Vocational College of Metallurgy and Technology, 27(4), 93–99. [In Chinese]

[19] Xi, Z. X., Ma, L., Jin, F. J., Wang, N. N., & Liu, Z. D. (2023). Spatiotemporal characteristics, types and paths of industrial transformation in typical resource-based cities of the Yellow River Basin. Resources Science, 45(10), 1977–1991. https://doi.org/10.18402/resci.2023.10.05. [In Chinese]

[20] Zhang, X. C., Hua, S. Z., Qi, J., & Ruan, Y. J. (2024). Progress and prospects of new smart city construction: AI-based big data, big models and big computing power. Journal of Geo-information Science, 26(4), 779–789. https://doi.org/10.12082/dqxxkx.2024.240065. [In Chinese]

[21] Zhang, C. B., Yu, X. Z., & Sui, Y. H. (2018). Resource-based cities: Industrial transformation and information support systems. China Scitechnology Think Tank, (6), 45–53. [In Chinese]

[22] Zhen, F., Xi, G. L., & Qin, X. (2015). Smart city planning and construction based on geographic perspectives: Some theoretical thinking. Progress in Geography, 34(4), 402–409. https://doi.org/10.11820/dlkxjz.2015.04.001. [In Chinese]

[23] Guo, J., Wang, K., Xu, J. L., Zhang, H. O., & Ye, Y. Y. (2024). Research and issues on China's smart city transformation under the perspective of 'socio-technical synergy'. Geographical Research, 43(10), 2511–2522. https://doi.org/10.11821/dlyj020220063. [In Chinese]

[24] Mu, T. W., & Zhang, Q. (2024). Does smart city construction improve social governance performance? An empirical test based on micro-data from the Chinese Social Survey (CSS). Scientific Decision Making, (1), 102–111. [In Chinese]

[25] Wang, B., Lu, P. Y., & Zhen, F. (2018). Urban geography research in the smart society: A perspective based on residents' activities. Geographical Research, 37(10), 2075–2086. https://doi.org/10.11821/dlyj201810015. [In Chinese]

[26] Dong, H. W., & Kou, Y. X. (2014). Criticism and practice of smart cities: A review of the international literature. City Planning Review, 38(11), 52–58. https://doi.org/10.11819/cpr20141109a. [In Chinese]