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How smart city building improved corporate performance: empirical evidence of China's a-share listed companies

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Smart city construction is crucial for regional economic development, and the micro-level impact of such construction on business operations cannot be ignored. Based on the panel data of Shanghai and Shenzhen A-share listed companies from 2008 to 2020, this paper investigates the relationship between smart city construction and firm performance and its mechanism of action. The study findings show that (1) smart city construction significantly improves enterprise performance; (2) the improvements are significant across all industries and regions; and (3) the impact of smart city construction on small and medium-sized enterprises (SMEs) and nonstate enterprises is more significant than that on large enterprises and state-owned enterprises. These findings provide a theoretical framework and fresh perspectives for encouraging coordinated regional development and new urbanization construction.

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Introduction

A smart city is a system that relies on the Internet of Things and cloud computing to transform the work and lifestyle of the government, enterprises, and people in the city, and the advantages of information technology in such systems can more actively and quickly respond than conventional cities to address needs in the areas of education, health care, enterprise trade, and technology development, which could achieve improved efficiency and work quality (Zhang Huanan et al., 2015). The IBM-proposed "smart earth" idea emerged during the 2008 financial crisis, and "smart city" is a key support for the implementation of "smart earth." Since first proposed, the concept of smart cities has received encouragement from countries around the world. For example, the United States and European Union countries have been representatives of the corresponding smart city construction program and made significant monetary investments to support the deployment of smart cities.

After becoming the president of the United States in 2009, Barrack Obama saw smart cities as the way for the United States to remain undefeated in the competition among countries in the 21st century (Liu-qin, 2011). Along with the economic development, the level of smart cities in Europe and the United States is also increasing, and the benefits brought by smart cities are gradually being revealed. The Internet of Things, which is gradually established by the strategy of smart city construction, offers tremendous convenience for urban development and people's lives through the inherent information advantages. In China, along with the rapid development of Internet technology, smart city construction has also accelerated. From the "Notice on National Smart City Pilot Work" in 2012 to the "New Smart City" proposed in the "National Informatization Development Strategy" in 2016, the policy updates reflect the continuous progress of China's smart city construction. From 2010 to 2019, China's smart city construction has experienced an exploration period, promotion period (Wang et al., 2020), and enhancement period, and the impact of information technology brought by the development of smart cities has also prompted China to continuously improve the urban governance system and promote the modernization and development of urban governance capacity. In addition, the innovative nature of smart cities can provide support for proposing, improving, and amending policies in the process being constructed, and the informationization impact driven by innovation based on smart cities can also provide lasting momentum for the development and innovation of enterprises in cities.

In the process of smart city construction, the power of information technology plays a crucial role in driving innovative development. In the China State Council's National New Urbanization Plan (2014–2020), six major development directions for the development of smart cities are proposed, three of which relate directly to the construction of information technology, and the remaining three are inseparably related to the impact of information technology. On the one hand, the impact of information technology derives, from advanced technologies (e.g., Internet of Things and cloud computing) and, on the other hand, from relevant government policies and the construction of a data-sharing network. The development of these technologies promotes the continuous progress of various modules in the city, including building systems (Selvaraj et al., 2023), building energy consumption (Gonçalves et al., 2020; Xu et al., 2023), infrastructure reconstruction (Kandpal, 2018), construction technology (Huang et al., 2021) and other aspects, and then achieve the goal of building smart cities. At the same time, with the development of smart cities, people's quality of life, people's happiness, corporate productivity, and the ecological environment are all improving day by day. This research plan analyzes existing research while summarizing the impact of smart cities on various industries, while trying to find influencing factors that have not been considered in the research, and then exploring the impact of smart cities on them.

Literature review

Related works. As an emerging urban system, smart cities have received extensive attention from scholars at home and abroad while developing rapidly in recent years. Most literature has focused on smart cities to promote urban technological innovation, facilitate green and low-carbon urban development, and promote the development of the innovation capacity of enterprises to further explore the positive effects brought by smart cities.

Section "Introduction" mentioned that smart cities have vigorously promoted technological progress in the civil engineering industry. In addition to innovation in the traditional sense, smart cities play an important role in the construction of urban data file informatization, the number of invention patents with high technical content, the construction of smart information-related service systems, and the governance of urban informatization (Song et al., 2023). Among the studies on smart cities and innovation development, a Chinese study shows that, along with the implementation of policies related to smart cities, the innovation capacity of cities has significantly improved, and the effect is especially significant in small and medium-sized cities (Liu et al., 2022). It is closely related to the driving effect of informationization driven by smart cities and the gathering of talent resources brought about by these smart cities (Wang & Deng, 2022).

The progress of economic indicators is bound to have a prominent role in promoting citizens' daily lives and enterprises' performance in related industries. Zhu et al. introduced a happiness-driven smart city mechanism, and the dynamic evaluation of this mechanism can better realize the development of smart cities in a happiness-driven direction (Zhu et al., 2022). Chen assessed the impact of smart city pilot policies on corporate total factor productivity. The results show that the approach can significantly improve the total factor productivity of enterprises, especially heavy-polluting enterprises, and can also alleviate the development gap between coastal and inland areas but will further intensify monopoly (Chen, 2022). Dana et al. explored the impact of urban entrepreneurship on sustainable enterprises in smart cities in the context of digital technology applications (Dana et al., 2022). The results show that urban entrepreneurship leverages and benefits from digital technologies and achieves sustainable business development. Li et al. believe that the impact of smart city construction on local entrepreneurial activities has received less attention (Li et al., 2023). They used a difference-in-difference (DID) model to evaluate the effects of smart city construction on urban entrepreneurial activities. The results show that smart city policies significantly increase the enthusiasm for urban entrepreneurial activities. Marchesani et al. studied the attractiveness of using digital technologies in cities for international talent mobility and creating innovative companies (Marchesani et al., 2023). Using a generalized least squares (GLS) approach, the study found that applying digital technologies in cities has increasingly become a driving force in attracting internal and international talent and promoting technological advancement in innovative companies.

Our research. Through the above literature research, this study found that no research has established the relationship between the development of smart cities and corporate performance in the

same period. Although we can roughly estimate how smart city construction will improve the performance of enterprises in various industries through previous research, we still need to find the trend between the two comprehensive factors through scientific quantitative analysis. Therefore, this study focuses on how smart cities impact enterprise performance. The impact of information technology brought by the construction of smart cities has been found to effectively promote the development of factors other than enterprises, such as continuous innovation in policy and continuous progress in science and technology. These external factors will either directly or indirectly affect the performance of enterprises and ultimately affect the business performance of enterprises and the development of the local economy.

The marginal contributions of this paper lie in the following three aspects:

The impact of smart city construction on corporate performance is incorporated into the system of corporate performance research, and the mechanism of its effect on corporate performance is elucidated from the perspective of smart city construction.

Most existing studies on smart cities are qualitative studies, while this paper involves a quantitative study on how smart city construction affects enterprises by studying the enterprise performance of listed companies, a focus that can fill the previous research gap.

In terms of research methods, this paper adopts a multiperiod DID approach and conducts heterogeneity and robustness tests to increase the reliability and accuracy of the research results.

The remaining content of this paper mainly includes a literature review, theoretical analysis and hypothesis, research design, empirical analysis, robustness test, and conclusions and recommendations.

Theoretical analysis and hypothesis

First, smart cities enhance the production technology of enterprises through information technology innovation to improve the production efficiency of enterprises and enhance the quality of products. Before the development of the smart city, enterprises in the city had little impetus for innovation, the enterprises' product innovation was slow, and the enterprises' own production capacity was low. In the process of the gradual construction of the smart city, the Internet technology developed and improved rapidly, providing technical support for the enterprises' innovation in all aspects and transforming the business operators' concepts. People increasingly saw how the development of science and technology reduces costs and improves product quality, thus increasing the introduction of high-tech talents. Collectively, these aspects encourage enterprises to innovate production methods and product design and then embrace the upgrading of the industry. Moreover, advanced products can help enterprises stand out among competing international enterprises and are more favored by buyers, which also makes enterprises more competitive in product exports and realize an increase in export volume.

Second, after the implementation of smart cities, the information communication between the government and enterprises is more thorough. That improved communication is also more conducive to the government's policy of creating a better business environment for enterprises, who can better realize the growth of their export business. On the one hand, local governments in regions where smart cities are implemented will introduce a series of policies to attract high-tech talent to settle in the region for the development of local science and technological innovation, and this talent is the indispensable mainstay of enterprise innovation. On the other hand, smart cities, as an urban development policy recognized by most countries globally, will also gain the favor of foreign investors after implementation. Among the many regions that have implemented smart cities, most regional governments have introduced policies that facilitate foreign investment by attracting investors to invest in the region and reach cooperation with local enterprises, which then increases their trade volume. Government and smart city-related policies and the innovation ability of enterprises are complementary. Smart city policies can promote the innovation and development of local science and technology, and the more advanced and innovative the city, the better the effect of smart city policies; the turnover of enterprises will also be further enhanced.

Finally, the data sharing realized by smart cities helps enterprises have an accurate grasp of market demand, enabling them to make timely adjustments to production strategies, better deploy the export distribution of products in various regions, and reduce costs to avoid waste. The construction of smart cities goes hand in hand with the development and progress of the Internet of Things, big data, and artificial intelligence, and the realization of smart city construction is inseparable from the use of technology for data sharing. Further, the construction of a city data network is not only about data collection but also about the deep integration of various data after collection to create a meaningful data-sharing network for solving real-world problems. With the formation of a data network through multifaceted cooperation, enterprises can determine the corresponding demand in response to market data to better match the demand side, better allocate product distribution, and avoid the mismatch between product demand and production quantity that affects enterprise performance. Based on these dynamics, this paper proposes that the information impact of smart city construction has a significant positive impact on the market performance of enterprises.

Model design

Econometric models. Based on the list of pilot smart cities released by the General Office of the Ministry of Housing and Urban-Rural Development in 2012, 2013, and 2015, this paper uses an empirical regression model to introduce a time-varying processing point DID method approach to study how smart city pilots impact enterprises' market performance. The list of smart city pilots is released year by year, so this paper uses a multiperiod DID approach to explore the impact of smart cities on the market performance of enterprises.

Two dummy variables are used in this paper; one is the dummy variable for the treatment and control groups, replaced by the pilot. If the city where the enterprise is located is a pilot smart city, the pilot value is 1 (treatment group); otherwise, the pilot value is 0 (control group). The second is the policy time dummy variable, replaced by post. In the year in which the smart city policy was implemented and subsequent years, the post is assigned the value of 1 but 0 otherwise.

If the city in which the enterprise is located has promulgated the policy related to a smart city pilot and the time is in the year the policy was implemented and the subsequent years, then treat = 1; otherwise, treat = 0. The time refers to the year the policy was implemented and the years thereafter.

This paper uses an empirical regression model and the time-varying processing point DID method to study how smart city pilots impact enterprises' market performance, based on the lists of pilot smart cities released by the General Office of the Ministry of Housing and Urban-Rural Development in 2012, 2013, and 2015. Since the list is released year by year, this paper uses a multiperiod DID approach to explore how smart cities impact the market performance of enterprises.

The specific model is as follows:

$$TobinQ_{i,t} = \beta_0 + \beta_1 treat_{i,t} + \beta_2 cv_{i,t} + \sum Industryfe + \sum Yearfe + \varepsilon_{i,t} \quad (1)$$

In the model (1), $TobinQ_{i,t}$ denotes the market performance of enterprise i at year t, and $treat_{i,t}$ is the core explanatory variable, which is the product of the group dummy variable pilot and the time dummy variable post. Control variable is influenced by $cv_{i,t}$, while *Industryfe* is the industry level fixed effect. *Yearfe* is a time-varying fixed effect, and ε is stochastic perturbation term.

Variables selection.

Dependent variable

This paper use the market performance of the enterprise (*TobinQi, t*) as the dependent variable, which indicates the market performance of enterprise *i* at year *t*.

Dummy variable

This paper employs two dummy variables. One is the dummy variable for the treatment and control groups, replaced by the pilot. If the city where the enterprise is located is a pilot smart city, the pilot value is 1 (treatment group); otherwise, the pilot value is 0 (control group). The second is the policy time dummy variable, replaced by post. In the year in which the smart city policy was implemented and subsequent years, the post is assigned the value of 1 and 0 otherwise.

Core explanatory variable

The core explanatory variable in this paper is smart city construction ($treat_{i,t}$), which is the product of the dummy variables pilot and post. If the city in which the enterprise is located has promulgated the policy related to a smart city pilot and the time is in the year the policy was implemented and the subsequent years, then $treat = 1$; otherwise, $treat = 0$. The core explanatory variable is the DID variable, which is the product of the two dummy variables in the model (Table 1).

Control variable

Based on the current literature, the main control variables (*cvi, t*) that affect the return on assets include the following aspects:

- Enterprise scale (*Size*): The total assets of the enterprise take the value of the logarithm, which can reflect the enterprise scale.
- Assets liability ratio (*Debt*): This ratio can reflect the capital structure of the enterprise.
- Enterprise cash flow (*flows*): The cash flow can indicate the financial position of the enterprise.
- Cash-to-profit ratios (*Profit*): These ratios reflect the profit quality of the enterprise.
- First shareholder's shareholding proportion (*top1*).
- Enterprise cash income (*cash_income*);

Empirical analysis

This section is divided by subheadings to provide a concise and precise description of the experimental results, their interpretation, and the experimental conclusions.

As an important initiative for urban development in China, smart cities play a key role in promoting innovation and business development in cities, as confirmed by many studies in the extant literature. Therefore, this paper proposes a reasonable hypothesis that the implementation of smart cities can improve the market performance of firms ($TobingQ_{i,t}$). We conducted a natural experiment using multiperiod DID to assess how smart cities impact the market performance of firms.

Descriptive statistics. The results of the descriptive statistics visualize the positive impact of smart cities on the market performance of companies through the model and regression analysis presented in the previous section. Table 2 shows that the mean value of market performance ($TobingQ_{i,t}$) is about 2.276, and the maximum and minimum values are 393.013 and 0.684, respectively, showing a large difference. Meanwhile, the mean value of the core explanatory variable (*treat*) is about 0.378, indicating that about 38% of the listed companies are affected by the smart city policy.

In terms of control variables, the maximum and minimum values of firm size (*Size*), the assets liability ratio (*Debt*), and the first shareholder's shareholding proportion (*top1*) are less different. However, the differences between the maximum and minimum values of corporate cash flows (*flows*), cash-to-profit ratios (*Profit*), and enterprise cash income (*cash_income*) are large, which also indicates that the market performance of firms is highly heterogeneous between different samples and that more room exists for interpretation. In the following section "Regression analysis", this paper, therefore, focuses on the influencing factors of smart city policy.

Regression analysis. To further investigate the causal relationship between smart city construction and enterprise performance, this paper measured the impact of smart city construction on enterprise performance based on a panel data fixed-effects regression model. The regression results are shown in Table 3.

In Table 3, the results of the regression analysis show that the *treat* coefficient is positive at the 1% level, indicating that the smart city policy significantly contributes to the improvement of the firms' market performance; therefore, the hypothesis is valid. The potential reasons for the above role include the following: (1) Smart cities can promote the development of local policies and accelerate the implementation of policies in favor of enterprise development. (2) Smart cities can promote the development of local Internet of Things, cloud computing, and other technologies to provide information security for business development. (3) Smart cities can promote the development of innovation capabilities and the technological progress of enterprises.

Table 1 Variable defintions.

Variable class	Variable name	Compute method
Dependent Variable	enterprise market performance (*TobinQ*)	enterprise market performance
Core Explanatory Variable	smart city construction ($treat_{i,t}$)	product of pilot and post
Control Variable	Enterprise Scale (*Size*)	Total capital at year-end
	Assets Liability Ratio (*Debt*)	Enterprise net assets per share
	Enterprise Cash Flow (*flows*)	The ratio of enterprise market value to capital replacement cost
	Cash-to-Profit ratios (*Profit*)	Ratio of corporate cash flow to profit
	first shareholder's shareholding proportion (*top1*)	Logarithm of GDP per capita (*lnPgdp*)
	Enterprise cash income (*cash_income*)	Cash receipts at the end of the year

Table 2 Descriptive statistics for the main variables.

Variable	Obs	Mean	Std. dev.	Min	Max
TobinQ	13390	2.276	5.063	0.684	393.013
treat	14100	0.378	0.485	0.000	1.000
Size	13944	21.929	1.31	13.076	27.569
Debt	13944	0.475	1.681	−0.195	178.345
Cash_income	13872	5.553e + 09	1.729e + 10	0.000	4.969e + 11
flows	13945	4.663e + 08	2.908e + 09	−1.200e + 11	1.051e + 11
top1	13785	33.674	15.042	0.29	93.61
Profit	12301	1.94	148.565	−8565.959	13878.941

Table 3 Benchmark regression results.

Tobin	Coef.	St. err.	*t*-value	*p*-value	[95% Conf	Interval]	Sig
treat	0.55	0.064	8.55	0.000	0.424	0.676	***
Size	−1.352	0.03	−45.15	0.000	−1.411	−1.294	***
Debt	5.978	0.053	112.49	0.000	5.874	6.082	***
Cash_income	0.000	0.000	8.06	0.000	0.000	0.000	***
flows	0.000	0.000	7.93	0.000	0.000	0.000	***
top1	−0.008	0.002	−3.79	0.000	−0.012	−0.004	***
Profit	0.000	0.000	−2.20	0.028	−0.001	0.000	**
Constant	29.329	0.642	45.71	0.000	28.071	30.587	***
Mean dependent var	2.179		SD dependent var		4.950		
R-squared	0.550		Number of obs		11666		
F-test	2034.525		Prob > *F*		0.000		
Akaike crit. (AIC)	61121.808		Bayesian crit. (BIC)		61165.995		

***$p < 0.01$, **$p < 0.05$.

Heterogeneity analysis

Enterprise size heterogeneity analysis. The empirical results show that smart city construction has a positive impact on enterprise performance and can effectively help enterprises improve performance. For different-sized enterprises, the degree of impact varies depending on the size. From the perspective of enterprise scale, larger enterprises have more complete data sources and operational systems than smaller entities but also have a more robust capital chain. Thus, relatively speaking, small and medium-sized enterprises (SMEs) need data sources. The capital chain in SMEs is therefore weaker than that of large-scale enterprises and will need more data and other aspects of support brought by smart city construction. In the process of smart city construction, SMEs can reap the data and other resources brought by such construction to better support the businesses. Therefore, the study believes that the impact of smart city construction on the performance improvement of SMEs is very significant, but it is not obvious for large enterprises.. To verify the above analysis, this paper uses the median size of enterprises as the boundary to divide large-scale enterprises and SMEs, and investigate whether the effect of smart city construction on enterprise performance is affected by enterprise size (Table 4).

Table 4 Analysis of enterprise size heterogeneity.

	(1) Tobin	(2) Tobin
treat	0.012	0.879***
	(0.52)	(6.99)
Size	−0.141***	−3.282***
	(−8.41)	(−29.71)
Debt	−1.311***	6.011***
	(−19.59)	(82.22)
Cash_income	0.000	0.000
	(0.38)	(1.80)
flows	0.000***	0.000***
	(7.43)	(7.12)
top1	−0.000	−0.020***
	(−0.28)	(−4.60)
Profit	−0.000	−0.004
	(−1.78)	(−1.91)
Constant	5.490***	69.587***
	(15.05)	(30.40)
N	6041.000	5625.000
r2_a	0.118	0.615

t-statistics in parentheses.
***$p < 0.001$.

The results show that the impact of smart city construction on the performance improvement of SMEs is more significant than the impact on the performance of large enterprises. Further analysis to explore why that difference exists shows that SMEs' resources are relatively weak compared to those of large enterprises, and the local big data, the Internet of Things, and other technologies developed by smart city construction provide better data support for the development of SMEs. In addition, the smart city construction road also indirectly drives the innovation of enterprise technology, making up for the weak innovation ability of SMEs due to the lack of funds, which is also conducive to SMEs' performance. The implementation of relevant policies driven by smart city construction is also conducive to the development of enterprises. Large enterprises have a stable capital chain, which is more advantageous compared to SMEs in terms of development, and a strong capital chain is more than enough to support large enterprises' access to better data support and research and development of innovative technologies. Therefore, the impact of smart cities on large enterprises is smaller than on SMEs but still has a positive impact. Based on this conclusion, smart city construction is a "blessing in disguise" for local SMEs and a "flower on top of a flower" for large enterprises, providing support for their development in terms of capital, data, and technology and promoting enterprise performance.

Enterprise ownership heterogeneity analysis. Smart city construction is an important initiative to develop the digitization of cities. While this paper mainly explores how smart cities impact firm performance, some variables of the firms themselves should be further explored to determine whether other variables will impact the results showing how smart cities affect firm performance. The important enterprise-based variables include ownership; do smart city constructions have different impacts on enterprises with different ownership? If so, which types of firms are affected more significantly? This paper further explores these questions.

From the heterogeneity of enterprise size above, we conclude that the impact of smart city construction on the performance of SMEs is more significant than for large enterprises because SMEs have comparatively weaker resources. Therefore, we can speculate that, at the enterprise-level ownership, privately owned enterprises pursue profit maximization due to the nature of their ownership and are more significantly affected by smart cities than state-owned enterprises (Table 5).

The results show that nonstate enterprises (i.e., private enterprises) are more significantly affected by smart cities in terms of performance than state-owned enterprises. Based on the business model, we hypothesized that private enterprises have more competitive pressure and relatively fewer resources than state-owned enterprises and therefore have more need for the digital resources brought by smart city construction. Private enterprises, due to their corporate nature, have higher performance requirements than state-owned enterprises, and smart cities present a more pronounced impact in terms of performance. In addition, the state-owned enterprises themselves are more extensive due to the public ownership of the means of production and the support of the state, and the impact of smart cities on this city is relatively limited. The impact of smart cities on the performance of state-owned enterprises is relatively limited, and some differences exist between the profit models of state-owned and private enterprises. Therefore, smart cities appear to have a positive impact on the performance of enterprises, and the impact on nonstate enterprises is more significant than that on state-owned enterprises, which is heterogeneous.

Robustness test

Robustness test for the industry. In exploring how smart cities impact firm performance, we found that firm ownership and firm size have heterogeneous effects on the results. Therefore, to ensure the accuracy of the experimental results, the experiment is now tested for robustness. At this stage, urban enterprises mainly include three major industries: agriculture, handicrafts, commerce, and modern services. The demand for resources varies among industries, so the positive and negative impacts of data and information resources that smart cities can provide on enterprises in different industries can inferred to be different, and the degree of impact may also vary. Therefore, to investigate the degree to which smart cities impact enterprises in different industries, a robustness test was conducted (Table 6).

The results show that the impact of smart cities on each industry is relatively average, and the coefficients do not differ much, which shows that smart cities have a positive impact on each industry. The degree of impact also does not have a large difference with the different industries but instead presents a relatively average state. Therefore, the impact of smart city construction on different industries is robust at the 1% level.

Robustness test for the region. To further demonstrate the robustness of smart city policies, this paper draws on existing research methods to verify their robustness. Since different firms are in different regions, the local economic development status and firm-related policies also differ, which may also cause bias in the estimation results. Therefore, here, we conduct robustness tests for the regions where the enterprises are located to ensure the accuracy of the experimental findings.

As the results in Table 7 show, after the implementation of smart city policies in the eastern, central, and western regions, enterprise performance has significantly improved, and other relevant indicators about the enterprises have also improved accordingly. However, the specific impact of smart city policies on enterprises in each region does not differ significantly across regions. The analysis of the data shows that the eastern region has a more developed city economy, a very prosperous import and export trade, a relatively large development scale of local enterprises, and a good trend in enterprise performance. Meanwhile, the western region is relatively underdeveloped and has a low industrial heightened level. Comparing the impact of smart cities on enterprises should therefore focus not only on the results but also on the degree of improvement of enterprise performance. According to the analysis of the results, smart cities have a good effect on improving the performance of enterprises in all regions, and the results are robust. Smart city policies can also reduce the gap between enterprises in the East and West while generally improving performance, which is important for the long-term stable development of enterprises in all regions.

Table 5 Analysis of enterprise ownership heterogeneity.

	(1) Tobin	(2) Tobin
treat	0.039	0.512***
	(0.94)	(7.11)
Size	−0.228***	−1.411***
	(−11.36)	(−41.68)
Debt	−0.799***	6.057***
	(−7.95)	(107.25)
Cash_income	0.000	0.000***
	(1.42)	(7.55)
flows	0.000*	0.000***
	(2.15)	(7.34)
top1	−0.004***	−0.009***
	(−4.27)	(−3.62)
Profit	−0.000	−0.001*
	(0.62)	(−2.53)
Constant	7.235***	30.680**
	(17.40)	(42.25)
N	1491.000	1.0e + 04
r2_a	0.245	0.560

t-statistics in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Discussion and conclusion

In order to explore the impact of smart cities on corporate performance, this study focused on the context of China's pilot implementation of three batches of smart city policy, based on the 2008–2020 Shanghai and Shenzhen A-share listed companies panel data, using a multiperiod DID approach to study the impact of smart city policy on corporate performance and the mechanism of action. The conclusions obtained are as follows: First, the implementation of smart city policy can improve corporate performance, and this conclusion still holds after robustness testing. Second, the positive impact of smart city construction on enterprise performance is relatively even across industries and regions in which enterprises are located; the degree of impact does not change significantly with changes in industry or region. Finally, the impact of smart city policies is more pronounced in SMEs and nonstate enterprises than in large enterprises and state-owned enterprises.

This study first uses macroscopic descriptive statistics and fixed-effects regression models to obtain the overall impact of

Table 6 Robustness test of the industry in which the enterprise is located.

	(1) Tobin	(2) Tobin
treat	0.451***	0.262
	(5.83)	(2.58)
Size	−1.169***	−1.201***
	(−27.84)	(−29.03)
Debt	2.170***	6.364***
	(11.50)	(141.88)
Cash_income	0.000***	0.000***
	(6.46)	(3.83)
flows	0.000***	0.000**
	(6.68)	(3.20)
top1	−0.014***	−0.003
	(−5.26)	(−0.98)
Profit	−0.000	−0.000
	(−0.12)	(−1.10)
Constant	27.020***	25.705***
	(30.58)	(29.01)
N	8718.000	2948.000
r2_a	0.091	0.880

t-statistics in parentheses.
$^{**}p < 0.01$, $^{***}p < 0.001$.

Table 7 Robustness test of the location of the enterprise.

	(1) Tobin	(2) Tobin
treat	0.651***	0.304***
	(4.40)	(4.81)
Size	−1.466***	−0.946***
	(−23.96)	(−29.30)
Debt	6.314***	1.422***
	(93.65)	(9.08)
Cash_income	0.000**	0.000***
	(2.77)	(9.08)
flows	0.000***	0.000***
	(5.21)	(5.23)
top1	−0.011*	−0.009***
	(−2.57)	(−4.27)
Profit	−0.002	−0.000
	(−0.84)	(−1.09)
Constant	31.895***	22.389***
	(24.03)	(33.65)
N	4589.000	7077.000
r2_a	0.677	0.127

t-statistics in parentheses.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

smart city construction on corporate performance. Then, heterogeneity analysis was conducted on enterprise size and enterprise ownership to further explore the impact of the smart city construction process on different enterprise types. Finally, this study conducts a robustness test on the industry and location of the enterprise to further ensure the accuracy of the measurement results. Taken together, the method described in this study takes into account both macro data and enterprise characteristics and has completed the answer to the question of "the impact of smart cities on enterprise performance" in a relatively complete manner.

This study also has some limitations. On the one hand, the data in this study only come from the A-share market in mainland China and do not involve the Hang Seng Index of the Hong Kong Special Administrative Region and other countries. This is also one of our future research directions. On the other hand, the data used in this study are up to 2020 and do not fully take into account policy changes and changes in corporate development during the COVID-19 pandemic. This research team will further expand the sources and time span of data in future studies to conduct more detailed and substantial related research.

Finally, based on the results of this study, our team believes that national government departments should increase the implementation of smart city policies in the central and western regions to improve the performance level of local enterprises. Enterprises should make full use of smart city policies to increase opportunities for improving their performance. Local governments should also strengthen their informatization levels, strive to obtain smart city pilots, and provide more preferential policies to support enterprises to improve local social governance and corporate performance.

Data availability

Data sets generated and analyzed during the current study are available online. The main data are available at https://doi.org/10.7910/DVN/BC2PH3.

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Author contributions

JX: methodology, software, formal analysis, investigation, writing—original draft. HX: methodology, investigation, writing—original draft. XL: writing—review & editing, funding, supervision. The above three authors contributed equally to this work, so they are co-first authors. Sort them by age from youngest to oldest. YZ: validation, writing—review & editing. WS: software, formal analysis, writing—original draft. XH: conceptualization, review & editing, supervision. WS and XH jointly supervised this work, they are two co-corresponding authors of this manuscript. They are also sorted in order of age from younger to elder.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

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