

Research on Infrastructure Construction in the Yangtze River Delta Region Oriented by New Quality Productive Forces: A Prefecture-level Analysis

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Abstract: Developing new quality productive forces, an advanced form of productive forces, is a key driving force for promoting regional structural layout and high-quality infrastructure development. Based on panel data from 41 cities in China's Yangtze River Delta region from 2011 to 2022, this paper constructs an evaluation index system grounded in theory and empirically analyzes the impact of new quality productive forces on infrastructure construction. The study finds that the development of new quality productive forces significantly promotes infrastructure construction in the Yangtze River Delta, a conclusion that holds after endogeneity treatment and a series of robustness tests. Heterogeneity analysis indicates that the impact of new quality productive forces on infrastructure is more pronounced in non-coastal cities and megacities. Mediation effect tests show that new quality productive forces can achieve high-quality infrastructure development by enhancing technological innovation capacity and strengthening government responsiveness. Therefore, this paper suggests providing momentum for the construction of a modern infrastructure system and regional coordinated development by systematically cultivating the core elements of new quality productive forces, implementing differentiated urban development strategies, smoothing collaborative transmission mechanisms, and removing regional administrative barriers.

Keywords: New Quality Productive Forces, Regional Infrastructure Construction, Technological Innovation, Government Responsiveness.

1. Introduction

In 2019, the Central Economic Work Conference pointed out that we should focus on the country's long-term development and strengthen the construction of strategic and network-based infrastructure. In 2022, the Report to the 20th National Congress of the Communist Party of China put forward the strategic deployment of "optimizing the layout, structure, functions and system integration of infrastructure and building a modern infrastructure system". It also emphasized adhering to the core position of innovation in the overall situation of China's modernization drive, accelerating the development of the digital economy, promoting the construction and intensive and efficient utilization of information and communication networks, major scientific and technological infrastructure, and advancing the renewal and digital and intelligent transformation of traditional infrastructure, which pointed out the direction for building a modern infrastructure system. A series of documents issued at the national level have clarified the scope of new infrastructure construction and promoted the layout of digital infrastructure such as computing power and industrial internet. The Third Plenary Session of the 20th Central Committee of the Communist Party of China further focused on the development of new quality productive forces, proposed improving the institutions and mechanisms for developing new quality productive forces in light of local conditions, promoting revolutionary technological breakthroughs, and fostering new industries, new models and new drivers, and explicitly identified new quality productive forces as the core driving force for promoting high-quality and efficient economic development and improving the modern infrastructure system. From a macro perspective, the construction of digital infrastructure has become the pillar of

new infrastructure construction, serving as the supporting foundation for the practical implementation and efficiency release of new quality productive forces [1], as well as the key hardware supporting innovation-driven development and alleviating ecological and social pressures [2].

Since the 21st century, the Marxist theory of productive forces has achieved localized innovation and breakthroughs in China, and the advanced productive forces development concept dominated by digitalization and innovation has been widely disseminated. Since entering the new development stage, the country has placed the development of new quality productive forces in a prominent position in its modernization drive, striving continuously to promote high-quality economic development and realize the people's aspiration for a better life. At present, China's economy has shifted to pursuing high-quality development. As an important support for the productive forces of Chinese-style modernization, new quality productive forces are the core key to coordinating regional infrastructure layout and addressing the unbalanced and inadequate development of infrastructure. To this end, the State Council issued the Opinions on Establishing a More Complete System and Mechanism for Market-Based Allocation of Factors, calling for the removal of institutional barriers that hinder the free flow of innovation factors, smoothing the channels for cross-regional and cross-sectoral factor mobility, and providing guarantees for the agglomeration of new quality productive forces factors into the infrastructure sector and for improving the efficiency of infrastructure resource allocation.

From a practical standpoint, after years of sustained investment, the Yangtze River Delta region, which has drawn the most attention, has basically completed its traditional infrastructure construction, yet it still faces numerous practical challenges. There are significant regional disparities

in the development level of new quality productive forces in China, with the eastern coastal region having the highest overall level [3]. However, imbalances still exist within the region: administrative barriers restrict the full exertion of positive spatial spillover effects [4], and the long-term coexistence of inter-regional and intra-regional disparities has led to infrastructure imbalances within the Yangtze River Delta, further widening the development gap of new quality productive forces. The new era calls for updated and appropriate infrastructure. With the diminishing marginal returns of traditional infrastructure, the development model that relies solely on scale expansion urgently needs improvement. Moreover, the relatively backward digitalization of existing facilities makes it difficult to meet the demands of industrial upgrading and people's livelihood services in the digital economy era. In addition, as the frontier of China's high-level opening-up, the Yangtze River Delta needs to align with international economic and trade rules and support the integration of global industrial and supply chains, which further necessitates digital upgrading of infrastructure through the empowerment of new quality productive forces.

Digital infrastructure, as the core carrier of new quality productive forces, can break down barriers to factor mobility and improve resource allocation efficiency [5], serving as a critical cornerstone for promoting regional coordinated development and industrial upgrading. New quality productive forces represent an advanced form of productive forces oriented by technological innovation, centered on digitalization and intelligence, and grounded in green and low-carbon development, have driven the development of digital infrastructure and provided technical support and a window of opportunity for the transformation and upgrading of existing facilities [6]. Against this backdrop, this paper focuses on the Yangtze River Delta region, clarifies the intrinsic logic between new quality productive forces and infrastructure construction, constructs index systems for new quality productive forces and infrastructure respectively, and employs multiple econometric models to empirically examine the impact of new quality productive forces on infrastructure construction in the Yangtze River Delta region. At the same time, it delves into the locational and city-size heterogeneity in the effect of new quality productive forces on infrastructure construction. Furthermore, using technological innovation and government responsiveness as mediating variables, the paper analyzes the internal mechanisms through which new quality productive forces affect infrastructure construction, with the aim of providing empirical evidence and practical reference for accelerating the construction of a modern infrastructure system and promoting regional coordinated development.

2. Theoretical Analysis and Research Hypotheses

2.1. New Quality Productive Forces and Infrastructure Construction

Marxist political economy holds that productive forces represent the human capacity to transform nature, consisting of three fundamental elements: laborers, means of labor, and objects of labor. New quality productive forces, as a new stage in the development of productive forces, are innovation-driven and can realize the digital, intelligent, and green transformation of the mode of production [7]. From the perspective of new quality laborers, high-quality laborers

constitute the core human capital for infrastructure construction. New quality laborers possess higher scientific literacy and professional skills, can proficiently apply digital and intelligent technologies, and the enhancement of their capabilities is an important driving force for the development of new quality productive forces, which continuously improves production efficiency through learning-by-doing effects [8], thereby promoting innovation in management models and achieving higher construction efficiency. Related studies further indicate that top-notch innovative talents and highly skilled personnel are key components of new quality productive forces and can provide intellectual support for technological breakthroughs and operational innovation in infrastructure [9]. The agglomeration of these talents is critical for new quality productive forces to empower urban development and also serves as the human resources for completing infrastructure digitization [10]. Therefore, as one of the most human-capital-intensive regions in China, the Yangtze River Delta possesses abundant new quality labor resources that can provide a driving-force guarantee for the digital construction of infrastructure.

From the perspective of new quality means of labor, advanced means of production constitute the material foundation for advancing infrastructure construction. The widespread application of new quality means of labor such as artificial intelligence and industrial robots can generate new construction demands, thereby driving the rapid development of digital facilities including data centers and the industrial internet. Meanwhile, the application of these new tools can also transform traditional industrial infrastructure, improve their operational efficiency, and promote industrial transformation and upgrading [1]. The application of digital technologies to means of labor enables refined management in agricultural production [11]. In the infrastructure sector, it allows for real-time monitoring of the entire life cycle of infrastructure through the Internet of Things and big data. It follows that the means of labor under new quality productive forces enable a material transformation of infrastructure, facilitate the liberation of human labor through technological advancements, and support infrastructure construction with greater efficiency.

From the perspective of new quality objects of labor, data factors and green factors expand the connotation and functions of infrastructure. As a new type of production factor, data enables information sharing and coordinated linkage across all links of infrastructure, improving the efficiency of resource allocation. By expanding the boundaries of objects of labor and optimizing the structure of factor allocation, new quality productive forces can drive infrastructure to shift from single hardware supply to integrated service supply. The development of green factor markets such as carbon trading, energy use rights, and pollution discharge rights has promoted the transformation of infrastructure construction towards a green and low-carbon direction and advocated the development of the green economy. Existing literature regards green development as a characteristic of new quality productive forces, pointing out that the development of new quality productive forces has driven the transformation of ecological values, requiring infrastructure construction to balance economic development and ecological protection. The green productive forces evolved from this have also generated demand for the construction of photovoltaic green infrastructure [12]. On these grounds, it can be seen that changes in the objects of labor help broaden the pathways and

possibilities of infrastructure development and promote its high-quality advancement.

In summary, through the roles of the three major factors of production, new quality productive forces can jointly promote the development of infrastructure construction from both the supply and demand sides. Based on the above analysis, the following hypothesis is proposed:

Hypothesis 1: The development of new quality productive forces can significantly promote the development of infrastructure construction in the Yangtze River Delta region.

2.2. New Quality Productive Forces, Technological Innovation and Infrastructure Construction

Technological innovation serves as a crucial bridge linking new quality productive forces and infrastructure construction. Existing studies show that scientific and technological innovation plays a significant mediating role in the process through which new quality productive forces empower the common prosperity of farmers and rural areas, and that new quality productive forces promote rural industrial revitalization by raising agricultural total factor productivity [13][14]. Since the improvement of total factor productivity is essentially the result of technological innovation, it can be preliminarily inferred that the promoting effect of new quality productive forces on infrastructure construction can be realized through the channel of technological innovation.

In terms of the transmission process, new quality productive forces can significantly enhance the level of regional technological innovation. The development of new quality productive forces attracts innovation factors to agglomerate within the region, increases R&D investment, and improves the innovation environment. Moreover, the new business forms engendered by new quality productive forces also generate substantial technological demand, thereby forcing enterprises and research institutions to intensify R&D efforts and continuously push for breakthroughs in core technologies, thus raising the overall innovation capacity of the region. Technological innovation driven by the digital economy can break down geographical barriers, accelerate knowledge spillovers, and provide sustained momentum for the coordinated upgrading of regional infrastructure. After infrastructure integration, technology flows and merges at an accelerated pace, directly raising the level of regional technological diversification, which in turn allows regional technological diversification to better exert its mechanism effect between industrial agglomeration and new quality productive forces [15], smoothing the transmission pathway.

Furthermore, technological innovation can provide strong support for infrastructure construction. Technological innovation constitutes the prerequisite for new infrastructure construction and serves as the driving force behind the establishment of a modernized digital infrastructure, capable of advancing intelligent transformation and enabling real-time monitoring and smart scheduling. In terms of application, it can also reduce infrastructure construction costs, enhance construction efficiency, and extend the service life of equipment. This requires leading enterprises to play a guiding role, driving the growth of local enterprises through large firms leading small ones, forming a complete industrial ecosystem, and thereby providing industrial chain support for infrastructure construction [16]. On the whole, technological innovation can propel the technological empowerment, business format innovation, and institutional reform of

construction, bringing about a dual upgrade in regional infrastructure construction and operational models [17]. Based on the foregoing analysis, we propose the following hypothesis:

Hypothesis 2: New quality productive forces can promote infrastructure construction in the Yangtze River Delta region by enhancing the level of technological innovation.

2.3. New Quality Productive Forces, Government Responsiveness and Infrastructure Construction

Infrastructure possesses the typical attributes of public goods, necessitating that the government play a leading role in its construction to ensure the stable operation of livelihood projects and economic development. Government responsiveness is the core link in narrowing regional disparities in new quality productive forces, the main measures include increasing funding for cross-regional construction and issuing policy documents that provide directional guidance. The government assumes critical responsibilities in the development of new quality productive forces at the county level, including policy guidance, factor provision, and environmental optimization [5]. Infrastructure construction, as the physical engineering underpinning the development of new quality productive forces, requires still more coordinated planning and strong government support. At the same time, the development of new quality productive forces exerts a substantial influence on the government's policy formulation and implementation, prompting it to enhance its responsiveness and thereby improve the speed and efficiency of infrastructure construction.

With the rapid development of new quality productive forces, traditional construction policies and management methods can no longer meet the requirements of the new situation. To seize development opportunities, local governments will proactively introduce a series of policies and measures, provide preferential treatment in fiscal subsidies and resource planning, and create a favorable social environment for its development. The government plays an important guiding role in the high-quality development of the county economy. By developing industrial parks with high standards and a high starting point and implementing county town renewal and transformation, it can provide support for factor development [16]. This requires governments in the Yangtze River Delta to play a communication role, strengthen inter-regional exchanges and jointly build collaborative platforms [18]. Practice in the Yangtze River Delta shows that through policy incentives and the construction of collaborative mechanisms, governments can promote infrastructure interconnection, which is a key lever for achieving regional coordinated development [19].

Infrastructure construction is often characterized by large investment, long cycles and high risks, requiring the government as a major platform to provide financial support to ensure the sustainable development of livelihood projects. As a key area of public fiscal expenditure, its development level directly depends on the intensity of government fiscal support. Governments at all levels in the Yangtze River Delta have continuously increased investment in digital and green infrastructure in recent years, building channels for new quality productive forces to release their efficiency. In terms of regional disparities, targeted government investment and policy support can effectively fill infrastructure gaps in less developed areas, and by strengthening investment and factor

provision, the government can solidify the physical foundation for cultivating new quality productive forces [20], thereby addressing the problem of unbalanced regional development. Furthermore, the development of new quality productive forces can enhance the government's governance capacity and responsiveness, promoting the digital transformation of government governance through the widespread application of digital technologies and enabling online handling of government services. Through digital platforms, the government can monitor the supply and demand of construction in real time, optimize resource allocation, and continuously improve the scientific and rational nature of planning—a crucial pathway for boosting high-quality development. Based on the above analysis, we propose the following hypothesis:

Hypothesis 3: New quality productive forces can promote infrastructure construction in the Yangtze River Delta region by strengthening government responsiveness.

3. Research Design

3.1. Variable Selection and Description

3.1.1. Dependent Variable: Infrastructure Construction (Infra)

Infrastructure refers to the material engineering facilities that provide public services to residents, which serve as an important guarantee for national economic and social development and the improvement of people's lives. Since the 21st century, traditional infrastructure construction has been gradually improved in various fields. With the rapid development of the digital economy, the connotation of infrastructure has been continuously expanded, and digital infrastructure has become a core component of infrastructure construction in the new era and has been widely applied.

Based on this, this paper constructs an evaluation index system by drawing on relevant studies of existing scholars [21][22], and uses the entropy weight method to assign weights to each index to measure the development level of infrastructure. As shown in Table 1:

Table 1. Evaluation Index System for Infrastructure Construction Level

Primary Indicator	Secondary Indicator	Proxy Variable
Infrastructure Construction	Mobile Internet Development	Year-end number of mobile phone users
	Telecommunication Development Level	Telecommunication business revenue
	Internet Usage	Number of international Internet users

3.1.2. Core Explanatory Variable: New Quality Productive Forces (Nqp)

Marxist political economy divides productive forces into three fundamental elements: laborers, means of labor, and objects of labor, which provides a theoretical framework for the current composition of new quality productive forces. Therefore, drawing on the research of Han Wenlong et al. [23], this paper constructs an evaluation index system combined with the main connotation of new quality productive forces, and uses the entropy weight method to assign weights to each index to measure the development level of new quality productive forces. As shown in Table 2:

Table 2. Evaluation Index System of New Quality Productive Forces

First-level Indicator	Second-level Indicator	Third-level Indicator
New Quality Productive Forces	New Quality Laborers	Average Wage of On-the-job Employees
		Employees in Strategic Emerging Industries
		Number of Regular Institutions of Higher Education
	New Quality Means of Labor	Number of Artificial Intelligence Enterprises
		Number of Green Patent Applications Filed in the Current Year
		Robot Installation Density
	New Quality Objects of Labor	Existence of Data Trading Platform
		Carbon Trading, Energy Use Rights Trading and Pollution Discharge Rights Trading

3.1.3. Mediating Variables

(1) Technological Innovation Level (Inn)

New quality productive forces, characterized by high technology and high quality, can promote technological R&D and transformation to facilitate their application and development in infrastructure [24]. Therefore, this paper selects the number of utility model patent applications filed in the current year as a proxy for the level of technological innovation.

(2) Government Responsiveness (Gr)

Government departments are the issuers and promoters of policies. Their responsiveness, including responding to public opinions and efficiently communicating policy demands, serves as a critical institutional transmission path linking new quality productive forces and infrastructure construction. Governments can strengthen feedback when absorbing the major scientific and technological achievements of new quality productive forces and stimulate vitality through financial support. Hence, this paper measures the level of government responsiveness by the ratio of local government expenditure on science and technology to general public budget expenditure.

3.1.4. Control Variables

(1) Per capita Gross Regional Product (Pgdp), used to control for the impact of economic development stages on infrastructure and eliminate errors caused by economic disparities.

(2) General public budget revenue of local governments (Gov) is used to control for the influence of government fiscal capacity on infrastructure investment and policy implementation.

(3) Degree of openness (Open) is measured by the ratio of actual utilized foreign investment in the current year to gross regional product of the current year, with the foreign investment amount converted into RMB at the current year's exchange rate.

(4) Financial development level (Fin) is measured by the ratio of the balance of deposits and loans of financial institutions at year-end to gross regional product.

(5) Industrial structure upgrading (Ind) is measured by the ratio of the value-added of the tertiary industry to that of the secondary industry, and is used to control for the influence of changes in industrial structure on infrastructure demand.

3.2. Model Specification

To test the impact of new quality productive forces on infrastructure, this paper employs a two-way fixed effects model for the test, which is specified as follows:

$$\text{Infra}_{it} = \gamma_1 \text{Nqp}_{it} + \gamma_2 \text{control}_{it} + a_0 + \lambda_t + \mu_i + \varepsilon_{it} \quad (1)$$

Where i and t denote region and year, respectively; Infra_{it} represents the infrastructure construction level in region i in period t ; Nqp represents the development level of new quality productive forces in region i in period t ; γ_1 and γ_2 are regression coefficients; Controls denotes the set of control variables; a_0 is the constant term; and λ_t , μ_i and ε_{it} are time fixed effects, individual fixed effects, and the random disturbance term, respectively.

Based on the above theoretical analysis, to examine the underlying mechanisms through which new quality productive forces affect infrastructure construction, we draw on the mediating effect research of Wen et al. [25] and construct two models: one for the impact of new quality productive forces on the mediating variable, and another for the joint impact of new quality productive forces and the mediating variable on infrastructure construction, as shown in Equations (2) and (3) below:

$$M_{it} = \gamma_1 \text{Nqp}_{it} + \gamma_2 \text{control}_{it} + a_0 + \lambda_t + \mu_i + \varepsilon_{it} \quad (2)$$

$$\text{Infra}_{it} = \gamma_1 \text{Nqp}_{it} + \gamma_2 M_{it} + \gamma_3 \text{control}_{it} + a_0 + \lambda_t + \mu_i + \varepsilon_{it} \quad (3)$$

Where M_{it} denotes the mediating variables—technological innovation level and government responsiveness—and the other variables are as defined above.

3.3. Data Description

The study period is 2011–2022, and the research object is the Yangtze River Delta region (Anhui Province, Jiangsu Province, Zhejiang Province, and Shanghai Municipality). To ensure data availability and authenticity, the primary data sources are the China City Statistical Yearbook, China Urban Construction Statistical Yearbook, provincial and municipal statistical yearbooks, municipal statistics bureaus and patent offices, and the EPS Data Platform. For a small number of missing data, linear interpolation is applied before the empirical analysis. The descriptive statistics of the variables are presented in Table 3.

Table 3. Descriptive Statistics of Variables

VarName	Obs	Mean	SD	Min	Max
Infra	492	0.140	0.162	0.0001	1.000
Nqp	492	0.116	0.147	0.002	0.768
Pgdp	492	11.081	0.600	9.462	12.100
Gov	492	14.811	1.102	13.025	18.071
Open	492	0.026	0.019	0.0005	0.087
Fin	492	2.913	1.049	1.393	6.299
Ind	492	92.031	5.541	74.090	99.680
Inn	492	8.547	1.282	5.366	11.895
Gr	492	0.038	0.027	0.004	0.178

4. Empirical Analysis

4.1. Multicollinearity Test

To avoid potential multicollinearity among the variables that would bias the regression results, this paper uses the variance inflation factor (VIF) to test for multicollinearity,

with the results presented in Table 4. The results show that the VIF values of all variables are less than 5 and below the critical value of 10, indicating that there is no multicollinearity problem among the variables and that further empirical analysis can be conducted.

Table 4. Multicollinearity Test Results

Variable	VIF	1/VIF
Pgdp	4.340	0.231
Gov	4.690	0.213
Open	1.070	0.935
Ind	4.020	0.249
Fin	1.490	0.673
Nqp	3.090	0.323
Mean VIF	3.110	-

4.2. Baseline Regression Results

This paper uses a two-way fixed effects model to test the impact of new quality productive forces on infrastructure construction in the Yangtze River Delta. The baseline regression results are reported in Table 5. Columns (1) to (3) successively include only the core explanatory variable, gradually add control variables, and simultaneously incorporate control variables and two-way fixed effects. The results show that the coefficient of new quality productive forces on infrastructure construction is consistently positive and passes the significance test at the 1% level across all specifications, confirming that new quality productive forces exert a positive driving effect on infrastructure construction and lending support to Hypothesis 1. A possible reason is that new quality productive forces, driven by factors such as scientific and technological innovation, green and low-carbon development, and high-efficiency growth, promote the intelligent upgrading and transformation of infrastructure construction. The development of new quality productive forces generates new demands for digitalized and intelligent construction, enhances resource allocation efficiency, and reduces infrastructure costs, jointly raising the level of infrastructure at both the supply and demand ends.

Table 5. Baseline Regression Results

	(1)	(2)	(3)
VARIABLES	Infra	Infra	Infra
Nqp	0.911*** (15.683)	0.312*** (5.830)	0.461*** (6.619)
Ind		-0.000 (-0.208)	-0.003 (-1.678)
Pgdp		-0.051*** (-4.926)	0.035*** (3.937)
Gov		0.096*** (13.089)	0.013* (1.775)
Open		0.512** (2.265)	0.324** (2.046)
Fin		0.038*** (7.850)	-0.005 (-0.813)
Constant	0.035*** (6.913)	-0.855*** (-12.243)	-0.241** (-2.045)
Observations	492	492	492
City FE	NO	NO	YES
Year FE	NO	NO	YES
r ² _a	0.687	0.859	0.790
Robust t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1, hereinafter the same			

4.3. Endogeneity and Robustness Tests

Table 6. Endogeneity Test Results

	(1)	(2)
	First stage	Second stage
VARIABLES	Nqp	Infra
IV	-0.00002*** (-3.916)	
Nqp		1.746*** (7.363)
Constant	0.106 (0.595)	-0.432 (-1.438)
Observations	492	492
Controls	YES	YES
City FE	YES	YES
Year FE	YES	YES
r2_a	0.504	0.924
Kleibergen-Paap rk LM	5.355 (P=0.0207)	
Kleibergen-Paap rk Wald F	17.162 (Critical value=16.38)	

To mitigate potential bias caused by possible endogeneity, this paper selects the interaction term between terrain ruggedness and time as an instrumental variable (IV) and employs the two-stage least squares (2SLS) method to conduct the test. Before proceeding with the 2SLS regression, the validity of the instrument is first examined. The results in Table 6 show that the p-value of the Kleibergen-Paap rk LM statistic is less than 0.05, rejecting the null hypothesis that the instrument is underidentified and thus passing the significance test. The Kleibergen-Paap rk Wald F statistic exceeds the Stock-Yogo weak identification test critical value at the 10% level, rejecting the null of weak instruments and

indicating that no weak instrument problem exists. After applying the instrumental variable, the coefficient of new quality productive forces passes the significance test at the 1% level, confirming the robustness of the preceding results.

To verify the robustness of the preceding results, the following methods are adopted. First, the core explanatory variable is lagged by one period. Since new quality productive forces are inherently dynamic, their impact on infrastructure construction may involve a time lag, which could bias the regression results. We therefore lag the core explanatory variable by one period, and the results are reported in column (1) of Table 7. Second, we exclude provincial capital cities. Given their special administrative status and policy support, provincial capitals differ substantially from other regions and may introduce bias into the estimates. To test the generalizability of the impact of new quality productive forces, we re-estimate the model after dropping the sample of provincial capitals; the results are shown in column (2) of Table 7. Third, we change the sample period. Considering the impact of major events on regional economies, we exclude observations from 2020 and onward to avoid the economic fluctuations caused by the pandemic; the results are presented in column (3) of Table 7. Fourth, we apply the double machine learning method to mitigate model specification bias. Traditional fixed effects models assume linear relationships among variables and may not adequately address omitted variable bias arising from high-dimensional confounders, potentially leading to biased estimates. To further verify the reliability of the conclusions, we employ the random forest algorithm with 5-fold cross-fitting. The regression results, shown in column (4) of Table 7, indicate that the coefficient remains significantly positive at the 1% level and that its magnitude is largely consistent with the baseline estimate, demonstrating the strong robustness of our core findings.

Table 7. Robustness Test Results

	(1)	(2)	(3)	(4)
VARIABLES	Core explanatory variable lagged one period	Excluding provincial capitals	Changing sample period	Double machine learning test
L.Nqp	0.398*** (6.066)			
Nqp		0.386** (2.611)	0.467*** (3.588)	0.385** (0.159)
Constant	-0.307* (-1.893)	-0.080 (-0.559)	-0.215* (-1.923)	
Observations	451	444	369	492
Controls	YES	YES	YES	YES
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
r2_a	0.778	0.740	0.716	

4.4. Heterogeneity Analysis

4.4.1. Coastal Location Heterogeneity

Following the China Marine Statistical Yearbook and the administrative jurisdiction criteria for coastline definition, we divide the sample cities into coastal cities and non-coastal cities, where cities whose administrative area contains a natural coastline are classified as coastal cities. The results in Table 8 show that the coefficient of new quality productive forces is significant at the 1% level in both groups, and the Chow test indicates that the between-group difference is

significant, meaning that new quality productive forces exert a significantly stronger driving effect on infrastructure construction in non-coastal cities while the positive impact is weaker in coastal cities. A possible reason is that non-coastal cities have substantial demand for shoring up infrastructure weaknesses and deploying new-type infrastructure, and new quality productive forces can effectively remedy existing construction shortcomings through technological innovation and upgrading, thereby providing new momentum for infrastructure construction. In contrast, coastal cities already possess a relatively high level of infrastructure, so the

marginal promotional effect of new quality productive forces is comparatively limited, likely resulting in a weaker boosting effect on infrastructure construction. Moreover, coastal cities can develop the marine economy through shipping routes and ports, an additional advantage over non-coastal cities; relying on marine resource endowments, coastal cities have achieved better economic development and experienced faster infrastructure growth in earlier stages, with their infrastructure now approaching full development.

Table 8. Heterogeneity Analysis Results by Coastal Location

	(1)	(2)
VARIABLES	Non-coastal cities	Coastal cities
Nqp	0.554*** (6.241)	0.351*** (3.464)
Constant	-0.078 (-0.625)	-0.235 (-0.177)
Observations	360	132
Controls	YES	YES
City FE	YES	YES
Year FE	YES	YES
r2_a	0.810	0.777
Chow Test p-value	0.005***	

4.4.2. City-Size Heterogeneity

In accordance with the Notice on Adjusting the Standards for Classifying City Sizes issued by the State Council, using the urban resident population from the Seventh National Population Census as the statistical caliber, the sample cities are divided into four groups: megacities, super-large cities, Type I large cities and Type II large cities, to test the heterogeneous impact of new quality productive forces on infrastructure construction. The results are shown in Table 9. The impact coefficient of new quality productive forces on infrastructure construction in super-large cities is significantly positive at the 1% level; in cities of other sizes, although the impact coefficients of new quality productive forces are positive, they are not significant. This confirms that the promoting effect of new quality productive forces on infrastructure construction exhibits significant city-size heterogeneity, which is mainly concentrated in super-large cities.

This can be attributed to the fact that most super-large cities are in a stage of rising development and still have development space such as land. They have urgent demands for infrastructure in terms of innovation resource agglomeration, industrial structure upgrading and modernization transformation of infrastructure. New quality productive forces are highly compatible with urban development needs and can effectively promote the layout and transformation of new infrastructure and the intelligent transformation of traditional infrastructure. Since the new era, megacities have been at the forefront of development, and their infrastructure systems have been relatively complete. As a result, the development space for new quality productive forces is relatively narrow, and they face higher transformation costs and more institutional constraints. Although Type I and Type II large cities have developed in recent years, restricted by factors such as innovation capacity, capital investment, talent reserve or brain drain, the technological advantages and innovation models of new quality productive forces are difficult to fully transform into

actual driving forces for infrastructure construction, resulting in the limited exertion of the promoting effect of new quality productive forces.

Table 9. Results of City-Size Heterogeneity Analysis

	(1)	(2)	(3)	(4)
VARIABLES	Megacities	Super-large cities	Type I large cities	Type II large cities
Nqp	0.180 (0.778)	0.303*** (4.324)	0.059 (1.420)	0.260 (1.660)
Constant	6.315** (5.230)	-0.485 (-1.185)	0.030 (0.204)	-0.079 (-1.215)
Observations	36	180	168	108
Controls	YES	YES	YES	YES
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
r2_a	0.923	0.875	0.898	0.852

4.5. Mediating Effect Test

After introducing the two mediating variables of technological innovation level and government responsiveness, we conduct empirical tests to examine the transmission mechanism of new quality productive forces on infrastructure, with the results shown in Table 10 and Table 11, respectively.

As can be seen from Table 10, the impact coefficients of both new quality productive forces and technological innovation level on infrastructure construction are significantly positive, indicating that new quality productive forces can effectively improve the regional technological innovation level and exert a partial mediating effect on infrastructure construction. This may be because the development of new quality productive forces can drive the agglomeration of innovation factors, increase R&D investment, and promote the transformation of technological achievements, fully activating regional innovation vitality and thereby enhancing the innovation level. The improvement of technological innovation level can provide core technical support for the construction of new infrastructure, promote the development and application of digital infrastructure and other fields, optimize the resource allocation efficiency of infrastructure construction, reduce costs and improve efficiency, and provide sustained momentum for infrastructure construction.

To verify the accuracy of the mediating effect, we further adopt the Sobel test for mediating effect verification. The results show that the corresponding P-value is less than 0.05, indicating that the mediating effect of technological innovation level is significant. Hypothesis 2 is thus verified.

As can be seen from Column (1) of Table 11, the estimated coefficient of new quality productive forces is 0.141 and significant at the 1% level, indicating that new quality productive forces can effectively improve the level of government responsiveness. This may be because new quality productive forces, as the core engine leading high-quality development, generate positive feedback that enables local governments to proactively accept its achievements and respond accordingly, improving the guarantee mechanism by optimizing policy supply and increasing fiscal investment. As can be seen from Column (2), the impact coefficient of government responsiveness on infrastructure construction is significantly positive, and the coefficient of new quality

productive forces also passes the significance test, indicating that government responsiveness also exerts a mediating effect in the impact of new quality productive forces on infrastructure construction. The strengthening of government responsiveness can provide policy support, financial guarantees and overall planning for infrastructure construction, solve problems such as factor constraints in the construction process to a certain extent, accelerate the development process of new infrastructure construction, and promote the improvement of regional infrastructure levels.

The Sobel test here also passes, indicating that the mediating effect of government responsiveness is significant. Hypothesis 3 is thus verified.

Table 10. Mediating Effect Test 1: Technological Innovation Level

VARIABLES	(1) Inn	(2) Infra
Nqp	1.687*** (2.969)	0.439*** (6.270)
Inn		0.013** (2.230)
Constant	1.521 (0.639)	-0.261** (-2.079)
Observations	492	492
Controls	YES	YES
City FE	YES	YES
Year FE	YES	YES
r2_a	0.837	0.796
Sobel test	Z value=2.778 P=0.005	

Table 11. Mediating Effect Test 2: Government Responsiveness

VARIABLES	(1) Gr	(2) Infra
Nqp	0.141*** (7.512)	0.420*** (13.108)
Gr		0.292*** (3.782)
Constant	-0.025 (-0.485)	-0.233*** (-2.777)
Observations	492	492
Controls	YES	YES
City FE	YES	YES
Year FE	YES	YES
r2_a	0.218	0.778
Sobel test	Z value =3.378 P=0.001	
t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1		

5. Conclusions and Policy Recommendations

Based on the panel data of 41 cities (3 provinces and 1 municipality directly under the Central Government) in the Yangtze River Delta region of China from 2011 to 2022, this paper constructs econometric models to analyze the impact of new quality productive forces on infrastructure construction from both theoretical and empirical perspectives, verifies the mechanism between them, and draws the following main conclusions:

(1) New quality productive forces can significantly and

positively promote the development of infrastructure construction and drive its transformation and upgrading. This conclusion remains valid after a series of robustness tests.

(2) The results of heterogeneity analysis show that the impact of new quality productive forces on infrastructure construction is significantly positive in both coastal and non-coastal areas of the Yangtze River Delta region, with a stronger effect in non-coastal areas than in coastal areas. Compared with cities of other sizes, the impact is more pronounced in super-large cities.

(3) New quality productive forces can indirectly promote infrastructure construction by improving the level of technological innovation and strengthening government responsiveness.

Based on the above conclusions, this paper puts forward the following policy recommendations:

First, systematically cultivate the core elements of new quality productive forces to consolidate the endogenous driving force for infrastructure upgrading. Centered on the three elements of productive forces in Marxist political economy, a well-adapted development pattern for new quality productive forces should be constructed. (i) Expand the scope of human resources and capital quality, and optimize the scientific layout of higher education institutions in the Yangtze River Delta. Priority should be given to the development of interdisciplinary fields such as digital intelligent manufacturing and electronic science and technology, steadily increasing the proportion of talent cultivation for emerging industries. At the same time, promote the mutual recognition of talent qualifications and cross-regional mobility, and guide talent agglomeration through salary incentives, funding tilts, and other means. (ii) Iteratively upgrade the means of labor and promote the translation of scientific and technological achievements into practical applications. Establish special regional funds for infrastructure-related scientific and technological innovation, increase R&D investment in artificial intelligence and industrial robots, and facilitate the transformation of patents into real-world applications, thereby advancing the sound development of the infrastructure sector. (iii) Expand the scope of objects of labor, accelerate the establishment of a unified data trading market in the Yangtze River Delta, improve the allocation systems for carbon trading, energy use rights, and pollution discharge rights, integrate green development and environmental protection into the entire infrastructure construction process, and enable digital drives and green regulations to push forward the transformation of infrastructure construction.

Second, implement differentiated urban development strategies to promote coordinated regional development. Given the actual circumstances of differing locational conditions and city sizes, region-specific development policies should be formulated. Coastal areas should focus on the intelligent and green transformation of infrastructure, relying on their existing well-developed infrastructure systems to prioritize the digital renovation of transportation hubs such as ports and rail lines, deploy new energy infrastructure, promote the deep integration of traditional infrastructure and the marine economy, and explore high-end pathways through which new quality productive forces can empower infrastructure. Non-coastal areas should shore up weaknesses in infrastructure by prioritizing the allocation of new quality productive forces resources to the weakest domains, accelerating the deployment of new infrastructure

such as the industrial Internet, and narrowing development gaps. Extra-large cities should fully leverage their advantages in agglomerating innovation resources, concentrate on building intelligent and smart projects, develop into science- and technology-oriented cities, and generate replicable and scalable experience in infrastructure upgrading. Megacities should employ new quality productive forces to enhance the operational efficiency and service capacity of existing infrastructure, and progressively advance projects that improve people's livelihoods, such as the renovation of old urban areas and the digitalization of municipal management. Various types of large cities can obtain talent, co-development, and technological support from larger cities through the counterpart assistance mechanism among core Yangtze River Delta cities, and can in turn influence small and medium-sized cities through similar means, gradually releasing the promotional effect of new quality productive forces.

Third, unblock the transmission pathways of productive forces and build a synergistic mechanism between technology and government. The critical links for translating new quality productive forces into infrastructure construction must be opened up, and the synergistic forces of technological innovation and government responsiveness should be brought into play. On the technological innovation side, support research institutes and infrastructure enterprises in jointly tackling core technologies, pool collective wisdom to solve difficult problems, lower the market risk of technology transfer, and accelerate the application of innovation outcomes in the infrastructure sector. On the government responsiveness side, optimize the structure of local fiscal expenditures, continuously raise the share of science and technology spending, and give priority to securing funding for new infrastructure and infrastructure-related technology R&D. Establish a dynamic monitoring mechanism for the development of new quality productive forces and infrastructure planning, promptly introduce adaptive industrial policies and regulatory rules, streamline infrastructure project approval procedures, and enhance the efficiency of government responses to the needs of infrastructure construction.

Fourth, break down administrative barriers and factor constraints to advance the connectivity of infrastructure in the Yangtze River Delta. Grounded in the national strategy for the integrated development of the Yangtze River Delta, break through administrative barriers by establishing a special coordination group for new quality productive forces and infrastructure development in the region, comprehensively plan regional new infrastructure construction, and unify construction standards and norms to avoid resource waste caused by redundant construction. Establish a cross-regional mechanism for the joint construction and sharing of infrastructure between adjacent areas, and progressively and deeply advance the interconnection of major infrastructure such as interprovincial transportation arteries and data centers from points to lines and from lines to planes. Improve the mechanisms for regional benefit distribution and ecological compensation, and build a scientific and reasonable cross-regional interest adjustment system by measuring the costs and benefits of different cities in infrastructure construction and the green living space occupied by development. This can involve quantifying the direct costs, opportunity costs, and the degree of provisions each city can supply in aspects such as construction, operation and maintenance, and environmental governance, while also estimating the comprehensive benefits

generated by infrastructure projects, so that costs are shared in proportion and benefits are distributed according to contribution. In addition, establish a special fund for ecological compensation of infrastructure in the Yangtze River Delta, prioritizing support for urban areas that assume ecological protection functions, to be used for local green construction, ecological restoration, and the cultivation of new quality productive forces, thereby driving the transformation of infrastructure in the Yangtze River Delta from self-construction to joint construction and from exclusive benefits to shared prosperity.

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References

- [1] Zhao Liange, Huo Yijia. New Quality Productive Forces Empowering the Enhancement of Agricultural Economic Resilience: Mechanism Analysis and Promotion Path [J]. Journal of Hubei University (Philosophy and Social Science), 2025, 52(1): 164-173.
- [2] Huang Tao, Yuan Xiaoling, Li Zhaopeng. Examining the Disparities in China's New Quality Productive Forces: Source Decomposition and Formation Mechanism [J]. Science & Technology Progress and Policy, 2025, 42(9): 1-12.
- [3] Lu Jiang, Guo Ziang. New Quality Productive Forces at the Municipal Level: Level Measurement, Spatiotemporal Evolution and Influencing Factors—A Study Based on Panel Data of 277 Cities in China from 2012 to 2021 [J]. Social Science Journal, 2024, (4): 124-133.
- [4] Liu Yuan, Duan Dingyun, Feng Zongxian, et al. Dynamic Evolution, Influencing Factors and Improvement Path of the Development Level of New Quality Productive Forces [J]. Science & Technology Progress and Policy, 2025, 42(12): 1-13.
- [5] Zhang Yongqi, Zhuang Tianhui. Digital Economy and Stable Income Increase of Farmers from the Perspective of New Quality Productive Forces: Empirical Evidence Based on Chinese County-Level Data [J]. Henan Social Sciences, 2024, 32(12): 67-80.
- [6] Cai Xianjun, Pan Huifeng, Wang Rui. The Disruptive Innovation Path of Latecomer Enterprises from the Perspective of New Quality Productive Forces [J]. Jiangsu Social Sciences, 2025, (1): 118-126+243.
- [7] Han Wenlong. A Political Economy Interpretation of New Quality Productive Forces [J]. Studies on Marxism, 2024, (3): 100-115.
- [8] Li Tianyi, Zhang Wei, Zhang Xuanyi. Development of New Quality Productive Forces and Common Prosperity: An Analysis Based on the Learning-by-Doing Effect of Workers [J]. Journal of Quantitative & Technological Economics, 2025, 42(3): 5-25.
- [9] Shen Guochang, He Pengli. The Endogenous Logic, Specification Requirements and Important Paths of Cultivating Top-Notch Innovative Talents from the Perspective of New Quality Productive Forces [J]. Journal of Beijing Normal University (Social Sciences), 2025, (1): 31-37.
- [10] Duan Yongbiao, Dong Xinyu. The Internal Logic and Realization Path of New Quality Productive Forces Boosting High-Quality Urban Development [J]. Journal of Xi'an Jiaotong University (Social Sciences), 2025, 45(2): 41-52.

- [11] Zhang Yaping, Zeng Lei. Research on Agricultural Digital Transformation Driving the Development of Agricultural New Quality Productive Forces in Southwest Border Counties [J]. Yunnan Social Sciences, 2025, (1): 40-50.
- [12] Zhang Xiangjie, Nie Liqing. The Development Path of New Quality Productive Forces Promoting the Adjustment of Social Division of Labor Structure [J]. Jiangsu Social Sciences, 2025, (1): 136-145.
- [13] Huang Shan, Zeng Fusheng. New Quality Productive Forces Empowering the Common Prosperity of Farmers and Rural Areas: Theoretical Analysis and Empirical Test [J]. Statistics & Decision, 2026, 42(1): 5-10.
- [14] Li Hongkai. New Quality Productive Forces Empowering Rural Industrial Revitalization: Theoretical Analysis and Empirical Test [J]. Statistics & Decision, 2026, 42(1): 11-16.
- [15] Fu Xiaohua. Strategic Emerging Industry Agglomeration, Regional Technological Diversification and Enterprise New Quality Productive Forces [J]. Statistics & Decision, 2025, 41(2): 161-166.
- [16] Ye Zhenyu. Power Upgrade and Path Breakthrough of High-Quality Development of County Economy [J]. People's Tribune, 2024, (18): 25-30.
- [17] Sun Chongming. New Quality Productive Forces Empowering High-Quality Development of New Rural Collective Economy: Internal Mechanism and Realization Path [J]. Contemporary Economic Research, 2025, (1): 57-65.
- [18] Zeng Fanjun, Feng Qian. How Is "Holistic Quality Governance" Possible? The Dynamic Mechanism of the Black-Box Dilemma of "Technology-Type Pseudo-Innovation" and Ways to Break It [J]. E-Government, 2025, (11): 111-124.
- [19] Zhang Yifan, Lu Minfeng. New Quality Productive Forces and Coordinated Development of Regional Economy: Symbiotic Mechanism and Co-Progress Path—Taking the Economic Development of the Yangtze River Delta as an Example [J]. Huxiang Forum, 2024, 37(4): 36-49.
- [20] Yang Zexia, Guo Shuhua. Promoting High-Quality Development of Border Areas with New Quality Productive Forces [J]. Yunnan Social Sciences, 2024, (6): 114-123.
- [21] Zhu Z Y, Liu C C. Impact of Digital Infrastructure on the Urban-Rural Income Gap and Its Threshold Effect [J]. Journal of South China Agricultural University (Social Science Edition), 2022, 21(5): 126-140.
- [22] Liu Jianjun, Liang Dapeng. Spatiotemporal Pattern of China's Digital Infrastructure Development Level [J]. Resources Science, 2025, 47(6): 1295-1311.
- [23] Han Wenlong, Zhang Ruisheng, Zhao Feng. Measurement of the Level of New Quality Productive Forces and New Growth Drivers of China's Economy [J]. Journal of Quantitative & Technological Economics, 2024, 41(6): 5-25.
- [24] Chen Shaohui, Sun Xiguo. Patient Capital and New Quality Productive Forces: The Logic and Approach of Synergistically Driving High-Quality Economic Development—From the Perspective of Marxist Political Economy [J]. Contemporary Economic Management, 2025, 47(4): 1-7.
- [25] Wen Zhonglin, Ye Baojuan. Analyses of Mediating Effects: The Development of Methods and Models [J]. Advances in Psychological Science, 2014, 22(5): 731-745.