Review MECAS V°22 / N°1 / June 2026

Impact of digital transformation on logistics optimization: lever of competitive advantage for Algerian companies.

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Received date: 29.03.2026, Accepted date : 02.05.2026, Publication date: 02.06.2026

Abstract :
In the context of economic volatility, the digital transformation of logistics is emerging as a major lever for competitiveness. This research examines the influence of the digitization of logistics processes on the competitive advantage of Algerian companies. Through a mixed approach combining a case study at PROMEDAL and a quantitative questionnaire analysis (SPSS), the study evaluates the effectiveness of digital tools (ERP, EDI, Cloud) in supply chain optimization. The results demonstrate that a coherent integration of digital promotes the reduction of operational costs and the improvement of customer satisfaction. The statistical model confirms that digital maturity significantly explains competitive performance, offering national companies a sustainable path of differentiation.
Keywords: Digital transformation; Logistics 4.0; Competitive advantage; Supply Chain Management; Algerian companies; SPSS.
Code JEL: M15, L21, L91, O33.

Introduction

Nowadays, the logistics function constitutes a central element in the functioning of organizations, but it is undergoing a profound transformation under the impetus of digital transformation which is redefining flow coordination and resource optimization(Cherifi & Khaldi, 2023). With the advent of Industry 4.0, the

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integration of digital technologies - such as integrated information systems (ERP/SIL), the Internet of Things (IoT) and data analysis - becomes an essential strategic lever for performance, particularly in an Algerian economic context marked by growing instability and globalized competition(Benzidia & Bentahar, 2023). The issue of this research is based on the need to understand the influence of digital transformation on logistics optimization as a source of competitive advantage for companies in Algeria, a field where the transition to digital tools is still in full emergence.

This study is important because it demonstrates how the digitization of logistics processes can support differentiation, reduce inefficiencies and strengthen managerial performance. The main objective is to analyze the impact of digital tools on the supply chain, with specific objectives to identify the technologies adopted by local companies, to evaluate its impact on the creation of a distinctive value and to propose recommendations to optimize flow management through digital. The central question that guides this research is: **How does the digital transformation of the logistics function contribute to the creation of a competitive advantage for Algerian companies?**

To better understand this issue, we formulate the following main hypothesis: **H1: The digital transformation of logistics exerts a significant influence on the competitive advantage of companies in Algeria.** The motivation for this study stems from the interest in technological management of operations and the need to understand how national actors, like PROMEDAL, integrate digital leverage to transform their logistical constraints into strategic assets.

The methodology of this research is based on a mixed approach: a qualitative study conducted at PROMEDAL to examine process agility, complemented by a rigorous quantitative analysis. The latter uses data from a sample of Algerian companies, processed using SPSS software. The use of statistical tables (frequencies and correlations) allows here to concretely measure the impact of information tools on cost reduction and customer satisfaction. The article is structured into four main sections: a literature review on digital logistics, the research methodology detailing the use of SPSS, the analysis of results demonstrating the link between digital and performance, and finally the conclusion highlighting the managerial implications of this transformation.

Literature review

1.1. Historical evolution: From operational logistics to logistics 4.0:

In an economic environment marked by growing instability and systemic complexity, logistics has shifted from a mere secondary function to a strategic pillar of organizational performance (Fares & Hassane, 2018). This transformation took place under the pressure of global competition and a shortening of product life cycles, which required companies to constantly optimize their resources. The so-called 'open logistics' phase (since 1990) marks a decisive turning point, where the company is considered as an interconnected link within a global ecosystem. This period is characterized by the emergence of the knowledge economy and the massive integration of information technologies, such as ERP, GPS and Web, which laid the foundation for Logistics 4.0 (Reggani & Benabid, 2025).

The importance of this technological shift has been highlighted by much contemporary research. Ageron et al. (2020) highlights the direct link between digital adoption and supply chain resilience, while Queiroz et al. (2020) demonstrates that digital maturity directly influences responsiveness and customer satisfaction. Thus, the transition to digital systems is no longer a technical option, but a strategic necessity to maintain a sustainable competitive advantage in the Algerian market.(Ivanov & Dolgui, 2021).
The table below summarizes this evolutionary trajectory by highlighting the transition from local optimization to integrated digital intelligence:

Table 1: Evolution of Logistics Paradigms : Toward the Digitalization Era

Feature	Traditional (50s-70s)	Integrated (75s-90s)	Global (90s-2015)	Digital 4.0 (Now)
Focus	Local Optimization	Internal Integration	Global Cooperation	Hyper-connectivity
Technology	Manual / Machines	Mainframes / IT	ERP & Internet	AI, IoT & Cloud
Priority	Mass Production	Inventory Control	Speed & Response	Agility & Resilience
Scope	Internal	Direct Partners	End-to-End (E2E)	Global Ecosystems
Data Flow	Paper-based	Digital Silos	EDI	Real-time / Big Data
Decision	Intuitive	History-based	Computer-aided	Predictive (AI)

Source: Own processing

The analysis of this table demonstrates that digital transformation shifts logistics from a support function (cost and inventory optimization) to a real lever for competitive advantage.
While classical models were limited to internal efficiency, the era of Logistics 4.0 allows companies to acquire a distinctive value thanks to the total visibility of flows and real-time responsiveness. For Algerian companies, this evolution is crucial: the shift from 'paper' to 'dematerialized' flows reduces market uncertainties and transforms digital agility into a strategic weapon against competition.
Beyond simple "open logistics", the era of Logistics 4.0 consecrates the advent of the Connected Supply Chain (or extended) (Mansour & Amara, 2025). For Algerian companies, this digital transition represents not only a productivity gain, but also a tool to reduce information asymmetry.
Indeed, in a market characterized by regulatory uncertainties and variable import delays, the implementation of a "Digital Control Tower" allows us to centralize data in real time. This approach, theorized by (Ivanov & Dolgui, 2021) as a lever for digital resilience, transforms the logistics of a series of sustained operations into a proactive system. It thus becomes capable of neutralizing bottlenecks (customs, port infrastructure) before they impact the final customer, by substituting visibility for uncertainty.

1.2. Theoretical approaches and typology of logistical flows

From a conceptual point of view, the supply chain is seen as a succession of procurement, manufacturing and distribution activities. As highlighted by

(Tounsi, 2009), this interconnection between partners gives rise to three fundamental categories of flows:

- **Physical flow:** They concern all material entities (raw materials, stocks, finished products) passing through the chain from upstream to downstream. In the era of Logistics 4.0, these flows are now traced in real time.
- **Information flows:** Pivot of coordination, they flow in both directions and concern the state of the system (stocks, demand).
- **Financial flows:** Often considered as the monetary result of physical flows, they mainly flow from downstream to upstream.

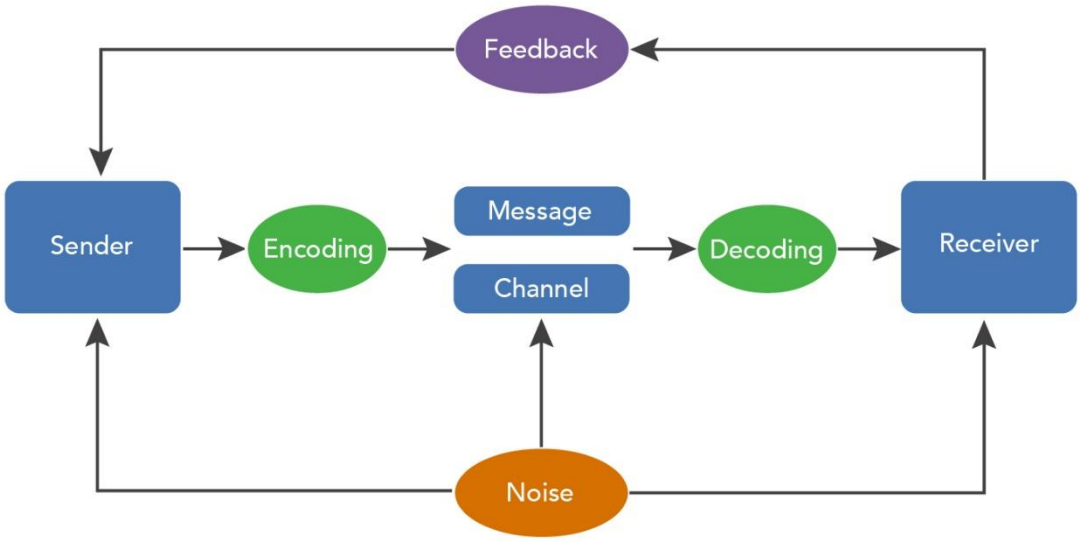
To shed light on the management of these flows, several classical models of systems theory complement this structural vision: (Ivanov & Dolgui, 2021)

- **Norbert Wiener's Cybernetics (Feedback):** The supply chain is envisioned as a dynamic system based on feedback. Digital transformation allows feedback to be automated: IoT sensors instantly adjust physical flows based on captured data, ensuring self-regulation minimizes breakages.
- **Shannon and Weaver's model:** This model highlights the importance of message clarity. In digital logistics, optimization aims to reduce the " noises "(data errors, silos) that hinder information flows. Synchronization without "noise" ensures perfect synchronization between partners, transforming sequential management into integrated management.

Figure 1 illustrates the integration of Shannon and Weaver's communication model with Wiener's cybernetic feedback loop within a Logistics 4.0 context (Tounsi, 2009).

- **Noise Reduction**: Technologies like EDI or Blockchain act as filters for semantic and technical noise, ensuring that an order (the message) is decoded without error by the warehouse (the receiver).
- **Automated Feedback**: IoT sensors turn feedback into real-time signals, allowing the system to adjust physical flows immediately upon detecting anomalies.
- **Dynamic Synchronization**: By minimizing "channel noise," digital integration transforms fragile, sequential management into a robust system capable of maintaining balance during market disruptions.

Figure 1 : Digital Optimization of Information Flows



Source : Own processing.

1.3. *Mapping and Functional* Coordination *in Logistics*

Effective flow management is a prerequisite for organizational performance. As demonstrated by Tixier et al. (1996), operational efficiency is fundamentally defined by the coordination between core functions—such as forecasting, order processing, and warehousing—and the specific direction of flows (goods versus information).(Mouloua, 2007)

Table 2 : Functional Mapping of Physical and Informationnel Flows

Logistics Function	Flow Direction	Digital Impact (Optimization)
Forecasting	Information (Downstream -> Upstream)	Big Data & AI for enhanced precision
Order Processing	Information (Downstream -> Upstream)	Digitization (EDI) and processing speed
Storage & Handling	Physical (Upstream -> Downstream)	Automation and WMS integration
Final Distribution	Physical (Upstream -> Downstream)	GPS tracking and real-time visibility

Source : Own processing

Analysis of Table 2 emphasizes the critical interdependence between operational activities and flow directions within the firm. Several key insights emerge from this mapping (Iraten, 2014; Mouloua, 2007):

- **Information Flow as a Primary Trigger**: Downstream activities, including demand forecasting and order processing, initiate upward information flows. In a digital environment, the speed of this transmission is vital; any latency

or "noise" can trigger a domino effect, leading to stockouts or the "Bullwhip Effect".

- **Synchronizing Physical and Data Flows**: Warehousing and material handling are no longer strict physical tasks. They represent convergence points where real-time data—such as inventory levels or expiration alerts—must be perfectly synchronized with actual movements. Integrated systems like ERP transform what was once a manual, sequential process into an instantaneous synchronization.
- **Global vs. Local Optimization**: The cross-directional nature of these flows indicates that logistics can no longer be managed in isolation. High-performing downstream goods movement is inseparable from the mastery of upstream information flows.

Ultimately, this mapping reveals that competitive advantage no longer stems solely from physical assets. Instead, it lies in a firm's ability to digitize and fluidize functional interactions. For Algerian companies like PROMEDAL, the objective is to shift from "artisanal" manual tracking toward an integrated model where information flow acts as the primary engine of logistical performance.

2. Digital Transformation: Toward a Data-Driven Supply Chain

Digital transformation is far more than the mere adoption of new software; it represents a profound reconfiguration of operational processes and business models. (Tomičić-Pupek et al., 2019) Within the logistics sector, this shift is driven by the integration of disruptive technologies such as the Internet of Things (IoT) for granular traceability, Cloud Computing for centralized and secure data sharing, and Artificial Intelligence (AI) for predictive demand and route optimization. Beyond the technological tools, this transformation is built upon three core dimensions:

- **Flow Dematerialization:** Transitioning from paper-based workflows to digital formats (EDI, e-invoicing) significantly reduces administrative lead times and minimizes human error—a critical factor for the fluidity of port and customs clearances.
- **System Interoperability**: The integration of core information systems (ERP, WMS, TMS) facilitates a cross-functional view of the supply chain, effectively breaking down traditional organizational silos.
- **End-to-End (E2E) Visibility**: The ability to monitor products in real-time from the upstream supplier to the downstream end-customer.

As highlighted by (Benzidia & Bentahar, 2023) and (Brahami & Belghaba, 2022), this evolution marks a transition from intuition-based management to a "Data-Driven" approach. In this new paradigm, data emerges as the organization's most asset. Every operational decision is now supported by real-time analytics, allowing for unprecedented responsiveness to the volatilities of the national market.

3. Digital Leverage for Competitive Advantage: A Resource-Based View (RBV)

To understand how digital transformation converts into sustainable competitive advantage, it is essential to mobilize the Resource-Based View (RBV) proposed by Barney (1991). As demonstrated by (Zamani et al., 2022) , competitive superiority does not arise from technology alone, but from the integration of analytical capabilities into the corporate culture to bolster organizational resilience.

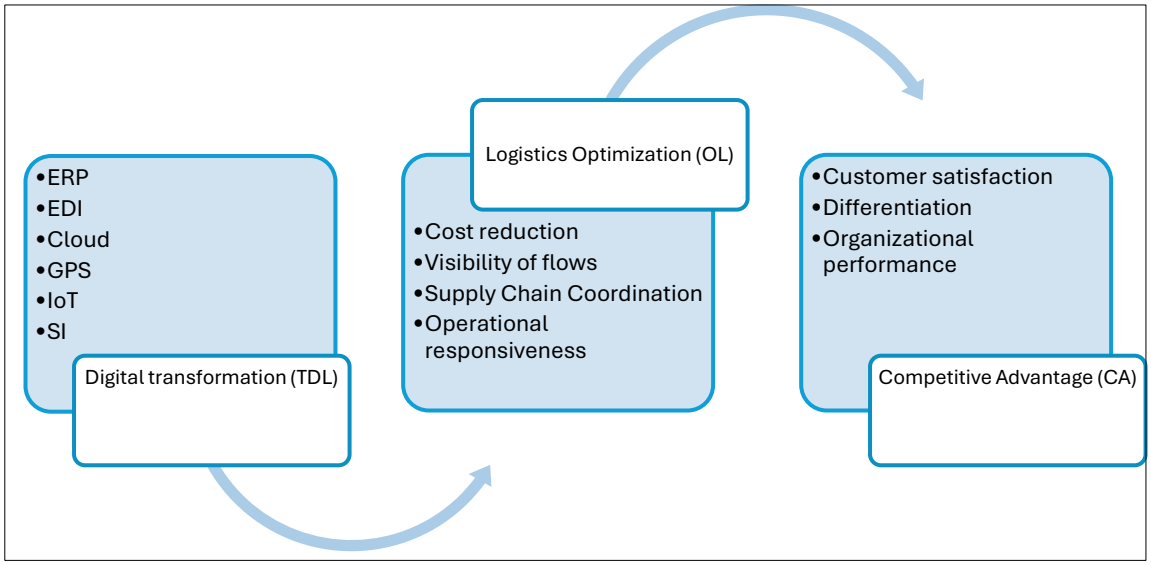
In the Algerian context, this strategic lens is articulated through the "dynamic capabilities" framework theorized by Teece et al. (1997). Digitization allows organizations to better "sense" market disruptions and respond with operational agility (Tiwari et al., 2024). For a company like PROMEDAL, digital maturity elevates logistics from a mere support function into a V.R.I.N. (Valuable, Rare, Inimitable, Non-substitutable) strategic asset, creating competitive entry barriers founded on efficiency and rapid decision-making.

Based on this synthesis of digital transformation and its impact on organizational performance, we propose the following conceptual model. This model highlights the mediating role of digital transformation in optimizing logistical processes to reinforce competitive positioning.

As illustrated in Figure 2, digital transformation serves as a primary strategic lever for process optimization. The integration of digital technologies—such as ERP systems, EDI platforms, and Cloud-based solutions—facilitates superior coordination between information and physical flows throughout the supply chain. This digitization enhances operational visibility, reduces lead times, and mitigates the errors inherent in manual procedures.

Consequently, optimized logistical processes translate directly into improved organizational performance, specifically through operational cost reduction, increased responsiveness to demand fluctuations, and higher service quality (Kraus et al., 2022). In this perspective, digital transformation represents more than just a technological upgrade; it is a key driver of strategic differentiation. It enables firms to sustain their competitive advantage by cultivating organizational capabilities rooted in agility, innovation, and information mastery.

Figure 2 : Conceptual Model of the Impact of Digital Transformation on Competitive Advantage



Source: Own processing

4. Empirical Study and Methodology

4.1. Econometric Model and Research Framework

The primary objective of this empirical study is to analyze the relationship between the Digital Transformation of the Logistics function (DTL) and Competitive Advantage (CA) within a sample of Algerian firms, with a qualitative focus on PROMEDAL.

The model is built on the hypothesis that integrating digital tools into the supply chain fosters the creation of distinctive value through cost reduction and service enhancement. The simple linear regression model is formulated as follows:

$$CA_i = \alpha + \beta\, DTL_i + \epsilon_i$$

Where:

- CA_i ***represents*** the perceived level of competitive advantage for firm i
- DTL_i denotes the degree of maturity of digital transformation in logistics.
- α is the model constant.
- β measures the marginal effect of digital adoption on competitive advantage.
- ϵ_i is the random error term.

4.2. Research Methodology and Data Processing

This research employs a mixed-methods design, combining a qualitative case study at PROMEDAL—aimed at examining internal process agility—with rigorous quantitative analysis. The latter relies on data processed via SPSS 26.0, applying a significance threshold of 5% ($\mathbf{p < 0.05}$). We began with a descriptive analysis to observe technology adoption levels, followed by correlation tests and linear regression to verify the statistical validity of our hypotheses. The use of statistical tables, specifically frequencies and correlations, allows for a concrete measurement of how information systems impact customer satisfaction and economic efficiency

4.3. Article Structure and Objectives

The study is organized into four interdependent sections: a comprehensive literature review on Logistics 4.0, a detailed presentation of the methodology including SPSS tools, an analysis of the results demonstrating the empirical link between digitalization and performance, and finally, a conclusion highlighting the managerial implications for the Algerian industrial sector. This structure ensures a logical transition from theoretical frameworks to empirical findings, offering managers a decision-making framework seeking to transform logistical inefficiencies into data-driven visibility

5. Results and Discussion

5.1. Descriptive Analysis of Digital Logistics Tool Adoption

Table 3 summarizes the survey results regarding the use of digital technologies to optimize flows within the studied firms.

Table 3 : Digital Tools for Logistics Optimization in Algeria

No.	Digital Tool	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Mean	Std. Dev	Trend	Rank
01	ERP / LIS	0	2	4	12	14	4.18	0.75	Strongly Agree	1
02	GPS Tracking	0	3	5	15	9	3.94	0.81	Somewhat Agree	3
03	Cloud Computing	1	4	6	13	8	3.71	0.92	Somewhat Agree	4
04	EDI (Exchange)	0	1	4	11	16	4.13	0.68	Strongly Agree	2
05	IoT / Sensors	5	8	10	6	3	2.78	1.12	Neutral	5

Source: own processing

According to Table 3, the integration of ERP/LIS (Logistics Information Systems) ranks first with a mean of 4.18, confirming that Algerian firms view data integration as the cornerstone of performance. EDI follows closely (4.13), highlighting the importance of paperless exchanges with partners. Conversely, IoT (2.78) remains at an embryonic stage, suggesting that Algerian logistics is currently in a phase of "computerization" rather than full "smartization."

5.2. Impact of Digitalization on Competitive Advantage Dimensions

Table 4 details how digital transformation specifically influences various strategic dimensions.

Table 4 : ANOVA Test Results

Impacted Dimension	Mean	Std. Deviation	Overall Trend
Customer Satisfaction	4.37	0.61	Strongly Agree
Cost Reduction	4.15	0.64	Strongly Agree
Strategic Differentiation	3.96	0.78	Somewhat Agree
a. Dependent Variable: Competitive Advantage *b. Predictors: (Constant), Digital Transformation.*			

Source: own processing

According to the ANOVA test (Table 4), the F-value is 89.642 with a p-value of .000 ($p < 0.05$). Consequently, we reject H0 and accept H1, confirming the model is statistically significant.

Table 5 : Regression Model Results

Variable	β Coefficient	Std. Error	Calculated (t)	Sig.
Constant	0.412	0.285	1.445	0.158
Digital Transformation	0.685	0.072	9.512	.000
Correlation Coefficient: R = 0.821 | Coefficient of Determination: R^2 = 0.674.				

Source: own processing

The results indicate a very strong positive correlation (**R = 0.821**). Furthermore, the **R^2 = 0.674** reveals that **67.4%** of the variation in competitive advantage is explained by the digital transformation of logistics.

The statistical data presented in the above tables provides a comprehensive overview of the digital landscape within the studied Algerian logistics functions. According to Table 3, the percentage of firms effectively utilizing ERP/LIS systems reached a dominant position with a mean score of 4.18, followed by EDI exchanges at 4.13.

It is noted here that most of the logistics operations are anchored in these two foundational tools, confirming that the digital maturity of the sample is primarily focused on data integration and the dematerialization of administrative flows. Conversely, the results indicate that IoT and sensor technologies recorded the lowest means of 2.78, placing them in a "Neutral" trend. This suggests that the surveyed organizations are still in an early stage of "computerization" rather than advanced "smartization," as capital-intensive automation tools have not yet achieved widespread adoption.

Through the analysis of Table 4, we find that digital transformation exerts its most significant influence on Customer Satisfaction, which reached a mean of 4.37, followed by Cost Reduction at 4.15. This is due to the nature of the Algerian market, where logistics reliability—often a weak point—becomes a major lever for differentiation when supported by digital responsiveness. These statistics reveal that managers perceive the digital shift not merely as a technical

upgrade, but as a strategic tool to stabilize the supply chain and meet client expectations in a volatile economic environment.

The inferential analysis further strengthens these observations. The ANOVA test results Table 4 show that the F-value reached 89.642 with a significance of .000. Since this value is lower than the 0.05 threshold, the null hypothesis H_0 is rejected in favor of the alternative hypothesis H_1. This statistical confirmation indicates that the model is robust and the impact of digital transformation is non-random. Furthermore, the regression results in Table 5 indicate a correlation coefficient of R = 0.821, attesting to a very strong positive relationship. The coefficient of determination R^2 = 0.674 reveals that 67.4% of the variations in competitive advantage are explained by the digital maturity of logistics. Through these statistics, we find that for the sample studied, the mastering of information flows has become a primary predictor of organizational success and strategic resilience.

Conclusion

The empirical results derived from the quantitative analysis indicate that the digital transformation of the logistics function exerts a significant and positive influence on the competitive advantage of firms in Algeria. The simple linear regression model revealed an F-value of 89.64 with a probability Sig. = 0.000 ($p < 0.05$), thereby confirming the statistical validity of the model. The correlation coefficient (R = 0.821) attests to a very strong positive relationship, while the coefficient of determination (R^2 = 0.674) shows that 67.4% of the variation in competitive advantage is explained by the degree of digital maturity within the supply chain.

Through these statistics, we find that the adoption of integrated tools such as ERP and EDI systems fosters operational cost reduction and enhances customer satisfaction. This finding aligns with the work of (Ageron et al., 2020) and (Queiroz et al., 2022), who demonstrate that digital maturity directly influences supply chain responsiveness.

However, our results provide an additional contribution to the literature by emphasizing the specific context of Algerian companies, such as PROMEDAL, operating in a market undergoing a digital transition. While most previous studies focus on hyper-automated Western contexts, this research highlights that for a national firm, competitive advantage primarily rests on information mastery and the dematerialization of administrative processes. Theoretically, these results support the Resource-Based View (Barney, 1991), where integrated digital capabilities act as strategic value-creating resources. On a managerial level, the implications are significant; leaders must perceive digital tools not as a cost, but as a strategic investment. It is noted here that promoting a "Data-driven" culture and prioritizing change management are essential to bridge the current technological gap. Despite the relevance of these findings, this study has certain limitations.

The sample, while representative, could be expanded to include a wider diversity of industrial sectors. Furthermore, the analysis focused on traditional information tools (ERP, EDI), leaving aside emerging technologies like AI or

Blockchain, which remain marginal in the local market. Through this study, we conclude that for firms like PROMEDAL, digital agility transforms the constraints of distributing critical medical products into a lever for reliability and differentiation.

In conclusion, digital transformation represents a historic opportunity for Algerian firms to modernize their flow management. Future research could explore the impact of disruptive technologies on predictive logistics or investigate "Green Logistics" assisted by digital tools. Such perspectives would allow national organizations to align with international sustainability standards while strengthening their competitiveness in global markets.

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