Proceedings of Business and Economic Studies, 2025, Volume 8, Issue 7
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Characteristics, Problems, and Countermeasures of the Development of Digital Industrial Clusters in Foshan City

Xinai Tang, Feifei Huang*, Ruzheng Jiang, Xiuwei Tan, Jiawei Huang

Guangzhou City University of Technology, Guangzhou 510000, Guangdong, China

**Author to whom correspondence should be addressed.*

Abstract: Digital industrial clusters are a core driver of high-quality regional economic development. Building on its strong manufacturing base, Foshan has actively developed digital industrial clusters, yet still faces practical challenges such as insufficient collaboration and digital imbalance. Based on complex network theory, this study employs a mixed-methods approach by combining the DBSCAN spatial clustering algorithm, questionnaire surveys, and multiple case studies, to examine the characteristics, challenges, and development pathways of Foshan's digital industrial clusters. The findings reveal that Foshan's digital industrial clusters exhibit a three-tier hierarchical structure of 'core, intermediate, and small' clusters. Core clusters are concentrated in Chancheng District, demonstrating combined advantages in quantity, scale, and density. However, the cluster development faces several prominent issues: micro and small enterprises constitute over 55% of the total, yet their digital coverage rate is only 12%; product homogenization leads to intense competition; significant disparities exist among enterprises in the timing and investment of digital transformation; and collaboration barriers arise from over-reliance on core enterprises and insufficient resource sharing. Accordingly, this study proposes recommendations including optimizing the clusters' hierarchical functions, constructing collaborative innovation platforms, implementing differentiated support policies, and deepening industry-university-research cooperation. The aim is to provide practical references for Foshan to overcome the dilemma of clusters being "physically agglomerated but not functionally integrated" and to promote successful digital upgrading.

Keywords: Foshan City; Digital industrial cluster; Complex network

Online publication: December 15, 2025

1. Introduction

In recent years, as a crucial component of digital economy development, digital industrial clusters have garnered widespread attention domestically and emerged as a prominent topic of contemporary interest. At the national level, China has successively introduced a series of policies to promote the development of digital industrial clusters. For instance, the State Council issued the *14th Five-Year Plan for Digital Economy Development* in 2021,

explicitly proposing to build internationally competitive digital industrial clusters and guide the digital industry toward clustering and large-scale development. The National Development and Reform Commission and the National Data Administration jointly released the *Key Tasks for Digital Economy Development in 2025*, which clearly outlines the phased cultivation and layout of digital industrial clusters with international competitiveness, regional pillar status, and regional characteristics.

Against this backdrop, Foshan has strategically identified the development of digital industrial clusters as a core driver for its industrial transformation and high-quality economic growth, leveraging its solid manufacturing foundation. In 2022, the Foshan Municipal Government formalized this strategy by issuing the Work Plan for Accelerating the Digital and Intelligent Transformation of Manufacturing Industrial Clusters in Foshan (2022–2025). The plan aims to capitalize on the city's profound manufacturing base to build high-quality digital industrial clusters and foster high-quality development. By the beginning of 2024, the Foshan Digital Economy Innovation and Agglomeration Zone had attracted over 70 high-quality digital economy projects, forming an industrial system characterized by "two trillion-Chinese Yuan clusters leading and twelve hundred-billion-Chinese Yuan clusters supporting".

However, the development of these digital industrial clusters faces several challenges. These include the dominance of traditional industries, the slow pace of digital transformation among small and medium-sized enterprises (SMEs), and difficulties in achieving economies of scale from digitalization efforts. To address these issues, this study employs complex network methods to analyze the characteristics of Foshan's digital industrial clusters. It further utilizes field surveys to examine the formation paths and identify existing problems. The ultimate aim is to provide actionable recommendations for fostering the coordinated, orderly, and differentiated development of digital industrial clusters, strategic emerging industrial clusters, and advanced manufacturing clusters, thereby accelerating the construction of a modern industrial system in Foshan.

So, do the existing literature adequately address the practical challenges of forming digital industrial clusters. While scholars have productively examined digital transformation from the perspectives of individual enterprises and supply chains. For example, Shi demonstrated how manufacturers optimize processes, retailers adopt digital marketing, and financial institutions leverage blockchain and big data as a significant gap remains [1]. Current research has yet to fully explore how enterprises can collectively drive digital development through clustering or how they can effectively collaborate within a complex industrial ecosystem to form competitive digital industrial clusters.

To address these theoretical and practical limitations, this study investigates the formation pathways of Foshan's digital industrial clusters by applying complex network theory. This framework enables an in-depth analysis of the connection patterns and interactive relationships among enterprises within the clusters, as well as the mechanisms governing the flow of information and resources. The research aims to identify the key factors influencing cluster formation and development, with the ultimate goal of systematically resolving the dilemmas of "physical agglomeration without functional integration" and homogeneous development. Consequently, this study provides empirical insights and practical recommendations for fostering Foshan's digital industrial clusters and contributes to promoting the high-quality development of its digital industry.

Literature review

The digital industry is an emerging industrial form centered on digital technology, supported by the circulation of

data factors, and encompassing areas such as digital technology R&D, digital product manufacturing, and digital service provision. Driven by the rapid advancement of technologies including big data, cloud computing, and artificial intelligence, the digital industry, resulting from the large-scale application and industrial transformation of digital technologies, has become a foundational and leading sector of the digital economy, representing a key domain for the development of new-quality productive forces.

The theory of industrial clusters offers a basis for understanding the agglomeration phenomenon within the digital industry. Porter first systematically elaborated the concept of industrial clusters in The Competitive Advantage of Nations, defining them as geographic concentrations of interconnected companies and institutions in a specific field [2]. Liu further summarized three core advantages of industrial clusters: they facilitate knowledge innovation and spillover, reduce costs, and help build regional brands [3]. As the digital industry matures, the need for collaboration grows more pronounced, leading to the geographic clustering of digital firms. Through this process, companies can achieve seamless data connectivity and supply chain integration, as well as refine the digital division of labor via open collaboration. This leads to the formation of digital industrial clusters characterized by specialized division of labor, economies of scale, knowledge spillovers, and cooperative competition.

The formation of digital industrial clusters is driven by three main factors as outlined:

(1) Government guidance acts as a key external driver. Jiao *et al.* noted that active government support can create a favorable policy environment, directly facilitating cluster formation [4]. At the national level, China has explicitly proposed pilot initiatives to establish data industry agglomeration zones, aiming to optimize industrial layout and accelerate the development of industrial ecosystems and scale advantages;

(2) Data factor empowerment serves as the core internal driver. Liu *et al.* argued that data factors foster cluster development by enabling innovation networks, empowering application scenarios, and promoting resource agglomeration [5]. In practice, the rapid expansion of the data industry and the continuous emergence of new data-driven business models underscore the critical role of data factors;

(3) Digital platforms provide technical support. Shi *et al.* observed that firms increasingly collaborate through digital platforms such as internet-based systems and the industrial internet [6]. By leveraging digital infrastructure, including networks and platforms, digital industrial clusters can extend industrial division of labor and collaboration from offline to online, attract global resources, and enhance collaborative efficiency and innovation capacity.

Notably, the widespread use of digital technologies has weakened the traditional reliance of industrial clusters on geographic proximity, allowing digital clusters to exhibit a “dual-carrier” trait, combining physical agglomeration with digital interconnection [7].

Studies have also affirmed the positive economic impact of digital industrial clusters. Wang’s research shows that such clusters strengthen regional innovation capacity by raising innovation efficiency, encouraging technology spillover, and facilitating collaborative innovation, thereby supporting regional economic growth [8]. Li and Lu contend that digital industrial clusters promote the platformization and ecological transformation of traditional clusters, improve supply chain coordination, and bolster technological innovation through resource pooling, network coordination, and reduced monopolization, thus driving high-quality development of the digital economy [9]. Ouyang emphasizes that digital industrial clusters foster industrial innovation through technological advances, deepen the integration of the digital and real economies, and guide value chain upgrading toward high-end segments, creating an endogenous growth driver for the digital economy and enhancing its international

competitiveness [10].

China's digital industry has now reached a substantial scale and continues to grow rapidly, serving as a new engine for digital economic development. This further highlights the importance of digital industrial clusters. However, most existing studies analyze the formation mechanisms and impacts of digital clusters from a macro, national perspective, while few examine their formation pathways from a regional viewpoint. This gap offers an entry point for the present study, which analyzes the case of Foshan through the lens of complex network theory.

3. Research design

3.1. Definition of research objects

This paper aims to explore the development characteristics and formation paths of digital industrial clusters in Foshan. The first step is to accurately identify these clusters. Given that the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) method does not require a pre-specified number of clusters, can identify agglomerations of arbitrary shapes, and is robust to outliers, it aligns well with the spatial characteristics of the digital industry. Therefore, building on the work of Xia and Liu on innovation networks in digital industrial clusters and Wang's empirical analysis, this study applies the DBSCAN spatial clustering algorithm to identify digital industrial clusters in Foshan.

Enterprise address data were collected from information platforms such as Tianyancha and Qichacha by searching for the keyword combination "Foshan City + digital economy-related". This yielded address information for approximately 120,000 enterprises whose business scope covers electronic information manufacturing, software and IT services, communications, internet-related industries, and digital product applications. Enterprises with abnormal operations, non-digital core businesses, or irregular registered capital were excluded, resulting in a "Foshan Digital Enterprise Basic Pool" of 15,305 firms in "communication equipment and electronic computer manufacturing", 12,200 labeled as "digital", and 84,256 classified as "information transmission, software and information technology services" for 2024. Latitude and longitude coordinates were then obtained using the Amap API, and the DBSCAN algorithm was implemented in Python to process the dataset. Clusters with more than 30 enterprises within a 500-meter radius were identified, including 65 clusters in communications, electronics, and digital sectors, and 285 clusters in information and software, resulting in approximately 350 digital industrial clusters. These were color-coded for visual distinction.

Following a "screening-clustering-sampling" logic, a longitudinal multiple-case study approach was adopted to examine typical cases from the identified clusters. Using survey data from 2021–2023 to trace evolutionary mechanisms, enterprises were sampled based on "cluster hierarchy + industrial attribute": leading firms (e.g., Midea) from core clusters, specialized service providers (e.g., Shunde's pan-home digital services) from medium-sized clusters, and supporting enterprises (e.g., Gaoming's cross-border e-commerce firms) from small clusters. This approach helps illustrate the dynamic mechanisms through which multiple factors shape cluster formation. Finally, based on cluster maps and patterns derived from complex network analysis, a structured questionnaire was administered. Stratified sampling was used across cluster types, with enterprises contacted by phone and email. Of the 300 questionnaires distributed, 246 valid responses were received. In addition, eight enterprises were selected for on-site research, each studied over 2–3 days through semi-structured interviews, observations of digital equipment operation, and documentation of team collaboration processes. This allowed an in-depth exploration of issues not fully captured by the questionnaire, such as inter-firm business conflicts and homogeneous competition.

3.2. Data analysis

Analysis of the 350 identified clusters reveals a distinct hierarchical structure among Foshan's digital industrial clusters, consisting of core large clusters, surrounding medium-sized clusters, and peripheral small clusters. The core clusters are located in Foshan's central urban areas, where they function as economic and technological innovation hubs anchored by leading enterprises. Medium-sized clusters, each with specialized focuses, engage in synergistic cooperation with the core clusters. Small clusters, composed mainly of SMEs and startups, exhibit high specialization and flexibility. This hierarchy reflects the flow of resources, collaborative innovation, and industrial chain integration within Foshan's digital industrial clusters.

Notably, core clusters are concentrated in Chancheng District. Between 2021 and 2023, the district introduced over 50 digital economy projects and developed a complementary industrial relationship with Shenzhen. Four enterprises in Chancheng were designated as digital demonstration factories, operating at a significantly larger scale than those in other core areas. As a regional economic and technology innovation center, Chancheng benefits from well-developed infrastructure and transport networks, providing a solid foundation for digital industry agglomeration.

As shown in **Table 1**, Chancheng District hosts 31 clusters in communications, electronics, and digital sectors, accounting for 46.3% of the city's total. Its leading cluster contains 178 enterprises, the highest in Foshan, and the average cluster density reaches 76.77 enterprises per cluster, significantly exceeding that of Nanhai District (66.36) and Shunde District (56.90). These advantages in number, scale, and density underscore Chancheng's strong position within the Guangzhou-Foshan Science and Technology Innovation Corridor.

In the information and software sector, a "one superpower, multiple strong players" hierarchy emerges. Chancheng District holds an absolute core position with 125 clusters (42.5% of the city total) and an average density of 116.03 enterprises per cluster, 34% higher than Nanhai and 77% higher than Shunde. Its leading cluster, comprising 604 enterprises, underscores its role as an engine of digital economy innovation in Foshan. Although Nanhai District has a similar number of clusters (107), its lower average density of 86.75 enterprises reveals a limitation in cluster strength. Shunde District, with 51 clusters averaging 65.51 enterprises, reflects the challenges of a fragmented ecosystem amid manufacturing transformation. It should leverage the open ecosystem of leading firms such as Midea to drive industrial upgrading.

Table 1. Clustering characteristics of core large clusters in Foshan's digital industry and information software sector

Industrial sector	Core indicator	ChanCheng District	Nanhai District	Shunde District	Gaoming District	Sanshui District
Communications, electronics and digital sectors	Number of clusters	31	25	10	-	-
	Maximum number of enterprises per cluster	178	173	95	-	-
	Average number of enterprises per cluster	76.77	66.36	56.9	-	-
Information and software sector	Number of clusters	125	107	51	8	1
	Maximum number of enterprises per cluster	604	593	252	82	45
	Average number of enterprises per cluster	116.03	86.75	65.51	59.75	45

Furthermore, descriptive statistics (e.g., frequency and percentage) were applied to classify and summarize data from the 246 valid questionnaires, resulting in a table of basic enterprise characteristics. The data show that micro and small enterprises accounted for more than 55% of the total sample within the identified clusters, yet their digital coverage rate was only 12%. Follow-up telephone interviews revealed that low profitability and concerns over insufficient returns on digital transformation are key factors behind the phenomenon of Foshan's digital industrial clusters being "agglomerated but not scaled." This finding indicates significant heterogeneity among enterprises within Foshan's digital industrial agglomeration areas in terms of competitive relationships, digitalization timelines, and levels of digital investment, which are characteristics closely associated with the three-tier "core-medium-small" cluster structure.

Table 2. Comparison of internal competition across different cluster types

Variables	Large agglomeration areas	Small agglomeration areas
Market concentration	Low (characterized by a large number of enterprises)	High (limited number of enterprises with constrained market capacity)
Product differentiation	High (stratified by brand and service quality)	Low (marked by severe homogenization)
Barriers to entry	High (requirements for rent and brand reputation)	Low (dominated by individual businesses)
Competition form	Non-price competition (innovation and branding)	Price competition (promotions and cost control)

4. Existing challenges

Using Midea Group, a representative large-cluster enterprise in Foshan, as a case study, field research shows that the company primarily focuses on R&D and international trade of air conditioners and home appliances. Surrounding Midea are digital industry firms that mainly supply key upstream components and handle downstream sales. Examples include Guangdong Dahua Bearing Co., Ltd. (a producer of key components for air conditioning manufacturing), Xiongfeng Special Steel Co., Ltd. (a core raw material supplier for smart air conditioning equipment), and Yingfeng Environmental Technology Co., Ltd. (a key downstream partner). The entire digital industrial chain is closely interconnected. However, based on cluster distribution patterns and field research, several issues have been identified. For instance, most enterprises within the clusters are small or micro-sized and exhibit over-reliance on core enterprises. This has led to the concentration of firms around core enterprises, large-scale agglomeration of homogeneous businesses, and significant product homogenization. These challenges are reflected in the following aspects below.

4.1. High degree of product homogenization within clusters

In the absence of differentiated innovation drivers, geographical agglomeration has failed to produce synergistic effects. Instead, it has led to an "involution trap" under homogeneous competition, which severely constrains the sustainable development of clusters. For example, as a bearing supplier for Midea's air conditioning compressors, Dahua Bearing holds a major share of NSK bearing sales in South China. Yet, it competes with over 300 similar enterprises in the region. Since most bearing products show little differentiation in core indicators such as precision and service life, competition ultimately centers on "price concessions." To secure orders from Midea, some firms have compressed profit margins to levels far below the core enterprise's average.

4.2. Divergent timelines for digitalization across enterprises

This discrepancy further hinders effective collaboration within the industrial chain. Some e-commerce firms began digital transformation as early as 2015, accumulating substantial experience and customer resources. In pursuit of higher efficiency, they often partner with mature external smart logistics providers. In contrast, many traditional manufacturers started digital transformation much later. Large enterprises like Midea Group have leveraged strong financial and technical capacity to invest heavily in digitalization. Since 2018, Midea has invested over 3 billion Chinese Yuan in digital transformation, achieving end-to-end digital integration across production, management, and sales. SMEs, however, have lagged in digital investment, leading to a growing digital divide and challenges in achieving seamless industrial chain cooperation.

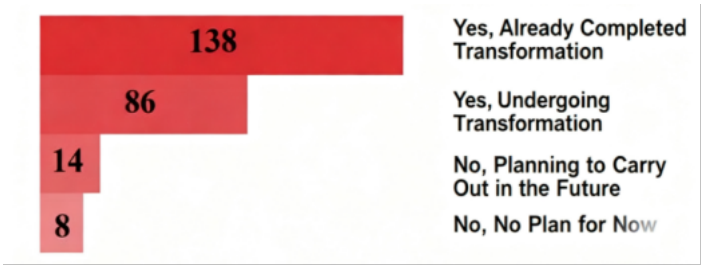

Figure 1. Digital transformation status of enterprises.

4.3. Significant disparities in digitalization progress within the cluster

Substantial gaps in the digital transformation progress among enterprises in the industrial cluster are generating structural contradictions and constraining the deepening of the regional development model. Leveraging their financial strength, large manufacturing firms have made considerable investments in digitalization, achieving markedly higher levels of digital maturity. These enterprises often require their upstream and downstream partners to possess corresponding digital capabilities. However, this uneven development has led to misalignment in technical interfaces, data standards, and collaborative processes across the cluster.

A large number of small and micro-enterprises within the cluster, constrained by limited capital and uncertainty regarding returns on digital investment, have demonstrated significantly slower progress in digital transformation. This impedes improvements in their production efficiency and market responsiveness. Research indicates that small and micro-enterprises account for up to 55% of the cluster, with average registered capital only one-twentieth that of large enterprises. More than half face financial shortfalls that hinder digital adoption.

Meanwhile, the distribution of digital talent is highly uneven. Leading enterprises employ a relatively high proportion of highly educated technical staff, while small and micro-enterprises struggle to attract and retain high-end technical talent. This inability to effectively operate sophisticated digital tools traps many smaller firms in a vicious cycle of "low investment-weak capability-low returns," further exacerbating digital stratification within the cluster.

5. Conclusion

The development of digital industrial clusters plays a vital role in strengthening regional economic competitiveness and securing a leading position in the digital economy. It is also highly significant for advancing industrial upgrading and high-quality growth in Foshan. Building on its manufacturing foundation and policy support, Foshan has developed a distinctive model for fostering digital industrial clusters. Using complex network analysis

and industrial cluster theory, this study examines the network structure of Foshan's digital industrial clusters and derives the following conclusions. Foshan's digital industrial clusters exhibit a nested "core-periphery" structure. The core area has evolved into an innovation hub, driven by policy support and built upon a traditional industrial base. Some enterprises have formed chain-type clusters along major transport corridors. However, there is a clear competitive imbalance within smaller clusters: large clusters compete mainly on technology, while small and medium-sized clusters are often trapped in price competition. Bottlenecks have emerged due to significant disparities in digital transformation progress, as well as a pronounced gap in investment capacity between leading firms and micro, small, and medium-sized enterprises, coupled with insufficient resource sharing. Looking ahead, Foshan's digital industrial clusters should optimize functions across levels: the core should focus on R&D strengthening; medium-sized clusters should cultivate niche segments; and small clusters need to enhance incubation capabilities. In addition, it will be essential to expand business markets, build collaborative innovation platforms, and implement differentiated policy measures, such as supporting high-value-added projects in large clusters, offering inclusive financial assistance to small and medium-sized clusters, and deepening industry–university–research cooperation to facilitate industrial upgrading.

Funding

2024 Guangdong Provincial College Student Innovation and Entrepreneurship Training Program Project (Project No.: S202412617039)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Shi F, 2020, The Impact of Digitalization Level on Corporate Operational Performance, thesis, Shanghai University of Finance and Economics.

[2] Porter M, 2007, The Competitive Advantage of Nations, CITIC Press, Beijing, 118–155.

[3] Liu J, 2012, Research on the Industrial Cluster Effect in Regional Economic Development. Commercial Times, 2012(14): 129–130.

[4] Jiao H, Ma G, Zhang W, 2024, Digital Industrial Clusters: Origin, Connotative Characteristics, and Research Framework. Industrial Economic Review, 2024(2): 72–91.

[5] Liu Z, Xia J, 2025, The Logic, Mechanism, and Path of Dat Factor Empowering Digital Industrial Clusters. China Business and Market, 39(6): 69–80.

[6] Shi L, Yang Z, Qian G, 2025, Digital Industrial Cluster Policy and Breakthrough Innovation in Key Core Technologies. China Industrial Economics, 2025(1): 100–117.

[7] Fernandez-Escobedo R, Eguía-Peña B, Aldaz-Odriozola L, 2024, Economic Agglomeration in the age of Industry 4.0: Developing a Digital Industrial Cluster as a New Policy Tool for the Digital World. Competitiveness Review: An International Business Journal, 34(3): 538–558.

[8] Wang W, 2025, The Impact of Digital Industrial Clusters on Regional Innovation Efficiency, thesis, Guizhou Normal University.

[9] Li Z, Lu Q, 2024, Promoting Industrial Technological Innovation Through Digital Industrial Clusters as a Key Driver. China Industry and Information Technology, 2024(7): 44–48.

[10] Ouyang R, 2025, The Logic and Path of Digital Industrial Clusters Enhancing Digital Economic Competitiveness. Guangdong Social Sciences.2025(1): 66–79.