E-Commerce Adoption in Industrial Manufacturing: Evidence from Romanian Firms in the Context of Digital Transformation

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Abstract: *The integration of e-commerce technologies in industrial companies represents both an opportunity and a necessity in the context of digital transformation. This paper investigates the impact of e-commerce adoption in Romanian manufacturing firms, focusing on their attitudes, infrastructural readiness, perceived barriers, and expected benefits. Based on a quantitative study conducted among 58 companies in the North-West region of Romania, the research highlights a growing openness toward digitalization, despite notable challenges related to workforce skills and regulatory gaps. The findings reveal that e-commerce can improve operational efficiency, customer interaction, and global competitiveness. The study proposes actionable insights to support industrial firms in leveraging e-commerce as a strategic development tool.*

Keywords: *Digital transformation; E-commerce adoption; Industrial competitiveness; Manufacturing sector; SME digitalization.*

1 INTRODUCTION

In the context of rapid technological development and globalization of markets, e-commerce has become a critical pillar of the modern economy. The use of the internet and digital technologies has fundamentally transformed how companies interact with customers, suppliers, and business partners. This transition is not merely a technological shift, but also an economic and social transformation, redefining how industrial firms operate and compete.

While traditionally rooted in face-to-face transactions and complex distribution networks, industrial companies are now increasingly expected to integrate digital tools and e-commerce platforms into their business models. This shift presents both significant challenges and substantial opportunities. Implementing e-commerce in the industrial sector often requires reconfiguring internal processes, adopting new technologies, and enhancing employees' digital competencies. However, when implemented effectively, e-commerce can streamline supply chains, reduce operational costs, improve customer service, and enhance global competitiveness.

This study investigates the impact of e-commerce on Romanian industrial firms, particularly those operating in the mechanical sector. The objective is to understand how these companies perceive e-commerce, the extent to which they are prepared for its implementation, the obstacles they encounter, and the benefits they expect to achieve. The research is based on a structured questionnaire applied to a sample of companies located in Romania's North-West region.

By analyzing both theoretical foundations and empirical data, this paper aims to contribute to the understanding of digital transformation in industrial environments. The findings are intended to provide strategic insights for managers, policymakers, and researchers interested in the intersection of e-commerce, industry, and digital innovation.

2 LITERATURE BACKGROUND

2.1 Conceptual Foundations of E-Commerce in Industrial Contexts

The transformation brought by e-commerce is no longer confined to retail or consumer-facing industries. Over the past two decades, it has increasingly permeated the industrial and manufacturing sectors, reshaping traditional business models, supply chain configurations, and customer relationships. The term “e-commerce” has evolved from referring to basic online transactions to encompassing a broader paradigm of digital business practices.

Wigand (1997) proposed one of the earliest comprehensive definitions of e-commerce, emphasizing its role in enabling value-creating activities both within organizations and across their networks of suppliers and customers. Similarly, Cornall et al. (2000) argued that e-commerce represents a convergence of communication technologies, business processes, and organizational change. Their view acknowledges not only the transactional component but also the infrastructural and cultural shift required for true digital integration.

This evolution has been mirrored by the progressive expansion of technological capabilities. Early e-commerce relied on Electronic Data Interchange (EDI), email, and static web pages; today’s platforms are supported by dynamic technologies such as cloud computing, artificial intelligence (AI), blockchain, and Internet of Things (IoT). These tools enable companies to collect, analyze, and act upon real-time data, optimize production and inventory, and personalize interactions with both business clients and end consumers.

Turban and King (2003) emphasized that e-commerce is best understood as a process that supports the exchange of goods, services, and information using electronic systems. This includes not only B2C interactions but also increasingly complex B2B ecosystems, where automated procurement, collaborative design, and shared platforms are becoming

the norm. In this regard, industrial e-commerce is no longer limited to product catalogues and online ordering systems—it includes digital twinning, predictive maintenance, and real-time supply chain analytics.

Moreover, the distinction between operational technologies (OT) and information technologies (IT) is increasingly blurred, as integration platforms allow seamless communication between enterprise systems (ERP), production lines, and digital marketplaces. E-commerce becomes a central axis for Industry 4.0 practices, enabling not just commercial activity but the entire lifecycle of industrial value creation—from raw materials to after-sales services.

Digital platforms such as Alibaba, Thomasnet, and Amazon Business illustrate the scaling of industrial e-commerce on a global level. These platforms offer functionalities such as automated RFQs (requests for quotations), AI-based supplier matching, and blockchain-based contract verification, demonstrating how far industrial e-commerce has progressed in practice. The integration of such tools leads to the dematerialization of supply chains, disintermediation of traditional channels, and increased resilience through diversification of sourcing strategies.

From a strategic perspective, e-commerce enables a redefinition of competitive advantage. Instead of relying solely on scale or physical proximity, firms can compete on the basis of data-driven insights, platform agility, and customer experience design. This shift requires not just investment in technology, but also a cultural transformation within organizations, where innovation and adaptability are prioritized.

2.2 Challenges and Opportunities in Industrial E-Commerce Adoption

Despite its vast potential, e-commerce implementation in the industrial sector is far from frictionless. One of the key inhibitors identified in the literature is organizational inertia—the resistance to change entrenched processes and hierarchies that are optimized for traditional operations. According to Schmitz (2000), industrial e-commerce faces barriers such as the complexity of product specifications, the need for long-term contractual relationships, and the absence of standardized interfaces between buyers and sellers.

Other scholars emphasize the dual challenge of digital literacy and infrastructural readiness. In emerging markets such as Romania, limited access to high-speed internet in some regions, coupled with a shortage of skilled IT professionals, creates structural limitations for industrial digitalization. Moreover, many firms—especially small and medium-sized enterprises (SMEs)—lack the internal capabilities to assess, select, and implement appropriate digital solutions (Gatautis, 2008). Another common obstacle is cybersecurity. Industrial companies express concerns about data breaches, intellectual property theft, and disruptions caused by cyberattacks. As noted by SwissRe (2000), companies seeking to operate securely in e-commerce environments must invest in multi-layered protection mechanisms, including encryption, user authentication, and intrusion detection systems. These are not only costly but also require specialized staff to manage and update regularly.

Li (2020), in a study of Chinese industrial firms, observed that although initial investments in e-commerce platforms may be high, over 86% of companies believe such systems reduce long-term costs related to promotion, logistics, and customer support. Furthermore, 83.78% reported that digital procurement had simplified their sourcing operations and improved access to competitive suppliers. This is corroborated by other research which finds that electronic marketplaces lower transaction costs, increase transparency, and reduce the risk of supply disruptions.

A crucial opportunity for industrial e-commerce is its ability to support flexible and responsive production systems. Through real-time customer data and automated feedback loops, companies can shift from make-to-stock to make-to-order or even engineer-to-order models. This enhances customization and reduces inventory waste—key competitive factors in today's dynamic markets.

In the Romanian context, several policy frameworks and development programs have been introduced to facilitate industrial digitalization. EU-funded initiatives such as "Digital Innovation Hubs" and national strategies like "Smart Industry Romania 2023" aim to provide technical support, training, and incentives for companies to adopt Industry 4.0 tools. However, uptake remains inconsistent, often due to the lack of awareness, access, or perceived urgency at the firm level.

Nonetheless, e-commerce adoption is progressing in specific sectors, such as mechanical engineering, automotive components, and industrial services. The present study builds on this momentum by offering a grounded analysis of how firms perceive e-commerce in practice—not just as a technology, but as a strategic shift involving mindset, operations, and long-term competitiveness.

In summary, while e-commerce presents a compelling proposition for the industrial sector, its successful integration depends on addressing structural, technical, and human challenges. The literature underscores that firms must move beyond pilot initiatives and embrace a holistic transformation approach—anchored in strategic alignment, workforce upskilling, and robust digital infrastructure.

3 RESEARCH METHODOLOGY

3.1 Research Objectives and Design

The primary objective of this study is to investigate the adoption and perceived impact of e-commerce in Romanian industrial companies, particularly within the mechanical and manufacturing sectors. The research seeks to understand how these companies approach digital transformation, what challenges they encounter in implementing e-commerce, and what benefits they anticipate from such integration.

To address this objective, a quantitative research strategy was employed. Quantitative methods are well-suited for identifying patterns, measuring perceptions, and analyzing relationships between predefined variables (McCartney, & Burchinal, 2006). This approach allows for the collection of structured, comparable data from a relatively large and diverse group of respondents across the industrial sector.

The research design is descriptive-explanatory, aiming both to document the current state of e-commerce implementation and to explore causal relationships between organizational characteristics and digital readiness. The study is structured around five key research questions, derived from both the literature and preliminary observations:

1. What are the general attitudes and perceptions of industrial firms toward e-commerce?
2. To what extent are these companies equipped with the infrastructure necessary for e-commerce adoption?
3. What are the major obstacles limiting the adoption of e-commerce in the industrial sector?
4. What are the most promising applications of e-commerce in the context of industrial production?
5. What specific benefits do firms anticipate from the implementation of e-commerce systems?

These questions were operationalized through a structured survey instrument designed to capture both subjective perceptions and objective indicators of digital readiness.

3.2 Data Collection and Sampling Procedure

The main instrument used for data collection was a standardized questionnaire, structured in six sections aligned with the research questions: (1) respondent profile, (2) perceptions and attitudes, (3) infrastructure and technical readiness, (4) perceived obstacles, (5) potential applications, and (6) expected benefits. The survey was administered online using a professional form-distribution platform and targeted industrial companies located in the North-West region of Romania, a representative area with diverse industrial activity. The contact information of the firms was retrieved from a national business registry (listafirme.ro), ensuring a mix of private and public sector organizations.

The sampling strategy was purposive, focusing on companies operating in manufacturing, mechanical engineering, and related industrial services. The survey was sent to 150 companies, including executives, managers, and technical specialists with decision-making responsibilities in areas relevant to e-commerce. Of these, 58 completed responses were received, resulting in a response rate of 38.67%, which is acceptable for exploratory industrial research.

The period of data collection was March 1–31, 2024. Respondents remained anonymous, and participation was voluntary. To encourage a high response rate and ensure data validity, all participants were informed of the study's academic purpose, and confidentiality was guaranteed.

3.3 Analytical Approach

Data were analyzed using descriptive statistics, cross-tabulations, and graphical representation of key results. The analysis focused on identifying trends, correlations, and deviations in responses, particularly in relation to company size, sector, and the digital maturity of the respondents.

Several response items used Likert-type scales (e.g., from "Very High" to "Very Low") to measure perceived preparedness, perceived barriers, and perceived value. These variables were aggregated and visualized to provide clear insights into industrial firms' readiness and interest in adopting e-commerce tools.

The research also considered demographic factors such as respondent age, educational background, and position within the company, which may influence perceptions of technological change and openness to digital innovation.

4 RESULTS AND DISCUSSION

4.1 Respondent Profile and Sample Characteristics

The study gathered responses from 58 industrial firms located in Romania's North-West region, providing a diverse cross-section of the country's manufacturing sector. The average age of respondents was 32 (fig.1), indicating a relatively young cohort of professionals engaged in managerial and operational roles. Educationally, over 70% held a bachelor's degree, and more than 20% had postgraduate qualifications, highlighting a well-educated workforce.

Occupationally, the respondents represented a balanced mix of organizational levels: 55% were technical experts, 14% were managers, 14.3% department heads, and 7% held executive-level roles (CEOs or directors). This distribution allowed the study to capture perspectives from both strategic and operational decision-makers within the firms.

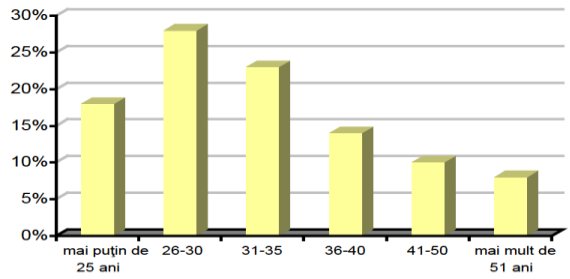

Fig. 1. Age of respondents

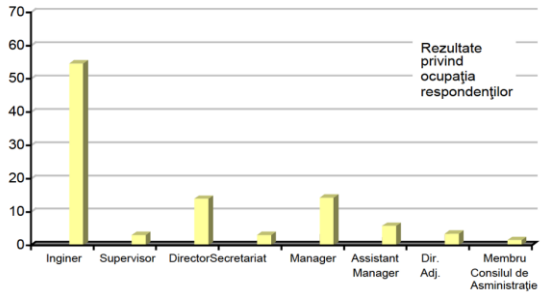

Fig. 2. Occupationally of respondents

4.2 Perceptions and Attitudes Toward E-Commerce

The findings suggest a generally favorable disposition toward e-commerce among Romanian industrial companies. When asked about their familiarity with e-commerce, over 80% of respondents indicated a moderate to high level of understanding, reflecting growing awareness of digital tools within the sector. Only a small minority (under 20%) reported low familiarity.

Similarly, when assessing the perceived impact of e-commerce on the industrial sector, more than 80% believed that it would significantly influence industry practices, suggesting that most companies acknowledge the transformative potential of digital commerce.

Respondents also characterized e-commerce predominantly as an opportunity (59%), while a smaller segment viewed it as a challenge (23%) or as ambiguous (18%). This indicates a nuanced understanding of both the potential gains and the hurdles involved in digital transformation.

4.3 Infrastructure Readiness

Infrastructure plays a pivotal role in enabling e-commerce adoption. The survey explored readiness across four domains: hardware and networks, software systems, IT expertise, and qualified e-commerce personnel. As shown in Table 1, most firms reported adequate hardware and software availability, with over 55% rating their systems as “moderate” to “high.”

However, notable gaps were identified in human resources. Only 24% of firms reported having sufficient IT experts, and just 14.4% indicated a strong presence of e-commerce-qualified personnel. This skills deficit remains a critical barrier to successful implementation and highlights the need for targeted training and recruitment.

Table 1. Infrastructure Readiness Levels (summary of responses)

Domain	High (%)	Moderate (%)	Low (%)
Hardware and Network	*55.1*	*37.5*	*7.4*
Software Systems	*32.6*	*44.9*	*22.5*
IT Experts	*24.3*	*38.7*	*37.0*
Qualified E-Commerce Staff	*14.4*	*22.3*	*63.3*

Respondents identified multiple obstacles to the adoption of e-commerce systems. The most frequently cited were (fig.3):

- Insufficient staff training and digital skills
- Resistance to change and organizational rigidity
- Limited sectoral infrastructure and supplier readiness
- Ambiguous or outdated legal regulations

Over 60% of firms also expressed concern about cybersecurity risks and compatibility with current business models, consistent with prior literature in industrial digitalization. These findings suggest that digital transformation is not solely a technological challenge, but also an organizational and regulatory one.

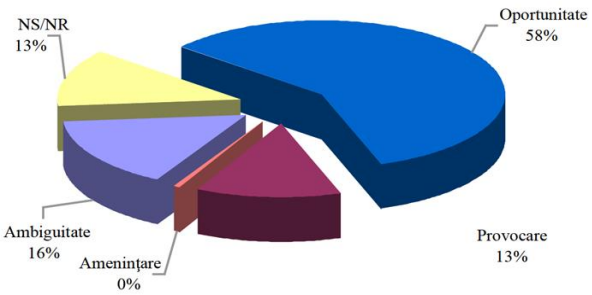

Fig. 3. Perception of e-commerce

4.4 Applications and Strategic Value

Participants were asked to evaluate the potential utility of e-commerce across different business functions. The highest-rated applications were:

- Marketing and sales enhancement
- Product and service development
- Customer service and complaint management
- Administrative efficiency and documentation flow

This aligns with literature emphasizing e-commerce’s ability to streamline value chains and improve customer-centric processes. Additionally, **over 70%** of firms expected improved transparency, better stakeholder communication, and enhanced data management through e-commerce integration.

The most commonly anticipated benefits included:

- Reduction in operational and acquisition costs

- Improved brand visibility and customer reach
- 24/7 availability and increased market flexibility
- Mass customization and innovation opportunities

These perceptions confirm that Romanian industrial firms recognize the strategic importance of e-commerce in enhancing competitiveness, resilience, and growth potential. However, the presence of significant implementation barriers tempers this optimism, suggesting that external support—whether through policy, funding, or training—is critical to unlocking full adoption.

5 CONCLUSION AND CONTRIBUTIONS

This study explored the adoption and perceived impact of e-commerce in Romanian industrial firms, with a particular focus on the mechanical and manufacturing sectors. Drawing on a structured quantitative survey conducted among 58 companies in the North-West region of Romania, the findings provide a comprehensive understanding of how industrial firms are navigating the shift toward digital commerce.

The results indicate a widespread recognition of e-commerce as a strategic enabler for industrial competitiveness. Most respondents perceive e-commerce not only as a tool for cost reduction and operational optimization, but also as a gateway to new markets, greater customer engagement, and enhanced flexibility in production and distribution. The ability to operate beyond traditional time and geographic constraints, personalize offerings, and streamline procurement and logistics are key advantages acknowledged by participating firms.

However, the study also highlights critical barriers that hinder full-scale adoption. These include limited availability of skilled personnel, especially in areas such as IT systems, cybersecurity, and e-commerce strategy; organizational resistance to change, particularly in firms with rigid hierarchies or legacy business models; and insufficient digital infrastructure and supplier alignment, which undermine integration efforts. Moreover, legal uncertainty and the absence of sector-specific standards contribute to a cautious approach among industrial actors.

From a scholarly perspective, the study makes several contributions:

- It addresses a significant gap in the literature on industrial e-commerce in Central and Eastern Europe, a region often underrepresented in digital transformation research.
- It proposes an integrated framework for assessing industrial e-commerce readiness, encompassing technical, organizational, and strategic dimensions.
- It emphasizes the role of human capital and organizational culture in shaping the success of digital initiatives—factors often overshadowed by purely technical analyses.

In practical terms, the findings suggest that the successful implementation of e-commerce in industrial firms requires more than investment in technology. It demands a coordinated change management effort, the upskilling of employees, and inter-organizational collaboration across supply chains. Firms that prioritize digital literacy, cross-functional integration, and adaptive leadership are more likely to unlock the full value of e-commerce.

Furthermore, the study offers guidance for policymakers and support organizations. National and regional authorities should consider developing targeted programs to support e-commerce adoption in the industrial sector—through tax incentives, training schemes, and infrastructure development. Business support institutions can act as facilitators, promoting awareness, knowledge-sharing, and access to digital ecosystems.

In conclusion, e-commerce represents a powerful catalyst for industrial innovation and growth. For Romanian manufacturing firms, it is not merely an option but a strategic imperative. Embracing this transition can position them more competitively within the European industrial landscape, foster resilience in volatile markets, and support the broader digital modernization of the economy.

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