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The Impact of Digital Capabilities on the Transition to a Low-Cost Supply Chain: Evidence from Moroccan manufacturing firms

L'impact des capacités digitales sur la transition vers une supply chain low-cost : Cas des entreprises industrielles marocaines

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Abstract

This article examines digital capabilities as strategic drivers for low-cost supply chains in Moroccan manufacturing firms. As global competition intensifies and pressing cost considerations arise, businesses adopt digital technologies like cloud computing, IoT, AI, and predictive analytics to enhance efficiency, responsiveness, and cost-effectiveness (Liu et al., 2023; Ngo et al., 2023). Empirical investigations remain scarce in emerging economies, particularly in North Africa, to measure how digital maturity translates into performance betterments in the supply chain (Weerabahu et al., 2023).

Qualitative feedback from managers shows that while technology investment must be made, organizational readiness—digital literacy, training, and change management—needs equal consideration to fully realize digital transformation benefits (Gupta et al., 2020; Calle et al., 2020). The article concludes with recommendations for strategic digital roadmaps, government policy support, and frameworks for developing digital capabilities for firms to lean on during the transition into cost-efficient supply chains.

Keywords: Digital capabilities; Supply Chain Management; Cost Reduction; Digital Maturity; Morocco.

Résumé

Cet article analyse le rôle des capacités digitales comme leviers stratégiques pour les entreprises engagées dans une trajectoire technologique vers des chaînes d'approvisionnement à faible coût, dans le contexte des entreprises de production au Maroc. Face à l'intensification de la concurrence mondiale et aux pressions croissantes sur les coûts, les entreprises adoptent des technologies telles que le cloud computing, l'Internet des objets (IoT), l'intelligence artificielle (IA) et l'analytique prédictive afin d'améliorer leur efficacité, leur réactivité et leur performance économique (Liu et al., 2023 ; Ngo et al., 2023). Les études empiriques restent toutefois limitées dans les économies émergentes, notamment en Afrique du Nord, pour analyser comment la maturité digitale se traduit concrètement en gains de performance au sein des chaînes d'approvisionnement (Weerabahu et al., 2023).

Les retours qualitatifs des managers montrent que, bien que l'investissement technologique soit indispensable, la préparation organisationnelle — incluant les compétences digitales, la formation et la gestion du changement — doit être prise en compte de manière équivalente pour exploiter pleinement les bénéfices de la transformation digitale (Gupta et al., 2020 ; Calle et al., 2020). L'article se conclut par des recommandations portant sur l'élaboration de feuilles de route digitales stratégiques, le soutien des politiques publiques et la mise en place de cadres de développement des capacités digitales, afin d'accompagner les entreprises dans leur transition vers des chaînes d'approvisionnement plus efficientes en coûts.

Mots-clés : Capacités digitales ; Gestion de la chaîne d'approvisionnement ; Réduction des coûts ; Maturité digitale ; Maroc.

Introduction

Global supply chains have evolved from linear, rigid systems into interconnected, data-driven networks, which was propelled mainly by fast and better digital technology (Lummus & Vokurka, 1999; Min et al., 2019). The incorporation of digital supply chains with artificial intelligence, IoT, cloud and blockchain technologies, big data analytics, and robotics has brought smarter decision-making, transparency, and operational efficiency (Korpela et al., 2017; Gupta et al., 2020). They help firms in real-time monitoring of their inventory, anticipation of disruptions, automation of routine works, and optimization of logistics across vast geographic regions (De Vass et al., 2021).

Predictive management is key trend in today's supply chain landscape. Traditional supply chains relied solely on historical figures interspersed with updates by time intervals; now, a much more digitalized network allows continuous streams of data that create dynamic responses to presenting market conditions (Christopher & Holweg, 2011). Developing resilience and agility to mold supply chains in, such as geopolitical instability, pandemic, or climate-disruption events, makes these evolutions valuable (Ngo et al., 2023; Michel-Villarreal et al., 2021).

New types of digital collaboration across the supply chain ecosystem will now emerge. Suppliers, manufacturers, distributors, and retailers will be able to sync their activities as they happen using cloud platforms or integrated ERP systems (Benjamin & Wigand, 1995). Blockchain, for example, holds vast promise for increasing trust and traceability, especially in areas such as food, pharmaceuticals, and luxury goods (Korpela et al., 2017). These technologies enhance the performance of operations and have their ways toward environmental and social sustainability through waste reduction, better traceability, and a reduced carbon footprint (Lerman et al., 2022; Awan et al., 2022).

However, several challenges still remain. For a good number of SMEs, capital, training, and digital tools to modernize their operations are some must-have resources that are denied to too many (Oyinlola et al., 2022). These challenges are worsened by varying digital literacy among the staff and therefore the managers and employees; these hinder digital capability integration to daily business activities at the workplace (Calle et al., 2020). This requires collaborative efforts to build capacities, promote innovation, and reduce barriers for under-resourced firms.

This study addresses the following central question:

"How do digital capabilities enable the transition to a low-cost supply chain in Moroccan manufacturing firms, and what are the main barriers and enablers of this transformation?"

This research adopts an interpretivist paradigm and an exploratory qualitative approach, consistent with a "how" research question. The scientific gap is threefold: limited empirical evidence on cost reduction, absence of industry-specific insights for the Moroccan context, and underexplored SME adoption barriers. The expected theoretical contribution is an operationalization of the Resource-Based View (RBV) and dynamic capabilities applied to digital supply chains in an emerging economy.

Examining how digital capacities convert into low-cost supply chains in Morocco is the prime concern of this article. It will show how digital technologies - when purposefully used - can reduce operational in equivocality at different supply chains by making them transparent and enabling cost optimization (Jiang et al., 2023).

The article adopts a qualitative multiple-case study approach based on semi-structured interviews with managers from Moroccan manufacturing firms in key sectors such as automotive, agriculture, textile, and logistics. This design provides an in-depth understanding of how digital capabilities support the transition toward low-cost supply chains in the Moroccan context.

1. Literature Review

1.1. Digital Capabilities in Supply Chain Management: AI, IoT, Blockchain, and Cloud

Business 4.0 has enshrined digital capabilities in contemporary supply chain management (Liu et al., 2023). Some of these transformational technologies are AI, IoT, blockchain, and cloud computing (Korpela et al., 2017). In addition to technical advancement, these innovations impact strategic agility, immediate responsiveness, and predictive ability, thereby setting new frontiers for contemporary supply chains.

AI offers significant inputs into enhanced demand forecasting, predictive maintenance, and dynamic pricing (Ning & Yao, 2023; Yang et al., 2023). Its extensive learning from the past allows the demand on the forward disruptions and sets forward responses to the behavior of consumers. Machine learning algorithms are increasingly integrated into supply planning to optimize their parameters for inventory and possible waste, hence following lean management principles (Malali, 2022).

IoT has revolutionized asset tracking and continuous monitoring (De Vass et al., 2021; Mostafa et al., 2019). By putting sensors into transport vehicles, warehouses, and products,

supply chain players gain visibility through flows. This is now an operating efficiency factor, while a predictive aspect allows for accurate timing as well as proactive issue management with the customer.

Blockchain has an important extra layer of security and transparency: to be for transaction verification, for smart contract execution, and to be able to trace goods back to their origins (Korpela et al., 2017). Being decentralized does rule out most of the fraud, provides excellent traceability, and assures compliance with global regulations, especially in pharmaceuticals and food.

Cloud computing provides SCM with data and various geographical networks for collaboration (Sola et al., 2025). With centralized storage of accessible data, real-time analytics, and scalable cloud computing power, a cloud-based solution is advantageous. This allows for even more flexible management of large logistics operations, reduced IT overhead, and rapid digitalization by companies.

Thus, these technologies work together to create a smart, responsive, adaptive supply chain (Gupta et al., 2020). But their success also depends on organizational capability and digital agility, as well as an innovation culture - which vary vastly by region and industry, especially in emergent economies like Morocco (Calle et al., 2020).

1.2. Cost-Efficiency and Low-Cost Supply Chains

Cost efficiency remains a central concern in a supply chain strategy (Christopher & Towill, 2002). In the digital age, cost pressure has moved out of operational streamlining and even bringing to bear technological leverage. A supply chain becomes low-cost not by actually minimizing costs but through a strategic deployment of digital tools capable of optimizing every node and flow in a supply network (Jiang et al., 2023).

Traditionally, cost savings came through outsourcing, offshoring, and lean manufacturing (Vonderembse et al., 2006). While certainly effective, such methods left firms exposed to certain vulnerabilities, e.g. geopolitical risks, long lead times, and supply disruptions (Christopher & Holweg, 2011). These were further highlighted by the COVID-19 pandemic, which effectively negated traditional cost-based models and hence moved firms toward digitally enabled resilience and agility (Ngo et al., 2023).

Digital transformations will not compromise with increased cost effectiveness, quality, or responsiveness. For example, AI-driven inventory optimization reduces holding costs while maintaining service levels (Ning & Yao, 2023). Also, IoT-enabled logistics enables real-time

rerouting of shipments avoiding congestion or weather-related delays, and thus minimizing fuel usage and labor costs (De Vass et al., 2021; Glidden et al., 2004).

Automating procurement and supplier management through the cloud platform has brought forth significant savings on administration overheads (Sola et al., 2025). Predictive analytics allow more accurate budgeting and resource allocation by allowing data-driven intelligent decisions that support cost confinement (Malali, 2022).

Most important, low-cost networks made possible through digital capabilities are also very sustainable over the long run: better forecasts, less overproduction, and little waste benefit financial performance as well as environmental responsibility (Lerman et al., 2022; Awan et al., 2022). Companies that invest in these systems keep a competitive advantage over competitors, especially where demand is growing in the market.

Emerging economies will often remain patchy as far as integrating digital solutions for cost efficiency is concerned (Oyinlola et al., 2022). Other barriers include a lack of infrastructure, high initial investments, and an insufficient pool of technical skills, which hinder full-scale adoption.

1.3. Digital Transformation in Emerging Markets

Emerging countries follow digital transformation pathways distinct from developed economies (Sturgeon & Kawakami, 2011). Adoption depends on local contextual factors: infrastructure availability, policy environments, cultural perceptions of technology, and market preparedness (Gupta et al., 2020).

Emerging economies across Africa, Asia, and Latin America are gradually incorporating digital technologies into their supply chains; however, it is at best partial and not wholly comprehensive (Weerabahu et al., 2023). Gaps include digital literacy, capital investment, and institutional support to overcome existing informality and enable industrial upgrading (Oyinlola et al., 2022).

Successes of government-led digital initiatives, such as in India and Vietnam, have introduced improved transparency and reduced transaction costs, while increasing SME participation (Lund et al., 2019).

Sub-Saharan Africa presents a paradox: while there are all the indications of rapid mobile and fintech growth, end-to-end digital supply chain solutions are barely available (Oyinlola et al., 2022).

Unreliable internet access, power shortages, and limited access to finance prevent business people from being able to invest in next-generation technologies such as AI and IoT.

Nevertheless, some bright spots are emerging. A major revolution in supply chains for agriculture, for instance, has occurred in Kenya through digital platforms, which now enable real-time price discovery, mobile payments, and traceability for farmers (Michel-Villarreal et al., 2021). In South Africa, digitization has found application in the major retailers' logistic systems to standardize across vast spans of distribution networks.

Morocco illustrates this dynamic. It has done so by linking Africa and Europe through investment in digital infrastructure, trade logistics, and an industrial modernization agenda. Yet the digital gap between multinationals and local suppliers persists. Morocco's capacity to harness digital capabilities depends on public-private partnerships, education investment, and clear policy frameworks supporting digital integration at scale.

1.4. Research on Moroccan Supply Chains

Scholarly discussions have grown on Moroccan supply chains based on trade and industrialization. Research sectors include automotive manufacturing, agriculture, textiles, and logistics, and how these benefit from policy reforms, infrastructure development, and global integration (Szalavetz, 2019).

Morocco's strategic location has made it a logistics hub for Europe, especially by using the Tangier Med port complex. Logistics infrastructure support lower trade costs with an observed time-to-market for exporters. However, many SMEs remain disconnected from global value chains due to organizational immaturity and poor digital capabilities (Sturgeon & Kawakami, 2011).

The growing interest in digital transformation research has been spurred by national initiatives like "Digital Morocco 2020" and "Green Generation 2020-2030." Some studies analyze digital technology use in logistics and warehousing (Mostafa et al., 2019), while others assess industrial cluster readiness.

Considerable gaps remain. Research focuses on policies and infrastructure, but little is known about firm-level digital transformation strategies. Technological tools are often treated in isolation rather than as part of a cohesive ecosystem for cost-effective supply chains.

The human-capital dimension is particularly neglected. Management capabilities, training, and change management essential for digital supply chain development remain largely overlooked (Calle et al., 2020).

1.5. Synthesis and Gaps in Current Knowledge

Recent international literature demonstrates how digital capabilities transform supply chain resilience, agility, and cost efficiency (Liu et al., 2023; Gupta et al., 2020). Advanced

economies have integrated these technologies to enhance end-to-end visibility, predictive analytics, real-time decision-making, and platform-based collaboration (Weerabahu et al., 2023). The opposite prevails in emerging markets like Morocco, where digital application remains early-stage, fragmented, with weak institutional support, poor infrastructure, and uneven technological awareness.

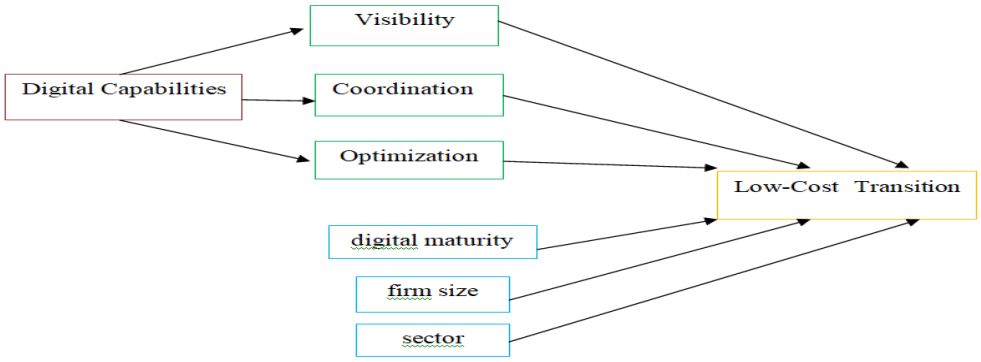
Researchers have hardly applied digital transformation frameworks, maturity models, or ROI assessments meaningfully to the Moroccan context.

The literature also neglects digital transformation as a strategic lever for cost-efficient supply chains in developing economies (Jiang et al., 2023). Human capital's critical role in enabling digital readiness is overlooked in Morocco, where the interplay between firm strategy, sectoral applications, and human capital remains ignored (Calle et al., 2020). Context-oriented research adapting digital capabilities to local industry dynamics, labor market realities, and socio-economic conditions remains scarce.

1.6. Conceptual Model

Based on the literature review, we propose a conceptual model in which digital capabilities (integrating IoT, cloud, AI, blockchain) influence low-cost transition through three mechanisms: (1) visibility and coordination (De Vass et al., 2021), (2) operational cost reduction (Jiang et al., 2023), (3) predictive optimization (Ning & Yao, 2023). This model is moderated by Moroccan contextual factors (digital maturity, sector, firm size).

Figure N°1: Proposed Conceptual Model



2. Scientific Gaps

2.1. Limited Empirical Evidence on Cost Reduction

The debate on theoretical advantages of digital capabilities for cost reduction lacks empirical support (Ning & Yao, 2023). Literature often discusses AI, blockchain, or IoT potential in isolation, neglecting synergistic effects and measurable cost impacts (Weerabahu et al., 2023).

Most available studies rely on case studies and theoretical modeling using secondary data, neglecting real-world evidence. Empirical gaps are glaring in emerging markets like Morocco, where supply chain dynamics differ from advanced economies.

In Morocco, the impact of AI-enabled demand forecasting, cloud-based inventory management, and IoT-enabled asset tracking has been addressed theoretically, lacking conclusive evidence of cost savings for SMEs.

2.2. Absence of Industry-Specific Insights

A significant gap is the lack of industry-specific information on how digital capabilities affect cost streams across different sectors (Weerabahu et al., 2023). Automotive, agriculture, pharmaceuticals, and textiles have distinct supply chain characteristics requiring tailored digital solutions.

For instance, automotive supply chains are global, involving extensive supplier networks where blockchain and IoT improve transparency and traceability (Korpela et al., 2017; De Vass et al., 2021). Agriculture faces different challenges: perishable goods and seasonal variations (Michel-Villarreal et al., 2021). Pharmaceuticals face strict regulations affecting digital tool implementation. Understanding these industry-specific needs is essential.

In Morocco's fast-growing automotive sector, digital technologies offer significant potential, but detailed case studies are lacking (Szalavetz, 2019). Similarly, agriculture and textiles require specific research.

2.3. Underexplored Barriers to SME Adoption

Most digital transformation research examines large corporations (Gupta et al., 2020). Resource-constrained SMEs often fail to adopt advanced digital tools, reducing their competitiveness.

Research has identified numerous barriers: high initial capital investment, lack of technical know-how, and limited digital infrastructure (Oyinlola et al., 2022). However, in-depth investigations specific to Moroccan SMEs are lacking.

While some studies examine downsizing digital solutions for SMEs, few consider how to simplify or adapt solutions for smaller firms. Although cloud-based solutions and AI are efficient for large enterprises, adaptations for SMEs receive limited attention (Sola et al., 2025; Malali, 2025). SMEs' unique characteristics—limited resources, smaller supply chain scope, different risk appetite—require agile, cost-effective, manageable solutions.

Table N°1: Barriers to SME Adoption of Digital Tools in Supply Chains

Barrier	Description	Impact on SMEs	Possible Solutions
High Initial Costs	High investment required for digital infrastructure and software	Limits adoption for resource-constrained SMEs	Government incentives, shared platforms
Lack of Expertise	Insufficient skills in data analysis, AI, IoT, and digital technologies	Delays implementation and integration	Training programs, external consultations
Infrastructure Gaps	Poor internet connectivity and energy reliability, especially in rural areas	Hinders real-time data exchange and process optimization	Investment in local infrastructure
Digital Integration	Difficulty integrating new digital tools into existing, often legacy, systems	Disrupts operations and increases complexity	Gradual adoption, scalable solutions

Source : Author

2.4. Disconnect Between Digital Capabilities and Sustainability

Another significant gap is the disconnect between digital technology adoption and sustainability pursuit within supply chains (Lerman et al., 2022; Awan et al., 2022). Digital transformation discussions focus on operational efficiency, cost reduction, and innovation, but the role of digital capabilities in achieving sustainability goals remains underexplored.

Sustainability in supply chains encompasses reducing environmental impact, enhancing social responsibility, and fostering long-term viability. However, digital tools like AI, IoT, and blockchain are often framed in terms of operational efficiency rather than environmental or social benefits (Liu et al., 2023). Their potential to drive sustainability—optimizing resource usage, reducing waste, improving transparency, supporting ethical sourcing—has been insufficiently researched.

In Morocco, where sustainability gains importance, particularly in agriculture and textiles, understanding how digital technologies contribute to both cost reduction and sustainability is critical. Urgent research is needed on leveraging digital tools for environmental and social sustainability while maintaining cost-effectiveness (Nehal & Gupta, 2024).

2.5. Lack of a Standard Cost-Oriented Digital Maturity Framework

Despite advances in digital transformation, an accepted framework for assessing digital maturity specifically for cost savings remains unavailable (Weerabahu et al., 2023). Existing maturity models rarely focus on cost achievement directly, providing limited guidance for measuring digital investment effectiveness.

Without internationally accepted cost-oriented digital maturity frameworks, Moroccan SMEs are particularly at risk, lacking resources for in-depth digital readiness assessments. A complete framework incorporating cost-efficiency at the heart of digital maturity evaluation

would enable organizations to prioritize investments and make informed technology decisions.

Such a framework would provide benchmarks for measuring progression and identifying development areas, establishing an academic foundation for standardized measurement of digital tools' influence on supply chain cost efficiency across sectors (Ning & Yao, 2023).

3. Statement of the Problem

3.1. Obstacles to Implementation Due to Initial Cost

The primary constraint to digital transformation for SMEs in developing nations like Morocco is the substantial initial investment required for adopting new digital technologies (Oyinlola et al., 2022). Digital transformation entails capital spending on hardware, software, and infrastructure. This initial financial investment often overwhelms SMEs. Acquiring advanced technologies including AI, IoT, and blockchain, plus integration with existing systems, easily exhausts smaller enterprises' budgets.

It also impacts SMEs' ability to obtain financing before adoption. Limited finances may cause companies to hesitate or delay installing productive technologies, adversely affecting growth and competitiveness, and resulting in competitive disadvantage against more digitally-advanced competitors.

3.2. Organization and Operational Barriers

Beyond financial challenges, SMEs face organizational and operational barriers that complicate digital capability deployment (Gupta et al., 2020). One devastating barrier is workforce digital literacy and lack of technical skills (Calle et al., 2020). Employees may know new technologies but resist due to job security fears or change aversion, slowing adoption and creating friction.

Additionally, SME organizational structures and operational processes often conflict with digital transformation requirements. Legacy systems, outdated workflows, and inefficient processes create disconnects when applying digital solutions (Mosch et al., 2021). Unless business goals align with digital initiatives, new technologies' potential cannot be realized.

3.3. Challenges in Data Utilization

Another critical issue is underutilization of data from digital systems (Malali, 2022). Despite massive data streams from digital transformation, most SMEs lack tools and skills to collect, store, or analyze data appropriately. Without infrastructure and analytical capabilities, valuable insights for demand forecasting, supply chain optimization, or cost-saving opportunities remain inaccessible.

Many SMEs don't know what additional data would add value. Data acquisition may be easy, but utilization and connection to business growth present greater challenges.

3.4. Cybersecurity Attacks

As SMEs digitize, data breach and theft risks escalate (Malali, 2025; Sola et al., 2025). Cybersecurity is a major concern for Moroccan SMEs, most lacking adequate security infrastructure to protect sensitive data. Cybercriminals target small businesses due to perceived weak security and limited resources.

Reputational damage or legal consequences from breaches can devastate small businesses. Yet many SMEs view cybersecurity investment as non-essential. Costs may appear prohibitive for businesses with narrow budgets, but the long-term cost of failing to invest is much higher (Malali & Praveen Madugula, 2025).

Table N°2: Summary of Challenges

Challenge	Impact on SMEs	Proposed Solutions
High Initial Investment Costs	Financial strain and delayed adoption of digital technologies	Government incentives, shared platforms, flexible payment models
Organizational and Operational Barriers	Resistance to change and misalignment of business processes	Training, change management, leadership support
Data Utilization Challenges	Inability to leverage data for decision-making	Investment in data analytics tools and training
Cybersecurity Risks	Increased vulnerability to cyberattacks and data breaches	Strong cybersecurity policies, employee awareness programs

Source : Author

4. Methodological Approach

4.1. Research Design

A qualitative multiple-case study design was adopted, appropriate for exploratory research in under-theorized contexts. This research adopts an interpretivist paradigm, seeking to understand how digital capabilities enable low-cost supply chains from the perspective of managers.

4.2. Sample

The study focuses on ten Moroccan manufacturing firms selected using maximum variation sampling (sectors: automotive, textile, agribusiness, logistics, consumer goods). Inclusion criteria: ongoing digital transformation for at least two years, proven supply chain complexity, and willingness to participate in in-depth interviews.

4.3. Data Analysis Techniques

Thematic Analysis: Qualitative data from interviews and narratives from case studies will undergo Thematic Analysis undertaken on NVivo. It will involve coding the data,

identification of patterns, and clustering of themes reflecting barriers, enablers, perceptions, and results of digital transformation**.**

4.4. Validation and Reliability Measures

Instrument Validation: Interview guides were subjected to expert review and piloted with a small sample of supply chain professionals in Morocco. Feedback refined question clarity and alignment with research objectives.

Triangulation: Triangulation is a major methodological feature through mixed qualitative data, enhancing credibility through multiple data sources (interviews, secondary documents), methods (case study, cross-sectional survey, longitudinal observation), and perspectives (executives, mid-managers, technical experts).

Ethical Considerations: Strict confidentiality and informed consent will be observed. Ethical clearance will be obtained from an accredited Institutional Review Board (IRB) prior to data collection.

5. Empirical Results

5.1. Overview of Participating Firms

Differentially sized and digitally mature, with a commonality in the complexity of the supply chain, all firms were under digitization at the last 3 to 5 years and had some outcome measures of cost and performance. Data collection involved semi-structured interviews with supply chain managers and digital performance reports.

5.2. Challenges and Constraints in Digital Implementation

Disparate challenges reported by organizations along their paths to digitalization limited their efforts towards realizing digital benefits in full.

Human Capital Gaps: A shortage of IT-skilled labor capable of management and interpretation of digital tools was reported by organizations as constraining their digitalization efforts.

Integration with Legacy Systems: Incompatibility issues between newer digital systems and older ERP platforms delayed implementation timelines for organizations.

Cybersecurity Concerns: Data security threats were acknowledged versus all partners, particularly in instances of cloud-based use or supplier portals.

Initial Investment Costs: Firms would accept that there was a high upfront technology implementation cost for IoT, blockchain, and AI, being offset by savings over time.

These barriers indicate the need for phased, well-funded, strategically managed digital transformation.

5.3. Summary of Key Empirical Insights

This study shows that digital capabilities can reduce supply chain costs and improve operational responsiveness. Proactive management of challenges such as integration, talent shortage, and cybersecurity is crucial for optimal outcomes. The results validate that investing in digital tools is strategic for efficiency and as a first step toward resilient and low-cost supply chains.

6. Key Challenges and Interconnections

Adopting low-cost, digitally-enhanced supply chains is a complex, multidimensional change process (Christopher & Holweg, 2011). Organizations must address interrelated challenges technically, strategically, financially, and culturally. This section discusses five major barriers and their interconnections.

6.1. High Up-Front Costs versus ROI Uncertainty

A primary barrier is the high upfront cost of installing advanced technologies like AI, blockchain, cloud infrastructure, and IoT (Oyinlola et al., 2022). For many Moroccan SMEs, such costs are viewed as extravagant and risky.

Unlike traditional fixed asset investments, digital technologies seldom promise immediate payback (Jiang et al., 2023). This absence of specific ROI timelines complicates decision-making. Benefits like real-time visibility and automation-driven efficiency are intangible and difficult to measure upfront.

In emerging markets like Morocco, scanty case studies and limited empirical benchmarks make ROI calculation impossible (Weerabahu et al., 2023). Financial issues intertwine with other hurdles: even well-funded projects yield limited ROI without skilled people or long-term strategy.

6.2. Skills Gap and Cultural Resistance

Technology implementation requires capable people (Calle et al., 2020). Morocco faces digital skill shortages in predictive analytics, cybersecurity, cloud-based logistics, and data integration (Gupta et al., 2020). Both technical staff and operational managers are lacking.

Widespread cultural resistance compounds this. Workers accustomed to traditional methods see automation as job threats or unnecessary complications (Mosch et al., 2021), leading to forceful resistance, slow adoption, or minimal compliance. Training alone does not guarantee adoption.

Lack of digital competency in leadership results in piecemeal, directionless transformation efforts.

6.3. System Interoperability and Data Silos

System interoperability is a major technical constraint (Weerabahu et al., 2023). Many Moroccan firms, especially SMEs, use legacy or incompatible software across departments, hampering communication and creating data silos.

Data silos prevent real-time decision-making (Malali, 2022). When logistics systems aren't integrated with procurement or inventory, companies cannot track supplies accurately or react quickly to disruptions. This fragmented landscape hampers demand forecasting, cost management, and resource optimization.

It also prevents integration of advanced technologies like AI or blockchain. Without standard data formats and linked systems, organizations incur expensive customization and maintenance costs

6.4. Cybersecurity and Trust

As organizations shift to digitally-driven supply chains, they face rapidly evolving threats (Malali, 2025). Data breaches, ransomware, supply chain espionage, and phishing attacks cause significant financial and reputational damage.

Morocco's data protection regulatory environment is still evolving. Low security standards, unencrypted systems, and lack of cybersecurity training accelerate exposure.

Trust concerns extend beyond internal systems. Digital supply chains require cooperation across suppliers, logistics providers, and customers (Korpela et al., 2017). Without strong cybersecurity assurances, partners may resist shared data environments, affecting digital integration, transparency, and collaborative innovation.

Security investments are often viewed as defensive rather than productive, but their absence makes breaches far costlier. Cybersecurity should be treated as central to cost-effective digital transformation (Malali & Praveen Madugula, 2025).

Table N°3 : Challenge Interconnections

Challenge	Related Challenges	Impact on Supply Chain
High Up-Front Costs	ROI Uncertainty, Skills Gap	Limits investment in key technologies
Skills Gap and Cultural Resistance	Digital Integration Issues, Strategic Uncertainty	Reduces effectiveness of digital implementations
System Interoperability and Silos	Lack of Roadmap, Technical Constraints	Inhibits end-to-end visibility and efficiency
Cybersecurity and Trust	Partner Collaboration, ROI Concerns	Reduces stakeholder confidence and data sharing
Lack of Strategic Roadmap	All Above Challenges	Results in fragmented, inefficient transformation

Source : Author

6.5. Lack of Strategic Roadmap

The absence of a clearly-defined long-term strategic roadmap is a formidable barrier to digital transformation (Gupta et al., 2020). Organizations often pursue fragmented initiatives with ad-hoc technology acquisition and reactive decision-making rather than structured holistic transformation.

Consequently, digital architecture is disjointed, data is unintegrated, and processes become increasingly complicated. For example, a company might purchase an advanced inventory management system without integrating it with procurement or logistics, creating duplicative activities (Mosch et al., 2021). Without a strategic model, technology investments fail to deliver ROI and may worsen bottlenecks.

A proper roadmap includes: vision and objectives, capability mapping, technology integration plan, change management framework, governance structure, and monitoring metrics (Chan, 2003).

7. Discussion

The results of this research indicate the significant importance of having digital capabilities that could facilitate the transformation of supply chains into more efficient lean cost models (Ning & Yao, 2023). These findings confirm previous work by Ning & Yao (2023) and Jiang et al. (2023) on the role of AI and cloud in cost reduction.

However, contrary to assumptions of rapid technology adoption in emerging economies (Oyinlola et al., 2022), our results show that lack of internal skills delays cost gains. Unlike global models (Weerabahu et al., 2023), this study highlights cultural barriers (resistance to change) specific to the Moroccan context.

The proposed cost-centric digital maturity model (foundational, connected, optimized, strategic) extends Weerabahu et al. (2023) by integrating cost-efficiency as a core maturity dimension.

One of the most important deductions is the combined effect of technologies, such as IoT and real-time data analytics, on inventory management and demand forecasting

(De Vass et al., 2021). Companies reported that their utilization of these instruments will result in massive savings on inventory carrying costs as well as stock-outs, which was in line with earlier studies about the efficiency accruing from predictive analytics. With increased demand visibility, automated replenishment processes are set in place hence reducing the need for excess inventory buffers-a traditional line of cost impacts in supply chains.

Secondarily, taking into account the recent development of synergy across the cloud and integrated platforms, they appeared major enablers of collaboration and process synchronizing among suppliers, manufacturers, and distributors (Sola et al., 2025). Ultimately, this integration eliminates delays, transfers the cost of transaction processing, and facilitates the adopted wealth of just-in-time (JIT) models. The arguments favor the Resource-Based View (RBV) in that firms with rare, inimitable digital assets achieve sustainable competitive advantage through cost leadership (Teece, 2018).

Notably, the study has limitations. Many companies in the emerging economies have deficiencies in digital infrastructure and skill endowments lacking what is required to take advantage of these technologies (Oyinlola et al., 2022). The result is a digital divide that prevents a generalized uptake of these low-cost digital supply chains globally. Hence, investments in developing human capital and digital infrastructures are as vital as technologies themselves.

The strategic link between digital transformation and supply chain goals is another significant finding. Organizations aligning digital initiatives and a broader cost reduction strategy have generally been more successful in securing measurable performance improvements (Gupta et al., 2020). On the contrary, insufficient or exploratory digital adoption has resulted in limited returns, suggesting that technology alone is insufficient without a comprehensive implementation strategy.

Although these do enhance cost efficiency with digital capabilities, there arises tension between cost reductions and resilience (Christopher & Holweg, 2011). Some digital transformations, notably nearshoring enabled by digital twin or blockchain, may decrease lead times, yet incur increased short-term expense. Organizations must trade off between factors such as industry dynamics and risk appetite.

Last but not least, the research adds to the literature concerning models of digital supply chain maturity-based costs, which means that the higher the score within the scale, the more benefits are derived from cost savings (Weerabahu et al., 2023). Firms operating at levels "adaptive" and "predictive" have realized more cost savings than those at "reactive" or "basic automation" stages, which indicates the need of phased, strategic development on digital capability building.

8. Recommendations

Based on the analysis of Morocco's digital supply chain landscape, this section brings forth a comprehensive, multilayered framework seeking to guide policymakers, industry

stakeholders, and SMEs to a low-cost digitally enabled resilient sustainable supply chain ecosystem.

8.1. Policy-Driven Support for SMEs

SMEs are Morocco's economic backbone, representing over 90% of enterprises and employing two-thirds of the workforce. Yet they lack the financial clout, technical know-how, and strategic vision for deeper digital transformation.

Financial Instruments: Digitalization grants with tiered structure (50% micro, 40% small, 30% medium), tax incentives (accelerated depreciation, R&D credits), and concessional finance (below-market loans, guarantee schemes).

Capacity Building: Digital skills academies with sectoral bootcamps, nationally-recognized certifications, and mentorship networks (Digital Champions Program, peer learning circles) (Calle et al., 2020).

Regulatory Innovations: Regulatory sandboxes for piloting technologies, digital public infrastructure (one-stop portals, open data initiatives).

8.2. Industry-Specific Digital Roadmaps

Digital transformation should align with sector-specific workflows, regulatory requirements, and market conditions (Weerabahu et al., 2023). Roadmap development begins with baseline assessment (digital maturity audit, value-chain analysis), strengthened through co-creation workshops with stakeholders, followed by phased implementation: quick wins (cloud-based inventory, mobile data capture), integration (system connectivity, supplier portals), and advanced capabilities (AI forecasting, digital twins, autonomous logistics) (Yang et al., 2023). Success requires continuous monitoring through KPIs like order cycle time, inventory turnover, and logistics cost per unit (Chan, 2003).

Table N°4: Model Levels and Criteria

Level	Characteristics	Cost Focus	Key Actions
Level 1: Foundational	Basic tools (email, spreadsheets)	Eliminate paper processes, reduce admin costs	Deploy cloud accounting; digitize invoicing
Level 2: Connected	Integrated core systems (ERP, CRM)	Identify high-cost processes, negotiate terms	Implement basic analytics dashboards
Level 3: Optimized	Process automation (RPA, IoT), advanced analytics	Reduce inventory carrying costs, minimize stockouts	Pilot predictive maintenance; automate orders
Level 4: Strategic	AI decision engines, digital twins, orchestration	Dynamic resource allocation, continuous improvement	Scale AI forecasting; integrate digital twins

Source: Adapted from Weerabahu et al. (2023

8.3. Integrating Sustainability and Cost Goals

Sustainability and cost minimization can be mutually reinforcing when digital technologies reduce waste and optimize resource consumption (Lerman et al., 2022; Awan et al., 2022). Key solutions include: energy management systems (real-time monitoring, demand response), waste tracking and circularity tools (IoT sensors, blockchain traceability) (Liu et al., 2023), green procurement platforms (supplier ESG scoring, AI compliance verification), and sustainability reporting (carbon accounting dashboards, ESG disclosure) (Nehal & Gupta, 2024).

A Moroccan agribusiness case illustrates this synergy: integrating energy management and IoT cold-chain sensors reduced post-harvest losses by 20% and energy costs by 12%.

8.4. Cybersecurity Best Practices

Moroccan SMEs face increasing exposure to cybersecurity threats. Firms should adopt top-down cybersecurity governance (ISO 27001, NIST), implement network segmentation, strong access controls with multi-factor authentication, and modern endpoint security (Sola et al., 2025). Employee awareness and continuous training are essential, with regular phishing simulations and secure coding workshops (Malali & Praveen Madugula, 2025).

8.5. Digital Supply Chain Transformation Framework

This framework presents a multi-layered progression model that guides SMEs from policy support to strategic planning, operational execution, sustainability integration, and cybersecurity protection.

The foundation layer represents the policy-driven support environment, including grants, tax incentives, capacity-building initiatives, and regulatory sandboxes that provide SMEs with the necessary conditions to begin their digital transformation journey.

Building on this, the strategic layer focuses on industry-specific digital roadmaps, which sequence quick-win technologies, system integration milestones, and advanced innovations aligned with sectoral requirements.

The operational layer introduces a cost-sensitive digital maturity model, enabling firms to assess their progress through basic, connected, optimized, and strategic stages while ensuring that each digital investment generates measurable cost savings.

Across all stages, the cross-cutting sustainability layer ensures that digital transformation simultaneously supports cost efficiency and environmental objectives through energy management, waste tracking, circular economy solutions, and green procurement practices.

Figure N°2 : Digital Supply Chain Transformation Framework

Source : Author

9. Conclusion and Future Research Directions

9.1. Strategic Insights

Digital transformation offers significant potential to enhance cost efficiency, inventory optimization, demand forecasting accuracy, and supply chain agility, strengthening both regional competitiveness and global market performance (Ning & Yao, 2023; Jiang et al., 2023). Digital capabilities also support sustainability by reducing waste, energy consumption, and carbon emissions (Lerman et al., 2022; Awan et al., 2022).

However, success depends largely on organizational readiness. Many Moroccan firms remain at early digital maturity stages, making leadership commitment, workforce upskilling, capacity building, and knowledge sharing essential drivers. These efforts can be reinforced through regional partnerships, university-industry collaboration, innovation hubs, and technology accelerators.

A major strategic benefit of supply chain digitalization is creating data-driven ecosystems, where real-time data enhances transparency, collaboration, and evidence-based decision-making (Malali, 2022). These capabilities enable firms to reduce logistics costs and lead times while improving product traceability—increasingly critical in B2B and B2C markets.

9.2. Main Contributions of the Research

Empirical contribution: This study provides the first qualitative empirical evidence on how digital capabilities enable low-cost supply chains in Moroccan manufacturing firms, a context previously underrepresented in international literature.

Theoretical contribution: It operationalizes the Resource-Based View (RBV) and dynamic capabilities framework in an emerging economy supply chain context, demonstrating that digital assets translate into cost leadership only when complemented by organizational factors (skills, leadership, strategic roadmap).

Managerial contribution: The proposed cost-centric digital maturity model (foundational, connected, optimized, strategic) offers SMEs a practical tool to assess their digital readiness and prioritize investments that generate tangible cost savings. The strategic roadmap provides actionable guidance for policymakers and industry stakeholders.

9.3. Future Research Directions

Although this study provides extensive insights into the role of digital capabilities in supporting the transition toward low-cost supply chains in Morocco, several promising avenues for future research remain. First, sector-specific and longitudinal studies are needed across key Moroccan industries such as textiles, agriculture, automotive, mining, and phosphates to capture differences in supply chain complexity, digital maturity, and return on investment over time.

Second, future work should focus on the development of localized digital readiness and maturity models that better reflect Morocco's socio-economic, institutional, and regional realities, particularly for SMEs. Such frameworks would offer more relevant benchmarks for both managerial planning and public policy interventions.

Another important direction concerns technology integration pathways, examining the most cost-effective adoption sequences for AI, IoT, blockchain, predictive analytics, and digital twins in resource-constrained environments. In parallel, behavioral and change management research should investigate how leadership, employee resistance, digital literacy, and organizational culture influence transformation success.

Further studies should also explore the role of public–private innovation ecosystems, including incubators, accelerators, and university–industry partnerships, in fostering supply chain modernization and regional development. At the regional level, research on cross-border digital integration under the AfCFTA framework could assess how shared logistics platforms, e-invoicing, and interoperable data standards strengthen intra-African trade.

In addition, the intersection of digital transformation, circular supply chains, and sustainability practices deserves deeper empirical attention, particularly regarding waste valorization, reverse logistics, and eco-design enabled by IoT, AI, and blockchain technologies.

Cybersecurity, data governance, and digital trust also represent critical priorities, especially for SMEs facing increasing exposure to cyber risks. Likewise, economic impact modelling is needed to evaluate the long-term returns of digital investments in terms of productivity, resilience, exports, and employment.

Finally, future research should integrate gender, inclusion, and social equity perspectives to ensure that the benefits of digital supply chains contribute not only to competitiveness and efficiency but also to inclusive and sustainable development in Morocco.

9.4. Limitations of the study

This research has several limitations that should be acknowledged.

First, the qualitative nature of the study limits the generalizability of its findings. While the in-depth case studies provide rich contextual insights, they cannot be statistically generalized to the entire population of Moroccan manufacturing firms.

Second, the sample size is relatively small, comprising only ten companies. Although selected through maximum variation sampling to capture diversity across sectors, this limited number of cases restricts the extent to which patterns can be confidently extended to other contexts.

Third, the study relies on managerial perceptions reported during semi-structured interviews. Despite efforts to triangulate findings with secondary documents, the risk of social desirability bias, recall bias, or subjective interpretation by respondents cannot be entirely ruled out.

Fourth, the absence of longitudinal quantitative indicators means that the reported cost reductions (e.g., 15–25% inventory savings) are based on managerial estimates rather than independently audited performance data. No pre- and post-digitalization metrics were systematically collected over time.

Finally, the study does not control for sectoral or regional variations within Morocco. The ten firms are located mainly in industrial zones around Casablanca and Tangier, which may not reflect the realities of SMEs in more rural or less developed areas.

These limitations suggest that the findings should be interpreted as exploratory rather than conclusive. Future research should address them through larger-scale quantitative surveys, longitudinal designs, and objective performance metrics.

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