The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/2755-0761.htm

Digital Transformation and Society

Does building smart cities necessarily enhance urban ICT development? Insights from a quasi-natural experiment based on Chinese pilot policy

Zhouhong Wang
School of Information Management, Sun Yat-Sen University, Guangzhou, China
Shuxian Liu
Faculty of English, University of Cambridge, Cambridge, UK, and
Jia Li and Peng Xiao
School of Information Management, Sun Yat-Sen University, Guangzhou, China

Received 16 May 2024
Revised 18 July 2024
Accepted 11 August 2024

Abstract

Purpose – With the help of a quasi-natural experiment on Chinese policies, this study aims to understand the actual contribution of Smart City (SC) policies to the development of information and communications technology (ICT) in different cities. It also discusses the social and digital differences that such policies may generate, with a particular focus on the potential for exacerbating urban inequalities.

Design/methodology/approach – To achieve this, the study employs a principal component analysis (PCA) to develop an ICT development indicator system. It then employs a difference-in-differences (DID) model to analyze panel data from 209 Chinese cities over the period from 2007 to 2019, examining the impact of SC policies on ICT development across various urban settings.

Findings – Our findings show that SC policies have significantly contributed to the enhancement of ICT development, especially in ICT usage. However, SC policies may inadvertently reinforce developmental disparities among cities. Compared to less developed areas, the benefits of SC policies are more pronounced in economically booming cities. This is likely due to the agglomeration of the ICT industry and the strong allure of developed urban centers for high-caliber talent.

Originality/value – This study contributes to the related literature by explaining the role of SC policies in driving ICT development and by focusing on the often-overlooked impact of SC policies on urban inequality. These findings can provide guidance to policymakers on the need to recognize and address existing urban inequalities.

Keywords Smart city, ICT, Difference-in-differences, Principal component analysis

Paper type Research paper

1. Introduction

The Smart City (SC) has emerged as a dynamic academic field in recent years, embodying people's aspirations for a better urban future. Integrating "physical, digital and human

Corrigendum: It has come to the attention of the publisher of *Digital Transformation and Society* that the following article by Zhouhong Wang, Shuxian Liu, Jia Li and Peng Xiao "Does building smart cities necessarily enhance urban ICT development? Insights from a quasi-natural experiment based on Chinese pilot policy", *Digital Transformation and Society*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/DTS-05-2024-0071, included incorrect content in Table 8. The correct Table 8 has now been published online. The authors sincerely apologise to the readers for any inconvenience caused.

Digital Transformation and Society
Emerald Publishing Limited
e-ISSN: 2755-077X
p-ISSN: 2755-0761
DOI 10.1108/DTS-05-2024-0071

systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens" (British Standards Institute, 2014). SC has shown great potential to bring about profound changes across all facets of urban planning and living. At the core of this transformation, the development of information and communications technology (ICT) is widely recognized as crucial for building SCs. Prevalent visions are that SCs will drive economic growth and urban prosperity through the effective use of ICT, leading to more efficient and transparent urban governance and social equity (Kitchin, 2015).

However, the reality of SCs is more complex and uneven. Disparities both between and within cities are evident, challenging the notion of SCs as technological utopias or instruments of social justice (Datta, 2015). The implementation and development of SCs often run the risk of marginalizing citizens (Evans *et al.*, 2019). Practical evidence also suggests that improperly deployed SC technologies could exacerbate spatial exclusion and deepen existing inequalities (Bandauko & Arku, 2023). Therefore, it is crucial to assess the impact of SC policies on urban ICT development to ensure they align with the vision of equitable urban growth.

China has introduced the concept of SC on a national scale and implemented it through diverse policy instruments, marked by large-scale SC pilot projects. These varied implementation stages across different regions offer fertile ground for analyzing the effects of SC policies under distinct urban conditions. Therefore, this paper uses this policy pilot as a quasi-natural experiment to evaluate the impact of SC policies on urban ICT development. We investigate the influence of SC policies on ICT access, usage, and impact in cities with different economic foundations. Additionally, we explore whether SC policies are bridging or widening the ICT development gap between different cities and explicate the causes of these disparities. This study not only enhances the understanding of the role of SC policies in bridging or exacerbating digital divides but also sheds light on the complexities and unintended consequences of these policies. Furthermore, it provides valuable guidance for policymakers and urban planners, underlining the importance of tailoring SC strategies to local economic and social realities.

2. Literature review

The concept of SC is a fusion of ideas about how the utilization of ICT might optimize urban functionality, enhance competitiveness, and provide creative solutions to tackle challenges like poverty, social inequality, and environmental issues (Harrison *et al.*, 2010). SC is built upon intelligent infrastructures' creation and ICTs-human connection (Arroub, Zahi, Sabir, & Sadik, 2016), with the ICT aspect being a central pillar of SC planning and the achievement of SC's objectives (Zheng, Yuan, Zhu, Zhang, & Shao, 2020). Therefore, promoting ICT development seems to be an inevitable consequence of SC.

But in fact, the replication role of ICT development in society is widely debated. For instance, Richmond and Triplett (2018) pointed out that while increased ICT access can drive economic growth, disparities in access and digital literacy can exacerbate social inequality. Caragliu and Del Bo (2023) also identified that the uneven diffusion of ICT and its unaffordability for lower-income citizens could potentially exacerbate income inequality in SCs. Specifically, in China, Loo and Wang (2017) observed a paradox: despite a general reduction in digital divides at the provincial level, the urban-rural gap in digital development has widened. They also underlined the importance of government policy in promoting wider and more diversified ICT applications to foster comprehensive e-development.

As SCs lean increasingly heavily on new ICT, there are increasing discussions on how new advancements in technology often lead to polarization and division across various aspects (Batty *et al.*, 2012). For example, in Madrid, despite the implementation of SC policies, areas characterized by lower income and education levels continued to exhibit limited digital access and usage, with no discernible reduction in their existing inequalities (Arroyo-Menéndez, Barañano-Cid, & Uceda-Navas, 2022). As Caragliu and Del Bo (2023) argued, the top-down creation of SCs often favors the already rich and technologically advantaged, excluding the majority of city residents from benefiting from ICT investments and reinforcing existing inequalities. Moreover, Lee, Woods, and Kong (2020) and Nijman and Wei (2020) pointed out that individuals already facing challenges due to socioeconomic status, gender, ethnicity, and income may find these disparities magnified by technological advancements in SCs. Therefore, it is imperative to address existing urban disparities to ensure equitable access to infrastructure and services for the effective implementation of "smart intervention" (Lee *et al.*, 2020; Nijman & Wei, 2020).

Recent theoretical approaches to the concept of SC have also developed from a technocentric approach to a more multidimensional and unified framework (Badran, 2023). Along with the development of this comprehensive perspective arise more critiques of SCs' implementation and outcomes, particularly questioning the potential for exacerbating social and economic inequality. For instance, Watson (2014) cautioned against the impracticality of implementing SC plans in underdeveloped regions, which might worsen local marginalization. Meanwhile, the distribution of benefits derived from SCs is closely linked to higher incomes and aggregated private investment, thereby perpetuating existing inequalities (Odendaal, 2011). Consequently, despite inclusion being a vision and goal of building SCs, it remains far from becoming a tangible reality.

On the whole, existing research illuminates the intricate effects of Smart Cities and associated ICT development on urban society, as well as the potential risk of inequality. However, it also exposes notable gaps in our understanding. Firstly, there is a notable deficiency in understanding the reciprocal impact of SC on the advancement of ICT itself. The intricate relationship between SC policies and their direct contributions to ICT development remains an underexplored area. This knowledge gap suggests a need for more focused research on how SC initiatives specifically foster or hinder ICT innovation and growth. Additionally, existing studies predominantly concentrate on the internal dynamics and outcomes within individual cities. This approach overlooks the opportunity for cross-sectional analysis, which could offer comparative insights across different urban contexts. Such comparisons are crucial for understanding the varied effects of SC initiatives and how different urban environments interact with SC concepts and practices.

3. Policy background and hypotheses

The pressing challenges in urban development are compelling governments worldwide to adopt policies focused on technological investment to enhance management efficiency. These initiatives, often grouped under the SC umbrella, represent a strategic response to urban development issues. While specific SC policies vary by nation and region, their core tools are generally consistent. For instance, the US government's SC initiatives have invested over $160 million in federal research and technical cooperation to help local governments address modern urban challenges such as transportation, crime, economic growth, climate change, and city services (The White House OOTP, 2015). Similarly, London planned a £200 million investment by 2018 to showcase SC strategies for improving urban planning and operations (Greater London Authority, 2013). Similar plans have also been implemented in third-world countries, a typical representative is Kenya's capital, the city of Nairobi, which hopes to develop into a modern, smart and world-class city through the rapid dissemination of ICTs and their innovative application in everyday life (Guma & Monstadt, 2021). The commonality in these policies suggests that insights from China's SC initiatives could inform global discussions on their impact.

Since 2009, China has been implementing policies to guide and encourage the development of SCs from high-level design to practical applications. The National Smart City Pilot (NSCP) launched in 2012 is an important attempt. The first phase included 90 cities, supported by a credit line of CNY 440 billion from the State Development Bank and commercial banks (Yao, Huang, & Zhao, 2020). By 2014, the NSCP expanded to 290 cities/parts of cities across numerous provinces. There is ample reason to believe that these pilot cities have received significant financial and policy support for the development of related industries, effectively fostering the growth of ICT. Based on these observations, we hypotheses:

H1. SC policies enhance urban ICT development.

Given China's vast size and internal heterogeneity, it serves as an ideal context to study how SCs affect ICT development across different cities. While SC policies may boost urban ICT development in general, they might disproportionately benefit cities with stronger economic and technological foundations. In contrast, cities with weaker foundations might not experience effective ICT development, potentially exacerbating inter-city inequality. This issue is particularly evident when comparing China's economically robust eastern regions with its less developed western inland areas, where investment related to smart initiatives seems negligible and regional disparities are prominent (Zhu & Zhang, 2021). Therefore, we propose the following hypotheses:

H2-1. SC policies increase disparities in ICT development between cities.

H2-2. SC policies more significantly promote the ICT development in cities in China's eastern region compared to those in central and western regions.

China's SC policies consist of a series of direction-guiding policies that focus on strengthening the information infrastructure and the communication network bandwidth, as well as initiating smart application services in areas like smart transport, safe cities, smart health services and smart government (Guo, Liu, Yu, Hu, & Sang, 2016). These reflect the emphasis on fundamental ICT accessibility and the impact of ICT applications. Empirical evidence demonstrates that SCs in China have shown notable progress in governance and infrastructure, while their performance in economic and environmental aspects is less pronounced (Shen, Huang, Wong, Liao, & Lou, 2018). However, ICT usage-related aspects are rarely mentioned in policy texts and related studies. Consequently, we propose:

H3-1. The effect of SC policies varies across different levels of ICT development.

H3-2. SC policies have the strongest facilitation effect on the ICT accessibility, followed by ICT impact, with the least effect on ICT usage.

In this research, we will construct an ICT development index using principal component analysis and consider China's National SC Pilot as a quasi-natural experiment. This approach enables validating H1 by calculating the magnitude of the impact of SC policies on ICT development index through a difference-in-differences model. Subsequently, we will test the heterogeneity to validate H2 and H3 and explore the influence of SC policies on different levels of urban ICT development and inter-city inequality.

4. Research design

4.1 Econometric model

Drawing on the research of Beck, Levine, and Levkov (2010) and Guo and Zhong (2022), we employ a bidirectional fixed-effects regression model:

$$ICT_{it} = \alpha + \beta \times SC_{it} + \gamma \times X_{it} + \mu_i + \delta_i + \varepsilon_{it} \quad (1)$$

In this model, ICT_{it} represents the ICT development index of the city i in year t. SC_{it} is a dummy variable indicating whether city i has implemented a SC policy in year t. If it has, the variable is equal to 1; if it has not, the variable is equal to 0. We control individual-fixed effect μ_i and time-fixed effect δ_i in the model, which allows the model to accommodate to the staggered introduction of SC pilots and enhancing the model's accuracy. X_{it} represents a set of control variables. The estimator β is a consistent estimate of the effects of SC policies.

4.2 Measuring ICT development

In current research, the concept of ICT development encompasses a range of elements from infrastructure and access to technology, to user skills and policy frameworks. This comprehensive approach to measuring ICT development has been widely adopted by relevant institutions and scholars. International Telecommunication Union delineating ICT evolution in stages: "ICT readiness", "ICT intensity", and "ICT impact", each with sub-indices for Access, Use, and Skills (ITU, 2017). Scholars such as Hao, Guo, and Wu (2022) have further compartmentalized ICT development into four key dimensions—penetration, coverage, information resources, and business. Ren, Hao, Xu, Wu, and Ba (2021) have also established a four-tier ICT indicator system focused on Internet-related metrics.

In summary, the evaluation of ICT development should follow the logic of moving from access to ICTs to use of ICTs to measuring the impact of ICTs. Therefore, based mainly on the most authoritative ITU indicator method and referring to previous studies on ICT, we selected indicators from the available data in China and constructed a composite indicator containing three levels:

(1) *ICT accessibility:* This level refers to the ability to have physical access to ICT and considers indicators like Internet and cell phone penetration as crucial (Cariolle, 2021). It is directly related to the technological dimension and in some simplified models; these are the sole parameters for measuring ICT development (Asongu, Le Roux, & Biekpe, 2017).

(2) *ICT usage:* This level assesses the intensity and skill with which society and citizens use ICT. Important indicators reflect the urban population's educational situation and their willingness and ability to utilize ICT (Lythreatis, Singh, & El-Kassar, 2022). Moreover, economic factors also influence residents' utilization of ICT from several perspectives. Lower income levels of individuals may hinder their access to the Internet (Chang, Jeon, & Shamba, 2020), and low-income populations tend to present lower digital literacy (Wong, Ho, Chen, Gu, & Zeng, 2015).

(3) *ICT impact:* This level encompasses the positive outcomes resulting from its utilization. This includes the degree of development of ICT-related industries (Fan, Xu, & Ma, 2022) and indicators such as patent R&D that are related to technological innovation (Comino, Manenti, & Thumm, 2019).

4.3 Data collection

As the SC policy is only implemented in mainland China, the term "China" in this paper refers specifically to Mainland China, not including Hong Kong, Macau, and Taiwan province.

China's SC policy pilots focus on prefecture-level cities, covering units at different administrative levels. We selected data from prefecture-level cities for the five years before and after the release of the pilot policy (i.e. 2007–2019). The following data processing steps were undertaken to reduce estimation error: (1) exclusion of cities where SC pilots were implemented only in certain parts rather than throughout the entire city; (2) exclusion of cities with more than half of the data missing during the specified period. After deleting 89 cities from consideration, a final sample size of 209 cities was obtained. These included an experimental group consisting of 99 cities (33 from 2012 when the policy was implemented, 39 from 2013, and 27 from 2014) and a control group comprising 110 cities.

To ensure the reliability of the estimates, we refer to other studies assessing ICT development and incorporate the following control variables in the model: (1) the level of economic development represented by the city's GDP; (2) population size, indicated by urban resident population; (3) urbanization level, measured as the urbanization rate.

The specific variables and statistical descriptions are shown in Table 1, and the data were compiled from the China Economic Database provided by CEIC Data Company Limited.

4.4 ICT development index

In this study, the principal component analysis (PCA) is selected as an effective statistical means to reduce the dimension of data, and synthesize multiple indicators for assessing urban ICT development (Palese, 2018). Firstly, we standardized the variables to avoid any

Table 1.
Variables and statistical descriptions

Level	Definitions	Units	Obs.	Mean	Std. dev.	Min	Max
Accessibility	Internet broadband penetration (Number of Internet subscribers divided by the total number of households in cities)	%	2,583	50.391	42.955	0.02	328.639
Accessibility	Cell phone penetration (Number of mobile phone subscribers divided by the total number of households in cities)	%	2,631	257.621	142.611	17.482	1194.678
Usage	Per capita urban disposable income	CNY	2,715	23428.922	9290.727	7,653	64,886
Usage	Per capita financial investment in education	thousand CNY	2,476	1.269	0.712	0.152	9.824
Usage	School student population ratio	%	2,412	16.674	4.296	7.755	34.393
Impact	Per capita business income from telecommunications	CNY	2,449	8.24	8.597	0.341	131.698
Impact	Number of patent applications per 1,000 persons	Piece	2,455	0.861	1.384	0.002	14.011
Impact	Number of employees in the information transmission computer services and software industry per 10,000 people	Person	2,460	1.27	1.368	0.02	18.356
Control variable	ln(GDP)	ln(Billion CNY)	2,716	4.636	0.872	1.822	7.392
Control variable	ln(Urban resident population)	ln(thousand Person)	2,478	8.083	0.665	5.447	9.422
Control Variable	Urbanization rate(the proportion of urban residents to total population)	%	2,684	50.096	14.701	16.413	100

Source(s): Authors' own work

bias towards indicators with large variance or magnitude. Given that another commonly used Z-transform method may require a larger sample size, we used the min-max method of Equation (2) to normalize data (Ang, Choong, & Ng, 2015).

$$stdX_{ij} = \frac{X_{ij} - \min\{X_{ij}\}}{\max\{X_{ij}\} - \min\{X_{ij}\}} \quad (2)$$

Before conducting PCA, KMO and Bartlett tests are needed to assess the suitability of the data (Biasutti & Frate, 2017). The obtained results are as follows: $KMO = 0.82$; Bartlett test: $x^2 = 9944.834, df = 28\ (p = 0.000)$. According to previous studies, a KMO value in the range of 0.80s is meritorious (Kaiser & Rice, 1974). Furthermore, the significant result of Bartlett's test confirms that the data used in this study is appropriate for PCA.

The results are shown in Table 2, where the cumulative contribution rate of the top three common factors indicates that these factors encapsulate 76.72% of the original variable's information content. Consequently, we construct the Principal Component of the ICT development index (DI), formulated as $DI = (f_1 \times 0.5235 + f_2 \times 0.1397 + f_3 \times 0.104) \div 0.7672$.

5. Empirical results

5.1 Benchmark regression

The estimation results of Equation (1) are presented in Table 3. The outcomes demonstrate that the estimated coefficients of the variables are statistically significant at the 5% level, thereby substantiating the positive impact of SC policies on fostering integrated ICT development in urban areas.

5.2 Inequalities among cities

The inequalities among cities explored in this study focus on cities that have implemented SC policies, aiming to determine whether such policies lead to inequalities. Figure 1 presents the range, standard deviation, interquartile range and mean absolute deviation within the experimental group. The findings show a significant widening in the dispersion of the ICT development index between cities following the implementation of SC policies, suggesting that these policies have not successfully reduce disparities in ICT development between cities.

To ensure result reliability, cities were categorized into East, Central, and West based on the National Bureau of Statistics' classification, excluding the Northeast due to insufficient samples and missing values. The study assumes SC impacts regional inequality, with inland areas having weaker economic bases affecting ICT development (Wen, Liang, & Lee, 2023). One-way ANOVA (for ICT development: $F(2, 2205) = 103.97$, $p < 0.001$); for GDP:

Component	Eigenvalue	Difference	Proportion	Cumulative
1	4.18767	3.06995	0.5235	0.5235
2	1.11772	0.28555	0.1397	0.6632
3	0.832175	0.191359	0.104	0.7672
4	0.640815	0.103917	0.0801	0.8473
5	0.536898	0.166673	0.0671	0.9144
6	0.370225	0.183439	0.0463	0.9607
7	0.186786	0.0590782	0.0233	0.984
8	0.127707		0.016	1

Source(s): Authors' own work

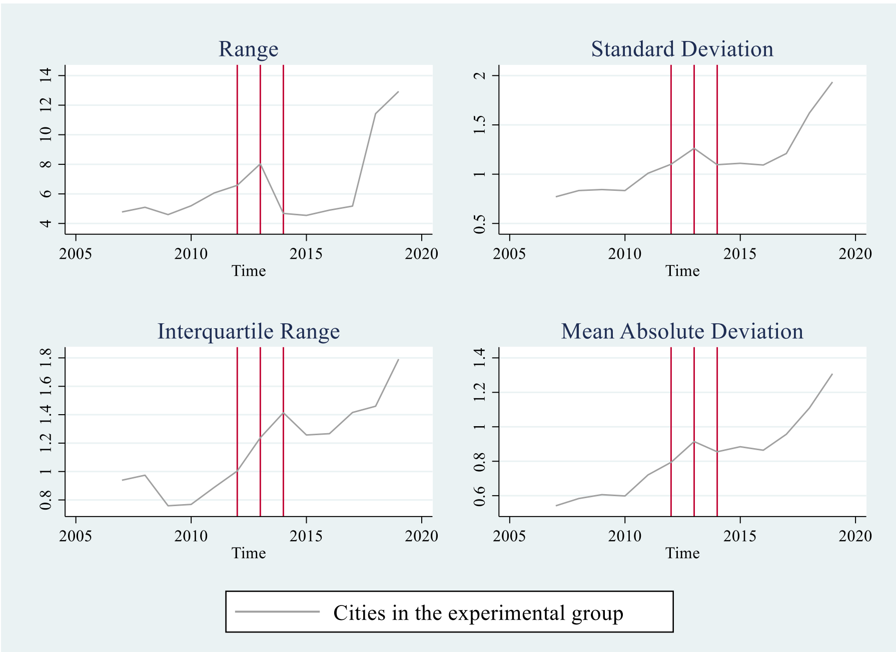
Table 2. Total variance decomposition of PCA

Variables	(1) Without CV	(2) With CV
DID	0.205**	0.161**
	(2.52)	(2.30)
ln GDP		0.358***
		(2.64)
ln Urban permanent population		2.171***
		(2.84)
Urbanization rate		−0.004
		(−0.36)
Constant	−0.060***	−19.166***
	(−2.68)	(−3.15)
Observations	2,245	2,239
R-squared	0.917	0.925

Note(s): ***, ** and * denote the significance level of 1, 5 and 10%, respectively; both year and city fixed effects are controlled in all the columns. The numbers in brackets represent *t*-values, which are calculated using robust standard error from clustering to the city level. The meaning is the same when not specified in the following table

Source(s): Authors' own work

Table 3.
Benchmark regression results



Source(s): Authors' own work

Figure 1.
Dispersion of data on urban ICT development within the experimental group by year

(F(2, 2598) = 222.45, $p < 0.001$) and Pearson correlation (as shown in Table 4) confirmed significant economic and ICT development disparities that decrease from east to west.

The heterogeneity test results in Table 5 indicate SC policies most strongly promote ICT development in eastern cities, moderately in central cities, and least in western cities. Less developed cities show minimal ICT development improvement from SC policies, supporting Hypotheses 2-2. Cities were categorized by GDP and the Development Index prior to policy implementation, yielding consistent conclusions. The detailed findings, omitted for conciseness, are available upon request.

5.3 Different levels of ICT development

We evaluate the impact of SC policies on ICT development levels, calculating the mean of dimensionless metrics as the dependent variable. Table 6 shows SC policies boost all ICT levels, most significantly in usage, followed by impact, with limited effect on accessibility, supporting Hypothesis 3-1 but not 3-2.

	Area	lnGDP	ICT development index
Area(Wast = 1; Central = 2; East = 3)	1		
lnGDP	0.4596(p < 0.001)	1	
ICT development index	0.2182(p < 0.001)	0.5454(p < 0.001)	1

Source(s): Authors' own work

Table 4. Pearson correlation coefficients between region, GDP and ICT development

Categorization		Area of China	
Group	West	Central	East
DID	0.057	0.179**	0.574***
	(0.87)	(2.50)	(3.34)
Control variables	Controlled	Controlled	Controlled
Constant	−10.048***	−13.955	−46.934***
	(−14.04)	(−11.61)	(−13.55)
Observations	814	718	669
R-squared	0.932	0.938	0.938

Source(s): Authors' own work

Table 5. Regression results categorized by regions

Region		Total			West China	
Variables	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
DID	0.005	0.015***	0.009**	0.005	0.001	0.003
	(0.78)	(2.87)	(2.01)	(0.92)	(0.14)	(0.61)
Control variables	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Observations	2,385	2,449	2,436	916	950	937
R-squared	0.929	0.884	0.772	0.921	0.885	0.737
Region		**Central China**			**East China**	
Variables	**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**
DID	0.004	0.018**	0.008**	0.026**	0.042***	0.036**
	(0.83)	(2.04)	(2.24)	(2.07)	(4.94)	(2.27)
Control variables	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Observations	742	748	748	727	751	751
R-squared	0.949	0.909	0.738	0.942	0.908	0.805

Source(s): Authors' own work

Table 6. Regression results categorized by different levels of ICT development

Examining regional policy implementation, eastern China shows significant growth in all ICT levels, while central China focuses on usage and western China on accessibility. The latter's economic and infrastructural needs suggest prioritizing accessibility, which may reduce the overall effectiveness of SC policies there, partially confirming our hypothesis on economic development, infrastructure, and policy efficacy.

5.4 Robustness tests

To ensure the reliability of our results, we conducted a series of robustness tests.

Parallel trend test: We applied Sun and Li's (2021) parallel trend test to observe the dynamic impact of the years before and after the policy announcement on ICT development. Figure 2 shows that coefficients were insignificant pre-implementation, indicating uniform ICT progression across cities, which confirming the parallel trend hypothesis.

Performed parallel trend sensitivity tests: We utilized Rambachan and Roth's (2023) robust tool for sensitivity testing in parallel trend tests, to ensure that our results are robust even in the presence of risks to the parallel trend assumption. Restricting relative magnitudes of the deviations, we tested the ICT development index and its three levels. Figure 3 shows the policy effect remains robust at the aggregate and individual levels, suggesting our DID estimates are reliable even with pre-treatment trend variations.

Placebo test: We assessed time-varying unobservables' potential bias using a placebo test akin to La Ferrara, Chong, and Duryea (2012). We randomly selected 100 cities as a control group and assigned a random year for policy impact, repeated 500 times. Figure 4 shows these placebo coefficients clustering around zero, below actual effects, indicating our estimates' robustness to unobservable influences.

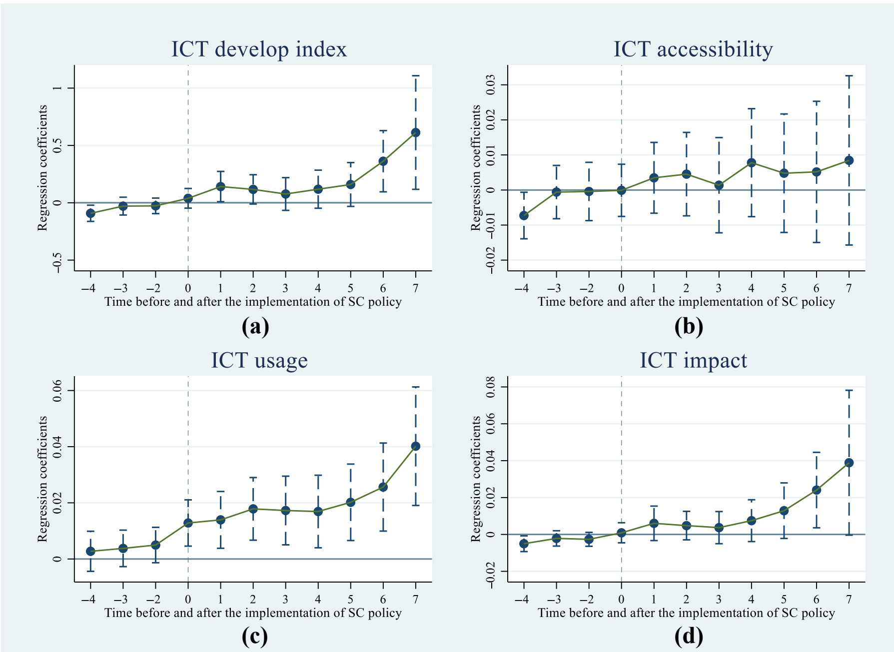
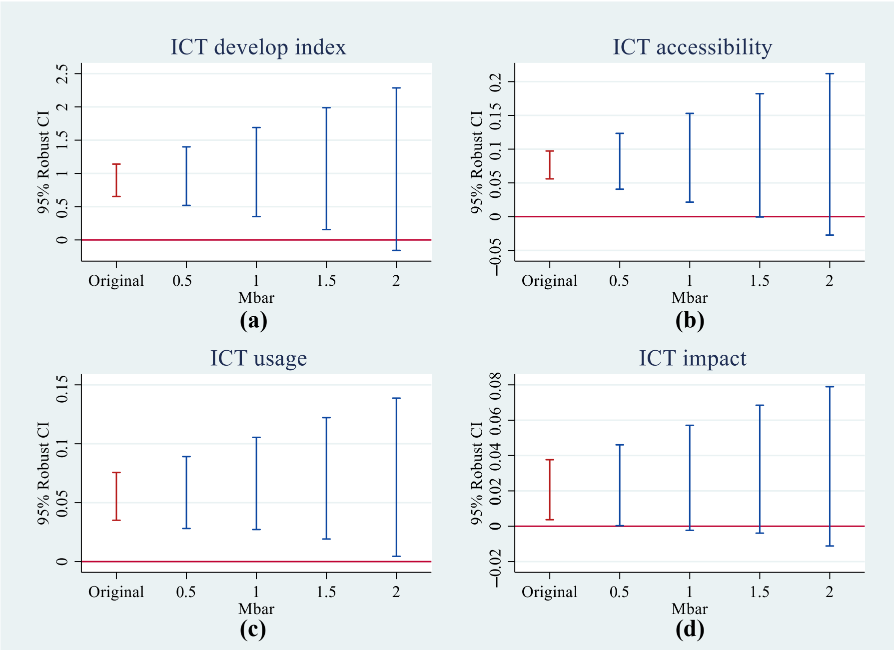


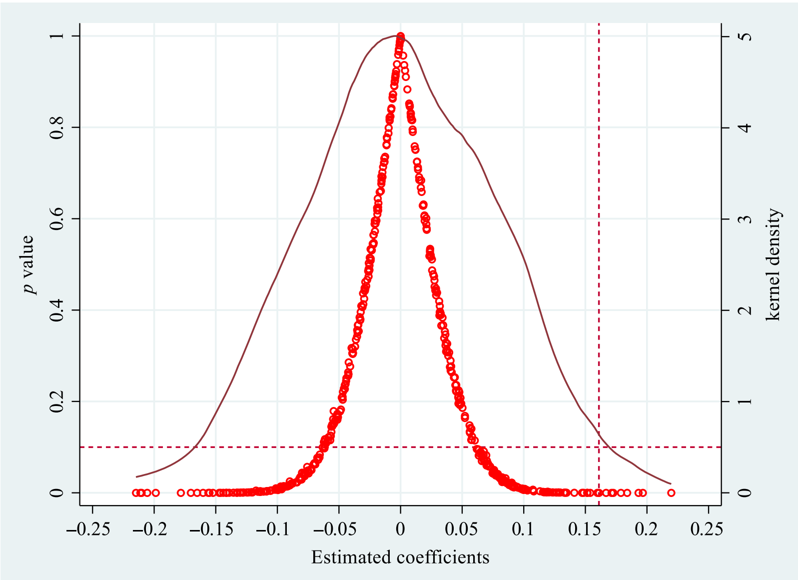
Figure 2.
Parallel trend test

Source(s): Authors' own work



Source(s): Adopted from Rambachan and Roth (2023). Authors' own work

Figure 3.
Sensitivity test of parallel trend hypothesis

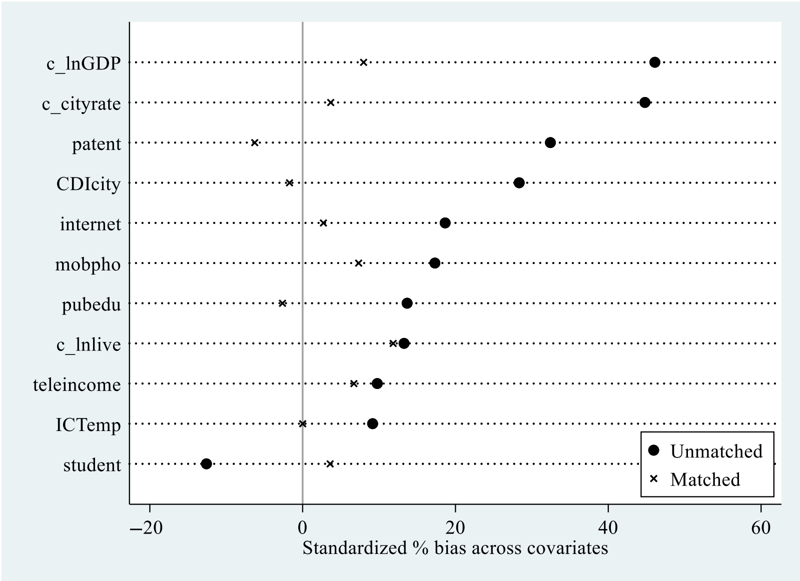


Source(s): Authors' own work

Figure 4.
Placebo test

PSM-DID: We addressed potential selection bias from non-random SC pilot selection by employing a 1:2 nearest-neighbor matching in PSM with a 0.05 caliper, using PCA indicators and control variables as criteria, following Wang, Chen, Wu, and Nie (2019). Figure 5 illustrates reduced covariate imbalances post-matching, ensuring minimized disparities. The adjusted regression results in Table 7 substantiate the reliability of our initial conclusions.

Excluding the impact of other policies: To isolate policy impacts, cities part of the "Broadband China" pilot since 2013 were excluded from our model. This policy, impacting broadband coverage and quality, could skew ICT development assessments. After re-analyzing the data, Table 7 reveals slightly reduced policy effectiveness but clearer regional disparities, underscoring urban policy inequality.



Source(s): Authors' own work

Figure 5.
PSM-DID balance test

Table 7.
Robustness test results for the benchmark regression and regional heterogeneity

Tests	PSM-DID				Remove "broadband China" policy cities			
Group	Total	East	Central	West	Total	East	Central	West
DID	0.149**	0.575***	0.178**	0.050	0.100	0.651***	0.041	−0.026
	(2.16)	(3.29)	(2.48)	(0.75)	(1.17)	(3.07)	(0.59)	(−10.37)
Control variables	controlled	controlled	controlled	controlled	controlled	controlled	controlled	controlled
Constant	2,209	649	715	807	−26.707***	−52.432***	−4.501	−8.090**
	0.925	0.937	0.938	0.935	(−12.96)	(−13.19)	(−10.79)	(−12.07)
Observations	2,209	649	715	807	1,417	429	414	546
R-squared	0.925	0.937	0.938	0.935	0.927	0.936	0.959	0.935

Source(s): Authors' own work

5.5 Mechanism

Understanding the mechanisms behind how SC policies enhance ICT development and their regional impact is crucial. Our review of pertinent literature suggests two primary catalysts: the ICT industry's agglomeration effect, where mature industries attract investment and improve economic strength (Lasch, Robert, & Le Roy, 2013), and SC policies' influence on attracting talent, vital for ICT advancement (Zheng, Wang, & Li, 2022; Ai, Zhou, & Yan, 2023).

To empirically substantiate these hypotheses, we've chosen proxy variables from the *China City Statistical Yearbook*. For industrial clustering, we utilize "the actual amount of foreign investment", which reflects the city's ability to attract investment and industry. For intellectual capital, we use "the number of employees in scientific research, technical services, and geological exploration", these intellectually concentrated industries gather a large number of high-quality talents. The data have been log-transformed.

Employing the analytical framework of Chen, Fan, Gu, and Zhou (2020), our findings, as delineated in Table 8, corroborate that SC policies exert a positive influence on cities' capacities to draw in investments and skilled personnel. Notably, this influence is more pronounced in the eastern and central regions, suggesting that the variance in the efficacy of SC policies across regions could be attributed to the disparities in industrial concentration and the endowment of human capital.

It bears emphasis that, while these proxies offer valuable insights, the empirical rigor of our tests is compromised by the absence of direct metrics on city-level talent and ICT sector intricacies. Thus, there is an imperative for future studies to incorporate more precise measures to fortify our conclusions.

6. Discussion

We hope that the results of this paper will help answer the following questions:

6.1 Which aspects of ICT development have been facilitated by SC policies?

We found that while SC policies can enhance ICT development in cities, this effect is uniform across all cities. Cities with a better development foundation received significant growth in ICT under SC policies, whereas those with a less developed foundation did not mirror this progress. This divergence suggests that, contrary to common perception, SC policies do not automatically translate into tangible improvements in ICT indicators. This finding is crucial for studies in relevant fields as it emphasizes the need to explore the interconnectedness and distinct roles of ICT and SCs, rather than presuming them to be synonymous. There is a need for further discussion of how ICT has played a role in SCs and how it has been facilitated.

Mechanism	Attract investment agglomeration				Attract high-quality talent			
Groups	Total	East	Central	West	Total	East	Central	West
DID	0.197*	0.254**	−0.037	0.254	0.054	0.132	0.157**	−0.050
	(1.89)	(2.18)	(−0.27)	(1.15)	(1.11)	(1.27)	(2.25)	(−0.58)
lnGDP	0.950***	−0.479	0.146	1.286**	0.098	0.035	0.615**	−0.094
	(3.26)	(−1.47)	(0.27)	(2.55)	(0.71)	(0.11)	(2.06)	(−0.50)
pplive	−0.061	0.729	0.721	−0.963	0.412**	1.041**	0.147	0.119
	(−0.11)	(1.04)	(1.43)	(−0.86)	(2.07)	(2.06)	(0.60)	(0.38)
cityrate	0.038***	0.067***	0.030*	0.023*	0.001	0.011	−0.009	0.001
	(3.27)	(4.16)	(1.69)	(1.68)	(0.18)	(1.65)	(−1.19)	(0.42)
Constant	3.566	3.064	2.131	9.086	4.383**	−1.121	4.571**	7.475***
	(0.75)	(0.51)	(0.49)	(1.01)	(2.59)	(−0.26)	(2.13)	(3.09)
Observations	2,275	722	735	781	1,833	548	555	702
$R-$squared	0.822	0.875	0.841	0.657	0.927	0.923	0.912	0.942

Source(s): Authors' own work

Table 8. Mechanism test results

Although SC policies may contribute to ICT development in certain cities, their impact operates differently than anticipated. Contrary to our Hypothesis 3-2, SC policies do not significantly enhance the most directly relevant dimension of ICT accessibility; instead, they exert a stronger influence on the usage dimension, which may not appear directly relevant. This outcome reflects the ambiguity of SC policies and their varied implementation across different policy frameworks. While ICT accessibility is often regarded as a crucial aspect of SCs (Yigitcanlar *et al.*, 2018), another significant policy called “Broadband China” has largely replaced SC’s role in this regard, specifically aiming to promote Internet diffusion in Chinese cities (State Council of China, 2013). The policy design of the NSCP clearly places a greater emphasis on high-level ICT applications rather than infrastructure development (Zhu, Li, & Feng, 2019).

Our findings highlight the need for a comprehensive understanding of SC policies, recognizing that their impact on ICT development is influenced by a city’s existing infrastructure and the specific objectives of the policy itself. This insight is important for policymakers and researchers in designing and evaluating SC initiatives that effectively leverage ICT for urban development.

6.2 Why do some cities benefit more in ICT development?

We argue that the significant disparity in how SC policies promote ICT development across different urban areas, may arise from human capital development and industrial agglomeration effects under the influence of SC policies. This idea is derived from research findings of the existing literature, and the mechanism test in 4.5 of this paper also provides support. Significantly, SC policies tend to promote ICT development in cities with advantageous coastal locations and a stronger economic and ICT development base, inadvertently deepening pre-existing urban disparities. This trend runs counter to the ideal of equality often associated with SC initiatives.

The nature of SC policies, as described by Marchesani, Masciarelli, and Bikfalvi (2023), focuses on creating environments that foster innovation, attract capital and talent, and improve local competitiveness. This approach inherently benefits cities with established ICT sectors. As Lasch *et al.* (2013) noted, ICT firms are characterized by strong agglomeration effects, meaning that cities with more mature ICT-related industries are more likely to attract investment, enhancing their ICT development and overall economic strength. Additionally, the strong spillover and network effects associated with ICT contribute to creating new productivity and economic growth opportunities, which further enhance the comprehensive competitiveness of the city (Cardona, Kretschmer, & Strobel, 2013).

Another factor is the challenge arising from talent mobility in the current fierce competition from globalization (Tarique & Schuler, 2010). SC policies provide a platform for cities to attract talent, thereby increasing talent capital (Zheng *et al.*, 2022) and labor force attractiveness (Ai *et al.*, 2023). Cities with better geographical locations, higher levels of economic development, and more solid industrial foundations are naturally more appealing to skilled workers. As a result, SC policies exhibit a “snowballing” effect, reinforcing the advantages of economically and industrially robust cities while widening the gap with less developed areas.

This finding aligns with previous research on SC policies in China, which indicates that the positive impacts of SC policy are more pronounced in economically advanced eastern cities, whether it’s carbon productivity (Song, Dian, & Chen, 2023), energy efficiency (Yu & Zhang, 2019), or other urban topics. This is generally attributed to weak information infrastructure and less efficient resource allocation in these regions (Wang, Zhou, Lan, & Wang, 2021). However, our study offers an alternative view that SC policies struggle to stimulate fundamental ICT development in these economically backward areas.

This difficulty can prevent cities from initiating a positive cycle of development through SC policies, leading to their diminished effectiveness in these cities. This uneven development outlines a crucial policy implication—the need for more inclusive and balanced SC strategies that address the unique challenges and strengths of diverse urban environments.

6.3 How to make the benefits of SC policies more equal?

To address the uneven distribution of benefits derived from SC policies, policymakers must acknowledge that SC initiatives may not be universally suitable, especially for cities with weaker economic and industrial bases. As Puron-Cid and Gil-Garcia (2022) observed, SCs incur high costs, and the financial burden of building and maintaining the necessary ICT infrastructure may render the projects unsustainable. Our findings show that the large-scale SC initiatives undertaken by some cities have not resulted in returns commensurate with their investment. This is evidenced by examples such as Masdar City in Abu Dhabi, which was envisaged as a pioneer of eco-cities but eventually had to abandon its initial master plan due to the huge costs entailed (Cugurullo, 2016). Such instances demonstrate that relying solely on SC concepts and government investment in ICT is not a viable path to urban prosperity and social equity.

Recognizing that not all cities are suitable for large-scale SC projects, it becomes crucial for policymakers to seek profit and avoid harm in SC policymaking and tailor their approaches to local realities. This involves identifying specific urban development needs and allocating limited resources judiciously. By focusing on a holistic approach rather than merely superimposing advanced technologies, SC policies can be more effective, achieving not only efficiency and resource optimization but also making significant strides towards their intended objectives. As Neirotti, De Marco, Cagliano, Mangano, and Scorrano (2014) emphasized, an in-depth understanding of local environmental factors is key for urban policymakers in developing effective SC strategies.

In the large-scale implementation of smart technologies and urban problem-solving, strategic planning by higher governmental levels is vital for coordinating resources and improving inter-city communication. Integrating smart interventions with solutions to existing urban inequalities is also essential in addressing existing and potential inter-city inequalities. The Chinese government has recognized this issue in its recent SC policies, proposing a hierarchical and classified approach to the development of new SCs (State Council of China, 2021). This approach places a greater emphasis on people-centered and locally adapted development concepts (Tang, Zhang, Shan, Wang, & Zhang, 2020). The effectiveness of these practical initiatives and the Chinese model in future SC construction warrant close attention of policy researchers. The lessons learned from the Chinese experience can provide insights for other countries and regions seeking to develop or enhance their own SC frameworks, and help them progress towards a more equitable and sustainable urban future.

7. Conclusion

The study concludes that SC policies significantly enhance urban ICT development, particularly in utilization and industry impact, with greater effects in cities with stronger economic and ICT bases. Two key explanations are proposed: ICT's strong spillover and network effects, and the talent attraction of developed cities. The research contributes to the literature by indicating SC policies could widen urban inequalities and extends discussions on urban disparity by examining inter-city effects.

Academically, the study clarifies mechanisms through which SC policies boost ICT development and points out their potential to increase inequality among cities, providing a fresh angle in smart city research. Practically, it offers insights for policymakers: acknowledging and addressing urban inequalities in SC strategy formulation is crucial, considering each city's economic development and infrastructure. Additionally, recognizing that SC policy implementation does not automatically ensure effective ICT development, policy researchers should consider multidimensional perspectives beyond technology.

References

Ai, H. S., Zhou, Z. Q., & Yan, Y. (2023). The impact of smart city construction on labour spatial allocation: Evidence from China. *Applied Economics*, *56*(19), 2337–2356. doi: 10.1080/00036846.2023.2186367.

Ang, B. W., Choong, W. L., & Ng, T. S. (2015). Energy security: Definitions, dimensions and indexes. *Renewable and Sustainable Energy Reviews*, *42*, 1077–1093. doi: 10.1016/j.rser.2014.10.064.

Arroub, A., Zahi, B., Sabir, E., & Sadik, M. (2016). A literature review on Smart Cities: Paradigms, opportunities and open problems. In *2016 International Conference on Wireless Networks and Mobile Communications (WINCOM)*. IEEE. doi: 10.1109/WINCOM.2016.7777211.

Arroyo-Menéndez, M., Barañano-Cid, M., & Uceda-Navas, P. (2022). Unequal in the smart city? Spatial segregation and digital inequalities in Madrid. *Revista Espanola de Investigaciones Sociologicas*, *180*, 19–44. doi: 10.5477/cis/reis.180.19.

Asongu, S. A., Le Roux, S., & Biekpe, N. (2017). Environmental degradation, ICT and inclusive development in sub-saharan Africa. *Energy Policy*, *111*, 353–361. doi: 10.1016/j.enpol.2017.09.049.

Badran, A. (2023). Developing smart cities: Regulatory and policy implications for the state of Qatar. *International Journal of Public Administration*, *46*(7), 519–532. doi: 10.1080/01900692.2021.2003811.

Bandauko, E., & Arku, R. N. (2023). A critical analysis of 'smart cities' as an urban development strategy in Africa. *International Planning Studies*, *28*(1), 69–86. doi: 10.1080/13563475.2022.2137112.

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., . . . Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics*, *214*(1), 481–518. doi: 10.1140/epjst/e2012-01703-3.

Beck, T., Levine, R., & Levkov, A. (2010). Big bad banks? The winners and losers from bank deregulation in the United States. *The Journal of Finance*, *65*(5), 1637–1667. doi: 10.1111/j.1540-6261.2010.01589.x.

Biasutti, M., & Frate, S. (2017). A validity and reliability study of the attitudes toward sustainable development scale. *Environmental Education Research*, *23*(2), 214–230. doi: 10.1080/13504622.2016.1146660.

British Standards Institute (2014), Smart city framework. In *Guide to establishing strategies for smart cities and communities*, BSI: London, PAS 181.

Caragliu, A., & Del Bo, C. F. (2023). Smart cities and the urban digital divide. *NPJ Urban Sustainability*, *3*(1), 43. doi: 10.1038/s42949-023-00117-w.

Cardona, M., Kretschmer, T., & Strobel, T. (2013). ICT and productivity: Conclusions from the empirical literature. *Information Economics and Policy*, *25*(3), 109–125. doi: 10.1016/j.infoecopol.2012.12.002.

Cariolle, J. (2021). International connectivity and the digital divide in sub-saharan Africa. *Information Economics and Policy*, *55*, 100901. doi: 10.1016/j.infoecopol.2020.100901.

Chang, Y. S., Jeon, S., & Shamba, K. (2020). Speed of catch-up and digital divide: Convergence analysis of mobile cellular, internet, and fixed broadband for 44 African countries. *Journal of Global Information Technology Management*, *23*(3), 217–234. doi: 10.1080/1097198X.2020.1792231.

Chen, Y., Fan, Z., Gu, X., & Zhou, L. (2020). Arrival of young talent: The send-down movement and rural education in China. *The American Economic Review*, *110*(11), 3393–3430. doi: 10.1257/aer.20191414.

Comino, S., Manenti, F. M., & Thumm, N. (2019). The role of patents in information and communication technologies: A survey of the literature. *Journal of Economic Surveys*, *33*(2), 404–430. doi: 10.1111/joes.12277.

Cugurullo, F. (2016). Urban eco-modernisation and the policy context of new eco-city projects: Where Masdar city fails and why. *Urban Studies*, *53*(11), 2417–2433. doi: 10.1177/0042098015588727.

Datta, A. (2015). New urban utopias of postcolonial India: 'entrepreneurial urbanization' in Dholera smart city, Gujarat. *Dialogues Hum Geogr*, *5*(1), 3–22. doi: 10.1177/2043820614565748.

Evans, J., Karvonen, A., Luque-Ayala, A., Martin, C., McCormick, K., Raven, R., & Palgan, Y. V. (2019). Smart and sustainable cities? Pipedreams, practicalities and possibilities. *Local Environment*, *24*(7), 557–564. doi: 10.1080/13549839.2019.1624701.

Fan, Y. X., Xu, H., & Ma, L. J. (2022). Characteristics and mechanism analysis of the influence of digital economy on the income gap between urban and rural residents. *China Soft Science*, 06, 181–192.

Greater London Authority (2013). Smart London plan. Available from: https://www.london.gov.uk/sites/default/files/smart_london_plan.pdf (accessed 8 December 2023).

Guma, P. K., & Monstadt, J. (2021). Smart city making? The spread of ICT-driven plans and infrastructures in Nairobi. *Urban Geography*, *42*(3), 360–381. doi: 10.1080/02723638.2020.1715050.

Guo, Q., & Zhong, J. (2022). The effect of urban innovation performance of smart city construction policies: Evaluate by using a multiple period difference-in-differences model. *Technological Forecasting and Social Change*, *184*, 122003. doi: 10.1016/j.techfore.2022.122003.

Guo, M. J., Liu, Y. H., Yu, H. B., Hu, B., & Sang, Z. (2016). An overview of smart city in China. *China Communications*, *13*(5), 203–211. doi: 10.1109/CC.2016.7489987.

Hao, Y., Guo, Y. X., & Wu, H. T. (2022). The role of information and communication technology on green total factor energy efficiency: Does environmental regulation work?. *Business Strategy and the Environment*, *31*(1), 403–424. doi: 10.1002/bse.2901.

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). *IBM Journal of Research and Development*, *54*(1), 1–16. doi: 10.1147/jrd.2010.2048257.

ITU (2017). The ICT development index (IDI): Conceptual framework and methodology. Available from: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx (accessed 29 November 2023).

Kaiser, H. F., & Rice, J. (1974). Little jiffy, mark iv. *Educational and Psychological Measurement*, *34*(1), 111–117. doi: 10.1177/001316447403400115.

Kitchin, R. (2015). Making sense of smart cities: Addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 131–136. doi: 10.1093/cjres/rsu027.

La Ferrara, E., Chong, A., & Duryea, S. (2012). Soap operas and fertility: Evidence from Brazil. *American Economic Journal: Applied Economics*, *4*(4), 1–31. doi: 10.1257/app.4.4.1.

Lasch, F., Robert, F., & Le Roy, F. (2013). Regional determinants of ICT new firm formation. *Small Business Economic Group*, *40*(3), 671–686. doi: 10.1007/s11187-011-9382-z.

Lee, J. Y., Woods, O., & Kong, L. (2020). Towards more inclusive smart cities: Reconciling the divergent realities of data and discourse at the margins. *Geography Compass*, *14*(9). doi: 10.1111/gec3.12504.

Loo, B. P., & Wang, B. (2017). Progress of e-development in China since 1998. *Telecommunications Policy*, *41*(9), 731–742. doi: 10.1016/j.telpol.2017.03.001.

Lythreatis, S., Singh, S. K., & El-Kassar, A. N. (2022). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change*, *175*, 121359. doi: 10.1016/j.techfore.2021.121359.

Marchesani, F., Masciarelli, F., & Bikfalvi, A. (2023). Smart city as a hub for talent and innovative companies: Exploring the (dis) advantages of digital technology implementation in cities. *Technological Forecasting and Social Change*, *193*, 122636. doi: 10.1016/j.techfore.2023.122636.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in smart city initiatives: Some stylised facts. *Cities*, *38*, 25–36. doi: 10.1016/j.cities.2013.12.010.

Nijman, J., & Wei, Y. D. (2020). Urban inequalities in the 21st century economy. *Applied Geography*, *117*, 102188. doi: 10.1016/j.apgeog.2020.102188.

Odendaal, N. (2011). Splintering urbanism or split agendas? Examining the spatial distribution of technology access in relation to ICT policy in Durban, South Africa. *Urban Studies*, *48*(11), 2375–2397. doi: 10.1177/0042098010388951.

Palese, L. L. (2018). A random version of principal component analysis in data clustering. *Computational Biology and Chemistry*, *73*, 57–64. doi: 10.1016/j.compbiolchem.2018.01.009.

Puron-Cid, G., & Gil-Garcia, J. R. (2022). Are smart cities too expensive in the long term? Analyzing the effects of ICT infrastructure on municipal financial sustainability. *Sustainability*, *14*(10), 6055. doi: 10.3390/su14106055.

Rambachan, A., & Roth, J. (2023). A more credible approach to parallel trends. *The Review of Economic Studies*, *90*(5), 2555–2591. doi: 10.1093/restud/rdad018.

Ren, S., Hao, Y., Xu, L., Wu, H., & Ba, N. (2021). Digitalization and energy: How does internet development affect China's energy consumption?. *Energy Economics*, *98*, 105220. doi: 10.1016/j.eneco.2021.105220.

Richmond, K., & Triplett, R. E. (2018). ICT and income inequality: A cross-national perspective. *International Review of Applied Economics*, *32*(2), 195–214. doi: 10.1080/02692171.2017.1338677.

Shen, L., Huang, Z., Wong, S. W., Liao, S., & Lou, Y. (2018). A holistic evaluation of smart city performance in the context of China. *Journal of Cleaner Production*, *200*, 667–679. doi: 10.1016/j.jclepro.2018.07.281.

Song, T., Dian, J., & Chen, H. W. (2023). Can smart city construction improve carbon productivity? -A quasi-natural experiment based on China's smart city pilot. *Sustainable Cities and Society*, *92*, 104478. doi: 10.1016/j.scs.2023.104478.

State Council of China (2013). Circular of the state Council on the issuance of the broadband China, strategy and implementation programme. Available from: https://www.gov.cn/zwgk/2013-08/17/content_2468348.htm (accessed 29 November 2023).

State Council of China (2021). Outline of the fourteenth five-year plan for the national economic and social development of the people's Republic of China and the vision 2035. Available from: https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm (accessed 29 November 2023).

Sun, L., & Li, W. (2021). Has the opening of high-speed rail reduced urban carbon emissions? Empirical analysis based on panel data of cities in China. *Journal of Cleaner Production*, *321*, 128958. doi: 10.1016/j.jclepro.2021.128958.

Tang, S. S., Zhang, Y. Q., Shan, Z. G., Wang, W., & Zhang, Y. Q. (2020). Development status, situation and policy recommendations of new smart cities in China. *E-Government*. *4*, 70–80. doi: 10.16582/j.cnki.dzzw.2020.04.007.

Tarique, I., & Schuler, R. S. (2010). Global talent management: Literature review, integrative framework, and suggestions for further research. *Journal of World Business*, *45*(2), 122–133. doi: 10.1016/j.jwb.2009.09.019.

The White House OOTP (2015). Fact sheet: Administration announces new 'smart cities' initiative to help communities tackle local challenges and improve city services. Available from: https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help (accessed 8 December 2023).

Wang, H., Chen, Z. P., Wu, X. Y., & Nie, X. (2019). Can a carbon trading system promote the transformation of a low-carbon economy under the framework of the porter hypothesis?

-Empirical analysis based on the psm-did method. *Energy Policy*, *129*, 930–938. doi: 10.1016/j.enpol.2019.03.007.

Wang, D., Zhou, T., Lan, F., & Wang, M. (2021). Ict and socio-economic development: Evidence from a spatial panel data analysis in China. *Telecommunications Policy*, *45*(7), 102173. doi: 10.1016/j.telpol.2021.102173.

Watson, V. (2014). African urban fantasies: Dreams or nightmares?. *Environment and Urbanization*, *26*(1), 215–231. doi: 10.1177/0956247813513705.

Wen, H. W., Liang, W. T., & Lee, C. C. (2023). Input-output efficiency of China's digital economy: Statistical measures, regional differences, and dynamic evolution. *Journal of the Knowledge Economy*, 1–26. doi: 10.1007/s13132-023-01520-5.

Wong, Y. C., Ho, K. M., Chen, H., Gu, D., & Zeng, Q. (2015). Digital divide challenges of children in low-income families: The case of shanghai. *Journal of Technology in Human Services*, *33*(1), 53–71. doi: 10.1080/15228835.2014.998576.

Yao, T. T., Huang, Z. L., & Zhao, W. (2020). Are smart cities more ecologically efficient? Evidence from China. *Sustainable Cities and Society*, *60*, 102008. doi: 10.1016/j.scs.2019.102008.

Yigitcanlar, T., Kamruzzaman, M., Buys, L., Ioppolo, G., Sabatini-Marques, J., da Costa, E. M., & Yun, J. J. (2018). Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities*, *81*, 145–160. doi: 10.1016/j.cities.2018.04.003.

Yu, Y. T., & Zhang, N. (2019). Does smart city policy improve energy efficiency? Evidence from a quasi-natural experiment in China. *Journal of Cleaner Production*, *229*, 501–512. doi: 10.1016/j.jclepro.2019.04.316.

Zheng, C. J., Yuan, J. F., Zhu, L., Zhang, Y., & Shao, Q. (2020). From digital to sustainable: A scientometric review of smart city literature between 1990 and 2019. *Journal of Cleaner Production*, *258*, 120689. doi: 10.1016/j.jclepro.2020.120689.

Zheng, J. L., Wang, X. H., & Li, Y. (2022). Can smart city construction improve the level of talent capital?. *Journal of Systems Science and Mathematical Sciences*, *42*(5), 1261.

Zhu, H. L., & Zhang, Z. X. (2021). Regional differences of China's intelligent construction. *Economic Geography*, *41*(08), 54–61. doi: 10.15957/j.cnki.jjdl.2021.08.007.

Zhu, S. Y., Li, D. Z., & Feng, H. B. (2019). Is smart city resilient? Evidence from China. *Sustainable Cities and Society*, *50*, 101636. doi: 10.1016/j.scs.2019.101636.

Corresponding author
Peng Xiao can be contacted at: xiaop25@mail.sysu.edu.cn