Smart City Construction Policy and Firm Performance: Empirical Evidence from Shanghai and Shenzhen A-share Listed Companies

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Abstract. I examine the effects of digitalization and informatization on firm performance (ROE). I employed a multistage DID model, using smart city development as a natural experiment. Using a sample of Shanghai and Shenzhen listed companies, I discover that firms affected by smart city policy are more likely to have better performance. This finding is robust to a series of robustness checks. Cross-section analysis indicates that nonstate-owned firms, firms with lower power levels concentration and western firms are more likely to benefit from smart city construction. These findings can help managers and policymakers to better understand the mechanisms underlying the relationship between smart city development and firm performance and to develop tailored strategies to leverage the benefits of smart city development.

Keywords: Smart City; Firm Performance; Power Concentration; Property Rights; Location Effect.

1. Introduction

Firm performance has been discussed worldwide, especially its consequences. First, prior firm performance may have an influence on the management of the company in many aspects. For instance, board composition and governance structure (Alix Valenti *et al.*, 2011; Mohan and Ruggiero, 2007), managerial tenure and longevity (Michael Patrick Allen *et al.*, 1982), and CEO turnover (Jenter and Lewellen, 2021). Second, a firm's strategies can be determined by its performance. There is a correlation between a firm's environmental, social and governance (ESG) activity and its performance (Huang, 2021; Albitar *et al.*, 2020). Firms' marketing strategies are also the embodiment of firm performance (Dyer and Reeves, 1985; Samara and Yousef, 2023; McKee *et al.*, 1989). Although the consequences of firm performance have been investigated intensively, less attention has been given to the driving factors of firm performance.

To date, digitalization and informatization have played an increasingly important role in technical progress and have aroused wide attention from academic circles. Specifically, the main concern is the real effect of digitalization and informatization. On the macro level, informatization and digitalization affect the industrial structure and promote economic growth (Frolova *et al.*, 2020; Barnett, 2006; Buhr, 2003; Mowery and Rosenberg, 1999; Magomedov *et al.*, 2020). On the micro level, information and digitalization can affect market structure and raise productivity (Brynjolfsson and Hitt, 2000; Manyika, 2017; Goldfarb and Tucker, 2019). Although numerous studies have shown the consequences of informatization, few have shown its impact on the firms themselves. As a micro individual, firms are crucial to the economy, so it is necessary to deeply explore the impact of digitalization and informatization on firms. However, as one of the most important indicators to measure a firm, few people have conducted in-depth discussions on the effect of digitalization and informatization shock on firm performance. Most of the current studies on digitalization and informatization are based on a policy impact. Smart cities, as a classic policy with unique functions, have aroused extensive attention and adoption by scholars. Therefore, whether the construction of smart cities can improve firm performance and its influence mechanism are all worth further testing.

To examine the impact of digitalization and informatization on firm performance, a multistage difference-in-differences (DID) model was used with smart city development as a natural experiment. The study controlled for industry and time fixed effects and estimated the effect of this policy on firms' return on equity (ROE) using data from listed companies in the Shanghai and Shenzhen stock exchanges. To further explore the mechanism of this impact, a cross-sectional analysis was conducted in terms of property rights, power concentration and location effect. The results show that firms affected by smart city development policies tend to perform better, particularly nonstate-owned firms, firms with lower power concentration levels and western firms. In contrast, the impact was not significant in state-owned firms, firms with higher power concentration levels and eastern firms. These findings provide insights into how smart city development affects firm performance and suggest that the impact may vary depending on firms' property rights, decision-making structures and development propensity. The finding that smart city construction has a positive effect on firm performance still holds after a series of robustness tests, including placebo tests and adding important control variables.

The marginal contribution of this article lies in the following three aspects:

First, this article incorporates the impact of smart city construction on firm performance into the system of firm performance research and explains the mechanism of its impact on firm performance from the perspective of smart city construction. From the perspective of smart city construction, a relatively pure natural experiment, I confirm its promoting effect on firm performance, enrich the economic consequences of smart city construction, and indirectly demonstrate the positive role of information technology construction in firm performance. Second, most of the existing research on smart cities is qualitative, while this article achieves a quantitative study of the impact of smart city construction on firms by examining the performance of listed companies, which can fill the previous gap. In terms of research methods, this article uses the multiperiod DID method and conducts heterogeneity analyses and robustness tests to increase the reliability and accuracy of the research results. Third, this article enriches the driving factors of firm performance. I find that smart city construction significantly promotes the development of firm performance and extends the factors affecting firm performance, which expands the connotation and depth of the related literature to some extent. This article attempts to explain the mechanism of the impact of smart cities on firm performance, which deepens the understanding of the literature on smart city construction and its consequences.

2. Related Literature and Theoretical Analysis

This article relates to two strands of literature: firm performance and the construction of smart cities.

Firm performance. Many studies have shown the driving factors of firm performance, which can be divided into internal factors and external factors.

The internal factors mainly consist of the following aspects. First, there is a linkage between management and firm performance. Klein, A. (1998) finds that there is a positive relation between the percentage of inside directors on finance and investment committees and accounting and stock market performance measures. Some literature finds that board size has a negative impact on firm performance (Guest, 2009; Cheng, 2008; Kyereboah-Coleman and Biekpe, 2006; Garg, 2007; Shakir, 2008), some says board size may be positively related to firm value (Larmou and Vafeas, 2010; Kalsie and Shrivastav, 2016; Himmelberg *et al.*, 1999), and in some specific regions, the correlation between board size and firm performance is not obvious (Topak, 2011; Bermig and Frick, 2010; N Vaidya, 2019). Board operations are also an important driving factor of firm performance (Vafeas, 1999; Liu, Y *et al.*, 2015; Bhagat and Bolton, 2008; Paul, 2017). Some studies have also discovered that longer board tenure is associated with better firm performance (Livnat *et al.*, 2019, 2021). Second, corporate ownership structure is also associated with firm performance. Some literature found that a more concentrated ownership structure positively relates to higher firm profitability (Kapopoulos and Lazaretou, 2007; Han and Suk, 1998; Alimehmeti and Paletta, 2012), but some found the opposite influence in different industries (Foroughi and Fooladi, 2011; Wang and Shailer, 2015). Some have found no systematic relation between ownership structure and firm performance (Demsetz and Villalonga, 2001; Demsetz, 1983; Chen *et al.*, 2005).

The most important external factor is external supervision. Hirtle *et al.* (2020) found that top-ranked banks that receive more supervisory attention have lower risk levels but do not have worse performance. Many studies have found that firm performance improves when it receives supervision (Mollah and Zaman, 2015; Lin *et al.*, 2014). Le. *et al.* (2006) found that external monitoring has a significant impact on either the form or the strength of the relationship between R&D spending and performance.

The consequences of firm performance are also discussed intensively.First, firm performance directly affects the careers and compensation of executives. Kaplan (1994a) found that turnover of the management board increases with poor firm performance, and Kaplan (1994b) found that the fortunes of Japanese top executives are positively correlated with stock performance and current cash flows. Many other articles show that CEO turnover is negatively related to firm performance (Kato and Long, 2006; Jenter and Kanaan, 2015; Lausten, 2002), and some argue that expected performance may be the factor that truly matters (Brickley, 2003; Puffer and Weintrop, 1991). Second, firm performance will influence the behavior of executives. Good performance may cause CEO overconfidence, which accounts for investment distortions (Malmendier and Tate, 2005). Third, firm performance will also affect its strategy. Lester *et al.* (2008) found that high-performing organizations prefer first mover strategies. Miller (1988) and Montemayor (1996) found that the relationship between cost leadership strategy and stable and predictable environments is more likely to be significant in groups of high-performing firms than in groups of poor performers. Many articles have found that high-performing companies or firms with top management team tend to be more inclined to undertake strategic changes, while low-performing companies are less willing to do so (Covin J G and Covin T J, 1990; O'Regan *et al.*, 2006; Wiersema and Bantel, 1992).

Smart city. Since smart cities are widely considered in many fields, many studies have shown the importance and difficulty of the construction of “smart cities” (Angelidou, 2014; Su *et al.*, 2011). Albino *et al.* (2015) provides the definitions of smart cities and how they perform. The positive impact of smart cities consists of many aspects. First, it enables the city to provide more effective services. Intelligent transportation systems have emerged as an efficient way of improving the performance of transportation systems (Zhang *et al.*, 2011; Dimitrakopoulos and Demestichas, 2010; Lee and Chiu, 2020). With increasingly more information gathered via patient monitoring systems, it is easier to make sophisticated analytical decisions in healthcare (Sakr and Elgammal, 2016; Demirkan, 2013; Wang and Alexander, 2020). Second, it has improved the environment of cities by implementing energy conservation systems and smart environment monitoring systems (Kim *et al.*, 2021; Khajenasiri *et al.*, 2017; Ullo and Sinha, 2020).

Smart city policy has also raised some problems. First, privacy preservation of generated data is a critical challenge (Gheisari *et al.,* 2021; Gupta and Rao, 2017; Kumar *et al.*, 2021; Seliem *et al.*, 2018; Ismagilova *et al*, 2020). The digital divide can also be a problem during the construction of smart cities. Partridge (2004) aids in developing a clearer and more comprehensive picture of the digital divide, which will allow organizations, such as public libraries, to better develop and tailor services and programs to more accurately and effectively narrow the gap between the information rich and information poor in society. Wiig (2016) argues that the rhetoric of intelligent, transformative digital change did not actually address urban inequalities.

In conclusion, smart city construction can enhance the level of informatization in companies, enabling them to collect more data and develop more effective strategies based on these data, thus promoting efficient development of the company. Based on the above information, this article proposes the following:

H1: Companies that have been affected by smart city policies are expected to have better performance than those that have not been affected by such policies.

3. Research Design

3.1 Research Design

According to the list of smart city pilots released by the General Office of the Ministry of Housing and Urban–Rural Development, PRC in 2012, 2013, and 2015, this article uses an empirical regression model and introduces a time-varying treatment point difference-in-differences (DID) method to study the impact of smart city pilot programs on the market performance of firms. Since the list of smart city pilots is released year by year, this paper adopts the method of multiperiod DID to conduct research to test the impact of smart cities on the market performance of firms. The specific model is as follows:

$$ROE_{i,t} = \beta_0 + \beta_1 smart_{i,t} + \beta_2 cv_{i,t} + \sum Industryfe + \sum Yearfe + \epsilon_{i,t} \quad (1)$$

In model (1), $ROE_{i,t}$ is the market performance of firm i in year t; $smart_{i,t}$ is the core explanatory variable, which is the product of the group dummy variable $pilot$ and the time dummy variable $post$; $cv_{i,t}$ refers to the control variables; $Industryfe$ represents the industry-level fixed effect; $Yearfe$ represents the time-varying fixed effect; and $\epsilon_{i,t}$ is a stochastic disturbance term.

3.2 Variable Selection

- **Independent variable**

This article refers to the related literature (Hart and Ahuja, 1996; Salim and Yadav, 2012) and selects return on equity (ROE) as the variable for a firm's market performance. $ROE_{i,t}$ represents the market performance of firm i in year t.

- **Dummy variable**

This article has set two dummy variables in total. The first is the dummy variable for the experimental group and the control group, which is represented by $pilot$. If the city where the firm is located is a pilot smart city, the value of $pilot$ is 1 (experimental group); otherwise, the value of $pilot$ equals 0 (control group). The second is the dummy variable for the time of policy implementation, which is replaced by $post$. In the year of smart city policy implementation and the years after, the value of $post$ is 1. Before the implementation of the policy, the value is 0.

- **Core independent variable**

The core independent variable of this article is the construction of a smart city ($smart_{i,t}$), which refers to the product of the dummy variables $pilo$t for the experimental group and $post$ for the time of policy implementation. If the city where the firm is located has issued relevant policies for smart city pilot programs, and the time is in the year of policy implementation and the years after, then $smart_{i,t} = 1$. Otherwise, $smart_{i,t} = 0$. The core independent variable $smart_{i,t}$ is a DID variable, which is the interaction term of the two dummy variables in the model.

- **Control variable**

According to the literature, the control variable ($cv_{i,t}$) that affects the return rate of a firm mainly contains the following:

(a) The size of the firm ($size$): replace it with the natural logarithm of the total assets of the company, which can reflect the size of the firm.
(b) Tobin's Q ($tobin$): the ratio of a company's market value to its net asset value.
(c) Financial leverage ratio ($Finlev$): a measure of a company's debt level and its ability to meet financial obligations.
(d) Top 1 shareholder's ownership ratio ($top1$)
(e) Market-to-book ratio ($mbratio$)
(f) investment expenditure ratio ($invt$): a measure of company's investment efficiency and quality in terms of capital expenditures.

(g) Asset structure ($tang$): a measure of company's financial health and risk profile.

Table 1. Variable Definition Table

Variable category	Name of variable	Definition
Dependent variable	Firm performance (ROE)	The ratio of a company's market value to its capital replacement cost
Core independent variable	Construction of smart city ($smart$)	Pilot times post
Control variables	Size of the firm ($size$)	Total assets at the end of the year
	Tobin’s Q ($tobin$)	The ratio of a company's market value to its net asset value
	Financial leverage ratio ($Finlev$)	The ratio of a company's total debt to its total equity
	Top 1 shareholder's ownership ratio ($top1$)	The percentage of total shares held by the largest shareholder
	Market-to-book ratio ($mbratio$)	Market price per share/book value per share
	Investment expenditure ratio ($invt$)	The proportion of a company's total assets that are invested in capital expenditures
	Asset structure ($tang$)	(Net Fixed Assets + Net Inventory)/Total Assets

The listed companies were used as the research sample in this article, and corresponding adjustments were made to the sample:

1. Cities where the smart city policy was only implemented in certain subregions were excluded from the sample.
2. Listed companies in the financial industry, public utilities, and ST, ST* companies were excluded from the data.
3. Trimming at the 1% level was applied to some variables.

In addition, the data for this article were mainly obtained from the database of Tai’an (CSMAR), corporate annual reports, and statistical yearbooks of various cities. To eliminate the impact of heteroscedasticity, the natural logarithm transformation was applied to per capita regional GDP and total capital at year-end for companies. Considering the lag effect of policy implementation, 2013 was taken as the first year of the smart city pilot policy implementation.

4. Empirical Analysis

4.1 Descriptive Statistics and Correlation Analysis.

The result of descriptive statistics (Table 2) of variables shows that the average value of return on equity (ROE) is -0.004, the minimum value is -176.38 and the maximum value is 90.71, which indicates that there are differences in ROE among firms, and some firms even have significant differences. The mean value of the dummy of smart city construction ($smart$) is 0.38, which means that 38% of the sample was affected by smart city policies. In terms of controlling variables, the mean value of firm size ($size$) is 21.97, which shows the average level of total assets. The mean value of Tobin’s Q ($tobin$), financial leverage ratio ($Finlev$), market-to-book ratio ($mbratio$) and investment ratio ($invt$) is consistent with previous studies. The mean value of capital structure ($tang$) is 0.397, which means fixed assets net amount and inventory net amount account for 39.7% of the total assets. The mean value of the top shareholder's ownership ratio is 33.85, which indicates that the average shareholding of the company's largest shareholder is 33.85%. The correlation coefficient matrix (Table 3) shows the Pearson correlation coefficient between different variables. Note that the absolute values of the Pearson correlation coefficients between the explanatory variables are mostly less than 0.5, multicollinearity may not be a serious problem.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ROE	12946	-.004	2.221	-176.38	90.705
$smart$	12946	.375	.484	0	1
$size$	12946	21.97	1.241	16.161	27.011
$tobin$	12946	2.16	3.294	.684	192.705
$Finlev$	12946	.441	.26	0	1.146
$top1$	12946	33.85	14.931	.29	89.99
$mbratio$	12946	.623	.245	.005	1.463
$invt$	12946	.056	.054	0	.545
$tang$	12946	.397	.177	0	.955

Table 3. Correlation Coefficient Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ROE	1.000								
(2) $smart$	0.012	1.000							
(3) $size$	0.002	0.140	1.000						
(4) $tobin$	0.160	0.005	-0.287	1.000					
(5) $Finlev$	-0.026	-0.014	0.278	-0.145	1.000				
(6) $top1$	0.015	-0.005	0.194	-0.106	0.017	1.000			
(7) $mbratio$	0.005	-0.003	0.527	-0.429	0.250	0.171	1.000		
(8) $invt$	0.022	-0.108	-0.018	-0.048	0.160	0.040	0.017	1.000	
(9) $tang$	-0.001	-0.053	0.149	-0.101	0.305	0.121	0.157	0.049	1.000

4.2 Baseline Regression

Table 4. Baseline Regression

	(1)	(2)
	ROE	ROE
$smart$	0.1117** (0.0504)	0.1151** (0.0522)
$\_cons$	-0.0461** (0.0189)	-2.0067* (1.1805)
CVs	No	Yes
$Industry\ fe$	Yes	Yes
$Year\ fe$	Yes	Yes
F	4.91	41.26
R^2	0.0048	0.0397
N	12946	12946

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. CVs refer to control variables, including the series of control variables mentioned earlier. Number in parentheses represents the std. err. of the variable. The same applies to all tables below.

Table 4 presents the test results of model (1). The independent variable is return on equity (ROE), and the dependent variable is the dummy variable for the construction of smart cities ($smart$). The results displayed in column (1) indicate that the estimated coefficient for $smart$ is approximately 0.1117, and it is significantly positive at the 5% level of significance (t=2.22), which means that the construction of smart cities has had positive effects on the performance of firms and proves H1. This also indicates that even without control variables, the impact of smart city construction on company performance is significant, further confirming the reliability of the conclusion in this article. To eliminate the interference of other factors and make the model predictions more accurate, this study controls for other variables such as size, with reference to related literature. The predicted results in column (2) show that the estimated coefficient of $smart$ is 0.1151, which is also significantly positive at the 5% significance level (t=2.21). The above results both support the hypothesis that the construction of smart cities improves firm performance.

5. Cross-section Analysis

While the study has found evidence to support the hypothesis that smart city construction has a positive impact on company performance, the specific mechanism through which this impact occurs has not been fully understood. Therefore, further research is needed to explore the transmission mechanism in more detail. For further exploration of this issue, we will use a cross-sectional analysis method and conduct analysis from multiple perspectives. This analysis analyzed the impact of smart city development on firm performance from the perspectives of property rights, power concentration and location effect to understand how the impact may vary depending on these factors. By doing so, I expect to identify the specific mechanisms underlying the impact of smart city development on firm performance.

5.1 Nature of Property Rights: State-owned Enterprises (SOEs) and Non-SOEs

To test whether there is a difference in the impact of smart city construction between state-owned and nonstate-owned enterprises, a test of model (1) was conducted on separate subsamples of state-owned and nonstate-owned enterprises.

The results in Table 5 (column (1) and (2)) show that in the sample of state-owned enterprises, the impact of smart city construction on ROE is not significant, and even after controlling for variables, a negative coefficient is observed. In the sample of nonstate-owned enterprises (column (3) and (4)), the coefficient of smart city construction was 0.1573 before controlling for variables (column (3)) and 0.1707 after controlling for variables (column (4)). Both coefficients were significantly positive at the 10% level (t=2.01 and 1.91).

A potential reason for the above results could be that there are shortcomings of state-owned enterprises in management and decision-making, such as inflexibility and low efficiency, which prevent them from fully utilizing the advantages of smart city construction. In contrast, in the sample of nonstate-owned enterprises, the positive and significant impact of smart city construction on ROE may be due to the more flexible and efficient management of nonstate-owned enterprises, allowing them to better utilize the opportunities and advantages brought by smart city construction.

Table 5. Property rights

	SOEs		**Non-SOEs**	
	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
$smart$	0.0005 (0.0167)	-0.0031 (0.0171)	0.1573* (0.0782)	0.1707* (0.0892)
$\_cons$	0.0054 (0.0057)	-0.7194 (0.1449)	-0.0704** (0.0306)	-2.6168 (1.5235)
CVs	No	Yes	No	Yes
$Industry\ fe$	Yes	Yes	Yes	Yes
$Year\ fe$	Yes	Yes	Yes	Yes
F	0.00	255.57	4.04	118.46
R^2	0.0058	0.0169	0.0085	0.0471
N	4199	4199	8747	8747

Another reason is that state-owned enterprises have certain competitive advantages over nonstate-owned enterprises, such as budget soft constraints, policy support, and monopoly advantages, which put them in a favorable position in their development. However, smart city construction mainly changes the accessibility of information, enabling previously disadvantaged enterprises to make more informed decisions. Compared to nonstate-owned enterprises, state-owned enterprises already have access to a large amount of market information due to their existing competitive advantages, so the impact of smart city construction on them is relatively smaller.

5.2 Concentration of Power

To test the impact of power concentration on the effectiveness of smart city construction, I classify the sample based on whether the chairman and general manager were the same person and test model (1) in each subsample. If the chairman and general manager are the same person, the company is considered to have a high degree of power concentration. If the chairman and general manager are not the same person, the company is considered to have a low degree of power concentration.

Table 6 shows the regression results for the high concentration sample and the low concentration sample. In the high concentration sample, coefficient of $smart$ is not significant both with (column (2)) and without (column (1)) controlling for other variables (t=0.53 and 0.63). In the low concentration sample, coefficient of smart city construction was 0.1354 before controlling for variables (column (3)) and 0.1243 after controlling for variables (column (4)). Both coefficients were significantly positive at the 5% level (t=2.38 and 2.30).

The idea that lower executive power concentration leads to more effective external information acquisition is supported by some theoretical perspectives. This is because when executive power is less concentrated, different members of the executive team have access to diverse networks and resources that can be used to acquire external information. These resources may include industry associations, social networks, customers, suppliers, and other sources. This external information can help organizations better understand market demand, competitors, new technologies, and trends, which can inform strategic decision-making. In contrast, when executive power is highly concentrated, decision-making may be limited to a few individuals who may rely heavily on their own experience and intuition, disregarding the importance of external information. This can result in slower responsiveness to market changes, missed opportunities, and reduced organizational performance and competitiveness.

Upper echelons theory believes that executive characteristics can affect corporate strategy. The larger the size and diversity of the top management team, the higher the level of innovation, which may lead to better performance.

Table 6. Power Concentration

	High Concentration		**Low Concentration**	
	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
$smart$	0.0388 (0.0731)	0.0410 (0.0650)	0.1354** (0.0568)	0.1243** (0.0540)
$\_cons$	0.0302 (0.0284)	-2.5494** (1.1541)	-0.0717*** (0.0211)	-0.8927*** (0.3085)
CVs	No	Yes	No	Yes
$Industry\ fe$	Yes	Yes	Yes	Yes
$Year\ fe$	Yes	Yes	Yes	Yes
F	0.28	46.00	5.68	33.54
R^2	0.0255	0.4433	0.0053	0.0091
N	3365	3365	9581	9581

5.3 Location Effect: Eastern and Western Companies

I have divided the companies' locations into two categories, Eastern and Western, based on the 2022 national statistical codes for administrative divisions and urban-rural classification codes, according to the province or municipality where the company is located, and conduct the baseline regression in each sample of the categories. Table 7 (column (1) and (2)) show the results of regressions in the sample of eastern companies. The coefficient of $smart$ is not significant in both cases, with (column (2)) and without (column (1)) the inclusion of control variables (t=1.38 and 1.26). Table 7 (column (3) and (4)) show the results of regressions in the sample of western companies. The coefficient of smart city construction was 0.1491 before controlling for variables (column (3)) and 0.1420 after controlling for variables (column (4)). Both coefficients were significantly positive at the 1% level (t=2.99 and 3.15).

The above results could be due to the following reasons:

First, western cities have greater development potential in smart city construction, as they are relatively less developed than eastern cities in terms of economy and urbanization. The main purpose of smart city construction is to enable companies to use a richer set of information more conveniently. In eastern cities, the degree of informatization may already be relatively high, and due to diminishing marginal returns, the impact of smart city construction on enterprise performance may not be significant. Second, eastern cities are more densely populated and economically developed, and have larger urban sizes, which may require more time and higher costs for smart city construction. Western cities, on the other hand, are smaller in size and may be easier to implement and promote smart city construction. Third, the industrial structure in eastern cities is more diversified and developed, and enterprise development is influenced more by market competition and industry regulations, rather than urban infrastructure and service levels, as well as information accessibility. In contrast, the industrial structure in western cities is relatively simple, and urban infrastructure and service levels, as well as information accessibility, have a more significant impact on enterprise development.

Table 7. Location Effect

	Eastern Companies		Western Companies	
	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
$smart$	0.1049 (0.0908)	0.1261 (0.0915)	0.1491*** (0.0499)	0.1420*** (0.0451)
$\_cons$	-0.0133 (0.0294)	-3.3872 (2.0993)	-0.0920*** (0.0213)	-0.6737*** (0.2122)
CVs	No	Yes	No	Yes
$Industry\ fe$	Yes	Yes	Yes	Yes
$Year\ fe$	Yes	Yes	Yes	Yes
F	1.33	37.43	8.92	72.82
R^2	0.0090	0.0782	0.0060	0.0095
N	6417	6417	6529	6529

6. Robustness Tests

6.1 Placebo Test

There is concern that firm performance may be affected by omitted nonrandom variables. This article follows the related literature (Wang *et al.*, 2023) and conducts a placebo test by randomly generating the $smart_{i,t}$ estimated items and estimating them repeatedly. The $smart_{i,t}$ estimated items are randomly redefined, selected 1000 times and estimated accordingly. I extracted the coefficients of the $smart_{i,t}$ items from each regression and plotted them in Figure 1. From Figure

1, the fact that the estimated coefficients of the $smart_{i,t}$ items follow normal distribution characteristics. By analyzing this distribution, I conclude that the mean value of the coefficients is 0, which is significantly different from the estimated coefficient of $smart_{i,t}$ (i.e., 0.1151) in the baseline regression. This analysis suggests that the impact of smart city development on firm performance is unlikely to be confounded by other unobserved nonrandom variables, which confirms the robustness of my main results.

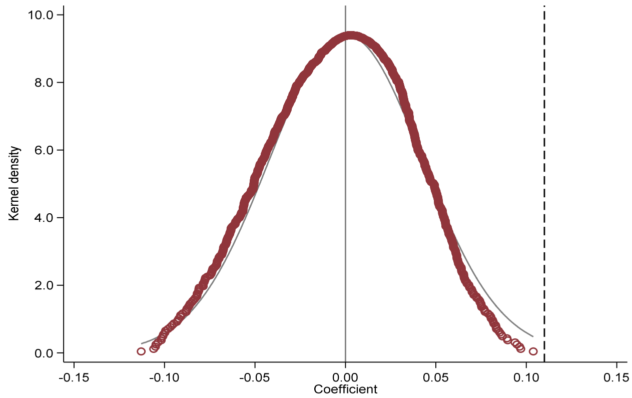

Figure 1. Placebo test

6.2 Adding Important Control Variables

Table 8. CVs added

Variable name	Definition
$Empnum$ $Excuhldn$	Numbers of employees Executive shareholding
$Lnage$	ln(year-year of listing)
$Negshrcr$	Proportion of shares held by the largest public shareholder

Table 9. Adding different control variables

	(1)	(2)	(3)	(4)
	ROE	ROE	ROE	ROE
$smart$	0.1882* (0.0953)	0.1751* (0.1000)	0.1689* (0.0937)	0.1661* (0.0924)
$\_cons$	-3.2006 (1.9253)	-3.0951 (1.9318)	-4.2246* (2.1361)	-3.8209* (2.1709)
CVs	Yes	Yes	Yes	Yes
$Industry\ fe$	Yes	Yes	Yes	Yes
$Year\ fe$	Yes	Yes	Yes	Yes
$Empnum$	Yes	Yes	Yes	Yes
$Excuhldn$	No	Yes	Yes	Yes
$Lnage$	No	No	Yes	Yes
$Negshrcr$	No	No	No	Yes
F	58.10	38.56	61.40	187.50
R^2	0.0475	0.0490	0.0509	0.0513
N	8249	8030	8030	8028

Note: CVs includes control variables that have been discussed previously.

In the previous research, I have shown the positive effect of smart city policy on firm performance. To further test the effect and ensure the robustness of the research results, some important control variables that are missing in the previous model are added. The added variables are shown in table 8, which are number of employees, executive shareholding, year listed, and proportion of shares held by the largest public shareholder. The results of the regressions are shown in table 9. After introducing each of these variables separately, we found that the significant effect of smart city development on our results remained at a 10% level of significance. This indicates that our results are robust and not biased by other factors.

7. Conclusion

Firm performance has always been a topic of great interest to people. It is widely recognized that firm managers strive to achieve higher levels of firm performance. Therefore, research on factors that impact firm performance is particularly important. Meanwhile, in recent years, digitalization and informatization have become a trend and are playing a unique role in the digital age. The rapid development of technology has transformed the way we live, work, and do business. Digitalization and informatization have enabled firms to collect, analyze, and utilize vast amounts of data to improve their operations and decision-making processes. This paper seeks to investigate the effects of digitalization and informatization on firm performance. To investigate the specific impact of digitalization and informatization on firm performance, I employed a multistage difference-in-differences (DID) model, using smart city development as a natural experiment. Controlling for industry and time fixed effects, I estimated the effect of this policy on firms' return on equity (ROE). The sample for this study included data from listed companies in the Shanghai and Shenzhen stock exchanges. To further explore the mechanism of the impact of smart city development, I conducted a cross-sectional analysis in three aspects: property rights, power concentration and location effect. The empirical results indicate that firms that are affected by smart city development policies tend to have better performance. Moreover, this effect is significant in nonstate-owned firms, firms with lower power concentration levels and western firms, while it is not significant in state-owned firms, firms with higher power concentration levels and eastern firms. These findings suggest that the impact of smart city development on firm performance is contingent on the property rights structure, power concentration levels and locations of firms. Specifically, firms with more decentralized decision-making structures, greater ownership diversification and greater development potential tend to benefit more from smart city development. These findings can help managers and policymakers to better understand the mechanisms underlying the relationship between smart city development and firm performance and to develop tailored strategies to leverage the benefits of smart city development for different types of firms.

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