Educational Innovation Research, 2026, Volume 4, Issue 7
https://bbwpublisher.com/journal/EIR
Online ISSN: 3029-1852
Print ISSN: 3029-1844

The Formation Logic of Regional Differentiation in the Digital Transformation of the Equipment Manufacturing Industry Under the Threshold of Digital Infrastructure

Pan Wang, Zhizhong Jing, Yuru Lian, Youhang Peng

Sichuan Technology and Business University, Meishan, Sichuan 620000, China

Copyright: © 2026 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The digital transformation of the equipment manufacturing industry exhibits a significant and continuously widening trend of regional divergence in the spatial dimension. Based on threshold theory, this study systematically elucidates the formation logic of regional differentiation under the constraints of digital infrastructure thresholds. The research indicates that the investment threshold of digital infrastructure, the threshold of digital human capital, and the composite threshold of factor synergy are intertwined and progress layer by layer, jointly constituting a constraint system for the digital transformation of the equipment manufacturing industry. Differences in factor endowments, geographic spatial decay, and variations in policy coordination are the three underlying causes of regional divergence. Amplified by threshold effects, these three factors overlap with each other, causing the transformation gap between early-movers and late-comers to exhibit a self-reinforcing and solidifying trend. Overcoming these thresholds requires implementing a trinity strategic combination: proactive layout of infrastructure, simultaneous introduction and cultivation of digital talent, and category-based regional policy implementation. This study provides a theoretical reference for understanding the formation mechanism of the regional digital divide and promoting coordinated regional development.

Keywords: Digital infrastructure; Threshold effect; Equipment manufacturing industry; Regional divergence

Online publication: July 26, 2026

1. Introduction

The digital transformation of the equipment manufacturing industry exhibits a significant trend of regional divergence. Relying on well-developed digital infrastructure and abundant human capital reserves, the eastern coastal areas are undergoing digital transformation significantly faster than the central and western regions. In contrast, due to weak digital infrastructure and a shortage of professional talent, some western cities have long remained at the stage of equipment automation in their digital transformation, struggling to make the leap to the intelligent stage. The “Overall Layout Plan for the Construction of Digital China,” issued by the

CPC Central Committee and the State Council, explicitly calls for consolidating the foundation of Digital China and unblocking the main arteries of digital infrastructure [1].

Existing literature has explored the regional differences in the digital transformation of the manufacturing industry from multiple dimensions. For instance, Wang et al. found that the digital economy promotes the high-quality development of the manufacturing industry by enhancing enterprise innovation capabilities, and this effect is subject to threshold constraints from the level of opening-up and the intensity of environmental regulation [2]. Yan et al. examined the impact mechanism of technological development policies on the high-quality development of the manufacturing industry [3]. Lan et al. found that digital infrastructure promotes the upgrading of manufacturing enterprises by alleviating resource constraints [4]. However, existing research suffers from three main shortcomings: First, most studies adopt empirical measurement methods, providing insufficient explanation of the theoretical logic behind the formation of this divergence; second, research on threshold effects mostly focuses on single factors, lacking a systematic analysis of factor synergy thresholds; third, there is a lack of targeted research on special regions such as western science and technology cities. Threshold theory posits that as a precursor capital, the construction level of digital infrastructure must reach a specific threshold to generate a significant transformation promotion effect. Only when multiple key factors simultaneously meet threshold requirements can the potential momentum of digital transformation be fully unleashed. This provides a theoretical perspective for understanding regional divergence.

2. Formation mechanism of thresholds

2.1. Infrastructure investment threshold

The infrastructure investment threshold constitutes the primary constraint on the digital transformation of the equipment manufacturing industry. In terms of hardware facilities, the procurement of core equipment such as smart equipment, industrial sensors, and Programmable Logic Controllers (PLCs) requires substantial capital investment. Furthermore, the digital retrofitting of existing equipment involves hardware interface upgrades, communication protocol modifications, and control system replacements, resulting in prohibitively high upfront costs and prolonged payback periods [5]. For small and medium-sized equipment manufacturing enterprises in central and western regions, which often operate with limited profit margins and weak financing capabilities, this lump-sum capital expenditure represents an insurmountable financial barrier. In terms of network environment, low-latency, high-reliability, and wide-coverage network connectivity serves as the foundational condition for real-time industrial data collection, remote monitoring, and distributed collaborative control. However, network infrastructure construction in some central and western regions remains relatively lagging. Consequently, even if enterprises acquire smart equipment, unstable network connections due to insufficient bandwidth and excessive latency prevent them from achieving stable networking, thereby hindering the full realization of equipment efficacy.

2.2. Digital human capital threshold

The digital human capital threshold represents a critical bottleneck constraining the digital transformation of the equipment manufacturing industry. The demand for digital human capital in the equipment manufacturing sector exhibits compound characteristics. It requires practitioners not only to master traditional engineering skills such as mechanical design, process manufacturing, and assembly and debugging, but also to possess digital technology capabilities including data analysis, algorithm modeling, and industrial software

application. Simultaneously, they must understand industrial mechanisms and business scenarios to implement digital solutions in real production environments. However, the supply of such compound talents is severely insufficient. Particularly in equipment manufacturing enterprises in western regions, employees' digital skills generally remain at the level of basic office software operation, making it difficult for them to handle tasks such as intelligent production line operation and data value mining [6]. Concurrently, the agglomeration trend of high-end digital talent in eastern developed regions continues to intensify, further exacerbating the imbalance in human capital distribution between regions and trapping central and western regions in a vicious cycle of talent shortage, transformation lag, and brain drain.

2.3. Factor synergy composite threshold

Digital infrastructure and digital human capital do not function independently; rather, they exhibit a significant complementary relationship and synergistic effect, jointly constituting the factor synergy composite threshold. From the perspective of factor complementarity, digital infrastructure provides the physical carrier and data source for human capital to exercise their skills, while digital human capital injects value-generating application capabilities into the infrastructure. Functionally, the two are mutually prerequisite and reinforcing. In other words, without advanced infrastructure and skilled operation and maintenance personnel, expensive smart equipment will remain idle or operate at low efficiency, making return on investment impossible. Conversely, without the support of corresponding infrastructure, even with a talent pool, their digital skills cannot be transformed into real productive forces, ultimately leading to talent attrition [7]. The factor synergy composite threshold implies that isolated investment in a single factor, even if it reaches a relatively high level, is unlikely to yield the desired transformation outcomes. Only when infrastructure and human capital are synergistically matched and mutually supportive in terms of quantity, quality, and structure can the promotion effect of digital transformation be fully realized and generate scale returns. The existence of this threshold precisely explains why some regions, despite massive investments in a single domain, have achieved minimal results.

3. Logic of regional divergence

3.1. Causes of factor endowment differences

Regional divergence stems primarily from the initial differences in factor endowments. After long-term reform, opening-up, and industrial accumulation, the eastern coastal areas have formed substantial capital reserves. Local governments there possess robust financial strength, enabling them to provide sustained funding guarantees for the construction of digital infrastructure, the establishment of Industrial Internet platforms, and the improvement of public service systems. Concurrently, the eastern region is densely populated with universities and research institutions, ensuring a plentiful supply of high-level engineering and technical talent, thereby forming a dual advantage where capital and talent mutually reinforce each other. In contrast, the central and western regions suffer from insufficient capital accumulation and limited capacity of local finances to support infrastructure investment. Coupled with severe outflows of high-end talent, their factor endowments are at a distinct disadvantage. More critically, the differences in factor endowments do not statically affect the transformation process; rather, they are further amplified through threshold effects. Once the eastern region crosses the synergy threshold, it can achieve significant scale returns and positive feedback loops, continuously enhancing its development momentum. Conversely, the central and western

regions, lingering below the threshold for extended periods, find it difficult for factor inputs to yield effective outputs, causing the endowment gap to widen over time and regional divergence to become self-reinforcing.

3.2. Logic of geographic spatial decay

The spatial spillover effects of digital transformation follow the law of geographic decay. The diffusion of digital technology and knowledge dissemination exhibit significant spatial limitations. Although information and communication technologies can theoretically break through geographical distance constraints to achieve long-distance transmission of data and information, face-to-face technical exchanges and collaborative innovation activities still heavily rely on geographic proximity. A large amount of process experience, problem-solving solutions, and scenario-based knowledge that the digital transformation of the equipment manufacturing industry relies upon belongs to tacit knowledge that is difficult to codify and transmit over long distances. Its dissemination highly depends on face-to-face interactions among personnel and collaborative networks within industrial clusters. Constrained by this, the experiential knowledge formed by equipment manufacturing enterprises in the eastern region during digital transformation primarily spreads and diffuses within the local area, making it difficult to effectively radiate to the distant central and western regions. Under the dual constraints of inferior factor endowments and geographic isolation, the self-accumulation capacity of the central and western regions is severely insufficient, ultimately leading to the continuous solidification of regional divergence.

3.3. Logic of policy coordination differences

Regional differences in the degree of policy coordination further amplify the divergence in digital transformation. In the eastern region, local governments have ample fiscal resources, enabling them to simultaneously advance multiple policies such as infrastructure construction, talent cultivation and recruitment, and industrial support incentives, thereby creating a synergistic amplification effect among policies. Digital infrastructure construction and talent introduction policies complement each other: improvements in infrastructure enhance the region's attractiveness to high-end talent, while the agglomeration of talent stimulates demand for higher-level infrastructure, forming a positive cycle that accelerates the crossing of thresholds. In contrast, constrained by fiscal limitations, policy implementation in the central and western regions often exhibits a fragmented manner, lacking effective connections between various policies. Thus, it can be seen that when the degree of policy coordination is high, various factor shortcomings can be quickly addressed and mutually reinforced, thereby accelerating the threshold-crossing process. When the degree of policy coordination is low, the isolated implementation of single policies is unlikely to produce systemic transformation effects, which not only wastes limited fiscal resources but also misses the window of opportunity for transformation, further solidifying regional divergence.

4. Pathways to crossing the thresholds

4.1. Proactive layout of infrastructure

The primary pathway to crossing the digital infrastructure threshold is to implement a proactive layout strategy for infrastructure. For the central and western regions, the construction of digital infrastructure should not simply copy the mature models of the eastern regions. Instead, it should be deployed differentially and precisely based on the characteristics of local leading equipment manufacturing industries and their actual

transformation needs. In terms of hardware infrastructure, priority should be given to building Industrial Internet Identifier Resolution nodes and regional data centers tailored to the equipment manufacturing sector, thereby lowering the barrier to enterprise access [8]. Regarding network infrastructure, efforts should accelerate the deep coverage of 5G networks and gigabit optical networks in key industrial parks and equipment manufacturing workshops to meet the demands of low-latency transmission and real-time control of industrial data. In terms of public service platforms, shared and open digital laboratories and technology pilot transformation platforms should be established, enabling small and medium-sized enterprises to access experimental verification environments and technical support services required for digital transformation at a lower cost, thus avoiding redundant construction and resource waste.

4.2. Simultaneous introduction and cultivation of digital talent

Crossing the digital human capital threshold requires implementing a talent strategy that emphasizes both introduction and cultivation. Regarding talent recruitment, targeted special talent introduction plans should be formulated in close alignment with the practical demand for compound talents in the digital transformation of the equipment manufacturing industry. These plans should offer regionally competitive salaries, housing security, and research start-up funds to attract high-end digital talents from the eastern region to flow orderly to the central and western regions. Concurrently, a flexible talent introduction mechanism should be established. Through project cooperation, technical consulting, and the "weekend engineer" scheme, the principle of "not necessarily owning them but making good use of their expertise" should be adopted, fully leveraging external intellectual resources to serve the transformation of local enterprises. In terms of talent cultivation, local universities and vocational colleges should be encouraged to optimize their curricula by adding emerging majors such as Intelligent Manufacturing Engineering and Industrial Internet Technology. Support should also be given to joint construction of practical training bases by equipment manufacturing enterprises and educational institutions to cultivate practical digital skills talents who are rooted in local communities and familiar with on-site operations.

4.3. Category-based policies for regional development

Crossing the factor synergy composite threshold requires implementing category-based regional policies. Specifically, for underdeveloped regions that have not yet crossed any single threshold, the policy focus should be on infrastructure popularization and basic talent cultivation, striving to address the most critical shortcomings to lay the foundation for future threshold crossing. For regions that have crossed a single threshold but not yet the synergy threshold, the policy priority should shift to shoring up weaknesses and promoting factor synergy, driving the mutual matching of infrastructure and talent teams to form a joint force. For developed regions that have already crossed the synergy threshold, the policy emphasis should be on optimizing the innovation ecosystem and promoting in-depth application, encouraging exploration of cutting-edge technologies and innovation in business models to play a demonstrative and leading role [9]. Category-based policy implementation requires local governments to accurately identify the threshold stage of their region to avoid resource waste caused by policy misalignment. At the same time, counterpart collaboration and benefit-sharing mechanisms between regions should be established and improved. Through joint construction via industrial transfer, mutual learning through experience exchange, and sharing of platform resources, the diffusion of digital transformation experience and technical capabilities to underdeveloped regions should be promoted, gradually narrowing the regional digital divide.

5. Conclusion

During the 15th Five-Year Plan period, the digital transformation of the equipment manufacturing industry enters a stage of in-depth advancement. The issue of regional divergence will directly affect the enhancement of the manufacturing industry's overall competitiveness and the formation of a coordinated regional development pattern. Based on threshold theory, this study indicates that this divergence is not a simple difference in transformation progress, but rather the result of the combined effect of the digital infrastructure investment threshold, the digital human capital threshold, and the factor synergy composite threshold. Amplified by threshold effects, the gap between early-movers and late-comerswill self-reinforce and tend to solidify [10]. Consequently, the key to crossing these thresholds lies not in additional investment in a single factor, but in the coordinated linkage of infrastructure, talent, and policy initiatives, as well as in promoting the diffusion of transformation experience to underdeveloped regions through counterpart collaborationand platform sharing.

It should be noted that this paper focuses on the theoretical explanation of the formation logic. The specific levels of these three thresholds and their regional heterogeneitystill await empirical testing. Subsequent research could integrate inter-provincial panel data with micro-enterprise datato measure threshold values, and establish a sound dynamic monitoring and evaluation mechanism for the transformation process, thereby providing a basis for the precise adjustment of regional policies.

Funding

2026 Municipal Social Science Research Planning Project of Mianyang Federation of Social Sciences, "Research on Performance Evaluation and Improvement Path of Digital Transformation of Equipment Manufacturing Industry in China Science and Technology City from the Perspective of Four-Dimensional Synergy" (Project No.: MY2026ZC069)

Disclosure statement

The authors declare no conflict of interest.

References

[1] CPC Central Committee, State Council, 2023, Overall Layout Plan for the Construction of Digital China, visited on July 10, 2026, https://www.gov.cn/zhengce/2023-02/27/content_5743484.htm.

[2] Wang S, Xue Z, 2024, How Does the Digital Economy Empower the High-Quality Development of Manufacturing Industry?—Based on the Test of Mediation Effect and Threshold Effect. Journal of the Knowledge Economy, 16(2): 7164–7190.

[3] Yan B, Wang Y, 2024, Evaluating the Impact of Technological Development Policy on the High-Quality Development of the Manufacturing Industry: Mechanisms and Threshold Effects. Heliyon, 10(16): e35858.

[4] Lan X, Hu Z, Pei X, et al., 2026, Does Digital Infrastructure Promote the Upgrading of Manufacturing Enterprises? Evidence From China. Growth and Change, 57(1): e70101.

[5] Yishake R, Sui D, Lv X, 2026, The Impact of Digital New Infrastructure on the Balanced Development of Digital–Real Economy Integration: Evidence for Sustainable Regional Growth. Sustainability, 18(10): 4636.

[6] Jia X, Li X, 2025, Has Digital Infrastructure Accelerated Enterprises' Specialization? Evidence From China. Business Process Management Journal, 31(4): 1560–1578.

[7] Yang L, Liu Y, 2025, The Impact of Digital Infrastructure on Industrial Chain Resilience: Evidence From China's Manufacturing. Technology Analysis & Strategic Management, 37(10): 1112–1128.

[8] Yu C, Charlène I, Yingliang Z, et al., 2026, Digital Infrastructure Development and Its Impact on Labour Market Segmentation: The Mediating Role of Regional Innovation Capacity and Heterogeneous Effects. Applied Economics, 58(35): 7234–7245.

[9] Zhao G, Zhang J, Chen W, 2026, Environmental Regulation Policy and Enterprise Digital Transformation: Evidence From Low-Carbon City Policies in China. International Journal of Emerging Markets, 21(1): 212–243.

[10] Dong Y, Qi C, Gui C, et al., 2025, Spatial Spillover Effects of Digital Infrastructure on Food System Resilience: An Analysis Incorporating Threshold Effects and Spatial Decay Boundaries. Foods, 14(9): 1484.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.