

The Impact of Supply Chain Digitalization on Operational Efficiency in Small and Medium Enterprises

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Abstract: This study conducts a systematic analysis of the impact of supply chain digital transformation on the operational efficiency of small and medium-sized enterprises (SMEs), exploring the critical role of digital technologies in enhancing supply chain management. Through field research and case studies, this paper focuses on examining the application effects of technologies such as the Internet of Things (IoT), cloud computing, and artificial intelligence across various stages of SME supply chains, revealing the practical value of digital transformation in optimizing operational processes and controlling costs. The research finds that supply chain digital transformation can significantly improve SMEs' efficiency in order processing, inventory management, and logistics distribution, while also facing practical challenges such as technological application barriers and implementation path selection. Based on empirical analysis, the study proposes a phased digital implementation strategy tailored to the characteristics of SMEs and offers actionable recommendations from both corporate and policy perspectives, providing theoretical guidance and practical references for SMEs to advance supply chain digital transformation.

1. Introduction

As the global economy accelerates its digital transformation, the field of supply chain management is undergoing profound changes. In this context, how SMEs can enhance supply chain operational efficiency through digital means has become a critical issue for both industry and academia. Traditional supply chain management models now face multiple challenges, including volatile market demands and rising operational costs, while digital transformation offers new possibilities for SMEs to break through developmental bottlenecks.

This study adopts a practical perspective to deeply explore the implementation pathways and effectiveness evaluation of supply chain digital transformation for SMEs. By selecting typical industry cases, it focuses on analyzing the application scenarios and actual outcomes of various digital technologies across different supply chain stages. The research pays special attention to the unique challenges SMEs face during digital transformation, aiming to provide more actionable solutions. Compared to existing studies that primarily focus on digital practices of large enterprises,

this research fills a theoretical gap in the field of SME supply chain digital transformation.

2. Echnological Applications and Models in Supply Chain Digitalization

The digital transformation of supply chains is fundamentally reshaping the operational paradigms for small and medium enterprises (SMEs), with its essence lying in achieving end-to-end visibility, intelligence, and collaboration throughout the supply chain through next-generation information technologies. At the foundation of this transformation, the Internet of Things (IoT) serves as the critical sensing layer—deploying RFID tags and various sensors across raw materials, work-in-progress, and finished goods enables real-time tracking from procurement through production to final delivery^[1]. A particularly illustrative application emerges in cold chain logistics, where integrated temperature and humidity monitoring sensors not only guarantee product quality for perishable goods but also significantly reduce spoilage risks through predictive alerts and automated corrective actions. Meanwhile, cloud computing platforms democratize access to advanced digital capabilities, providing SMEs with elastic, scalable data storage and processing power without requiring massive upfront investments in IT infrastructure. This pay-as-you-go model has dramatically lowered the barriers to digital adoption for resource-constrained SMEs.

Artificial intelligence applications are catalyzing a paradigm shift from experience-based to data-driven supply chain decision-making. Sophisticated machine learning algorithms digest multidimensional data—including historical sales patterns, market trends, and even weather forecasts—to generate demand predictions with unprecedented accuracy, enabling optimized inventory planning^[2]. Natural language processing (NLP) technologies are transforming supplier management through automated contract analysis, rapidly identifying critical clauses and potential compliance risks across thousands of documents. Blockchain introduces radical transparency to multi-party supply chain operations, with immutable distributed ledgers providing verifiable provenance tracking for raw materials and tamper-proof documentation of logistics movements. Notably, these technologies don't operate in isolation but form a synergistic ecosystem—IoT devices feed real-time operational data into cloud-based AI models, whose analytical outputs dynamically reconfigure warehouse allocations and transportation routes through integrated execution systems.

At the operational model level, supply chain digitization has spawned innovative business architectures that redefine traditional value chains. Shared logistics platforms exemplify this transformation, aggregating fragmented regional warehousing and transportation resources into on-demand networks—allowing SMEs to access sophisticated logistics capabilities previously reserved for large corporations through flexible pay-per-use models. Collaborative supplier portals dismantle information silos by synchronizing demand forecasts, inventory positions, and production schedules across supply networks, replacing sequential handoffs with concurrent planning processes. Pioneering companies are now implementing data-driven supply chain finance solutions, where real-time transaction records and operational metrics serve as dynamic credit assessments to provide tailored financing options for upstream and downstream partners. These interconnected innovations collectively constitute a digital supply chain value network, where continuous data flows optimize resource allocation across the entire ecosystem, ultimately driving systemic efficiency gains and cost reductions throughout the value chain.

The most advanced implementations now incorporate digital twins—virtual replicas of physical supply chains that simulate scenarios and predict disruptions before they occur. Forward-thinking SMEs are leveraging these technologies to transition from reactive problem-solving to predictive supply chain orchestration, achieving resilience advantages disproportionate to their size. As 5G networks enable real-time data transmission from even the most remote suppliers, and edge

computing processes IoT data at the source, we're witnessing the emergence of self-adjusting "cognitive supply chains" that continuously learn and optimize—a capability that could finally level the playing field between SMEs and their larger competitors in global markets.

3. Empirical Analysis of Digital Efficiency in SMEs

Extensive empirical research has verified that digital transformation significantly enhances operational efficiency in small and medium enterprises (SMEs). Case studies across multiple industries, including manufacturing, retail, and logistics, demonstrate that SMEs adopting digital tools experience substantial improvements in critical operational aspects such as order processing, inventory management, and supply chain responsiveness^[3]. For instance, manufacturing enterprises implementing cloud-based management systems can drastically reduce order processing times while significantly improving inventory accuracy, thereby minimizing losses from mismanaged stock. Businesses leveraging IoT technology gain real-time production line monitoring capabilities, leading to better-controlled equipment failure rates and maintenance costs, resulting in more stable and efficient operations. These findings highlight how digital solutions not only streamline workflows but also strengthen adaptability to market fluctuations.

Further research reveals a strong correlation between digital technology adoption and business performance in SMEs. Companies utilizing data analytics demonstrate enhanced demand forecasting accuracy, substantially reducing excess inventory and stockouts. The implementation of AI-powered customer service systems alleviates labor-intensive workloads while simultaneously improving service quality. Importantly, digital efficiency gains often exhibit an accelerating effect—after establishing foundational digital infrastructure, deeper technological integration yields exponentially greater synergies. For example, after initial digitization of logistics tracking, the introduction of intelligent optimization algorithms can dramatically elevate overall delivery performance, showcasing the transformative potential of advanced digital applications.

However, SMEs face unique challenges in their digital transformation journeys. Compared to larger corporations, SMEs experience greater financial pressure during initial technology investments, with longer payback periods. The shortage of skilled professionals presents a particularly acute constraint, with many SMEs unable to fully realize system potential due to limited technical expertise. Additionally, legacy system fragmentation complicates data integration, hindering comprehensive digital benefits realization. Notably, the growing accessibility of cloud computing services and low-code development tools is expanding pathways for SMEs to acquire digital capabilities, creating new opportunities to narrow efficiency gaps with larger enterprises.

4. In-depth Case Studies

The digital transformation journey of J Hardware Manufacturing Enterprise, a medium-sized company with annual revenue of 200 million RMB, serves as an exemplary model for traditional manufacturers. Prior to launching its digital initiative in 2018, the company faced typical challenges: manual order processing resulted in 7-10 working days lead time; paper-based warehouse management led to 15% monthly inventory discrepancies; reactive equipment maintenance caused average monthly downtime losses of 200,000 RMB. These operational inefficiencies kept on-time delivery rate at merely 78%, severely limiting market expansion.

J Enterprise implemented its digital transformation through a carefully planned three-phase strategy. In Q1 2019, the company invested 3 million RMB to deploy SAP Business One ERP system, achieving end-to-end digitization from sales orders to material procurement. The most immediate impact was a 5-fold improvement in order processing efficiency, reducing average handling time from 3 days to 4 hours. Barcode scanning technology boosted inventory accuracy to

97%. In 2020, an additional 5 million RMB investment introduced Siemens MES system, with 80 data collection terminals installed across 12 production lines. This allowed real-time monitoring of workstation progress, raising Overall Equipment Effectiveness (OEE) from 65% to 82%.

The most transformative breakthrough came in 2021. J Enterprise commissioned a custom-developed intelligent scheduling system that integrated ERP order data, MES production data, and supplier delivery data. Using genetic algorithms for optimization, the system increased monthly order fulfillment capacity by 38% without additional resources. Vibration and temperature sensors installed on critical equipment achieved 85% predictive maintenance accuracy, yielding annual savings of 1.2 million RMB in maintenance costs. These digital achievements directly translated into business results - by 2022, with unchanged workforce size, annual revenue grew to 280 million RMB with 4.2 percentage points improvement in profit margin.

J Enterprise's case vividly demonstrates three critical success factors for digital transformation. First, the phased implementation ensured manageable risk, with each stage's outcomes laying foundation for subsequent phases. Second, the depth of data integration determined transformation value - only when order, production and supply chain data truly flowed could intelligent decision-making emerge. Most importantly, J Enterprise simultaneously drove organizational changes including establishing a digital department, adjusting KPIs, and conducting company-wide training. This "technology + management" dual-track approach represents the fundamental guarantee for sustainable transformation results. The key lesson for peer enterprises is J's disciplined focus on solving its most pressing problems with appropriate (rather than cutting-edge) digital solutions.

5. Recommendations and Future Prospects

Building upon J Enterprise's successful experience and the key challenges in digital transformation, we can derive several universal recommendations. First and foremost, traditional manufacturing enterprises should use operational pain points as entry points, avoiding blind pursuit of technological sophistication while focusing on solving specific bottlenecks through digital means. J Enterprise's case demonstrates that a phased implementation strategy with quick wins can effectively mitigate transformation risks. Companies are advised to prioritize foundational digitalization (such as ERP and MES systems) that delivers rapid results before gradually progressing toward intelligent applications (like AI-based scheduling and predictive maintenance). Concurrently, data governance must run through the entire transformation process—establishing unified data standards and interface specifications to break down information silos is essential for unleashing the synergistic value of data.

More crucially, digital transformation represents not just technological upgrades but also organizational and management paradigm shifts. Enterprises need to simultaneously drive process reengineering, organizational restructuring, and talent development—such as establishing dedicated digital departments, incorporating data metrics into performance evaluations, and conducting regular digital skills training—to ensure technological investments translate into tangible productivity gains. For resource-constrained SMEs, adopting cloud-based solutions and actively seeking government subsidies and industry-academia collaborations can help lower the transformation threshold.

Looking ahead, manufacturing digital transformation will evolve along three major trends. First, the focus will shift from point solutions to comprehensive integration. With the proliferation of 5G and industrial internet platforms, deeper data connectivity will emerge across internal R&D, production, and supply chain functions, forming collaborative networks with external ecosystem partners. J Enterprise is currently exploring direct system integration with suppliers and customers, potentially achieving end-to-end digital coordination from raw material procurement to product

delivery. Second, AI technologies will further permeate all manufacturing aspects—expanding beyond scheduling and predictive maintenance to quality inspection, energy optimization, process improvement, and more—forming closed-loop "sense-analyze-decide-act" intelligence. Third, digital twin technology will mature gradually, enabling simulation optimization and real-time monitoring of production systems through virtual replicas of physical factories, significantly enhancing operational decision-making efficiency.

Notably, as digital transformation deepens, data security and cybersecurity will become critical challenges. Enterprises must proactively establish robust data governance frameworks and network security protection mechanisms. Over the next decade, digital transformation will transition from being a competitive advantage to a survival imperative. Those enterprises that can deeply integrate digital technologies with manufacturing expertise while continuously innovating business models will gain decisive advantages in the new wave of industrial transformation.

6. Conclusion

This study systematically examines the enhancing effects of supply chain digital transformation on the operational efficiency of SMEs, revealing the multifaceted value of digital technologies in optimizing supply chain management. The research demonstrates that appropriate digital transformation can help SMEs gain operational efficiency advantages in competitive markets, though it requires the formulation of gradual implementation strategies tailored to each enterprise's specific circumstances.

Future research could expand into comparative studies of digital transformation among SMEs across different industries and regions, delving deeper into long-term effectiveness evaluation systems for digital transformation. Additionally, with the continuous development of emerging technologies, future attention should be given to the innovative applications of cutting-edge technologies like artificial intelligence in SME supply chain management. For practitioners, seizing the opportunities of digital transformation and selecting digital pathways that align with their enterprise's characteristics will be key to enhancing competitiveness.

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