Proceedings of Business and Economic Studies, 2026, Volume 9, Issue 3
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Research on the Digital Transformation Paths of Small and Medium-Sized Enterprises (SMEs) in Daqing City

Huize Xi, Jinyan Han

Heilongjiang Bayi Agricultural University, Daqing 163319, Heilongjiang, China

Abstract: As the digital economy reconstructs global industrial landscapes, the digital transition of small and medium-sized enterprises (SMEs) has evolved from a strategic option to a survival imperative, particularly for revitalizing the manufacturing sector in Northeast China. Taking Daqing City as a focal point, this study interrogates the structural impediments-ranging from capital volatility to technical misalignments-that stifle local SME modernization. By synthesizing these constraints, we propose the digitization, data-driven, intelligentization, ecosystem (DDIE) framework, a multi-tiered evolutionary roadmap tailored to the idiosyncratic needs of Daqing's industrial base.

Keywords: SMEs; Digital transformation; Daqing City; DDIE model

Online publication: April 16, 2026

1. Introduction

At present, profound progression is observed in the current epoch's technological revolution along with industrial transformation. The digital economy has significantly changed production methods and enterprise management models, and it has become an important driver of industrial upgrading in many regions [1]. It may be noted from the report rendered by the 20th National Congress of the Communist Party of China that emphasis has been distinctly placed on "accelerating the development of the digital economy" alongside facilitating its substantive integration with the real economy. Within the context of China's expansive manufacturing sector, such digitization processes no longer operate under the guise of discretionary alternatives; rather, they have evolved into imperatives integral to both existential continuity and progressive advancement for enterprises.

As a conventional city relying on resource development, Daqing is confronted with notable challenges amid the digital era. This time-honored industrial hub gained its development momentum mainly by depending heavily on the oil industry. Yet as resource exhaustion draws near, Daqing is plagued by over-dependence on traditional industrial sectors, a shortage of advanced and sustainable production capacity, as well as an underdeveloped cultural atmosphere for innovation. It is thus essential for the city to push forward industrial upgrading,

technological innovation and industrial structure adjustment [2].

The SMEs in Daqing hold a vital position in the local industrial restructuring drive, and their development not only bears on their own long-term growth prospects but also affects the industrial stability and innovative vitality of the whole region. In comparison with cities in the developed coastal areas of southeast China, however, Daqing's SMEs show low enthusiasm for digital transformation, lack the practical capacity to carry out transformation work, and are generally plagued by anxiety about the transformation process [3,4]. Such problems are caused by multiple factors, including insufficient capital support, high labor input costs, and a relatively weak understanding of the core value that digitalization can bring. This reflects that in the digital economic context; local SMEs still have difficulty in accurately identifying digital technologies and applying such technologies in an effective way.

Current academic research into digital transformation is mostly centered on large enterprises or industrial clusters in developed regions, while there are relatively few targeted research studies on the digital transformation of SMEs in resource-based cities located in the old industrial base of Northeast China. To make up for this research gap, this paper takes Daqing as a research case and puts forward the four-stage DDIE framework, including DDIE construction, as the basic theoretical analysis tool. Combining the actual industrial development scenarios of Daqing's equipment manufacturing industry and petrochemical supporting industries, the paper conducts an in-depth analysis of the current situation and restrictive factors of local SMEs' digital transformation. On this basis, it designs hierarchical transformation paths for these enterprises and proposes three specific practical models for digital transformation. This research can not only provide feasible implementation guidance for Daqing's SMEs in their digital transformation, but also offer theoretical reference and practical experience for the industrial upgrading of other similar resource-based cities in Northeast China and the whole country.

2. Status of digital transformation of SMEs in Daqing city

2.1. Overall development trend and infrastructure foundation

Within the recent developmental chronology characterizing Daqing City's socio-economic landscape, discernible is an active engagement with the national "Digital China" strategy, a framework within which the digital economy has been assigned primacy as the paramount initiative for industrial transformation. Evidence by the termination of fiscal year 2023 substantiates that the aggregate value achieved by core industries constituting Daqing's digital economic sector exceeded 110 billion yuan, a milestone unprecedented hitherto. Such quantification renders manifest the progression whereby digital technologies move beyond mere auxiliary functionality to become integrative agents pervading various substrata of Daqing's industrial structure.

As seen through the prism of spatial-industrial configuration, there emerges in Daqing a nascent carrier for digital economic activities whose nucleus coalesces around what has been articulated as the "Two Parks and One Center", comprising, notably, entities such as the Daqing Digital Economy Industrial Park and the Huawei Cloud Data Center. This constellation affords coverage across domains categorized under emerging frontiers, including, among others, the industrial internet, specialized oilfield service software research and development, as well as Internet of Things (IoT) application frameworks. From this triangulated setup originates a technology diffusion environment perceived as catalytic especially for small and medium-sized enterprises positioned structurally at multiple levels within local industry chains [4].

With regard to infrastructural fortification, observation permits the conclusion that Daqing City's foundational

digital architecture acquires increasing robustness. Marked have been deliberate efforts toward expansionary deployment of 5G base stations, paired with comprehensive infusion of high-capacity optical fiber broadband throughout urban precincts-interventions collectively culminating in the construction of a city-wide network connection system characterized by velocity and omnipresence. Among direct sequelae are ameliorations in traditional accessibility impediments and cost barriers historically encountered by local SMEs vis-à-vis network integration.

Attention ought also to be directed to the postulation that the operationalization of four fundamental databases-specifically legislative across categories comprising population, legal entities, credit and electronic licenses-has induced cross-tier data interconnectivity on scales encompassing municipal, provincial, and national hierarchies. Through such systemic linkage, procedural redundancies embedded in governmental services experience abatement. Thus, processes in which data mobility supersedes human enterprise interactions emerge. The cumulative outcome signifies not only facilitation for businesses encountering institutional transaction costs but also lays groundwork for transformative optimization of the business environment observed contemporaneously in Daqing [5,6].

2.2. Benchmark demonstration effects in key areas

On top of inclusive infrastructure, Daqing City has shown a trend of "point-based breakthroughs" in the digital transformation of key industries, playing a significant role in demonstration and guidance.

In the manufacturing sector, relying on the strong technical empowerment of the Huawei (Daqing) Industrial Internet Innovation Center, local manufacturing industries have begun to attempt "cloud migration and data utilization." Statistics show that the center has cumulatively provided in-depth counseling and completed full-process digital transformation for four benchmark enterprises. By introducing the deep integration of manufacturing execution system (MES) and enterprise resource planning (ERP), these pilot enterprises have achieved real-time collection and visualization of production data. The average production efficiency has significantly improved, not only reducing material consumption but also shortening product delivery cycles, establishing a tangible model for surrounding SMEs that are currently adopting a wait-and-see approach.

In the energy sector, as Daqing's pillar industry, the digital transformation of Daqing Oilfield is at the forefront of the nation. To date, Daqing Oilfield has completed the digital transformation of 61,972 oil and water wells and 3,913 stations. Through the linkage of IoT sensors and the "Oilfield Cloud" platform, intelligent monitoring of the entire process from exploration and development to gathering and transportation has been realized. This large-scale digital practice has not only improved the oilfield's own development efficiency but also provided clear technical standards and docking interfaces for thousands of SMEs in oilfield services and equipment manufacturing that rely on the oilfield industrial chain, thereby forcing and driving the digital upgrading of the entire industrial chain.

2.3 Deep-seated constraints on transformation

Despite significant achievements, it must be clearly recognized that the digital transformation of SMEs in Daqing City is still in the primary stage of "climbing slopes and overcoming obstacles," facing pressure from both internal and external environments.

2.3.1. Structural shortcomings in internal resources and capabilities

Digital transformation is a systematic engineering project requiring high investment and long cycles. For the large

number of SMEs in Daqing engaged in traditional machining and oilfield supporting services, thin profit margins make it difficult to support the high costs of server procurement, software licensing, and system maintenance. Coupled with rising raw material prices in recent years, corporate cash flow is generally tight, and financing channels are narrow, making "reluctance to transform" a norm.

Moreover, Northeast region has long faced the challenge of brain drain. Existing technical personnel in SMEs are mostly traditional mechanical or process engineers who knows little about emerging technologies such as cloud computing and big data. There is a scarcity of composite talent who understand both industrial production processes and digital technologies. Furthermore, local enterprises find it hard to offer salary and welfare packages that can match those in China's first-tier cities, which in turn leads to the failure to attract outstanding talents and keep the existing professional ones in place.

A great number of local SMEs still adopt the conventional master-apprentice teaching model or family-based management approaches, and the standardization level of their internal business processes remains extremely low. Enterprise managers often regard digitalization as nothing more than purchasing computer devices and installing relevant software, and they lack the strategic vision needed to restructure the company's core business processes. This kind of cognitive misunderstanding makes digital tools run in isolation from the original enterprise management system, which not only fails to boost operational efficiency but also adds extra frictions to the daily management work of the enterprise.

2.3.2. Systematic barriers in the external ecological environment and market

While the local government has issued a series of supportive policies for digital transformation, many SMEs report that the application criteria for relevant subsidies are overly strict, the application procedures are complicated and time-consuming, and the whole approval process takes a long time. Besides, the digital transformation solutions available on the market vary greatly in quality and service, and there is a shortage of low-cost, customized solutions that are tailored to the development features of Daqing's local industries, such as the demand for cold resistance and compliance with special oilfield industry standards.

Daqing's industrial layout is dominated by large central state-owned enterprises including Daqing Oilfield and Daqing Petrochemical, while local SMEs mostly occupy a supporting position in the industrial chain. At present, the data barriers between these central SOEs and local small and medium-sized enterprises are still very prominent. The lack of smooth data sharing between different enterprises makes it hard to achieve effective collaborative development of the entire supply chain, and also restricts the full release of network effects brought by digital transformation.

Against the backdrop of changing international geopolitical situations, the demand and pressure for domestic replacement of industrial software have been on the rise. At the same time, most local SMEs lack the professional capabilities and technical reserves for network security protection. Faced with the frequent occurrence of ransomware attacks and the potential risks of data leakage, these enterprises usually have no effective response measures, and such anxiety about digital security also curbs their willingness to carry out cloud migration for business operations.

3. Tiered path planning for the digital transformation of Daqing's SMEs

In view of the various pain points in digital transformation mentioned above, this research holds that there is no

universal transformation model that fits all enterprises. On the contrary, it is necessary to build the four-stage progressive DDIE framework according to the different levels of digital development maturity of each enterprise. This framework can guide enterprises to select transformation strategies that match their own development status and implement targeted digital transformation measures.

3.1. Operational digitization: Establishing a standardized data foundation

As the initial stage of digital transformation, the core goal of this phase is to help micro and small enterprises move away from the traditional management mode relying on paper documents and electronic spreadsheets, and build a unified digital management system for the enterprise. The focus of this stage is not to pursue the application of cutting-edge digital technologies, but to realize the digital integration of the enterprise's core business processes. By introducing basic ERP management systems and lightweight SaaS application tools, enterprises can realize the synchronous sharing of data in procurement, inventory management and product sales links. This digital transformation process is key to breaking the internal information barriers of enterprises, cultivating the digital operation habits of all employees, and laying a standardized data foundation for the further expansion of digital transformation in the future.

3.2. Analytical upgrading: Converting accumulated data into practical decision-making insights

This phase is designed for growing enterprises that have already built a basic information management infrastructure. It represents a strategic transformation for enterprises, shifting the focus from simple data collection and storage to in-depth data mining and practical application. By integrating the Industrial IoT into production and operation, enterprises can realize real-time monitoring and data collection of equipment operation status, energy consumption and production output indicators. When these detailed and granular operation data are analyzed and processed through professional business intelligence analysis systems, they can be converted into practical and actionable insights, which can provide data support for scientific production scheduling and effective cost control of enterprises. For example, in the oilfield equipment manufacturing industry, enterprises can build predictive analysis models for market order fluctuations, which can help them achieve more refined inventory management and rationalize the allocation of corporate capital resources.

3.3. Intelligent operation: Realizing algorithm-driven management and cyber-physical system integration

This stage is adapted for specialized and innovative SMEs as well as the hidden champion enterprises in various industries that aim to further improve production efficiency and stabilize daily business operations. The focus of transformation at this stage turns to the in-depth application of artificial intelligence technology and digital twin technology, so as to realize the self-optimization of the enterprise's entire production and operation system. Enterprises can replace manual quality inspection work with AI-based computer vision technology, or use digital twin technology to build virtual models of production lines for simulation operation and pressure testing. Through these means, enterprises can identify potential bottlenecks and problems in production and operation in advance and take targeted solutions. The ultimate goal of this stage is to build a fully automated unmanned smart factory, which can drive a substantial improvement in the total factor productivity of the enterprise.

3.4. Ecosystem co-development: Restructuring the industrial value chain and realizing collaborative development of the whole chain

At the advanced stage of digital transformation, enterprises will gradually shift their development focus from internal digital optimization to cross-enterprise collaborative development in the entire supply chain. Leading digital platform enterprises can take advantage of their own industry influence to build open industrial internet ecosystems, and open up their data interfaces related to order distribution, inventory status and logistics transportation to upstream and downstream cooperative enterprises in the industrial chain. The real-time sharing and synchronization of this kind of industrial data can help build a highly resilient industrial value chain integrating product design, manufacturing and after-sales service. At this transformation stage, the competition pattern of the industry will also change fundamentally, shifting from the competition of a single enterprise's product strength to the competition of the overall strength of the entire industrial ecosystem, which will reshape the value network of the entire regional industry in essence.

4. Three practical models for the digital transformation of Daqing's SMEs

The four-stage DDIE transformation framework is formulated on the basis of the "Technology–Organization–Environment" theory and the mature evaluation models of enterprise digital development. The TOE theoretical framework points out that the adoption and application of new digital technologies by enterprises are affected by their own organizational development capabilities and the external market environment. Based on the findings of on-site research and investigation of local enterprises, this research divides the digital transformation of Daqing's SMEs into four progressive development stages with distinct characteristics.

4.1. Smart manufacturing model: Upgrading the core production links with professional digital technologies

This digital transformation path is more applicable to the asset-heavy manufacturing enterprises in Daqing, such as the enterprises engaged in petroleum equipment manufacturing and fine chemical production. Field investigation shows that these enterprises usually operate with aging equipment and relatively complex production processes. Digital upgrading therefore starts from equipment networking and process standardization rather than full automation.

This kind of digital upgrade is generally carried out in three sequential steps. To begin with, sensing devices and PLC control systems are fitted on key production equipment to enable real-time data collection on production activities. Next, MES management systems are adopted to standardize the overall arrangement and execution of production plans. In the final step, data analysis methods are introduced step by step to adjust and optimize various production parameters. Most enterprises choose to carry out digital upgrading in a gradual way to control potential risks, rather than striving to build fully unmanned smart production workshops at one time.

4.1.1. Specific implementation approach

Focus on the five core elements of the production site, namely personnel, equipment, materials, production methods and on-site environment. For instance:

(1) Install sensors and PLC controllers on existing machine tools and reaction kettles to realize network connection and cloud migration of these old production devices;

(2) Apply MES systems to realize digital distribution of production tasks and real-time tracking and feedback

of the whole production process progress;

(3) Make use of big data analysis technology to optimize various key parameters in the production process.

4.1.2. Expected transformation effects

Drive the production side of enterprises to shift from a model relying on manual experience to one guided by data and algorithm analysis. For example, enterprises engaged in the production of oil pumping units can realize flexible and customized production according to the geological characteristics of different oilfields through such intelligent transformation, which can shorten the trial and development cycle of new products and enhance the added value of their products at the same time.

4.2. Supply chain digitalization model: Coordinated transformation following core industrial chain enterprises

This transformation model is suitable for the large number of local SMEs that provide supporting services for Daqing Oilfield and Daqing Petrochemical, as well as those engaged in logistics and warehousing services in the region. The business development of these enterprises is highly dependent on the order resources of core large enterprises, and they are in a relatively passive position in the entire industrial supply chain.

4.2.1. Specific implementation approach

Taking the collaborative development of the supply chain as the starting point of digital transformation, local SMEs need to proactively connect with the procurement platforms and supply chain management systems of core enterprises, so as to realize the full digitalization of the whole process including order processing, delivery notification and account checking and settlement. Meanwhile, blockchain technology can be applied to ensure the authenticity and traceability of financial data in the supply chain, which can help relevant enterprises alleviate the difficulties in financing and capital turnover.

4.2.2. Expected transformation effects

This model can effectively cut down the communication costs and transaction frictions among all participants in the supply chain, and further enhance the anti-risk capability of the entire industrial chain. By establishing smooth data communication channels with state-owned core enterprises, SMEs can obtain more stable expectations of market orders, realize accurate matching of supply and demand in the industrial chain and dynamic management of enterprise inventory, and thus transform their role from simple product and service suppliers to deep cooperative partners of core enterprises.

4.3. Platform empowerment model: Lightweight digital breakthrough relying on professional service platforms

This transformation model is targeted at the numerous micro and small enterprises with insufficient capital support and scarce technical talents. For these enterprises, it is neither cost-effective nor practical to independently build private cloud platforms or purchase large-scale professional digital software systems.

4.3.1. Specific implementation approach

Relying on the shared service platforms built by institutions such as the Huawei (Daqing) Industrial Internet Innovation Center, government-led public service platforms and leading enterprises in various industries, SMEs

can use cloud-based ERP management, cloud design, cloud storage and other digital tools in a on-demand manner through the SaaS service model.

4.3.2. Expected transformation effects

Realizing the lightweight digital transformation of enterprises featuring asset lightening, rapid deployment and flexible iteration., enterprises can enjoy high-level digital services without the need to purchase expensive server equipment or employ professional IT operation and maintenance teams. This model greatly lowers the threshold for micro and small enterprises to carry out digital transformation, allowing them to take the first step of digital upgrading with the minimum trial and error cost, and effectively solving the problem of enterprises' fear of carrying out digital transformation due to high costs and technical barriers.

5. Research conclusions and implementation proposals

5.1. Main research conclusions

Through an in-depth and detailed analysis of the digital transformation practice of SMEs in Daqing, this research draws the following comprehensive conclusions.

First of all, although Daqing has built an initial digital infrastructure foundation and cultivated a number of benchmark enterprises in different industrial fields, the overall penetration rate of digital transformation among local SMEs is still restricted by various structural obstacles. In particular, the instability of corporate capital flow, the shortage of professional digital talents and the inertia of traditional development and management models continue to hinder the large-scale promotion of digital transformation, leading to a fragmented development pattern of digitalization in the local SME sector.

In addition, the four-stage DDIE transformation framework constructed in this research is more than just a simple stage division standard for digital development. It also provides a clear strategic development roadmap for the digital transformation of local enterprises and defines distinct evolutionary directions for each transformation stage. By matching the adoption and application of digital technologies with the actual digital maturity of enterprise organizations, this framework can effectively avoid the blind follow-up risks that often exist in the digital transformation process of enterprises with inadequate overall planning.

Finally, dividing digital transformation into three different implementation models, smart manufacturing, supply chain integration and platform empowerment, can effectively meet the diversified digital transformation needs of enterprises in different industries and with different development scales. These three models together form a flexible and practical "policy and practice toolkit" for the digital transformation of SMEs, providing differentiated implementation paths for the digital revitalization and development of local SMEs in Daqing.

5.2. Specific implementation proposals

To ensure the smooth and effective implementation of the above-mentioned digital transformation paths and models, joint efforts and coordinated cooperation from the government, enterprises and all sectors of society are needed.

5.2.1. Government policy level: Shift from extensive policy support to precise policy empowerment

The Daqing municipal government needs to further optimize the top-level design of digital transformation policies for local SMEs as follows:

(1) Financial support measures: Set up a special guidance fund for the digital transformation of SMEs, and explore and build a diversified financial support model combining government subsidies, joint bank support and enhanced credit guarantee; Provide direct financial subsidies or preferential interest loans for enterprises that purchase cloud digital services or carry out intelligent transformation of production links, so as to effectively relieve the capital pressure faced by enterprises in the process of digital transformation;
(2) Talent attraction and cultivation: Relying on local universities such as Northeast Petroleum University and Bayi Agricultural University, co-build "Digital Transformation Talent Incubation Bases" and open relevant micro-majors to specifically train composite talent who understand both industry and digital technology. Simultaneously, introduce more attractive tax and housing policies to attract IT talent back to the Northeast;
(3) Standards and security: Formulate data exchange standards that fit the characteristics of Daqing's industries to break down the data barriers between central and local enterprises; Establish a regional industrial internet security situational awareness platform and promote low-cost cloud security services to build a solid digital security defense line for SMEs.

5.2.2. Enterprise level: Shifting from "Passive Adaptation" to "Active Change"

The strategies are employed as outlined:

(1) Strategy first: The "top leaders" of enterprises must change their concepts, personally leading digital transformation and elevating it to a corporate strategy rather than a mere technical renovation;
(2) Step-by-Step implementation: Follow the principles of "overall planning, step-by-step implementation, and small steps with fast running;" Prioritize solving the most painful problems (such as inventory backlogs and chaotic scheduling), build confidence through quick-win projects, and then gradually deepen the process;
(3) Leveraging external brains: Actively utilize the professional capabilities of third-party consulting agencies and platform service providers to conduct diagnostic consultations and formulate personalized "one enterprise, one policy" schemes to avoid detours.

5.2.3. Ecosystem level: Shifting from "Single Combat" to "Cluster Combat"

The actions are performed as listed:

(1) Platform leadership: Encourage top platform enterprises like Huawei to further sink their services and develop more "small, fast, light, and precise" solutions adaptable to Daqing's local scenarios;
(2) Central-local integration: Promote central enterprises like Daqing Oilfield to open more application scenarios and data resources. Through "the big leading the small," build a digital ecosystem group where large, medium, and small enterprises develop in integration;
(3) Integration of industry and education: Create an innovation consortium deeply integrating "Industry-Academia-Research-Application," accelerating the conversion and application of university research results in SMEs, and forming an endogenous driving force for the development of the regional digital economy.

In summary, the digital transformation of SMEs in Daqing City is a protracted war. Only by adhering to stratified advancement, model innovation, and ecosystem synergy can the endogenous power of SMEs be truly activated, contributing to the steady development of the regional digital economy.

Funding

Daqing Philosophy and Social Science Planning Research Project (Project No.: DSGB2025014)

Disclosure statement

The author declares no conflict of interest.

References

[1] Chen Y, 2023, Status, Dilemma and Strategy of Digital Transformation of Small and Medium-Sized Manufacturing Enterprises. China Economic & Trade Herald, 2023(4): 136–138.

[2] Zhao Y, 2024, Research on Empowering the Development of Real Economy with Digital Economy in Daqing City. Daqing Social Sciences, 2024(1): 100–104.

[3] Zhou Y, Sun H, Liu R, 2024, Impact of Digital Economy on Investment Efficiency of SMEs in Daqing City. Co-operative Economy & Science and Technology, 2024(15): 56–57.

[4] Dai X, Liu N, Zhao J, 2023, Daqing Oil City Transformation Has "Numbers". Heilongjiang Daily, December 7, 2023, 1.

[5] Zhao Y, 2025, Research on Empowering the Development of the Real Economy with Digital Economy in Daqing City. Daqing Social Sciences, 2025(1): 100–104.

[6] Wang Y, 2024, Research on the Coupling and Coordination between Digital Economy and High-quality Development in Daqing City. Modernization of Market, 2024(16): 130–132.