Original Paper

China's Smart City Development and the Enhancement of Enterprise New Quality Productive Forces

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Abstract

This paper constructs a quasi-natural experiment based on China's batch-by-batch smart city pilot policy implemented between 2012 and 2015. Using a sample of 907 listed companies classified as "specialized, sophisticated, distinctive, and Novel" enterprises in China's Yangtze River Delta region from 2011 to 2023, we employ a multi-period difference-in-differences model to empirically examine the driving effect of smart city development on the new quality productive forces of these firms. The findings reveal that the implementation of the smart city pilot policy has a significant positive impact on enhancing the level of new quality productive forces among the specialized, sophisticated, distinctive, and Novel(SSDN) enterprises in the Yangtze River Delta region. This conclusion remains robust after undergoing a series of tests, including parallel trend tests.This study not only enriches the research on the microeconomic effects of smart city policies but also provides empirical evidence and practical pathways for local governments to leverage smart city development for the targeted cultivation of new quality productive forces in enterprises.

Keywords

Smart city pilot, New quality productive forces, Specialized, Sophisticated, Distinctive and Novel (SSDN) Enterprisesl

1. Introduction

Foundational studies by Caragliu et al. (2011) and Chourabi et al. (2012) have confirmed that smart city development, centered on digitalization and intelligence, has become a core strategy for countries worldwide to unleash the dividends of the digital economy and drive high-quality economic development. For China, new quality productive forces, with scientific and technological innovation at their core, serve as the fundamental engine for economic transformation and upgrading. Specialized,

Sophisticated, Distinctive and Novel (SSDN) enterprises are the key micro-level carriers for cultivating these new forces, and their development quality and efficacy are deeply intertwined with the urban digital development environment. The Yangtze River Delta region, a pioneer in China's smart city initiatives and a major cluster for SSDN enterprises, provides an ideal empirical setting for this study.

Existing research on new quality productive forces has yielded substantial results. Regarding its conceptual connotation, scholars such as Hong and Liu (2024) and Jin (2024) have systematically defined its theoretical essence and economic logic. In terms of measurement, at the macro level, Zhang Jun and Gao (2024) constructed a provincial-level evaluation system for new quality productive forces, while Wang et al. (2024) and Zhao and Xu (2024) developed comprehensive evaluation frameworks at the enterprise level. Concerning driving factors, current studies predominantly focus on macro-level policies (Liu & Wu, 2024; Yang & Tan, 2024) and internal firm factors (Huang and He, 2024; Zhou & Zhao, 2024). A systematic explanation is still lacking for how city-level, holistic digital strategies empower the new quality productive forces of SSDN enterprises. Concurrently, while studies by Wang and Huang (2020), Zhang and Li (2019), and Zhang and Gao (2021) have verified the macroeconomic effects of smart cities, and a significant body of literature including Li and Shen (2019), Guo and Wang (2022), and Chen and Hu (2023) has confirmed both the macroeconomic effects and the micro-enterprise empowerment resulting from smart city construction, three critical research gaps persist. First, insufficient attention has been paid to enterprise groups like SSDN firms that are highly sensitive to the external environment. Second, research often focuses on traditional total factor productivity, lacking targeted causal identification specifically for new quality productive forces. Third, there is a dearth of targeted examination for the Yangtze River Delta region and in-depth exploration of spatial spillover effects.

Furthermore, while existing research has separately verified the mediating roles of technological innovation (Li & Wang, 2020) and industrial structure upgrading (Yu & Pan, 2019) in the process of smart cities empowering enterprise development, as well as the moderating effects of human capital (Wang & Li, 2021) and enterprise digital transformation (Chen & Li, 2023), alongside the spatial spillover effects of smart city policies (Ma & Liu, 2022), these pathways have not been integrated into a unified analytical framework. Such integration is necessary to systematically reveal the internal logic and boundary conditions through which smart city construction drives the leap in new quality productive forces of SSDN enterprises.

To address these gaps, this paper employs the three batches of smart city pilot policies (2012-2014) issued by China's Ministry of Housing and Urban-Rural Development as a quasi-natural experiment. Using a sample of 907 A-share listed SSDN enterprises in the Yangtze River Delta region from 2011 to 2023, we construct a comprehensive evaluation system for enterprise new quality productive forces. Applying models such as the multi-period difference-in-differences, we systematically examine the causal effect, mechanisms, boundary conditions, and spatial spillover characteristics of smart city development on these forces. The findings reveal that smart city construction significantly enhances the

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new quality productive forces of SSDN enterprises in the Yangtze River Delta. Industrial structure upgrading and technological innovation are identified as two core mediating channels, while regional human capital and enterprise digital transformation exert positive moderating effects. The policy also demonstrates significant positive spatial spillover effects. This research not only fills the identified gaps in the literature but also provides empirical evidence and practical pathways for optimizing regional policies and fostering high-quality enterprise development in the Yangtze River Delta.

2. Research Hypotheses

New quality productive forces are innovation-driven at their core, and their cultivation and development rely on breakthroughs in technological innovation, optimal allocation of production factors, improvement of the institutional environment, and the construction of an industrial innovation ecosystem. Smart city development, centered on digital technologies, provides comprehensive, multi-dimensional support for fostering new quality productive forces in Specialized, Sophisticated, Distinctive and Novel (SSDN) enterprises through city-wide digital and intelligent transformation.

First, smart city development creates a foundational enabling effect by constructing inclusive digital infrastructure. By establishing an urban digital foundation centered on new-type digital infrastructure such as 5G, the Industrial Internet, and cloud computing, and leveraging its strong public goods attributes and positive spillovers, smart cities significantly lower the barriers and costs for SSDN enterprises to adopt digital technologies. This promotes the penetration of digital technologies throughout the entire R&D and production processes, providing foundational support for enterprise technological innovation and efficiency gains, thereby driving the development of new quality productive forces.

Second, smart city development generates an optimization effect on factor allocation by promoting the circulation of data as a production factor. Focusing on data aggregation, governance, and application, smart cities break down data silos through government data openness and the construction of data factor markets. This facilitates the transformation of data into a core, circulatable production factor, assisting SSDN enterprises in optimizing R&D decisions and precisely matching market demand. This achieves innovative and optimal allocation of production factors, aligning with the requirements for cultivating new quality productive forces.

Thus, this study proposes the following hypothesis:The implementation of the smart city pilot policy has a significant positive driving effect on the new quality productive forces of SSDN enterprises in the Yangtze River Delta region.

3. Research Design

3.1 Sample Selection and Data Sources

The sample of this study consists of A-share listed Specialized, Sophisticated, Distinctive and Novel (SSDN) enterprises in the Yangtze River Delta region (Shanghai, Jiangsu, Zhejiang, and Anhui) from

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2011 to 2023. After excluding observations with abnormal financial data or missing core variables, and applying a 1% winsorization to continuous variables, the final dataset comprises 11,803 unbalanced panel observations from 907 enterprises.

Firm-level data were sourced from the CSMAR and Wind databases. City-level data on the smart city pilot program were obtained from the official lists of the three batches of pilot cities released by the Ministry of Housing and Urban-Rural Development. Macro-level data were collected from the corresponding cities' statistical yearbooks and statistical bulletins.

3.2 Variable Definitions and Measurement

The core variables involved in this study are categorized into three main groups: the dependent variable, the core explanatory variable, and the control variables. The specific definitions and measurement methods for each variable are as follows:

Dependent Variable: Enterprise New Quality Productive Forces (NP)

Drawing on mainstream measurement methods from studies such as Li et al. (2024)and Zhang et al. (2025), this paper constructs a multi-dimensional comprehensive evaluation index system for enterprise new quality productive forces. This system is based on four core dimensions: new quality laborers, new quality objects of labor, new quality means of labor, and green means of labor. It specifically includes 12 detailed tertiary indicators, such as the proportion of R&D personnel, the proportion of highly educated employees, the number of patents granted, the degree of enterprise digitalization, and the proportion of green patents. Subsequently, the entropy method is employed to objectively assign weights to each indicator. Finally, a comprehensive index of enterprise new quality productive forces is calculated. A higher value of this index indicates a higher level of development of the enterprise's new quality productive forces.

Core Explanatory Variable: Smart City Pilot Policy (DID)

This paper utilizes China's national smart city pilot policy, implemented in batches from 2012 to 2014 by the Ministry of Housing and Urban-Rural Development, to construct a quasi-natural experiment. The core interaction term of the multi-period Difference-in-Differences (DID) model is used as the core explanatory variable, defined as DID = Treat × Post. Here, Treat is a grouping dummy variable, assigned a value of 1 (treatment group) if the enterprise's registered city is included in the national smart city pilot list for 2012-2014, and 0 otherwise (control group). Post is a time dummy variable, assigned a value of 1 for the year in which and all years after the enterprise's city officially becomes a smart city pilot, and 0 for years prior.

Control Variables

To control for the influence of potential confounding factors, this study incorporates control variables at both the enterprise and city levels into the regression model. At the enterprise level, controls include firm size (Size, measured as the natural logarithm of total assets at period-end), the asset-liability ratio (Lev, measured as the ratio of total liabilities to total assets), return on total assets (ROA, measured as the ratio of net profit to average total assets), and ownership concentration (Top5, measured as the

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shareholding proportion of the top five shareholders). At the city level, controls include the regional financial development level (Finance, measured as the ratio of the year-end loan balance of financial institutions to regional GDP) and the degree of regional openness (Open, measured as the ratio of actually utilized foreign direct investment in the current year to regional GDP).

3.3 Model Specification

To examine the impact of the smart city pilot policy on enterprise new quality productive forces, this paper constructs a multi-period Difference-in-Differences (DID) model as the baseline regression model. The specification is as follows:

$$NP_{it} = \alpha_0 + \alpha_1 DID_{it} + \sum \beta_k Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{1}$$

where the subscript i denotes the enterprise and t denotes the year. The dependent variable, NP_{it} represents the comprehensive index of new quality productive forces for enterprise i in year t. The core explanatory variable, DID_{it}, is the Difference-in-Differences interaction term for the smart city pilot policy. Control$_{it}$ encompasses the series of control variables defined previously. μ_i denotes enterprise fixed effects, which control for time-invariant, firm-specific heterogeneous characteristics. λ_t denotes year fixed effects, which control for common annual macroeconomic shocks that affect all enterprises. ε_{it} is the random disturbance term of the model. This study focuses primarily on the magnitude and statistical significance of the core coefficient α_1. A significantly positive α1 would indicate that the implementation of the smart city pilot policy significantly enhances the level of enterprise new quality productive forces, thereby supporting the research hypothesis proposed in this paper.

4. Empirical Analysis

4.1 Descriptive Stats

Table 1 presents the descriptive statistics of the core variables in this study. The results show that the mean value of the dependent variable, enterprise new quality productive forces (NP), is 12.682, with a standard deviation of 7.296, a minimum of 1.220, and a maximum of 36.991. This indicates significant cross-sectional variation in the development level of new quality productive forces among the sample enterprises, providing sufficient sample variation for the empirical analysis in this paper. The mean value of the core explanatory variable, DID, is 0.870, suggesting a relatively high proportion of cities in the Yangtze River Delta region included in the smart city pilot program, with treatment group enterprises constituting the majority of the sample. This aligns with the reality of the Yangtze River Delta being a pioneering region in China's smart city development. The mean values, standard deviations, and extreme values of the remaining control variables all fall within reasonable ranges, consistent with the statistical results of existing similar studies, indicating good data quality of the selected sample without severe outlier issues.

Table 1. Results of Descriptive Statistics

	COUNT	MEAN	SD	Min	Max
NP	11803	12.682	7.296	1.220	36.991
DID	11803	0.870	0.336	0.000	1.000
Size	11803	22.115	1.220	19.585	26.440
Lev	11803	0.393	0.197	0.032	0.925
ROA	11803	0.046	0.063	-0.375	0.254
Top5	11803	0.545	0.150	0.176	0.892
Finance	11803	1.874	0.588	0.488	3.405
Open	11803	0.695	0.434	0.009	2.157

4.2 Baseline Regression Results

Table 2 presents the baseline regression results examining the impact of the smart city pilot policy on enterprise new quality productive forces. Column (1) reports the results controlling only for firm and year fixed effects without any additional control variables. Column (2) presents the results after incorporating the full set of enterprise-level and city-level control variables.

The regression result in Column (1) shows that the coefficient of the core explanatory variable DID is 3.2633, which is significantly positive at the 1% statistical level. This provides preliminary evidence that the smart city pilot policy has a significant positive driving effect on enterprise new quality productive forces. In Column (2), after including all control variables, the coefficient of DID remains highly significant at the 1% level, with a value of 2.0127. This indicates that the positive driving effect of the smart city pilot policy on enterprise new quality productive forces remains robust after controlling for firm-specific characteristics and city-level macroeconomic environmental factors. In economic terms, after a city becomes a smart city pilot, the comprehensive index of new quality productive forces for enterprises located there increases by an average of 2.0127 units. This demonstrates that the implementation of the national smart city pilot policy has a significant empowering effect on cultivating the new quality productive forces of Specialized, Sophisticated, Distinctive and Novel (SSDN) enterprises in the Yangtze River Delta region. In summary, the research hypothesis H1 proposed in this paper is strongly supported by the empirical results.

Regarding the control variables, the coefficient for firm size (Size) is significantly positive at the 1% level, indicating that larger enterprises exhibit higher levels of new quality productive forces development. The reason is that larger SSDN enterprises possess more abundant financial and human resources for R&D innovation and digital transformation. The coefficients for the asset-liability ratio (Lev) and return on total assets (ROA) are significantly negative. This suggests that excessive debt pressure or an overemphasis on short-term profitability may crowd out resources for long-term R&D innovation, which is detrimental to the sustained cultivation of enterprise new quality productive forces. This finding aligns with the conclusions of existing similar studies.

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Table 1. Baseline Regression Results of the Impact of the Smart City Pilot Policy on Enterprise New Quality Productive Forces

	(1) NP	(2) NP
DID	3.2633***	2.0127***
	(20.8918)	(10.5683)
Size	—	1.6812***
		(14.0982)
Lev	—	-1.0167*
		(-1.9584)
ROA	—	-2.4003**
		(-2.3129)
Top5	—	1.0441
		(1.5422)
Finance	—	-0.7809***
		(-3.7623)
Open	—	-0.8169***
		(-2.6206)
Constant	9.8426***	-24.6024***
	(69.2118)	(-9.5837)
Enterprise FE	Yes	Yes
Year FE	Yes	Yes
COUNT	11803	11803
R²	0.041	0.067

Note. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The values in parentheses are the t-values clustered at the firm level.

4.3 Robustness Tests: Parallel Trends Test

The validity of the Difference-in-Differences (DID) estimation results hinges on the core prerequisite of satisfying the parallel trends assumption. This assumption posits that, prior to the implementation of the smart city pilot policy, there were no significant systematic differences in the development trends of new quality productive forces between the treatment group (enterprises in pilot cities) and the control group (enterprises in non-pilot cities). To test this assumption, this paper employs an event study approach to conduct a parallel trends test, while also visually presenting the dynamic marginal effects

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of the policy. The revised and standardized test model is specified as follows:

$$NP_{it} = \alpha_0 + \sum_{k=-4,k\neq-1}^{9} \alpha_k Event_{it}^k + \sum \beta_k Control_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where represents the policy timing dummy variable, and k denotes the year relative to the implementation of the smart city pilot policy: k < 0 indicates the |k|th period before policy implementation, k = 0 indicates the year of policy implementation, and k > 0 indicates the kth period after policy implementation. This study uses the period one year before the policy implementation (k = −1) as the baseline period; therefore, the dummy variable for k = −1 is omitted from the model. The point estimates of the coefficients and their 95% confidence intervals from the test results are shown in Figure 1.
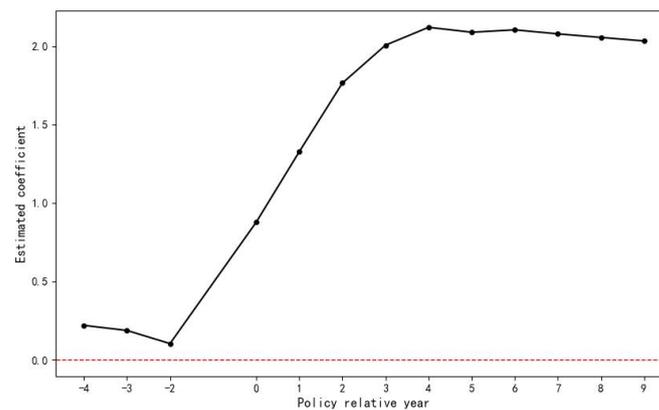
Figure 1. Dynamic Effects of the Smart City Pilot Policy on Enterprise New Quality Productive Forces and the Parallel Trends Test

As clearly shown in the test results of Figure 1, prior to the implementation of the smart city pilot policy (k = -4, -3, -2), the estimated coefficients of the event dummy variables are all close to zero, and their 95% confidence intervals all include zero, indicating no statistical significance. This suggests that before the policy intervention, there were no significant systematic differences in the development trends of new quality productive forces between the treatment and control groups of enterprises. Thus, the parallel trends assumption of the Difference-in-Differences model is fully satisfied. In the year of policy implementation (k = 0), the estimated coefficient turns from negative to positive and passes the statistical significance test at the 1% level. Furthermore, in the periods following policy implementation (k ≥ 1), the coefficients remain significantly positive, exhibiting an overall trend of rapid initial increase followed by gradual stabilization. This indicates that the positive driving effect of the smart city pilot policy on enterprise new quality productive forces begins to materialize shortly after the policy takes effect and demonstrates strong sustainability and stability, further corroborating the robustness of the baseline regression conclusions in this paper.

5. Conclusion

In summary, this study constructs a quasi-natural experiment based on China's batch-by-batch smart city pilot policy implemented from 2012 to 2014. Using a sample of 907 listed Specialized, Sophisticated, Distinctive and Novel (SSDN) enterprises in the Yangtze River Delta region from 2011 to 2023, we empirically examine the impact of smart city development on the new quality productive forces of these enterprises through a multi-period difference-in-differences model. The main research conclusions are as follows:

The implementation of the smart city pilot policy has a significant positive driving effect on enhancing the new quality productive forces of SSDN enterprises in the Yangtze River Delta region. After the city where an enterprise is located is selected as a national smart city pilot, the development level of its new quality productive forces shows a significant improvement. This conclusion remains robust after passing the parallel trends test, indicating that smart city development can effectively empower the cultivation of new quality productive forces in SSDN enterprises.

Furthermore, the empowering effect of smart city development on enterprise new quality productive forces is primarily realized through four core pathways: 1) creating a foundational enabling effect by constructing inclusive digital infrastructure, thereby lowering the barriers to enterprise innovation; 2) generating an optimization effect on factor allocation by promoting the circulation of data as a production factor, thereby injecting new productive factors; 3) forming an institutional cost mitigation effect through digital government reforms, thereby stimulating enterprise innovation vitality; and 4) fostering an innovation ecosystem agglomeration effect by concentrating innovation factors, thereby creating a favorable industrial development environment. These four pathways collectively support the enhancement of new quality productive forces in SSDN enterprises.

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