

Article

Digital Infrastructure and Manufacturing Supply Chain Capabilities: Evidence from China's Pilot Cities

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Abstract

The reconfiguration of global value chains has raised concerns about the resilience and upgrading of manufacturing supply chains. This study examines whether digital infrastructure improves manufacturing supply chain capabilities, using the 2016 “Information for the People” pilot city program as a quasi-natural experiment. Based on panel data from Chinese prefecture-level cities from 2006 to 2023, a difference-in-differences model is employed to identify the causal effect. The results show that digital infrastructure significantly enhances manufacturing supply chain capabilities, and this finding remains robust after multiple tests. Heterogeneity analysis indicates that the effect differs across China's eight economic regions and strengthens with longer policy implementation, showing regional and cumulative characteristics. Mechanism analysis suggests that innovation-oriented talent inflow is an important transmission channel. Further analysis shows that financial development positively moderates the impact of digital infrastructure by improving cities' capacity to absorb and allocate digital and innovation resources. These findings suggest that policymakers should shift from uniform digital infrastructure investment to region-specific strategies that integrate talent attraction, financial support, and supply chain modernization.

Keywords: digital infrastructure; manufacturing supply chain capabilities; regional heterogeneity

1. Introduction

The 2025 *Global Digital Trade Development Report* reveals that the value of digitally supplied services trade has attained \$4.64 trillion [1]. Digital technologies have enhanced the efficiency of industrial chain collaboration by 15–20%, markedly decreasing communication expenses in cross-border cooperation. In recent years, intricate and unstable international conditions have expedited the reorganization of supply networks. The contraction and realignment of global value chains, along with the growth of silo effects, have revealed the fragility and instability of the supply chain division structure, thereby precipitating dangers such as “chain disruption” and “supply chain breakdowns” [2]. In this context, as a leading industrial power, China must address shortcomings in “chokepoint” sectors while strengthening its competitive advantages in key areas. China seeks to enhance the collaborative synergy between local and international industrial cycles by promoting organic cross-industry integration and the nested fusion of value chains. This strategy aims to improve the overall competitiveness of industrial sectors [3] and attain a refined rebalancing of resilience, efficiency, and modernization” within the supply chain ecosystem. The digital



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economy is transforming the manufacturing sector. By integrating digital technologies and data as production elements, it establishes a “new engine” for the internal operational dynamics of supply chains [4], therefore enhancing their ability to endure unknown hazards. Furthermore, the implementation of digital infrastructure allows organizations inside the value chain to utilize new elements for innovation-focused endeavors, hence enhancing the modernization of the entire industrial and supply chain framework [5].

Existing research has provided important insights into the relationship between digital infrastructure and supply chain development. First, studies on digital infrastructure generally show that it functions not only as a communication facility but also as a foundational condition for improving resource allocation, reducing information frictions, and supporting sustainable urban and industrial development [6–8]. These findings suggest that digital infrastructure can reshape the external environment in which manufacturing firms organize production, exchange information, and coordinate across regions. Second, research on industrial and supply chains emphasizes that supply chain capability is a multidimensional concept. It involves not only production and logistics efficiency, but also value creation, resilience, security, green transformation, and the capacity to move toward higher value-added activities [9,10]. This literature provides a basis for measuring manufacturing supply chain capabilities from multiple dimensions rather than relying on a single output-based indicator. Third, recent studies have examined how digital technologies and digital transformation affect supply chain performance. Evidence shows that blockchain technology, corporate digital transformation, digital innovation, green innovation, digital finance [11], and intellectual property protection can enhance supply chain coordination and resilience by improving information sharing [12–14], reducing transaction costs, and strengthening innovation capacity [15,16]. Overall, existing studies indicate that digitalization can improve supply chain performance through information, technology, and factor allocation channels.

However, two gaps remain. First, most existing studies focus on firm-level digital transformation, global value chain upgrading, or specific digital technologies, while less attention has been paid to digital infrastructure as a macro-level institutional and technological condition shaping manufacturing supply chain capability. Second, much of the existing evidence is based on correlation analysis or proxy variables, making it difficult to identify the causal effect of digital infrastructure development. To address these gaps, this study treats the “Information for the People” pilot policy as a quasi-natural experiment and uses a difference-in-differences framework to examine whether policy-induced digital infrastructure development improves manufacturing supply chain capability. In addition, this study further investigates the mechanisms through which digital infrastructure affects supply chain capability, with particular attention given to human capital accumulation and capital resource allocation.

Research on digital infrastructure and manufacturing supply chain competencies provides significant insights for this study; nonetheless, two essential areas require additional investigation. Existing studies have mainly examined the evolution of manufacturing supply chains from the perspectives of global value chain specialization, industrial upgrading, and firm-level digital transformation. In contrast, relatively little attention has been given to the role of digital infrastructure as a macro-level institutional setting in shaping manufacturing supply chain capabilities. The marginal contributions of this study are mainly reflected in the following three aspects. First, from the perspective of research focus, this study moves beyond treating digital infrastructure merely as a general external environment or technical condition. Instead, it conceptualizes digital infrastructure as an important macro-level institutional infrastructure that shapes manufacturing supply chain capabilities. By constructing an analytical framework of “digital infrastructure–factor

allocation–supply chain capability enhancement,” this study extends the intersection between digital economy research and manufacturing supply chain research. Second, in terms of identification strategy, this study uses the “Information for the People” pilot city program as a quasi-natural experiment and applies a multi-period DID model to identify the causal effect of digital infrastructure development on manufacturing supply chain capabilities, thereby alleviating potential endogeneity problems in traditional correlation-based analyses. Third, regarding the mechanism explanation, this study not only examines the overall impact of digital infrastructure on manufacturing supply chain capabilities, but also reveals its transmission mechanisms through human capital accumulation and capital resource allocation. This further explains how digital infrastructure promotes the enhancement of manufacturing supply chain capabilities by improving factor quality and factor allocation efficiency.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and develops the research hypotheses by discussing the policy background of the “Information for the People” pilot program, the economic role of digital infrastructure, and the theoretical relationship between digital infrastructure and manufacturing supply chain capability. Section 3 presents the empirical research design, including the difference-in-differences model, the construction of the manufacturing supply chain capability index, variable definitions, data sources, and sample selection. Section 4 reports the empirical results, including the baseline regression, parallel trend test, placebo test, robustness checks that control for concurrent policy interference, and heterogeneity analysis across China’s eight economic regions and different policy implementation durations. Section 5 further examines the underlying mechanism and moderating effect, focusing on the roles of innovation-oriented talent inflow and financial development. Section 6 concludes the paper by summarizing the main findings, discussing policy implications, and outlining possible directions for future research.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. Policy Background

As digital technologies advance, governments have increasingly turned to digital governance to improve administrative efficiency and public service provision [17]. China has actively advanced the digital transformation of public administration through several policy initiatives designed to integrate information technologies into governmental operations and public services. Among these initiatives, the Information for the People Policy, launched in 2016, represents an important policy experiment designed to enhance digital governance and improve citizens’ access to public services. The policy was jointly issued by multiple central authorities. Its primary aim is to advance the integration of information technologies into government administration and public service systems. Under this initiative, a group of cities across China was selected as pilot areas to explore innovative approaches to digital governance and to accumulate experience that could later be replicated nationwide. The pilot cities exhibit considerable differences in economic development, industrial composition, and levels of digitalization, creating a suitable quasi-natural experimental framework for empirical study.

The implementation of the policy mainly focused on three aspects. Firstly, pilot cities were required to build unified government information platforms and promote data sharing across government departments, aiming to break down information silos and improve administrative coordination. Secondly, the strategy promoted the establishment of cohesive online public service platforms, enabling individuals and businesses to obtain a diverse array of government services via digital channels. Third, to facilitate the functioning of

digital government services, pilot cities were directed to enhance the development of digital infrastructure, encompassing broadband networks, big data platforms, and information-sharing systems. These measures significantly improved the digital environment of pilot cities and enhanced the capacity of governments to collect, process, and utilize digital information. Beyond the improvement of public service efficiency, the policy also generated broader economic impacts. The expansion of digital infrastructure, together with platform development, improved the local digital ecosystem and promoted the diffusion of digital technologies across sectors. In particular, enhanced digital connectivity and information sharing reduced transaction costs and improved information flows among firms, thereby creating favorable conditions for the upgrading of industrial systems. These changes are especially important for the manufacturing sector, where efficient information sharing and coordination across the supply chain are essential for overall performance. The implementation of the “Information for the People” pilot program provides a valuable quasi-experimental setting for examining how digital infrastructure development influences manufacturing supply chain capabilities.

2.1.2. Digital Infrastructure

Digital infrastructure is generally defined as the underlying technological system supporting data generation, transmission, storage, computation, and application. Its core scope is no longer confined to traditional communication networks but has progressively expanded into a composite infrastructural architecture comprising broadband networks, mobile communication networks, internet exchange points, data centers, and cloud computing platforms [18]. Compared to traditional physical infrastructure such as transportation and power grids, digital infrastructure exhibits more pronounced network externalities, economies of scale, and characteristics of a General-Purpose Technology. It functions not only as a “conduit” for factor mobility but also serves as the critical foundation for resource allocation and the restructuring of production organization in the digital era by mitigating information frictions, enhancing data processing capabilities, and facilitating knowledge diffusion [19]. Recent studies by the OECD and the World Bank emphasize that the connotation of digital infrastructure has extended from connectivity infrastructure toward data infrastructure. Specifically, emerging facilities such as data centers, cloud services, and exchange nodes are becoming pivotal pillars for digital transformation and productivity enhancement [20]. Early literature focused predominantly on the relationship between broadband penetration, network access quality, and firm performance, positing that higher-quality digital connectivity reduces search, coordination, and transaction costs, thereby improving innovation efficiency [21]. Moreover, researchers have broadened the function of digital infrastructure to encompass sustainable development, demonstrating its potential to facilitate the decarbonisation of energy consumption and enhance Green Total Factor Productivity (GTFP) by stimulating technological innovation [22].

2.1.3. Supply Chain Capability

Supply chain capability denotes the integrated capacity of a system or firm to continuously orchestrate internal and external resources across activities such as procurement, production, and relational governance, thereby improving efficiency and value creation [23]. Supply chain research typically analyzes them via the lenses of security, resilience, sustainability, and sophistication. From a security standpoint, supply chains are defined as production and distribution networks that connect stakeholders via the movement of goods, information, and capital. The primary objective is to ensure the stable supply of critical factors through risk management mechanisms to maintain industrial continuity. Regarding resilience, the supply chain functions as a dynamic system capable of maintain-

ing operations and achieving recovery amidst external shocks. This requires enhancing systemic adaptability through structural configuration and resource redeployment [24]. The supply chain assumes responsibility for environmental protection by implementing green management from raw material procurement to product recycling [25]. Ultimately, the perspective of industrial sophistication indicates that supply chain advancement entails an enhancement of the division of labor. Through technological innovation and digital transformation, firms can progressively ascend toward high-value-added segments within the global value chain [26].

2.2. Research Hypotheses

2.2.1. Digital Infrastructure and Manufacturing Supply Chain Capabilities

Resource allocation theory asserts that the success of data flow determines the effectiveness of resource allocation, suggesting that inadequate market knowledge or low transmission efficiency results in inefficiencies; misallocation is likely to occur. Digital infrastructure optimizes resource allocation by reducing information acquisition costs and enhancing transmission efficiency [27]. Through the deep coverage of 5G and the industrial internet, digital infrastructure directly compresses order delivery cycles and significantly reduces inventory costs by enabling precise supply-demand matching, thereby achieving real-time physical perception and direct data connectivity across all supply chain segments. This technological embedding directly eliminates information barriers caused by manual intervention and hierarchical transmission in traditional supply chains, reconfiguring discrete production, warehousing, and logistics nodes into an integrated system [28]. Simultaneously, as the digital arteries of the modern economy, information infrastructure facilitates direct factor allocation and enhances the circulation efficiency of labor, capital, and data within the supply chain. It not only breaks the traditional information silos noted by Zhou and Xu [29] but also empowers midstream enterprises to directly access end-market demand, thereby weakening the monopoly power of lead firms, optimizing the profit distribution structure across the entire industrial chain [30], and substantially improving the overall productivity of the supply chain to generate intrinsic growth impetus for the industrial sector.

As an exogenous shock, policy has amplified the actual constraining effect of improved digital infrastructure on resource allocation. Compared to general technological progress, this policy has accelerated the coverage and implementation of information infrastructure in pilot regions through institutional mechanisms, resulting in a significant improvement in information efficiency. In this process, the reduction in information acquisition costs and transmission delays no longer relies solely on corporate technology adoption but is achieved simultaneously at the regional level through exogenous shocks [31], thereby significantly reducing information asymmetry across various links in the supply chain. After digital technologies are embedded into supply chain operations, they not only improve information and communication efficiency and reduce coordination costs, but also facilitate supply chain process reconfiguration and performance optimization, thereby providing both technological support and an organizational foundation for the enhancement of supply chain capability [24]. Building on this foundation, improved information flow has further enhanced companies' ability to respond to shifts in demand, shifting production and inventory decisions from reactive adjustments to more timely, dynamic alignment, thereby reducing excess inventory and idle resources. Simultaneously, enhanced information connectivity across supply chain nodes diminishes coordination expenses and elevates overall operational efficiency [32].

H1. *Digital infrastructure significantly promotes manufacturing supply chain capabilities.*

2.2.2. Digital Infrastructure Enhances Manufacturing Supply Chain Capabilities Through Innovation-Oriented Talent Inflow

Digital infrastructure reshapes the spatial allocation of innovation resources by weakening geographical constraints on the circulation of information, knowledge, technology, and human capital. Unlike conventional physical infrastructure, which primarily improves material connectivity, digital infrastructure strengthens informational connectivity, data circulation, and platform-based coordination. By reducing information asymmetry and matching frictions among market participants, it creates favorable conditions for the agglomeration and reallocation of innovation factors. Recent evidence suggests that digital infrastructure can enhance cities' attractiveness to high-skilled talent by improving interregional information flows, expanding digital industries, and strengthening urban innovation efficiency [33]. Moreover, digital talent mobility is increasingly shaped by industrial conditions, urban development environments, and regional innovation capacity [34]. Therefore, digital infrastructure may affect manufacturing supply chain capability not only through technological upgrading, but also by facilitating the inflow of innovation-oriented talent factors.

The inflow of innovation-oriented talent factors constitutes an important channel through which digital infrastructure affects manufacturing supply chain capabilities. On the one hand, digital infrastructure enhances the local innovation environment and talent development conditions. More advanced information networks, digital platforms, and public information service systems improve information transmission efficiency and public service provision, while facilitating knowledge exchange and technological interaction among firms, universities, research institutions, and producer-service organizations. In the empirical setting, the National Information Benefiting People Pilot Policy serves as a policy-based proxy for digital infrastructure development, as it promotes information resource integration and public information service upgrading. Such improvements strengthen a city's attractiveness to R&D personnel, technical professionals, and digitally skilled workers, thereby encouraging the inflow of innovation-oriented talent factors. This logic is consistent with studies showing that digital talent inflow can promote the co-agglomeration of digital economy industries and manufacturing, especially in cities with stronger digital infrastructure and more favorable industrial conditions [35]. Talent-oriented institutional arrangements have also been found to stimulate regional innovation by improving the spatial allocation of heterogeneous labor forces [36].

On the other hand, the inflow of innovation-oriented talent factors provides the knowledge base and technical support required for upgrading manufacturing supply chain capability. Manufacturing supply chain capability is reflected not only in the coordination of procurement, production, inventory, logistics, and sales, but also in firms' ability to identify, absorb, and respond to changes in market demand, technological conditions, and external risks. Innovation-oriented talent brings specialized knowledge, technical expertise, and managerial experience to manufacturing firms, enhancing their capacity to absorb and apply digital technologies, improve supply chain information sharing, and optimize production planning, inventory control, logistics allocation, and demand responsiveness. Existing empirical evidence indicates that digital transformation can strengthen supply chain resilience by improving supply chain power and transparency [37]. More directly, innovative human capital has been shown to enhance supply chain resilience by serving as a conduit for knowledge transfer and technology diffusion [38]. Accordingly, the inflow of innovation-oriented talent factors can strengthen firms' technological absorption, digital application, and supply chain coordination capabilities, thereby improving manufacturing supply chain capability. Therefore, the following hypothesis is proposed:

H2. *Innovation-oriented talent inflow mediates the relationship between digital infrastructure development and manufacturing supply chain capability.*

2.2.3. Digital Infrastructure Improves Manufacturing Supply Chain Capabilities by Streamlining Financial Development

For manufacturing firms, the effective use of digital infrastructure often requires complementary investments in information systems, intelligent equipment, logistics technologies, and supply chain management platforms. Such investments are usually capital-intensive and involve uncertain returns, making financial development an important factor in determining whether firms can convert digital connectivity into supply chain capability [39]. In this regard, digital finance and financial development can ease financing constraints and support firms' digital transformation by improving the accessibility and efficiency of external capital [40]. A higher level of financial development can strengthen this conversion process. In regions with more developed financial systems, firms usually face lower financing constraints, broader financing channels, and more efficient capital allocation. These conditions enable manufacturing firms to undertake digital transformation, upgrade production and logistics systems, and improve coordination with upstream and downstream partners [41]. Financial support is particularly important for enhancing industry-chain and supply chain resilience, as it provides the capital basis for firms to reorganize production networks and respond to external shocks [42]. Moreover, digital finance can improve value co-creation among supply chain participants by facilitating information sharing and resource coordination [43]. As a result, the connectivity advantages created by digital infrastructure are more likely to be transformed into improvements in supply chain information sharing, production coordination, inventory management, logistics allocation, and risk response [44].

By contrast, when financial development is relatively weak, the enabling effect of digital infrastructure may be constrained. Even if digital infrastructure improves regional digital connectivity, firms with limited access to external finance may lack the resources needed to adopt digital technologies and reorganize supply chain processes. Supply chain finance can enhance firms' supply chain resilience by alleviating capital shortages and improving the stability of inter-firm transactions [45]. Similarly, when financing constraints are effectively reduced, firms are more capable of increasing innovation investment and upgrading supply chain-related technologies [46]. The development of digital financial inclusion also helps expand firms' access to financial resources and promotes enterprise innovation, which is essential for transforming digital infrastructure advantages into supply chain capability. Financial development can be regarded as an important boundary condition under which digital infrastructure exerts its supply-chain-enhancing effect. Accordingly, the following hypothesis is proposed:

H3. *Financial development positively moderates the relationship between digital infrastructure development and manufacturing supply chain capability.*

Overall, as illustrated in Figure 1, driven by the "Information for the People" pilot policy, digital infrastructure improves public service provision and facilitates data circulation, which promotes more efficient information flows and mitigates information asymmetry, thereby directly strengthening manufacturing supply chain capabilities. In addition, digital infrastructure exerts indirect effects through two main channels. It promotes the efficient flow of capital within the supply chain by improving capital allocation efficiency and strengthening digital financial support. It also enhances human capital by facilitating skill upgrading and knowledge acquisition. Together, these mechanisms contribute to

improvements in manufacturing supply chain capabilities in terms of high-end positioning, green development, and resilience.

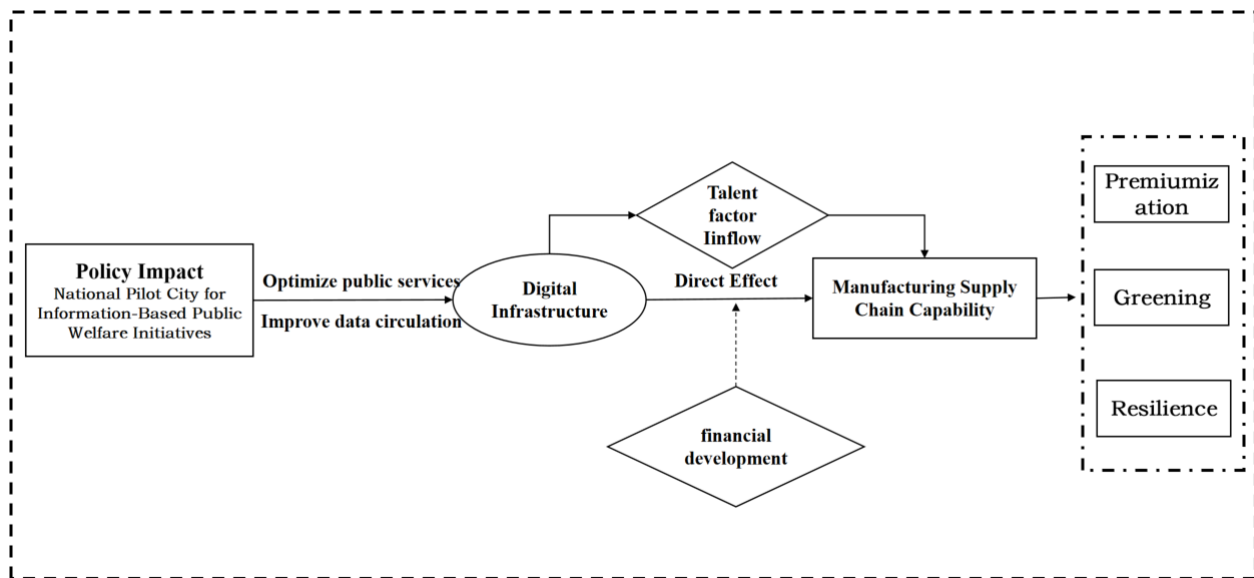


Figure 1. Path mechanism diagram.

3. Model Specification and Variable Selection

3.1. Model Specification

Using the “Information for the People” pilot cities as a quasi-experimental setting, this study applies a difference-in-differences framework to evaluate how digital infrastructure affects manufacturing supply chain capabilities, while controlling for individual and time-invariant effects to reduce estimation bias and capture the net impact of the policy. The difference-in-differences model is set up as follows:

$$MSCC_{i,t} = \alpha_0 + \alpha_1 Policy_{i,t} + \alpha_2 X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (1)$$

In the designated model, α_0 is the constant term, where α_1 and α_2 are the coefficients to be estimated for the primary explanatory variable and the collection of control variables, respectively. The dependent variable, $MSCC_{i,t}$ represents manufacturing supply chain capabilities. The primary explanatory variable, $Policy_{i,t}$ represents the state of the “Information for the People” national pilot city policy. Specifically, $i = 1$ if a city is classified as a pilot region, and $i = 0$ otherwise; likewise, $t = 1$ denotes the post-implementation phase of the policy, and $t = 0$ otherwise. $X_{i,t}$ denotes a vector of control variables. To address unobserved variables, μ_i and θ_t are integrated to denote fixed impacts that are specific to both the city and the year. $\varepsilon_{i,t}$ denotes the idiosyncratic error term.

To investigate the correlation between national pilot city policies for information-driven public welfare and manufacturing supply chain capabilities, we enhance the benchmark model by developing a mediation model between the two variables. This seeks to investigate the extra routes via which national pilot city policies for information-based public welfare impact manufacturing supply chain capabilities. Consequently, based on the research conducted by Baron & Kenny (1986) [47] and Preacher & Hayes (2008) [48], talent factor inflow is utilized as a mediating variable. The model is designed in the following manner:

The model is constructed as follows:

$$Med_{i,t} = \beta_0 + \beta_1 Policy_{i,t} + \beta_2 X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (2)$$

$$MSCC_{i,t} = \gamma_0 + \gamma_1 Policy_{i,t} + \gamma_2 Med_{i,t} + \gamma_3 X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (3)$$

In Equation (3), γ_2 denotes the coefficient on the mediating variable. The term $MSCC_{i,t}$ denotes the extent of manufacturing supply chain capabilities, while $Med_{i,t}$ functions as the mediating variable, incorporating Digital Infrastructure (DI) and Talent factor inflow (TFI). All covariates are aligned with the baseline specification to ensure the reliability and robustness of the mediation analysis. This study additionally utilizes the Sobel test and Bootstrap method to perform supplementary validation of the aforementioned mechanisms.

To examine the moderating role of financial development in the relationship between policy implementation and manufacturing supply chain capabilities, this study introduces financial development and its interaction term with the policy variable into the baseline regression model. The model is specified as follows:

$$MSCC_{i,t} = \delta_0 + \delta_1 Policy_{i,t} + \delta_2 FDC_{i,t} + \delta_3 (Policy_{i,t} \times FDC_{i,t}) + \delta_4 X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (4)$$

where $FDC_{i,t}$ denotes the mean-centered level of financial development, and $Policy_{i,t} \times FDC_{i,t}$ represents the interaction term between the policy variable and financial development. The coefficient of interest is δ_3 . If δ_3 is significantly positive, it indicates that financial development positively moderates the effect of policy implementation on manufacturing supply chain capabilities.

For policy evaluation within a difference-in-differences framework, a crucial condition is that the parallel trends assumption holds. This requires that, prior to the policy intervention, pilot and non-pilot cities exhibit comparable development patterns without systematic divergence. In light of the incremental implementation of the national pilot program for information-based public services and its mitigating influence and sustained impact on the progression of manufacturing supply chains, we employ the event analysis methodology suggested by Beck et al. (2010) [49] to develop the subsequent dynamic model:

$$MSCC_{i,t} = \eta_0 + \sum_{k=-3}^4 \eta_k D_{i,t}^k + \eta^T X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (5)$$

$D_{i,t}^k$ denotes the event-time dummy variable, while η_k represents the dynamic effect across periods before and after policy implementation. The estimated coefficients of primary interest in this paper denote the estimated values of the policy dummy variables for the three years prior, two years prior, and one year prior to policy implementation, as well as the first, second, third, and fourth years following implementation. The remaining variables are set identically to the baseline model.

3.2. Variable Selection

3.2.1. Dependent Variable

Using techniques from Aslam, H. et al. (2018) [50] and Zhao et al. (2023) [24], this study constructs a manufacturing supply chain capabilities indicator system encompassing three dimensions: high-end positioning, green development, and resilience. The manufacturing supply chain capability index of China's prefecture-level cities is constructed using the entropy-weighted comprehensive evaluation method. The main steps are as follows:

To eliminate the influence of different dimensions and orders of magnitude, the range normalization method is adopted to standardize all indicators uniformly. The formula is as follows:

$$x'_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (6)$$

where x'_{ij} denotes the raw value of the i -th indicator for the j -th observation. To prevent undefined values in subsequent logarithmic operations, a small displacement is applied to the standardized results.

$$x'_{ij} = 10^{-6} \quad (7)$$

Determine the contribution (weight) of the i -th sample to the j -th metric:

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^n x'_{ij}} \quad (8)$$

where n represents the aggregate quantity of samples.

According to the definition of information theory, the control entropy e_j of the j -th indicator is calculated as:

$$e_j = -\frac{1}{\ln(n)} \sum_{i=1}^n p_{ij} \ln(p_{ij}) \quad (9)$$

First, calculate the information utility value for each indicator e_j :

$$d_j = 1 - e_j \quad (10)$$

The coefficient of variation was then normalized to obtain the final weights for each indicator w_j :

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j} \quad (11)$$

Finally, the comprehensive score of each evaluation object is calculated by aggregating the standardized indicators according to their entropy-based weights:

$$S_i = \sum_{j=1}^m w_j \cdot x'_{ij} \quad (12)$$

It does this while adhering to the principles of data availability and comprehensiveness. The specific composition of the third-level indicators is shown in Table 1.

Table 1. Measurement of manufacturing supply chain capability.

Aggregate Indicator	Primary Indicators	Secondary Indicators	Tertiary Indicators
Manufacturing Supply Chain Capabilities	High-end Positioning	Invention Patent Grants	Number of digital-economy-related invention patents granted in the current year
		Artificial Intelligence Development Level	Number of existing artificial intelligence enterprises
		Utility Model Patent Grants	Number of digital-economy-related utility model patents granted in the current year

Table 1. *Cont.*

Aggregate Indicator	Primary Indicators	Secondary Indicators	Tertiary Indicators
Manufacturing Supply Chain Capabilities	Green Development	Industrial SO ₂ Emissions	Total industrial sulfur dioxide emissions in the region at year-end
		Industrial Smoke and Dust Emissions	Total industrial smoke and dust emissions in the region at year-end
		Industrial Wastewater Discharge	Total industrial wastewater discharge in the region at year-end
	Resilience	Scientific and Technological Level	Share of high-tech personnel in total manufacturing employment
		Organizational Support for Innovation	Number of newly registered high-tech enterprises in the current year
		Industrialization Level	Share of value added of the secondary industry in total value added across the primary, secondary, and tertiary industries
		Industrial Organizational Foundation	Number of industrial enterprises above designated size
		Industrial Operating Capacity	Total operating profit of industrial enterprises above designated size

3.2.2. Explanatory Variables and Control Variables

We use the implementation status of the “Information for the People” pilot policy as the core explanatory variable. The variable takes the value of 1 for a pilot city in and after the year of policy implementation, and 0 otherwise. To mitigate potential omitted-variable bias, we include population density (PD), economic development level (EDL), degree of openness (OD), industrial structure (IS), and fiscal pressure (FP) as control variables.

3.3. Data and Sample Selection

This study sets the sample period as 2006–2023 and uses Chinese prefecture-level cities as the research sample. The choice of 2006 as the starting year is based mainly on three considerations: policy background, research design, and data availability. First, 2006 marks an important turning point in China’s informatization development, as the country shifted from preliminary exploration to more systematic promotion. The introduction of the National Informatization Development Strategy for 2006–2020 elevated informatization development to the level of a national strategy and provided an institutional foundation for the subsequent development of digital infrastructure, information resource utilization, and digital technology application. Therefore, using 2006 as the starting year helps capture the early-stage evolution of China’s digital infrastructure development. Second, this study uses the “Information for the People” pilot city program as a quasi-natural experiment. Starting the sample in 2006 provides a relatively long pre-policy observation period, which helps more fully compare the pre-treatment trends of the treatment and control groups. Finally, from the perspective of data availability and comparability, city-level statistical yearbooks and related databases have provided relatively continuous economic, industrial, technological, and informatization-related indicators since 2006, which helps ensure consistency in variable measurement and the completeness of the panel dataset. Based on

these considerations, this study finally selects 2006–2023 as the sample period. Of them, 80 cities are classified as pilot cities, and the others are non-pilot cities. The data sources primarily consist of publicly available information from China’s National Development and Reform Commission. The data employed to establish the dependent variable and for the control variables primarily originate from annual statistical yearbooks, including the *China Statistical Yearbook*, *China Science and Technology Statistical Yearbook*, *China Industrial Statistical Yearbook*, *China Energy Statistical Yearbook*, and provincial or municipal statistical yearbooks. The research sample omits Hong Kong, Macao, and Taiwan. The sample from the Tibet Autonomous Region was eliminated due to significant data issues. Table 2 depicts the descriptive statistics for the variables.

Table 2. Baseline regression results.

Variables	(1)	(2)	(3)	(4)
	MSCC	MSCC	MSCC	MSCC
Policy	0.0224 *** (0.0057)	0.0166 *** (0.0041)	0.0166 *** (0.0042)	0.0165 *** (0.0042)
PD		0.1066 *** (0.0248)	0.1069 *** (0.0248)	0.1059 *** (0.0254)
EDL		0.0020 (0.0028)	0.0033 (0.0034)	0.0026 (0.0036)
OD			0.0167 (0.0242)	0.0188 (0.0243)
IS			−1.4976 (1.6760)	−1.6781 (1.6931)
FP				−0.0094 (0.0109)
Observations	4882	4882	4882	4882
Within				
R-squared	0.2169	0.3505	0.3507	0.3508
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Note: The values in parentheses are t-values, with *** indicating significance at the 1% level.

4. Results

4.1. Baseline Regression

Table 2 reports the baseline regression results for the effect of digital infrastructure on manufacturing supply chain capabilities. Column (1) includes the policy variable together with city and year fixed effects but excludes the control variables. Columns (2)–(4) progressively introduce the control variables. The estimated coefficient of Policy remains positive and statistically significant at the 1% level across all specifications, ranging from 0.0165 to 0.0224. In the fully specified model reported in Column (4), the coefficient of Policy is 0.0165, with a city-level cluster-robust standard error of 0.0042. This indicates that, relative to non-pilot cities, the “Information for the People” pilot policy increases the manufacturing supply chain capability index of pilot cities by an average of 0.0165 units. These findings provide robust support for H1.

4.2. Robustness Tests

4.2.1. Parallel Trend Test

The dynamic effect results presented in Figure 2 visually illustrate the parallel trend test and the dynamic change process of policy shocks. Only when the treated and control groups meet the parallel trends assumption can the DID framework produce reliable causal estimates for the “Information for the People” pilot program. To validate the identification

strategy, an event study method is applied to assess pre-intervention trend comparability between pilot and non-pilot cities, from which a dynamic effect model is developed. The empirical results show that, before policy implementation, the estimated coefficients fluctuate around zero, and their confidence intervals all include zero. This indicates that there were no statistically significant differences in the pre-policy trends of manufacturing supply chain capabilities between the pilot and non-pilot cities. Therefore, the parallel trends assumption required for the difference-in-differences estimation is satisfied.

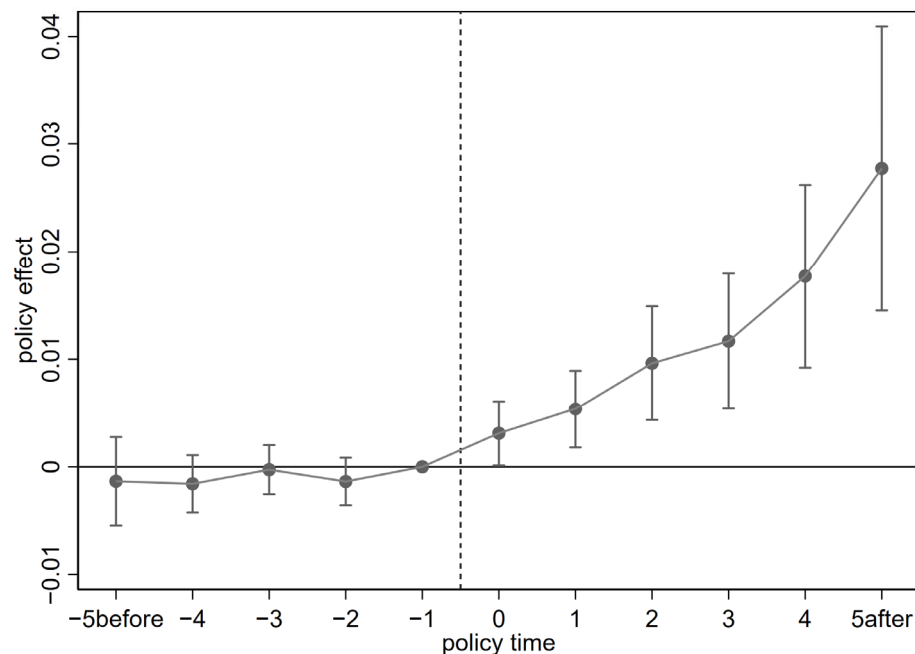


Figure 2. Parallel trends test and dynamic policy effects.

Following policy implementation, the estimated coefficients become positive and exhibit an overall upward trend. The policy effect gradually becomes statistically significant and continues to increase over time, indicating that the positive impact of digital infrastructure development on manufacturing supply chain capabilities has clear persistence and cumulative characteristics. This suggests that the effects of digital infrastructure construction are gradually released through improved information transmission, enhanced resource allocation efficiency, and stronger coordination among firms along the supply chain.

4.2.2. Placebo Test

A placebo test is performed by randomly assigning pilot city labels to determine if the benchmark regression findings are influenced by unobserved heterogeneity or common trends at the city level. The policy pilot status is randomly redistributed across all sample cities, and the simulation is conducted 500 times. This creates a counterfactual scenario devoid of an authentic policy shock, resulting in the sample distribution of the pseudo-treatment effect.

As shown in Figure 3, the estimated coefficients obtained from the random permutations are mainly concentrated around zero, and most of the corresponding p -values are greater than 0.1. In contrast, the estimated coefficient of the actual policy effect is 0.0151, which lies clearly outside the main distribution of the randomly generated estimates. This indicates that the significant policy effect identified in the baseline regression is unlikely to be driven by random assignment, unobserved chance factors, or spurious correlations.

Therefore, the placebo test provides further support for the robustness and reliability of the baseline findings.

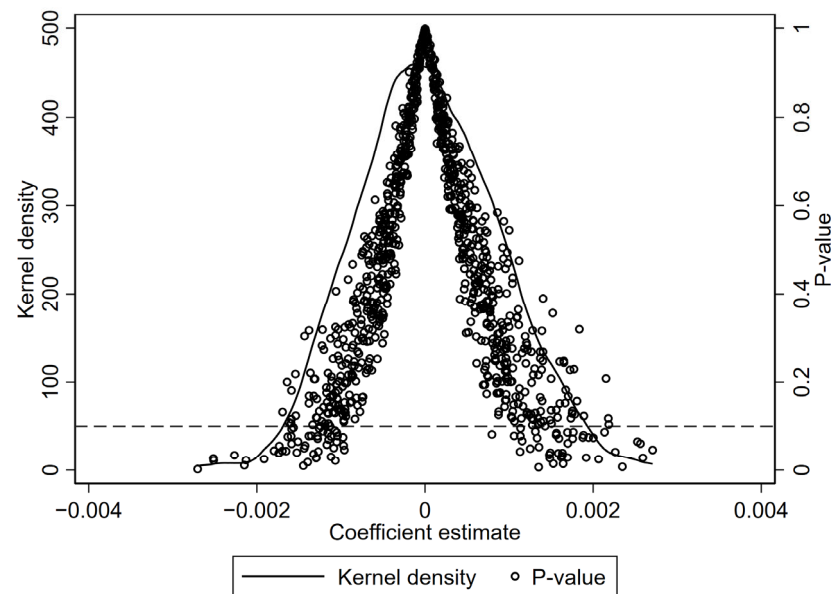


Figure 3. Placebo test.

4.2.3. Validation Test for the Digital Infrastructure Effect of the Policy

To further verify whether the “Information for the People” pilot policy can be regarded as a policy-induced shock to digital infrastructure development, this study conducts an additional validation test using internet penetration as the dependent variable. Internet penetration is measured based on the registered-population caliber and reflects the network access conditions and digital infrastructure foundation of prefecture-level cities. The same two-way fixed-effects DID specification is employed, with city fixed effects, year fixed effects, and the same set of control variables included.

As shown in Table 3, the coefficient of Policy is 630.501 and is statistically significant at the 1% level. This indicates that, after policy implementation, pilot cities experienced a significant increase in internet penetration relative to non-pilot cities. Therefore, the result provides direct empirical support for treating the “Information for the People” pilot policy as a quasi-natural policy shock related to digital infrastructure development.

Table 3. Validation test for the digital infrastructure effect of the policy.

Variables	Internet Penetration
Policy	630.501 ***
	−182.864
Controls	Yes
City FE	Yes
Year FE	Yes
Observations	4882
Number of cities	272
Within R-squared	0.0865

Notes: Robust standard errors clustered at the city level are reported in parentheses. *** indicating significance at the 1% level.

4.2.4. Controlling for Concurrent Policy Interference

To prevent interference from other policies during the digital infrastructure building phase, this study re-executes the regression utilizing a sample unimpacted by these policy disruptions (Table 4). It specifically accounts for the effects of the Broadband China Pilot Program (Broad), National Big Data Comprehensive Pilot Zones (Data), and Smart City Pilot Program (Smart). The results of the regression study back up the premise that improving digital infrastructure leads to better development in manufacturing supply chains, even when there are other factors at play.

Table 4. Exclusion of policy interference.

VARIABLES	(1)	(2)	(3)	(4)
	MSCC	MSCC	MSCC	MSCC
Policy	0.01658 *** (3.87250)	0.01507 *** (3.53857)	0.01721 *** (4.07207)	0.01580 *** (3.62730)
Smart City Pilot	−0.00075 (−0.27716)			−0.00076 (−0.28399)
Broadband China		0.00643 ** (2.37693)		0.00673 ** (2.45512)
National Big Data Pilot			0.00648 (1.45785)	0.00673 (1.47808)
Controls	Yes	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	4882	4882	4882	4882
Within R ²	0.35091	0.35626	0.35573	0.36166

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$), ** ($p < 0.05$).

4.2.5. PSM-DID Test

The PSM-DID approach is employed to mitigate potential endogeneity arising from sample selection bias. Population density (PD), economic development level (EDL), degree of openness (OD), industrial structure (IS), and fiscal pressure (FP) are used as matching covariates. Propensity scores are estimated using a Logit model, after which the DID model is re-estimated using the matched sample.

Table 5 reports the PSM-DID regression results. Column (1) presents the DID estimates based on the full sample, whereas Column (2) presents the PSM-DID estimates based on the matched sample. The estimated coefficient of Policy is 0.0165 in the full sample and 0.0123 after propensity score matching, and both coefficients are positive and statistically significant at the 1% level. Although the magnitude of the estimated policy effect decreases slightly after matching, its sign and statistical significance remain unchanged. These findings indicate that the positive effect of digital infrastructure on manufacturing supply chain capabilities remains robust after alleviating potential sample selection bias.

Table 5. PSM-DID regression results.

Variables	(1)	(2)
	DID (Full Sample)	PSM-DID (Matched Sample)
	MSCC	MSCC
Policy	0.0165 *** (0.0042)	0.0123 *** (0.0029)
PD	0.1059 *** (0.0254)	0.0656 *** (0.0128)
EDL	0.0026 (0.0036)	0.0038 (0.0040)
OD	0.0188 (0.0243)	0.0016 (0.0269)
IS	−1.6781 (1.6931)	0.4311 (1.6299)
FP	−0.0094 (0.0109)	−0.0241 ** (0.0104)
Observations	4882	3881
Within R-squared	0.3508	0.4361
City FE	Yes	Yes
Year FE	Yes	Yes

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$), ** ($p < 0.05$).

4.2.6. Additional Robustness Test

To further assess the robustness of the baseline findings, this study conducts four additional robustness checks from the perspectives of variable transformation, outlier treatment, sample composition, and sample period. Specifically, the dependent variable is first log-transformed; all continuous variables are then winsorized at the 1st and 99th percentiles; the four municipalities directly under the central government—Beijing, Tianjin, Shanghai, and Chongqing—are excluded; and the sample period is shortened to 2008–2021. As reported in Table 6, the estimated coefficients of the DID term are 0.206, 0.014, 0.016, and 0.013, with corresponding t-statistics of 5.32, 5.44, 4.36, and 4.04, respectively. All coefficients remain positive and statistically significant at the 1% level. Although the magnitude of the coefficient in the log-transformed specification is not directly comparable with those in the other models because of the change in measurement scale, its sign and statistical significance remain consistent with the baseline results. Moreover, the positive policy effect persists after mitigating the influence of extreme observations, excluding municipalities with distinctive administrative status and resource endowments, and shortening the sample period. These findings indicate that the baseline results are not driven by a particular functional form, outliers, special-city samples, or the choice of sample period, thereby providing further evidence for the robustness and reliability of the estimated positive effect of the “Information for the People” pilot policy on manufacturing supply chain capabilities.

Table 6. Robustness test results.

Variables	(1)	(2)	(3)	(4)
	Log-Transformed	1% Winsorization	Excluding Municipalities	Shortened Sample Period
DID	0.206 *** (5.32)	0.014 *** (5.44)	0.016 *** (4.36)	0.013 *** (4.04)
Controls	Yes	Yes	Yes	Yes
City fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	4882	4882	4810	3801
Within R ²	0.7009	0.4900	0.3978	0.3120

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$).

4.3. Heterogeneity Analysis

4.3.1. Regional Heterogeneity Across the Eight Economic Regions

To further examine regional differences in the impact of the “Information for the People” pilot policy on manufacturing supply chain capabilities, this study divides the sample cities into eight economic regions and conducts separate regressions for each region. The regional grouping follows the classification framework of China’s four major zones and eight comprehensive economic regions proposed by the Development Research Center of the State Council. The detailed classification is reported in Appendix A, Table A1. To further examine whether the estimated policy effects differ significantly across regions, this study conducts a formal group difference test. The null hypothesis is that the policy effects are equal across the eight comprehensive economic regions. As reported in Panel A of Table 7, the p -value of the group difference test is 0.0651, indicating that the differences in policy effects across regions are statistically significant at the 10% level. Therefore, the regional heterogeneity identified by the subgroup regressions is further supported by the formal coefficient-difference test. Overall, the policy effect is more pronounced in the Southern Coastal, Eastern Coastal, Southwest, Northwest, and Middle Reaches of the Yellow River regions, while the effect is relatively weaker or insignificant in the Northern Coastal and Middle Reaches of the Yangtze River regions.

Table 7. Heterogeneity test results.

Panel A. Regional Heterogeneity across the Eight Economic Regions								
Variables	Northeast	Northern Coastal	Eastern Coastal	Southern Coastal	Middle Reaches of Yellow River	Middle Reaches of Yangtze River	Southwest	Northwest
Policy	0.0036 * (0.0021)	0.0013 (0.0159)	0.0272 ** (0.0130)	0.0493 *** (0.0179)	0.0079 ** (0.0037)	0.0056 (0.0044)	0.0169 ** (0.0081)	0.0037 ** (0.0014)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	611	521	450	575	822	934	807	162
Group Difference Test (p -value)	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651

Table 7. Cont.

Panel B. Heterogeneity by Policy Implementation Duration			
Variables	Short Term (0–2 Years)	Medium Term (3–5 Years)	Long Term (6 Years or More)
Policy	0.0072 *** (0.0024)	0.0194 *** (0.0048)	0.0296 *** (0.0073)
Controls	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	6138	6138	6138

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

4.3.2. Heterogeneity by Policy Implementation Duration

To examine whether the policy effect changes with the duration of implementation, this study divides the policy period into the short term, covering zero to two years; the medium term, covering three to five years; and the long term, covering six years or more. The three policy-duration variables are simultaneously included in the same two-way fixed-effects model. As reported in Panel B of Table 7, the estimated coefficients for the short-, medium-, and long-term policy effects are 0.0072, 0.0194, and 0.0296, respectively, and all are statistically significant at the 1% level.

The gradual increase in the estimated coefficients indicates that the policy effect has clear persistence and cumulative characteristics. During the initial stage, the policy primarily improves manufacturing supply chain capabilities by strengthening digital infrastructure and information transmission. As policy implementation continues, deeper digital technology adoption, more efficient resource allocation, and stronger coordination among supply chain participants further release the policy benefits. Therefore, the policy generates not only an immediate positive effect but also increasingly pronounced medium- and long-term effects.

5. Mediating Mechanisms

5.1. Testing for Mediating Effects

To further identify the mechanism through which the policy affects manufacturing supply chain capabilities, this study uses talent factor inflow (TFI) as the mediating variable and conducts a stepwise mediation test. Table 8 reports the estimation results based on a consistent sample.

Table 8. Mediation effect result.

Variables	(1)	(2)	(3)
	MSCC	TFI	MSCC
Policy	0.0156 *** (4.33)	3.1103 *** (2.89)	0.0138 *** (4.62)
TFI			0.0006 *** (3.4)
Controls	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4713	4713	4713
Within R-squared	0.4008	0.0939	0.4333

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$).

Column (1) examines the total effect of policy implementation on manufacturing supply chain capabilities. The coefficient of Policy is 0.0156 and is statistically significant at the 1% level, indicating that policy implementation significantly improves the level of manufacturing supply chain capabilities after controlling for relevant factors. Column (2) further examines the effect of policy implementation on the mediating variable, TFI. The coefficient of Policy is 3.1103 and is significant at the 1% level, suggesting that policy implementation significantly promotes talent factor inflow. This finding implies that the policy shock can attract talent resources to pilot cities by improving the urban development environment and strengthening cities' factor-attraction capacity.

Column (3) further incorporates TFI into the baseline model. The coefficient of TFI is 0.0006 and is significant at the 1% level, indicating that talent factor inflow significantly contributes to the improvement of manufacturing supply chain capabilities. Meanwhile, the coefficient of Policy remains significantly positive at 0.0138, but declines compared with the total-effect coefficient of 0.0156 in Column (1). This result suggests that TFI plays a significant partial mediating role in the relationship between policy implementation and manufacturing supply chain capabilities. Based on the product of coefficients, the indirect effect transmitted through TFI is approximately 0.0019, accounting for about 11.9% of the total effect. This indicates that talent factor inflow constitutes an important transmission channel through which the policy takes effect.

These findings further indicate that policy implementation can enhance cities' attractiveness to talent factors, promote the agglomeration of talent resources, and subsequently optimize the efficiency of innovation factor allocation. As the most dynamic and initiative-driven factor in innovation activities, talent inflow not only improves cities' knowledge production capacity and technology transformation efficiency, but also facilitates the coordinated allocation of innovation resources such as capital, technology, and information. Consequently, talent factor inflow strengthens the positive effect of the policy on the level of manufacturing supply chain capabilities.

5.2. Moderating Effect

Table 9 reports the moderating effect of financial development on the relationship between policy implementation and manufacturing supply chain capabilities. The coefficient of Policy is 0.0105 and is significant at the 1% level, indicating that policy implementation significantly improves MSCC after controlling for city fixed effects, year fixed effects, and a set of city-level control variables.

Table 9. Regulatory effect result.

Variables	MSCC
Policy	0.0105 *** (0.0028)
FD	−0.0014 (0.0021)
Policy × FD	0.0081 ** (0.004)
Controls	Yes
City FE	Yes
Year FE	Yes
Observations	4882
Within R-squared	0.3737

Note: The values in parentheses represent t-statistics, with significance levels denoted as *** ($p < 0.01$), ** ($p < 0.05$).

The coefficient of FD is negative but statistically insignificant, suggesting that financial development alone does not exert a significant direct effect on MSCC in this specification. More importantly, the coefficient of the interaction term Policy $\times$ FD is 0.0081 and is significant at the 5% level. This positive and significant interaction term indicates that financial development positively moderates the effect of policy implementation on MSCC. In other words, the promoting effect of the policy on manufacturing supply chain capabilities is stronger in cities with higher levels of financial development.

This finding suggests that financial development enhances cities' capacity to absorb, transform, and utilize the institutional incentives and resource allocation effects generated by the policy. Cities with higher financial development are better able to translate policy advantages into improvements in innovation factor allocation through stronger knowledge accumulation, technology absorption, and innovation resource integration capabilities. Therefore, the results confirm that financial development strengthens the positive impact of policy implementation on MSCC, thereby supporting the moderating-effect hypothesis.

6. Conclusions and Discussion

Using a DID framework, this study examines the impact of digital infrastructure on manufacturing supply chain capabilities by treating the "Information for the People" pilot city program as a quasi-natural experiment. Based on panel data from Chinese prefecture-level cities, the results show that digital infrastructure significantly improves manufacturing supply chain capabilities. Specifically, enhanced digital connectivity and information-sharing capacity help reduce information frictions, strengthen coordination among upstream and downstream firms, and improve the resilience and operational efficiency of manufacturing supply chains. This finding remains robust after a series of tests, including the parallel trend test, placebo test, controls for concurrent policy interference, variable transformation, outlier treatment, and sample adjustment.

The heterogeneity analysis reveals clear regional and temporal differences in the effects of digital infrastructure. Across the eight economic regions, the policy effect is most pronounced in the Southern Coastal and Eastern Coastal regions, and is also significantly positive in the Northeast, the Middle Reaches of the Yellow River, the Southwest, and the Northwest. By contrast, the estimated coefficients for the Northern Coastal region and the Middle Reaches of the Yangtze River are positive but statistically insignificant. Moreover, the policy effect increases with the duration of implementation, indicating that digital infrastructure development has persistent and cumulative effects. These findings suggest that the effectiveness of digital infrastructure policies depends on regional industrial foundations, digital absorptive capacity, and supporting institutional conditions.

Further analysis helps explain the internal mechanism and boundary conditions of this effect. The mechanism test shows that innovation-oriented talent inflow serves as an important transmission channel through which digital infrastructure enhances manufacturing supply chain capabilities. By improving the local digital environment, information accessibility, and innovation conditions, digital infrastructure helps attract high-skilled and innovation-oriented talent, thereby strengthening firms' technological absorption, digital application, and supply chain coordination capabilities. In addition, the moderating-effect analysis shows that financial development strengthens the positive impact of digital infrastructure on manufacturing supply chain capabilities. Cities with higher levels of financial development are better able to provide external financing, support firms' digital transformation, and transform digital infrastructure advantages into supply chain upgrading.

This study investigates the ways in which digital technologies augment the capabilities of manufacturing supply networks. Using the DID framework, we provide evidence

that attributes the marked advancement in manufacturing supply chain capabilities directly to the expansion of digital foundations. This substantiates Hypothesis 1 posited in this study, further illustrating that digital infrastructure growth transcends basic physical connectivity, dismantling information silos and diminishing transaction costs across connections. Through the optimization of resource allocation efficiency, digital infrastructure efficiently reduces information asymmetry across upstream, midstream, and downstream firms, thereby improving the overall risk resilience and modernization of industrial chains at the macro level. This conclusion corresponds with the research findings of other scholars. Technological innovation drives the transformation of traditional supply chain management toward digitalized systems within the online economy [51]. Zhao (2023) [24], utilizing dynamic capability theory, offers a technique whereby supply chain digitalization augments resilience and hence enhances overall performance. Subsequent analysis indicates that the digital economy's promotional impact on the modernization of advanced manufacturing industrial chains demonstrates a nonlinear characteristic of growing marginal impacts, corroborating the conclusions of this paper.

Second, this study provides meso-macro empirical evidence for digital empowerment theory, showing that digital infrastructure promotes the upgrading and resilience of manufacturing supply chains by improving factor quality, information connectivity, and resource allocation efficiency. This finding is consistent with the view that digital technologies can reshape production organization and supply chain coordination by replacing or complementing traditional physical processes. For example, Perano et al. (2023) [52] introduced the concept of “de-materialization,” arguing that digital technologies, such as digital twins, can substitute for physical prototypes and improve supply chain flexibility and environmental performance. The mechanism analysis further shows that innovation-oriented talent inflow is an important transmission channel through which digital infrastructure enhances manufacturing supply chain capabilities. The deployment of digital infrastructure reduces barriers to knowledge acquisition, skills training, and interregional information exchange, thereby improving the local innovation environment and strengthening cities' attractiveness to high-skilled and innovation-oriented talent. Such talent inflow enhances firms' technological absorption, digital application, and supply chain coordination capabilities, supporting Hypothesis 2. This result suggests that the supply-chain-enhancing effect of digital infrastructure depends not only on technological connectivity itself, but also on whether cities can transform digital advantages into human capital accumulation and innovation capacity.

Third, the moderating-effect analysis indicates that financial development strengthens the positive relationship between digital infrastructure and manufacturing supply chain capabilities, thereby supporting Hypothesis 3. A more developed financial system can ease financing constraints, improve capital allocation efficiency, and provide the financial resources needed for firms to adopt digital technologies, upgrade production systems, and reorganize supply chain processes [53]. Therefore, financial development acts as an important boundary condition: in cities with stronger financial support, the advantages of digital infrastructure are more effectively transformed into improvements in supply chain coordination, resilience, and modernization [54].

Overall, the contribution of this study lies not simply in verifying the relationship between digital infrastructure and manufacturing supply chain capabilities, but in explaining the internal logic through which manufacturing supply chain capabilities are enhanced from the perspective of macro-level public digital infrastructure. First, this study incorporates digital infrastructure into the analytical framework of manufacturing supply chain capability enhancement, thereby supplementing existing studies that mainly focus on enterprise digital transformation, global value chain specialization, and industrial upgrading.

Second, this research develops a multidimensional indicator system for manufacturing supply chain capabilities, encompassing high-end positioning, green development, and resilience [24,50]. The revised indicator system incorporates technological innovation, environmental performance, industrial organization, and operating capacity, thereby providing a comprehensive framework for assessing manufacturing supply chain upgrading. Third, based on the policy shock of the “Information for the People” pilot city program, this study adopts a multi-period DID approach for causal identification, providing more credible empirical evidence on how digital infrastructure promotes manufacturing supply chain capabilities. Finally, this study reveals the transmission mechanism and boundary condition of digital infrastructure from the perspectives of innovation-oriented talent inflow and financial development. The findings show that digital infrastructure not only reduces transaction costs by improving information connectivity, but also enhances the resilience, coordination efficiency, and modernization level of manufacturing supply chains by promoting talent agglomeration, technological absorption, and financial support. These findings deepen the understanding of the economic effects of digital infrastructure and clarify the theoretical and empirical contributions of this study. In practice, due to the context-dependent utility of digital infrastructure, policy formulation must forgo uniform approaches in favor of tailored strategies.

International policy practice provides a useful reference for understanding how digital infrastructure can be embedded into manufacturing supply chain modernization. The systematic enhancement of digital infrastructure in the United States has effectively propelled the modernization and upgrading of manufacturing supply chains. Within the “CHIPS for America” initiative, the United States has developed a sophisticated research and development and production system focused on semiconductor manufacturing, utilizing advanced digital infrastructure like digital twins, the industrial internet, and high-performance computing. Manufacturing innovation platforms such as SMART USA have developed high-precision digital twin systems to facilitate virtual modeling and optimization of manufacturing processes, equipment operations, and supply chain coordination. This markedly improves predictability and resource allocation efficiency in industrial processes. These digital platforms concurrently enable data exchange and collaborative decision-making among upstream and downstream firms, equipment suppliers, and research institutes, thereby improving supply chain transparency and resilience. This approach illustrates that digital infrastructure enhances company efficiency while transforming information sharing and collaboration methods, advancing manufacturing supply chains towards more intelligence, coordination, and value-added capabilities.

Although the institutional context differs from that of China, the U.S. experience highlights a similar logic: digital infrastructure produces stronger supply chain effects when it is combined with innovation platforms, skilled talent, financial support, and inter-firm coordination mechanisms. Based on the empirical evidence, several strategic recommendations emerge for the pursuit of manufacturing supply chain sophistication amidst the ongoing digital revolution. First, strengthening digital infrastructure remains a foundational condition for enhancing supply chain coordination and operational efficiency; rather than being limited to physical investment, digital infrastructure functions as a platform that enables information integration throughout different stages of the manufacturing value chain. Policies that promote the deployment and effective utilization of digital networks, computing capacity, and industrial internet systems can reduce information frictions, improve production predictability, and enhance inter-firm coordination. Integrating digital infrastructure into critical phases such as research and development, production planning, logistics, and supply chain management helps enhance the coherence and robustness of manufacturing supply chains. Second, the effectiveness of digital infrastructure critically

depends on complementary investments in human capital. Digital transformation does not automatically translate into supply chain upgrading unless the workforce possesses the skills required to absorb and apply new technologies. Policymakers should therefore emphasize the development of a workforce that combines digital competencies with manufacturing expertise. Expanding access to digital skills training, promoting interdisciplinary education, and encouraging firm-level learning can enhance the alignment between labor supply and the evolving demands of digitally enabled manufacturing systems. Thus, the buildup of human capital functions as a crucial conduit by which digital infrastructure enhances value-added and fortifies supply chains. Third, enhancing institutional frameworks for coordination and resource distribution is crucial to fully harness the advantages of digital infrastructure. Digital technologies can enhance transparency and traceability along supply chains, enabling more efficient allocation of financial and productive resources toward critical and high-value segments. Policies that support data sharing frameworks, platform-based coordination, and digitally enabled financial services can strengthen linkages among firms, financial institutions, and innovation actors. Such mechanisms not only improve allocative efficiency but also enhance supply chain robustness in the face of external shocks, contributing to more sustainable and adaptive manufacturing systems.

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Appendix A

Table A1. Classification of the eight comprehensive economic regions.

Economic Region	Provinces/Municipalities Included
Eastern Coastal Comprehensive Economic Region	Jiangsu, Zhejiang, Shanghai
Northern Coastal Comprehensive Economic Region	Beijing, Tianjin, Hebei, Shandong
Southern Coastal Comprehensive Economic Region	Fujian, Guangdong, Hainan
Middle Reaches of the Yangtze River Comprehensive Economic Region	Hunan, Hubei, Anhui, Jiangxi
Middle Reaches of the Yellow River Comprehensive Economic Region	Shanxi, Henan, Shaanxi, Inner Mongolia
Greater Northwest Comprehensive Economic Region	Gansu, Ningxia, Qinghai, Xinjiang
Greater Southwest Comprehensive Economic Region	Sichuan, Chongqing, Yunnan, Guizhou, Guangxi
Northeast Comprehensive Economic Region	Liaoning, Jilin, Heilongjiang

Table A2. List of the 80 cities included in the “Information for the People” national pilot policy.

No.	City	No.	City	No.	City
1	Shenzhen	28	Jinan	55	Yinchuan
2	Foshan	29	Weifang	56	Jiaxing
3	Suzhou	30	Yingtian	57	Benxi
4	Wuhu	31	Changchun	58	Urumqi
5	Guangzhou	32	Siping	59	Chengdu
6	Wenzhou	33	Weihai	60	Linfen
7	Xiamen	34	Fuyang	61	Guiyang
8	Dongguan	35	Fuzhou	62	Quanzhou
9	Chongqing	36	Dalian	63	Golmud
10	Xianyang	37	Luoyang	64	Daqing
11	Hangzhou	38	Xiaogan	65	Yiyang
12	Xi'an	39	Xinyu	66	Shenyang
13	Liaoyuan	40	Huai'an	67	Qinhuangdao
14	Hohhot	41	Qingdao	68	Yuxi
15	Wuxi	42	Guilin	69	Shizuishan
16	Ningbo	43	Zhengzhou	70	Yuncheng
17	Yichang	44	Baiyin	71	Beijing
18	Wuzhou	45	Nanning	72	Shihezi
19	Shanghai	46	Jiyuan	73	Xiangtan
20	Shangrao	47	Neijiang	74	Chengde
21	Wuhai	48	Qitaihe	75	Lhasa
22	Tianjin	49	Lanzhou	76	Baoshan
23	Hefei	50	Shijiazhuang	77	Aral
24	Putian	51	Wuzhong	78	Karamay
					Wenshan
					Zhuang and
					Miao
					Autonomous
					Prefecture
					Yining
25	Mianyang	52	Xiangyang	79	
26	Changsha	53	Liaoyang	80	
27	Harbin	54	Dunhuang		

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