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Research on the Quantum Leap Path of Digital Transformation in Manufacturing Enterprises from the Perspective of Dynamic Capabilities
—A Case Study of Ailebo Robot

Youyang Wu. Rui Feng. Yueli Chen and Sibo Zhao
Foshan University of Economics and Trade, Foshan 52800, China

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Abstract

This study takes Ailebo Robot Co., Ltd. as a case to analyze the dynamic capability evolution mechanism of digital transformation in SMEs. Through an embedded single-case research method, it reveals the enterprise's transformation path across three dimensions: technology, business, and internationalization. The company has built six core technological systems to achieve cross-domain innovation, relying on a repository of 3 million process cards to support flexible production of 65,000 types of parts, forming a three-stage development model of "specialization, innovation - platformization - globalization". The research finds that through precise demand perception (e.g., 80 iterations of automatic stretching manipulator development), resource integration and reconfiguration (technology system migration to semiconductor inspection and other fields), and organizational model innovation (intelligent machining sharing platform), the enterprise has successfully transformed from an equipment supplier to an industry standard setter. Its practice path of "industrial thinking-dominated digitalization" provides a replicable transformation paradigm for manufacturing enterprises with annual output value below 500 million yuan, particularly significant in avoiding the "digitalization for digitalization's sake" pitfall. The research results expand the application scenarios of dynamic capability theory in the equipment manufacturing field, providing theoretical support and practical guidance for SMEs' digital transformation.

Keywords

Temp Digital Transformation; SMEs; Manufacturing; Dynamic Capabilities; Enterprise Transformation Strategies

1. Introduction

1.1. Research Background

The global manufacturing industry is undergoing a systemic transformation centered on intelligence. In 2025, the global smart manufacturing market is projected to

reach $1.5 trillion, with an annual growth rate of 15%. The flexible manufacturing segment in China demonstrates explosive growth, with a compound annual growth rate exceeding 20% from 2023 to 2030. This trend stems from dual drivers: surging personalized demand at the consumer end and efficiency revolutions at the production end. Industries such as automotive and electronics face a 30%-50% decline in single-line capacity utilization due to accelerated product iteration, compelling enterprises to adopt cost-effective "small-batch, multi-variety" production models through flexible transformation.

China's manufacturing upgrading exhibits pronounced policy-driven characteristics. The 2025 government work report explicitly includes "smart manufacturing pilot demonstrations" as a key task for industrial stabilization and growth. The accompanying Action Plan for Manufacturing Digital Transformation sets a target to achieve over 95% penetration of digital R&D tools in industrial enterprises above designated size by 2027. Against this backdrop, SMEs confront dual transformation pressures: breaking through efficiency bottlenecks in traditional labor-intensive production models while establishing differentiated capabilities in global competition. The practice of Foshan Ailebo Robot Co., Ltd. indicates that implementing a "deep intelligentization" strategy focused on niche sectors may constitute an effective path for SMEs to overcome resource constraints.

1.2. Research Questions

This study addresses three dimensions of Ailebo's digital transformation:

Technological capability development: How did the company achieve a 300% per capita efficiency improvement through 80 iterations of automatic stretching manipulator R&D, resolving process pain points such as oiling and material distribution? How does its standardized process library of 3 million cards support flexible production for 65,000 types of components?

Business expansion logic: How does the technology reuse mechanism operate in cross-domain expansion from cookware automation lines to semiconductor inspection equipment and intelligent warehousing systems? Can the innovation process of developing 5-micron precision visual inspection equipment for BOE validate the transferability of its six core technological systems (e.g. mechanical structure, sensing technology, algorithm systems)?

Globalization layout: Do the establishment of the Indian factory in 2023 and the delivery of Mexico's first automated production line in 2024 signify a transition from "equipment export 1.0" to "solution output 2.0"? How has environmental adaptation experience accumulated in Tibet's high-altitude projects been translated into technical solutions for overseas high-altitude regions?

1.3. Research Value

This study, grounded in the dynamic capabilities theory framework, conducts an in-depth analysis of the capability evolution mechanism in SMEs' digital transfor-

mation. Taking Ailebo Robotics Co., Ltd. as a typical case, the research findings fully validate Teece's three-element model of dynamic capabilities: In the environmental sensing dimension, the company achieved deep integration into the cookware manufacturing industry chain, accurately identified efficiency bottlenecks in manual sanding processes, and developed an automatic stretching manipulator after 80 iterations. For resource integration, it established a technological system encompassing six core modules including industrial robot control and sensing technologies, enabling cross-domain technology migration from pot automation to semiconductor inspection equipment. During organizational restructuring, the company transformed from equipment supplier to industry standard setter through the construction of an atomic process library containing 3 million standardized process cards, supporting flexible production of 65,000 components.

At the practical level, Ailebo's transformation path provides a replicable three-stage development paradigm for manufacturing SMEs: The "specialized, refined, distinctive, and innovative" phase focuses on niche markets, building technical barriers to achieve over 80% market share in pot automation. The platformization phase leverages a self-developed MES system to deliver customized solutions for nearly 30 enterprises, establishing an industrial ecosystem collaboration network. The globalization phase replicates the domestic "4-hour service circle" model in emerging markets, upgrading from equipment exports to Indian factories to production line solution exports in Mexico. Notably, the company adheres to the innovation principle of "solving internet challenges with industrial thinking," implementing IoT-based equipment interconnection while maintaining production process standardization principles. This approach effectively avoids the pitfall of "digitalization for digitalization's sake," offering significant practical guidance for SMEs with annual output below 500 million yuan.

2. Literature Review

The Dynamic Capabilities Theory emphasizes that enterprises achieve sustainable competitive advantages in dynamic environments through environmental sensing, resource integration, and organizational reconfiguration. Teece's framework, a classical model in this field, identifies three core elements: environmental sensing capability, resource integration capability, and organizational reconfiguration capability.

Environmental Sensing Capability, the foundation of dynamic capabilities, requires enterprises to accurately capture market demand changes through diversified channels. In manufacturing, this capability manifests as keen insights into market trends, customer pain points, and technological developments. Ailebo Robotics exemplifies this by deeply cultivating the pot manufacturing industry and precisely identifying market demand pain points in automated production, such as inefficiencies in traditional manual sanding processes and high labor costs. Through technological innovation, Ailebo developed automated sanding equipment, reducing the workforce for

sanding from 22 to 2, significantly enhancing production efficiency and product quality, thereby securing a leading market position.

Resource Integration Capability, the core of dynamic capabilities, involves optimizing resource allocation to enhance competitiveness. In manufacturing, this translates to effective integration of technologies, talents, and capital. Ailebo optimized technical resource allocation by establishing six core technical modules. The company also prioritized talent development, with R&D personnel accounting for 60% of its workforce, providing strong support for technological innovation. Additionally, through close collaboration with suppliers and clients, Ailebo integrated industrial chain resources, further strengthening its resource integration capacity.

Organizational Reconfiguration Capability, the advanced stage of dynamic capabilities, requires enterprises to innovate business models for sustainable development. In manufacturing, this involves reinventing production, business, and management models. Ailebo transformed from a traditional equipment manufacturer into a full-industry-chain solution provider through digital transformation. For instance, the company established an intelligent machining sharing platform to enable flexible task allocation and efficient resource utilization. Furthermore, by defining industry standards for pot automation production through technological innovation, Ailebo enhanced its market influence and authority.

This case study of Ailebo highlights how dynamic capabilities theory provides a practical framework for SMEs to navigate digital transformation, emphasizing the interplay of sensing, integrating, and reconfiguring resources to achieve sustainable growth.

3. Research Methodology and Case Overview

3.1. Methodological Choice

This study employs an embedded single-case research method to investigate the digital transformation path and internationalization strategy of Ailebo Robotics Co., Ltd. Centered on Ailebo as the primary research subject, this approach enables an in-depth analysis of its developmental trajectory and underlying logic across sub-units such as technology, business operations, and internationalization layout. The embedded single-case method allows researchers to gain granular insights into processes while capturing the complexity and dynamism of organizational transformation through multi-dimensional analysis.

To ensure research reliability and validity, a data triangulation approach was adopted. Data sources included corporate annual reports, patent information, interview transcripts, industry reports, and government documents. Corporate annual reports and patent records provided quantitative and qualitative baseline data, reflecting Ailebo's technological R&D progress and market performance. Interview records, derived from in-depth discussions with corporate executives, technical experts, and frontline employees, offered firsthand insights into internal decision-making pro-

cesses, technological innovation strategies, and employees' perceptions of organizational change. Industry reports and government publications, such as materials from the Nanhai District "Hidden Champions" evaluation, supplied external perspectives, facilitating a macro-level understanding of Ailebo's industry position and the impact of policy environments on its development. Cross-validation of multi-source data minimized potential biases from single data sources and strengthened the credibility of research conclusions.

3.2. Case Enterprise Profile

Foshan Ailebo Robotics Co., Ltd. is a high-tech enterprise specializing in automated equipment for the cookware manufacturing industry. Leveraging its strong technical expertise and rich industry experience, the company has emerged as a national leader in this field. Established in 2012, Ailebo has successfully delivered over 800 automated production lines to more than 200 renowned domestic and international manufacturing enterprises, including Midea and Supor, achieving an 80% market share in the automated cookware production line sector.

Ailebo's technical prowess is underscored by over 100 patents spanning six core technological systems, including industrial robot operation logic, R&D algorithm systems, mechanical design, and sensing technologies. With R&D personnel accounting for 60% of its workforce, the company demonstrates substantial commitment to technological innovation. This technology-intensive positioning not only solidifies Ailebo's domestic market foundation but also provides a robust technical foundation for its international expansion.

4. Research Findings

4.1. Stage 1: Niche Focus (2012-2016)

Ailebo's developmental trajectory demonstrates a clear strategic focus. During its startup phase, despite market temptations to pursue multi-sector expansion, management opted to concentrate resources on the vertical niche of cookware manufacturing automation. This decision was grounded in systematic industry analysis: Traditional cookware production, a labor-intensive sector, faced structural challenges including rising labor costs, production inefficiencies, and quality inconsistencies—all urgently requiring technological upgrading for industrial transformation. Through sustained resource allocation and market, Ailebo rapidly established technical barriers and market dominance in automated cookware production lines.

Technological breakthroughs formed the backbone of its core competitiveness. In 2013, the company developed and launched the industry's first automatic stretching manipulator, which underwent 80 rounds of technical iteration to resolve critical challenges in oiling and material separation processes, significantly enhancing production efficiency and product yield rates. This innovation not only filled domestic

technical gaps in cookware automation but also secured Ailebo's first-mover advantage. The following year (2014), the development of a dual-arm robot further solidified its technological leadership, achieving dual benefits of labor cost reduction and capacity improvement (e.g., single-workstation labor reduction and 30% overall efficiency gains).

Service system optimization also underpinned its market position. In 2015, Ailebo established a network of five 4S service centers covering major industrial clusters, forming a rapid-response "4-hour service circle" mechanism. This service innovation shortened technical support cycles, improved after-sales efficiency, and effectively enhanced customer loyalty while building a professional and reliable brand reputation. The step-by-step development pathway—from strategic positioning to technological breakthroughs and service upgrades—exemplifies the company's systematic exploration and practice in intelligent transformation within traditional industries.

4.2. Digital Foundation Building (2017-2021)

During the critical phase of digital transformation, Ailebo achieved production system reconfiguration through innovative management reforms. In 2017, the company launched an industry-benchmarking intelligent machining sharing platform, which introduced a "ride-hailing-style" task allocation mechanism. This platform empowered production personnel to autonomously select machining tasks based on their skill sets, breaking the rigid constraints of traditional centralized dispatch systems. This decentralized production management model not only quadrupled per capita productivity but also established a more flexible production organization framework.

Concurrently, Ailebo initiated the construction of a large-scale process knowledge management system, culminating in a digital containing 3 million standardized. This system supports flexible production for 65,000 component types. Through modular packaging and intelligent retrieval of process parameters, the company developed agile manufacturing capabilities to rapidly respond to market changes, effectively addressing production management challenges in multi-variety, small-batch orders and significantly enhancing market competitiveness.

The deep integration of these management innovations with digital technologies generated substantial operational efficiency improvements. Data shows that while the workforce was reduced by 50%, monthly average production capacity doubled, and product qualification rates exceeded the industry benchmark of 99%. These quantitative outcomes not only validated the strategic value of digital transformation but also laid a solid operational foundation for subsequent multi-sector technological expansion and global market Layout. From production organization innovation to knowledge management system construction, Ailebo exemplifies a typical pathway for traditional manufacturers to achieve efficiency leaps through management digitization.

4.3. Multi-Sector Expansion (2022-Present)

Ailebo's development trajectory exemplifies a traditional manufacturer's transformation through strategic focus and technological iteration. Initially, the company concentrated resources on addressing pain points in the cookware industry, achieving breakthroughs in automation technologies such as the automatic stretching manipulator (80 iterative optimizations) and dual-arm robots (30% efficiency gains), thereby establishing technical barriers in the niche. The 2015 "4-hour service circle" system further strengthened market responsiveness.

The 2017 launch of the intelligent machining sharing platform introduced a "ride-hailing-style" bidding mechanism, achieving dual breakthroughs of 300% per capita efficiency improvement and 50% workforce reduction. Concurrently, the establishment of a standardized library of 3 million process cards supported flexible production for 65,000 component types. Digital transformation yielded remarkable results, including doubled monthly production capacity and over 99% product qualification rates, laying the foundation for subsequent multi-sector expansion.

A technology reuse strategy propelled the company into new energy, semiconductor, and other fields: In 2022, its self-developed ROS/WMS/WCS systems were successfully applied to hydrogen energy factory warehousing projects, 5-micron precision vision inspection equipment entered BOE's supply chain, and three-face synchronous machining technology saved 75% space. Through customized MES system services, Ailebo empowered nearly 30 manufacturing enterprises in their digital transformations, forming a sustainable development model of "technology export + ecological co-construction."

4.4. Globalization Leap

Ailebo's internationalization process exhibits staged evolution. In 2023, the company initiated overseas market expansion, entering emerging markets such as Vietnam, India, and Egypt through equipment exports. It established a production base in India to strengthen regional. In 2024, the company transitioned from product export to solution export, successfully delivering its first automated cookware production line in Mexico. This project not only established technical credibility in the Americas but also laid a practical foundation for deeper penetration into the North American market.

In terms of localization strategies, Ailebo enhanced global operational capabilities through technological adaptation and service network construction. Technologically, the company systematically reused experience from environmental adaptability in Tibet's high-altitude cookware production lines for projects in other high-elevation regions, demonstrating cross-regional technological migration innovation. Service-wise, leveraging its mature domestic network of five 4S service centers, Ailebo built a rapid-response network for overseas markets, ensuring standardized service processes and equalized technical support efficiency for global clients. This "technology adaptation + service extension" localization strategy effectively increased

overseas customer loyalty and brand international competitiveness.

Through these strategic implementations, Ailebo has completed its transformation from a single-sector equipment provider focused on cookware automation to a multi-technology enabler and global solution provider. Its development path offers a typical case for traditional manufacturers to achieve international breakthroughs through technology reuse and ecological co-construction, while contributing a replicable model for the global practice of manufacturing digital transformation.

5. Transformation Mechanisms from a Dynamic Capabilities Perspective

5.1. Three Links of Capability Reconfiguration

5.1.1. Demand Sensing

Ailebo positioned demand sensing as the core starting point of its dynamic capabilities throughout the transformation. By deeply engaging with the cookware manufacturing industry, the company acutely identified pain points in traditional manual sanding processes, such as low efficiency, high labor costs, and unstable product quality. To address these issues, Ailebo developed automated sanding equipment, reducing the workforce for sanding from 22 to 2 and significantly enhancing production efficiency and product quality. This precise sensing of market demands not only earned market recognition but also laid the foundation for subsequent technological innovation and business expansion.

5.1.2. Resource Integration

Resource integration served as a critical link in Ailebo's dynamic capabilities. The company optimized technological resource allocation by establishing six core technological systems, including industrial robot operation logic, R&D algorithm systems, mechanical design, and sensing technologies. These systems not only supported deep cultivation in the cookware automation sector but also provided a solid technical foundation for cross-domain innovations in semiconductor equipment, intelligent warehousing, and aluminum processing. For example, the 5-micron precision vision inspection equipment developed for BOE was built on the company's strong R&D algorithm systems and sensing technologies. Through resource integration, Ailebo achieved rapid market response, technological iteration, and application expansion.

5.1.3. Strategic Reconfiguration

Strategic reconfiguration represented the advanced stage of Ailebo's dynamic capabilities. Through digital transformation, the company evolved from a traditional equipment manufacturer into a full-industry-chain solution provider. For instance, Ailebo not only delivered high-quality automated equipment but also offered comprehensive technical services, including installation, debugging, technical training,

and remote monitoring/maintenance. Furthermore, through technological innovation, the company defined industry standards for cookware automation production, such as establishing an atomic process library that supports flexible production for 65,000 component types. This strategic shift from "equipment making" to "defining industry standards" not only enhanced market influence and authority but also provided strong support for globalization.

5.2. The Uniqueness of Industrial Thinking

5.2.1. Philosophical Core

Throughout its transformation, Ailebo has adhered to the core philosophy of "solving internet challenges with industrial thinking." Unlike traditional internet thinking, which emphasizes agility and user engagement, industrial thinking prioritizes production process standardization, and efficiency. By integrating IoT, big data analytics, and lean management, Ailebo achieved digital and intelligent upgrades in manufacturing. This industrial mindset not only addressed traditional manufacturing pain points but also provided the company with a unique competitive edge during digital transformation.

5.2.2. Practical Manifestation

Ailebo’s practices fully embody the uniqueness of industrial thinking. The company enabled through IoT technologies, achieved real-time production monitoring and optimization via big data analytics, and enhanced efficiency while reducing costs through lean management. For example, its intelligent machining sharing platform adopted a "ride-hailing-style" bidding mechanism, enabling flexible task allocation and resource utilization. This tripartite model of IoT + lean management + big data analytics not only elevated production efficiency and management standards but also secured significant market advantages.

Through the dynamic capabilities lens, Ailebo’s transformation mechanism can be summarized as follows: capturing market pain points through precise; building robust technological systems ; and evolving from equipment manufacturer to industry standard setter through strategy restruction. This dynamic capability evolution framework not only drives Ailebo’s sustained growth but also offers valuable lessons for other manufacturing SMEs.

6. Practical Insights and Limitations

6.1. Implications for Small and Medium-sized Manufacturing Enterprises

6.1.1. Technology Aspect

Ailebo's transformation practice demonstrates that the foundation for digital trans-

formation in discrete manufacturing enterprises lies in the standardization of production processes. By establishing standardized process flows and quality management systems, enterprises can effectively reduce uncertainty and waste in production, providing a solid foundation for the application of digital technologies. For instance, Ailebo established a standardized process library containing 3 million process cards, supporting flexible production of 65,000 types of parts, significantly enhancing production efficiency and product quality. This offers a crucial insight for other SMEs in the manufacturing sector: before advancing digital transformation, production processes must first be standardized to ensure digital technologies can fully realize their effectiveness.

6.1.2. Strategy Aspect

Ailebo's transformation path provides clear strategic guidance for SMEs. First, enterprises need to achieve a breakthrough in a specific niche area to establish a competitive advantage, such as Ailebo's deep cultivation in automated production lines for cookware. Second, enterprises need to consolidate capabilities, transforming the technological and managerial experience accumulated from the focal point breakthrough into core competencies; for example, Ailebo optimized the allocation of technological resources by building six major technology systems. Finally, enterprises need to empower the ecosystem by extending their core capabilities to other domains and enterprises, achieving a transition from equipment manufacturer to full-link solution provider. This "Focal Point Breakthrough → Capability Consolidation → Ecosystem Empowerment" three-step path provides SMEs with clear transformation direction and strategic thinking.

6.1.3. Internationalization Aspect

Regarding international expansion, Ailebo's practice shows that SMEs should adopt a step-by-step progression strategy. First, enterprises can start with culturally similar markets with strong demand, such as Southeast Asia, accumulating international operational experience through equipment exports and technological adaptation. Subsequently, enterprises can gradually expand into advanced markets, such as those in the Americas, enhancing their international influence and market competitiveness through solution exports and localized services. This step-by-step progression strategy not only reduces the risks associated with internationalization but also helps enterprises gradually establish a global market presence, achieving the strategic goal of transitioning from domestic leadership to international leadership.

6.2. Research Limitations and Future Directions

6.2.1. Limitations

This study employed an embedded single-case research method. While this approach allows for an in-depth analysis of Ailebo's transformation path and mechanisms, the

limitation of a single-case study lies in the potential constraints on the generalizability of its conclusions. As a company with unique technological advantages and market positioning, Ailebo's transformation experience may not be fully applicable to other small and medium-sized manufacturing enterprises (SMEs). Furthermore, this study did not conduct a quantitative analysis of the economic benefits of Ailebo's digital transformation, such as changes in enterprise profits, return on investment (ROI), and other metrics before and after the transformation. This, to some extent, affects the comprehensiveness and persuasiveness of the research findings.

6.2.2. Future Outlook

Future research could expand the scope of study by comparing the digital transformation paths of different types of enterprises. This would help reveal the differences and commonalities in the transformation processes of equipment manufacturers versus consumer electronics companies, for instance. Equipment manufacturers typically face challenges such as complex production processes and high equipment renewal costs, while consumer electronics companies often place greater emphasis on rapid response to market changes and product iteration. Comparative analysis can provide more targeted transformation suggestions for different types of enterprises and simultaneously enrich theoretical research on digital transformation in manufacturing. Additionally, future research could employ quantitative analysis to delve deeper into the impact of digital transformation on corporate economic benefits, thereby providing stronger support for enterprises' transformation decisions.

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