Romania within the Smart Supply Chain Architecture: from Transit Point to Key Actor

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Abstract
The reconfiguration of global supply chains, accelerated by the pandemic, geopolitical conflicts and economic pressures, is causing companies to seek for safer, faster and closer solutions to markets. In the context of the transition from global supply chains to regional models, Romania is consolidating its position as a strategic logistics hub in Central and Eastern Europe. Its advantageous geographical positioning, access to the Black Sea through the Port of Constanta, as well the membership in the European Union, provide Romania with a favorable framework for attracting investments in infrastructure and logistics. The objectives of the research propose to identify and highlight the country's competitive advantages, such as low operational costs, a skilled workforce and access to European funds, in the context of the reconfiguration of global logistics chains to regional models, but also persistent challenges, such as insufficiently developed road and rail infrastructure, administrative bureaucracy and labor migration. Amid both progress and persistent challenges, investments in supply chain digitalization are emerging as a cornerstone of future competitiveness. Digital transformation is vital for enhancing efficiency and ensuring transparency. Romania is making notable strides in this area, with investments in automated logistics centers, IoT technologies, and transport management platforms. However, the digital divide between large enterprises and SMEs continues to pose a significant challenge. Romania stands at a pivotal crossroads. Through strategic vision, sustainable investment, and a cohesive approach to logistics development, the country has the opportunity to evolve from a mere transit corridor into a central hub within European supply chains. The future of Romania's logistics sector hinges on its ability to convert potential into tangible performance.

Keywords: Nearshoring, Regionalization in Supply Chain, Romania Logistic Hub, Digitalization in Supply Chain

JEL Classification: L9, N7, O18, R4

DOI: 10.24818/REJ/2025/91/09

1. Introduction

The global logistics landscape is undergoing a profound transformation, shaped by technological innovation, shifting geopolitical dynamics, and the growing need for resilient and regionally integrated supply chains. In this evolving context,

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Romania is emerging as a strategic logistics actor in Europe, transitioning from a traditional transit corridor to a digitally enabled and regionally connected distribution hub.

Romania's geographic location, at the intersection of Central, Eastern, and Southeastern Europe, combined with its access to the Black Sea and full membership in the European Union, provides a strong foundation for its logistics ambitions. The country's integration into key EU transport corridors, such as the Orient/East-Med and Rhine-Danube routes, enhances its connectivity to major European markets and trade gateways. Recent accession to the Schengen Area for land transport further streamlines cross-border movement, reinforcing Romania's role in facilitating intra-European trade.

Beyond physical infrastructure, Romania is investing heavily in digital transformation to align with EU standards and improve supply chain efficiency. The implementation of systems such as e-Invoice, e-Transport, SAF-T, and e-CMR reflects a broader commitment to transparency, automation, and interoperability. These platforms enable real-time data exchange, reduce administrative burdens, and support compliance across borders. Additionally, Romania's participation in the European Digital Innovation Hub (EDIH) network positions it as a regional center for logistics innovation, with active development in areas such as artificial intelligence, blockchain, and smart mobility.

As supply chains shift toward nearshoring and regionalization, Romania is increasingly viewed as a viable location for distribution, warehousing, and production. However, this transition is not without challenges. Labor shortages, regulatory complexity, and infrastructure gaps continue to affect competitiveness. Addressing these issues through strategic investment and policy reform will be critical to sustaining Romania's momentum and unlocking its full potential within the European supply chain architecture.

This paper explores Romania's evolving role in smart supply chains, analyzing its infrastructure development, digital integration, and strategic positioning. It also examines the opportunities and constraints that define Romania's transformation from a transit point to a key logistics actor in the region.

2. Methodology

To position Romania within both regional and international supply chain contexts, the research was based on a multi-method approach, starting with an analytical

review of specialized literature. Romania's performance assessed in relation to peer countries, such as Poland, that have successfully developed into regional logistics hubs. These comparative insights are complemented by examples of best practices from other European states, offering potential models for adaptation and implementation in Romania.

To gain a deeper understanding of the strategic landscape, stakeholder perceptions, and operational realities, the research incorporates a quantitative component. A structured questionnaire (DOBRE, 2025) was distributed to logistics professionals, including transport operators, supply chain managers, and industry consultants. The survey aimed to evaluate perceptions of Romania's infrastructure quality, level of digitalization, and overall competitiveness in the logistics sector.

The respondents primarily came from the transport, logistics/distribution, production and trade sectors, with company sizes ranging from micro (1-9 employees) to large enterprises (+250 employees), and were mostly based in Bucharest-Ilfov, with additional representation from the West, South-West, and Center regions.

The findings from the questionnaire were triangulated with documentary analysis, drawing on national policy documents, EU strategic reports, investment plans, and regulatory frameworks. Additionally, statistical analysis of logistics performance indicators, based on official national and European datasets, was conducted to support and contextualize the results. This multi-method approach ensures a comprehensive and evidence-based evaluation of Romania's current position and future potential within the smart supply chain architecture.

3. Literature Review

This research is grounded in the analysis of specialized literature, drawing on studies whose conclusions are supported by concrete evidence obtained through observation, experimentation, or direct experience. The research synthesizes insights from both academic literature and industry reports to highlight Eastern Europe's strategic importance as a nearshoring destination, particularly in the context of supply chain resilience, manufacturing competitiveness, and sustainability.

The region's geographic positioning, at the intersection of Europe, Asia, and the Middle East, combined with robust infrastructure, play a significant logistical

advantages, according to (Monaghan, 2023), where countries like Poland offer modern ports, railways, and road networks, making the region ideal for nearshoring. (Bontadini, et al., 2025) presents a detailed analysis of nearshoring and "farsharing" trends in Europe. It finds that European value chains are increasingly sourcing from within the region (nearshoring), while exporting globally "farsharing", highlighting Eastern Europe's dual role in global value chains. The research further explores these trends using OECD input-output data. It confirms Eastern Europe's growing role in intra-European sourcing and global exports. Complementary, (Laura, 2024) MSc dissertation investigates sustainability as a driver for nearshoring in Europe. While cost and resilience are primary motivators, sustainability is gaining importance due to regulatory and consumer pressures.

Furthermore, industry trends reveal a shift toward nearshoring driven by cost efficiency, geopolitical stability, and reduced delivery times. The study by (Helen-Sydney, 2024) explain the companies such as Goodyear and H&M are investing in logistics infrastructure across Eastern Europe to build resilient supply chains, while sectors like battery manufacturing are actively relocating operations to the region. (Ashcroft, 2023) cites an invert study showing that 57% of European firms already source from Eastern Europe, with 32% planning to relocate there. Key drivers include geopolitical stability, cost efficiency, and shorter delivery times.

Looking from the perspective of the logistics infrastructure and connectivity, Romania's role in the European supply chain, especially in the context of nearshoring, logistics, and industrial resilience has its own competitive advantage. According to (Malik, 2025) report, Romania's full accession to the Schengen Area has significantly enhanced its attractiveness for nearshoring. With 25–50% lower labor costs, strong infrastructure, and proximity to key EU markets, Romania is becoming a preferred location for automotive, defense, and manufacturing sectors. Romania's exports to the EU ~73% of total exports, are dominated by machinery and transport equipment, with Germany, Italy, and France as top partners. (Genc, 2024) research highlights Romania's strategic location between Asia and Europe, with access to the Black Sea via the Port of Constanta and over 20 river ports. This enables faster shipping routes and positions Romania as a key logistics node. The Danube corridor offers a 3–4 day advantage over North Sea ports, enhancing time-to-market for European network.

In terms of supply chain integration and performance, an older study (Wright, 2016), finds that industry efficiency, rather than supply chain ownership, drives performance in Romania. Integration helps, but success depends on sector-

specific dynamics. A SpringerLink conference paper (Nagy-Bota, et al., 2022), identifies the price volatility and supplier reliability as key risks for Romanian companies. Building long-term supplier relationships is seen as the best mitigation strategy, in terms of resilience and risk management.

Romania's manufacturing sector is expanding rapidly, driven by industrial growth and increasing investments, particularly in the automotive industry. The report (DPWORLD, n.d.) gives insights about companies like Mercedes-Benz, Dacia, and Ford, running major operations in the country. In this regards, DP World invested 115$ million in Constanta for a new RO-RO terminal, expected to handle 80,000 vehicles per year.

Romania's €28.5 billion Recovery and Resilience Plan, approved by the European Commission, (EU-comission, n.d.), includes major investments in green energy, transport infrastructure, and digitalization, all of which support supply chain resilience. Sustainability is also gaining traction as a strategic driver, influenced by regulatory frameworks and consumer expectations. While cost and resilience remain primary motivators, environmental considerations are increasingly shaping supply chain decisions.

In terms of Green Energy, according to (KRESTON, n.d.), Romania is on track to source 71% of its electricity from clean sources, making it attractive for sustainable supply chain operations.

Understanding Romania's role in European supply chains, (Paraschiv, et al., 2021) examines Romania's international trade in goods following the COVID-19 crisis, highlighting a faster recovery in exports compared to imports. Key export sectors such as machinery, automotive, and electronics have driven this rebound, with approximately 73% of Romania's exports directed toward EU member states, underscoring the country's deep integration within the European single market. Additionally, policy measures, including access to EU recovery funds and Romania's accession to the Schengen Area, have significantly enhanced trade logistics and cross-border efficiency, contributing to the overall resilience and competitiveness of Romania's post-pandemic trade landscape.

Since the pandemic and all the turbulences that took boost since 2020, the supply-chain drifted from a stable, to a dynamically model. (Nicolescu, et al., 2025) explores the evolving landscape of Romanian business transformation, emphasizing the increasing adoption of digital tools such as ERP and supply chain management systems. Small and medium-sized enterprises (SMEs) are actively

pursuing internationalization strategies, particularly through nearshoring within the European Union, to enhance market access and operational efficiency. However, this transition is challenged by persistent issues including talent retention, infrastructural limitations, and regulatory complexity, which continue to shape the pace and effectiveness of digital and strategic expansion.

(Alexandra-Constantin, et al., 2025) investigates the impact of digitalization on supply chain competitiveness and trade openness across Romania, Bulgaria, and Poland, using multifactorial linear regression analysis based on data from 2013 to 2022. The findings for Romania reveal that broadband penetration plays a significant role in enhancing both supply chain performance and international trade. However, while the development of the ICT workforce is recognized as a critical factor, it remains underutilized. Additionally, transport infrastructure, particularly air and rail, shows limited effectiveness unless integrated with digital technologies. The study concludes that Romania stands to benefit substantially from digitalization, but achieving full potential requires coordinated policy efforts and strategic investments in infrastructure and human capital.

(Radu, 2024) Romania has quietly emerged as a strategic supply chain hub in Europe, driven by its geographic proximity to key markets, expanding logistics infrastructure, and increased cargo volumes, particularly as a rerouting point for Ukrainian exports. Backed by robust GDP growth and substantial EU funding for energy and digitalization, the country offers growing opportunities in logistics, agriculture, and IT. However, challenges such as fiscal imbalances, wage-productivity gaps, and infrastructure bottlenecks remain, requiring targeted policy and investment to sustain its momentum.

4. Romania's logistics infrastructure, digitalization, and competitiveness

4.1 Infrastructure quality

According to World Bank Logistics Performance Index (LPI) (WORLDBANK, n.d.), Romania place on a score (2022) of 2.9/5 for infrastructure quality, indicates moderate performance, with room for improvement in transport-related infrastructure. An analysis of Romania's existing infrastructure, based on (EU-Commission, n.d.), highlights few key aspects.

Ports: Port of Constanta is Romania's largest and most strategic port. Recent upgrades have improved operational efficiency and capacity, making it a key transit point for Eastern Europe.

Multimodal Terminals: Many rail-road terminals are outdated or poorly equipped, where the last-mile connections to ports and airports are missing or inefficient. EU-funded modernization and ERTMS rollout are in progress.

Roads: Total road length: ~86,388 km, including 997 km of highways. As a major challenge, Romania has one of the shortest motorway networks in the EU, causing bottlenecks and slow freight movement. While motorway upgrades are progressing, safe truck parking and alternative fuel infrastructure lag behind.

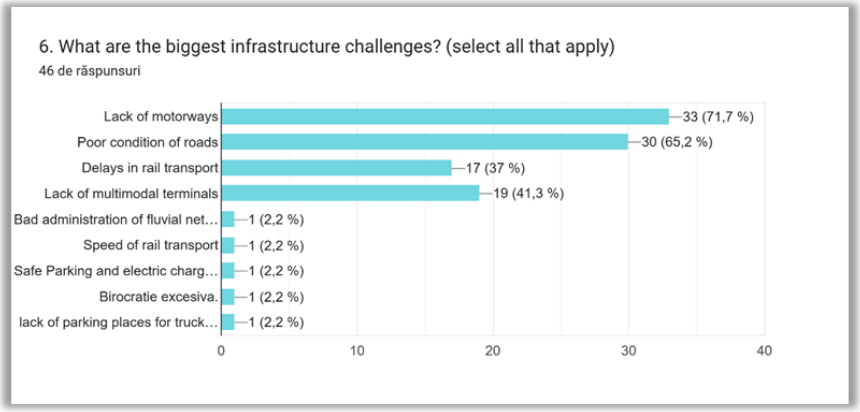
Rail: with ~10,600 km of rail network, where only 20% is double-tracked and ~4,000 km electrified. Among many other challenges, the Timisoara- Sofia railway section remains a critical bottleneck due to outdated infrastructure and limited operational speeds. Low levels of electrification and ERTMS implementation further hinder rail efficiency and cross-border interoperability. Commercial freight transport speeds average around 15 km/h, significantly below EU standards, negatively affecting long-distance transport.

Airports: Lack of high-speed rail or direct rail connections to major airports. Limited infrastructure for alternative aviation fuels.

4.1.1 Infrastructure assessment based on the questionnaire review

Looking at the road infrastructure, most respondents rated it as Satisfactory (41.3%) and Poor (41.3%) at the same weight, with main key issue related to the Lack of motorways, that was the most frequently cited challenge. Other concerns are connected with the poor condition of roads, lack of multimodal terminals, and delays in rail transport Figure 1.

Figure 1. Answers to question No. 6



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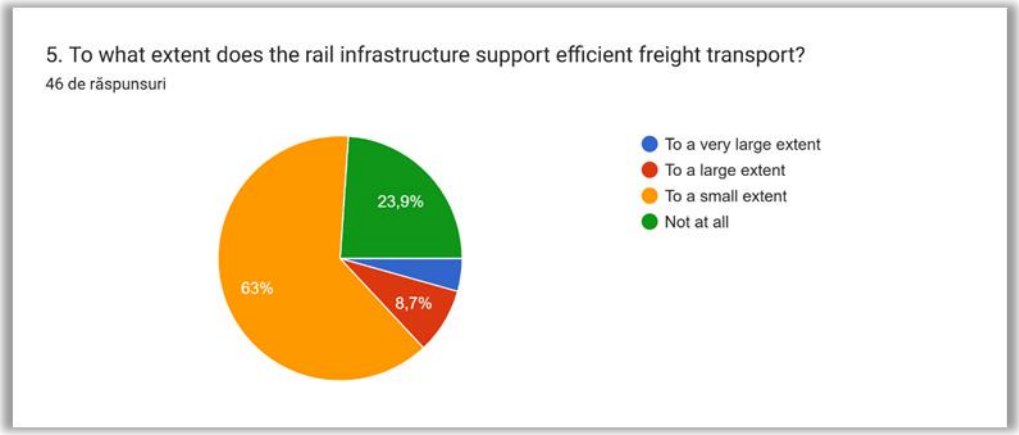
Regarding the rail infrastructure, generally rated poorly "To a small extent" or "Not at all" in terms of supporting efficient freight transport. Only 8.7% from respondents rated it as supporting logistics to a large extent and 2.7% from respondents rated it as supporting logistics to a very large extent, **Error! Reference source not found.**.

Figure 2. Answers to question No. 5



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4.1.2 Romania's integration into TEN-T Corridors

Romania is strategically positioned (EU-Commission, n.d.), within two major TEN-T Core Network Corridors:

1. **Orient/East- Med Corridor (OEM):** connects German ports (Hamburg, Bremen) through Austria, Hungary, and Romania's Port of Constanta, continuing to Bulgaria, Turkey, and Greece. Includes rail, road, airports, ports, and inland waterways, facilitates trade between Central Europe and the Eastern Mediterranean.
2. **Rhine- Danube Corridor:** links Western Europe (Strasbourg, Mannheim) via Germany, Austria, Slovakia, and Hungary to Romanian ports Constanta and Galati. Covers rail, road, inland waterways, and multimodal terminals. Supports freight movement along the Danube and enhances East-West connectivity.

Romania's integration into TEN-T corridors positions it as a key logistics and trade gateway between Central Europe and the Black Sea region. However, accelerated investment, policy alignment, and regional cooperation are essential to overcome infrastructure gaps and unlock full potential.

4.1.3 Priority infrastructure projects

Key infrastructure and digital priorities are shaping Romania's logistics transformation within the European supply chain architecture. These include the modernization of critical rail corridors, particularly the Timisoara–Sofia section and the Constanta- Bucharest- Brasov axis, to improve freight capacity and connectivity. The expansion of the Port of Constanta is central to accommodating rising cargo volumes and enhancing hinterland access to inland transport networks.

To support multimodal logistics, Romania is investing in the development of advanced freight terminals equipped with modern handling technologies. The nationwide deployment of the European Rail Traffic Management System (ERTMS) is underway, aiming to ensure interoperability and compliance with EU rail standards. Additionally, improvements in cross-border infrastructure with Hungary and Bulgaria are streamlining freight movement and reducing transit delays.

Complementing physical upgrades, Romania is integrating digitalization and smart mobility solutions to enhance logistics efficiency, transparency, and sustainability. These efforts collectively position Romania as a strategic logistics hub capable of supporting regional distribution and long-term supply chain resilience.

4.2 Romania's logistics digitalization

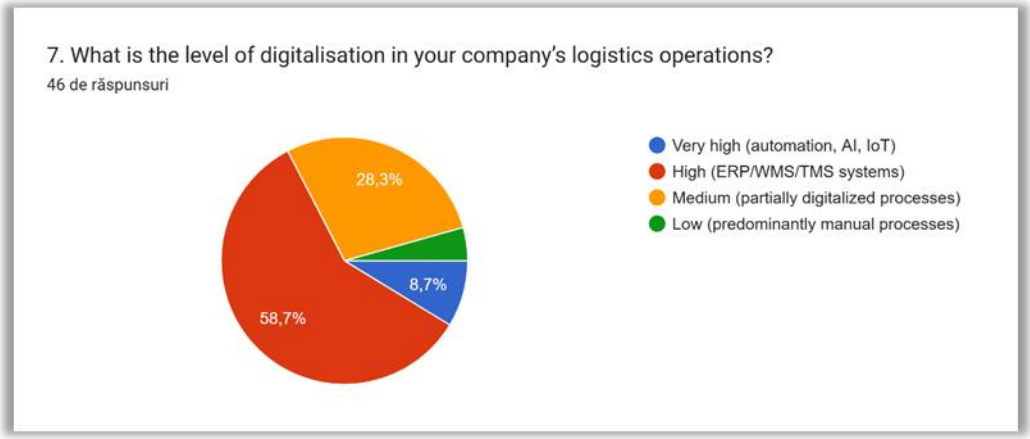
According to the Digital Decade Country Report (2024), (EU-Commission, 2023), SME digitalization reach only 26%, meet basic digital intensity criteria (EU avg: 58.7%), 5G coverage: 32.8%, far below EU average of 89.3% and FTTP (Fibber to the Premises) reach an outstanding coverage of 94%, a strength for future logistics tech, in comparison with EU average of 61%.

Digitalization positively impacts trade openness in Romania (Alexandra-Constantin, et al., 2025), key drivers in broadband penetration and freight transport efficiency.

4.2.1 Assessment based on the questionnaire review

Romanian logistics companies exhibit varied levels of digitalization, with larger firms leveraging ERP/WMS/TMS systems while smaller ones rely on manual processes, **Error! Reference source not found.**.

Figure 3. Answers to question No. 7



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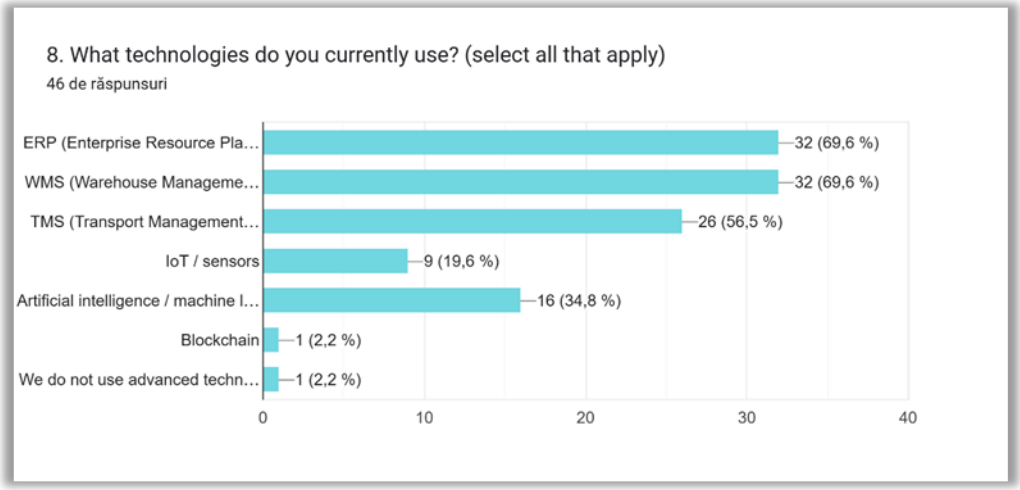
Although core technologies are widely adopted, including AI, where we see a boost during the last period, emerging tools like blockchain and IoT remain niche ***Error! Reference source not found.***, hindered by high costs, skill shortages, and resistance to change.

Figure 4. Answers to question No. 8



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4.2.2 Digital adoption in Romania vs EU

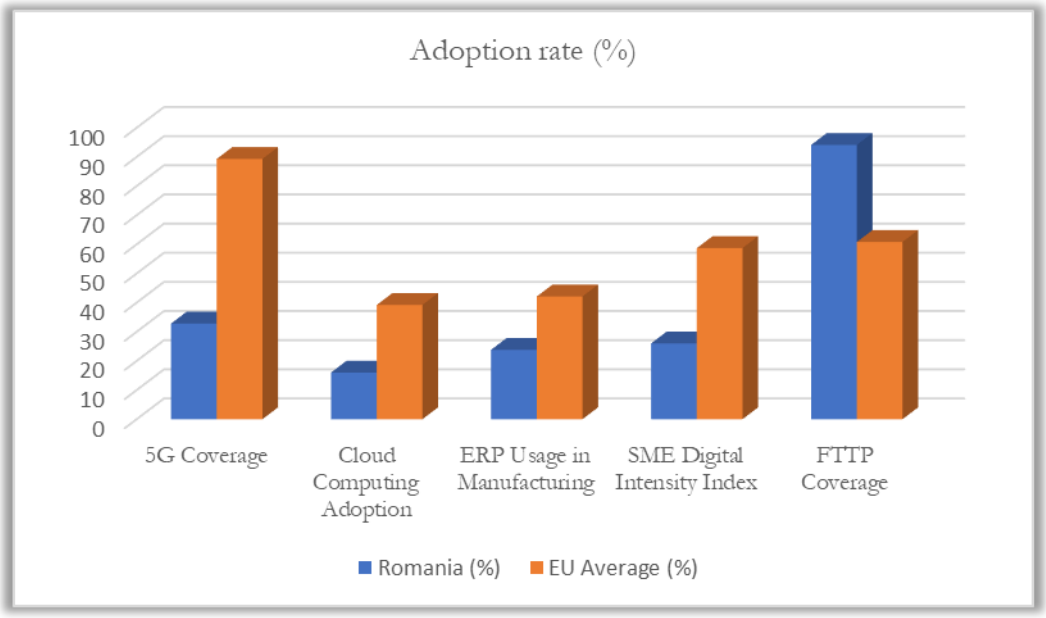
In order to evaluate the level of digital adoption rate in Romania, within the supply chain and manufacturing sectors, the present research paper used bellow key indicators, for 2024, as consolidated in **Error! Reference source not found.** and *Figure 5*.

- **Digital Intensity Index (DII)**, to measure the use of at least 4 out of 12 digital technologies (e.g., ERP, CRM, cloud, AI, big data), where Romania's SMEs show low adoption, with only 26% meeting basic digital intensity criteria (EU average: 58.7%).
- **Enterprise Resource Planning (ERP)**, such systems are critical for supply chain integration, with an average adoption rate in Romania of 23.8%, average EU benchmark of 42.1%, with a gap of 18.3 percentage points.
- **Cloud Computing Adoption,** cloud platforms enable scalable supply chain management, where Romania's adoption is growing but still below EU average. But considering as Romania has implemented e-Invoice, e-Transport, and SAF-T systems, shows Romania is on the right path to digital maturity in logistics and compliance.
- **5G and Broadband Infrastructure**, 5G coverage: 32.8% (EU avg: 89.3%).
- **FTTP (Fiber to the Premises), w**ith an average adoption rate in Romania of 94%, average EU benchmark of 61%, with a gap of -33 %, Romania leads in FTTP coverage, but lags significantly in 5G and SME digitalization **Error! Reference source not found.**.

Table 1. Digital adoption ratio in Romania vs. EU average

Indicator	Romania (%)	EU Average (%)	Gap to EU Average (%)
5G Coverage	32.8	89.3	56.5
Cloud Computing Adoption	16	39.2	23.2
ERP Usage in Manufacturing	23.8	42.1	18.3
SME Digital Intensity Index	26	58.7	32.7
FTTP Coverage	94.1	60.8	-33.3
Average (2024)	**38.54**	**58.02**	**19.48**

Figure 5. Digital adoption ratio in Romania vs. EU (average)



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4.2.3 Trade openness impact

Using as methodology the panel regression based on data from 2013- 2024, $R^2 = 0.99$, is indicating a strong correlation between Digital adoption and LPI (Logistic Performance Index), used for competitiveness assessment *Table 1*.

Table 1. Competitiveness assessment

Category	Key Metric	Romania Status
LPI Infrastructure Score	*1–5 scale*	2.9 (World Bank)
Trade Openness Impact	*Regression* R^2	0.99 (strong correlation)

The model used a dependent variable, Logistic Performance Index (LPI) and an independent variable, digital adoption, analyzed on a country fixed effect, Romania vs EU.

Looking at Digital adoption (LPI), for each 1 point increase in digital adoption, LPI improves by 0.0042 units, this is a positive significant relationship. Following the Country Effect (Romania), where Romania's baseline LPI is 0.66 points lower than EU, even after accounting for digital adoption, this gap reflects structural differences (infrastructure, customs efficiency, logistics services). The result of R^2

= 0.9986, means 99.86% of the variation in LPI, explained by digital adoption and country effect. Such a high R^2 indicates an almost perfect fit.

4.2.4 Data sources used

Eurostat (EU-Commission, n.d.): Digital technology usage by enterprise size and sector.

DESI- Digital Economy and Society Index (EU-Commission, n.d.).: Country level digital performance.
Romanian Ministry of Economy (Economy, n.d.): Reports on industrial digitalization.

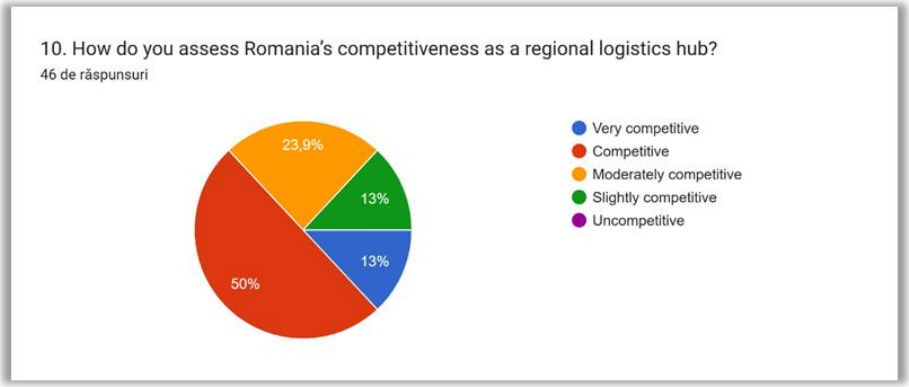
Regression model linking digital adoption to LPI competitiveness.

4.3 Competitiveness

Romania's competitiveness within the European economic landscape has strengthened in recent years, driven by targeted investments, digital reforms and sustainability initiatives. The following part evaluates key indicators shaping Romania's performance and strategic positioning.

Based on the questionnaire review, Romania is generally perceived as moderately to highly competitive in logistics, with most stakeholders envisioning its future role as a key transit point or major regional hub within European supply chains, especially in the western region ***Error! Reference source not found.***.

Figure 6. Answers to question No. 10



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4.3.1 Nearshoring

Defining a comparative report between Romania and Poland regarding the potential of nearshoring in 2025, with a focus on opportunities, challenges and logistics infrastructure *Table 3*, we find out that Romania is in a phase of accelerated expansion (Malik, 2025), with great opportunities in nearshoring, especially due to low costs and entry into land Schengen.

Poland has a much more mature logistics infrastructure and is already attracting large volumes of investment, but the costs are higher (Turp, n.d.).

Romania can be a complementary or competitive alternative for companies seeking operational efficiency and flexibility in supply chains.

Table 1. Comparison between Romania and Poland

Criteria	Romania	Poland
Land Schengen Access	Land Schengen entry in 2025, reduced transit times and increased predictability	Long-standing Schengen member, infrastructure already adapted
Labor Costs	25–50% lower than in Western Europe	Competitive, but higher than in Romania
Available Logistics Space	~7 million sqm of industrial and logistics space	~30 million sqm, much more developed infrastructure
Access to Transport Corridors	Road, rail, maritime, strategic position in SE Europe	Road and rail, central position in Europe
Digitalization and Automation	Growing, investments in electric fleets and digital platforms	More advanced, wider adoption of logistics technologies
ESG Pressure and Sustainability	Growing demand for green solutions, electric trucks on the rise	More advanced in ESG reporting and green infrastructure
Availability of Skilled Labor	Good, but with increasing demographic pressures	More stable, but with similar challenges
Foreign Direct Investment (FDI)	Growing, but below Poland	High level, Poland is already a magnet for FDI

4.3.2 Infrastructure investments

Romania has made substantial progress in expanding and modernizing its transport infrastructure. The national highway network has grown to over 1,200 kilometers, with major projects such as the A7 Moldova Highway and Sibiu–Piteşti corridor enhancing regional connectivity and integration into the TEN-T Core Network. Rail modernization efforts include the upgrade of over 1,200

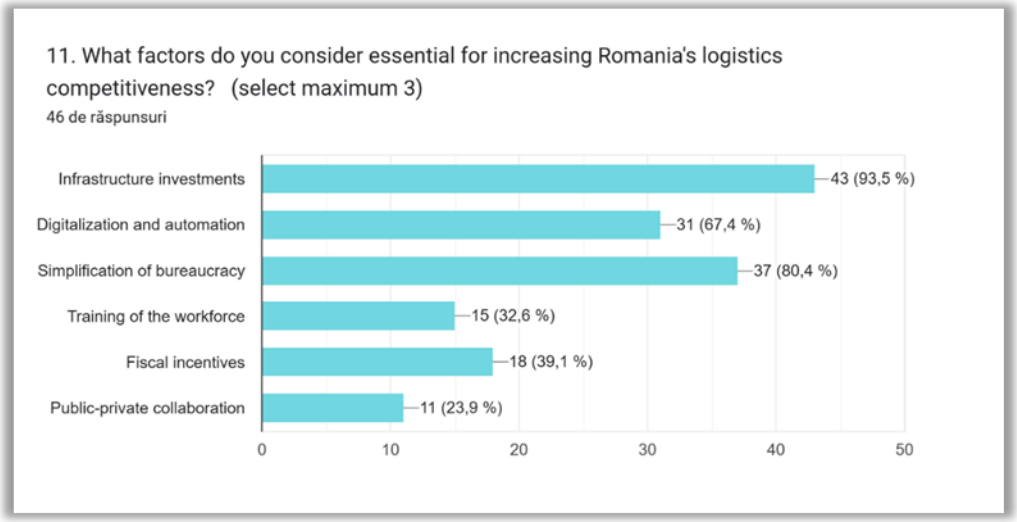
kilometers of track and the acquisition of electric rolling stock, although commercial speeds and interoperability remain below EU standards. The Port of Constanta, a strategic Black Sea hub, is undergoing expansion with multimodal terminals and improved hinterland access, positioning Romania as a key logistics gateway.

4.3.3 Digital transformation: fiscal and trade systems

Romania has accelerated its digitalization agenda through the implementation of e-Invoice, e-Transport, and SAF-T systems. These platforms enhance fiscal transparency, reduce administrative burdens, and improve compliance. The mandatory adoption of e-Invoice for B2B and B2C transactions, alongside the integration of SAF-T with e-VAT, reflects Romania's commitment to aligning with EU digital standards. These systems also support trade facilitation and data-driven governance.

Based on the questionnaire perceptions review, improving Romania's logistics competitiveness depends on infrastructure investments, bureaucratic simplification and digitalization, complemented by fiscal incentives, workforce training, and stronger public-private collaboration ***Error! Reference source not found.***.

Figure 7. Answers to question No. 11



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4.3.4 Green Logistics and Electric Mobility

Romania is emerging as a regional leader in green logistics and electric vehicle (EV) adoption. Over 40% of new vehicle registrations are electric or hybrid, supported by national subsidies and fleet electrification programs. Logistics operators, have begun transitioning to carbon-neutral operations, with electric trucks expected to account for 30% of cargo transport by 2030. Investments in charging infrastructure and alternative fuels further support Romania's sustainability goals.

4.3.5 Challenges to competitiveness

Despite notable progress, Romania continues to encounter significant structural constraints. Acute labor shortages, particularly within construction, logistics, and information technology, pose substantial risks to productivity and timely project execution. The regulatory landscape remains complex, characterized by frequent legislative amendments and insufficient stakeholder engagement, which diminishes business confidence and predictability. Moreover, ongoing geopolitical disruptions, most notably the conflict in Ukraine, have amplified Romania's strategic importance, while simultaneously introducing volatility in trade flows and energy supply chains.

Based on the questionnaire evaluation, the findings indicate that Romania's logistics sector must address infrastructure bottlenecks and the digital divide, while enhancing competitiveness through strategic investments, policy reforms, and targeted support for SMEs and workforce development.

Romania's competitiveness is underpinned by strategic infrastructure investments, digital modernization, and sustainability leadership. However, addressing labour market constraints, regulatory inefficiencies, and geopolitical risks is essential to sustaining growth and attracting long-term investment. Continued alignment with EU standards and targeted policy reforms will be critical in consolidating Romania's role as a resilient and forward-looking economy.

5. Result

The result of the study meets the challenges and good practices identified, and propose an optimistic scenario for improving Romania's performance in the race to become a central hub for the European Union.

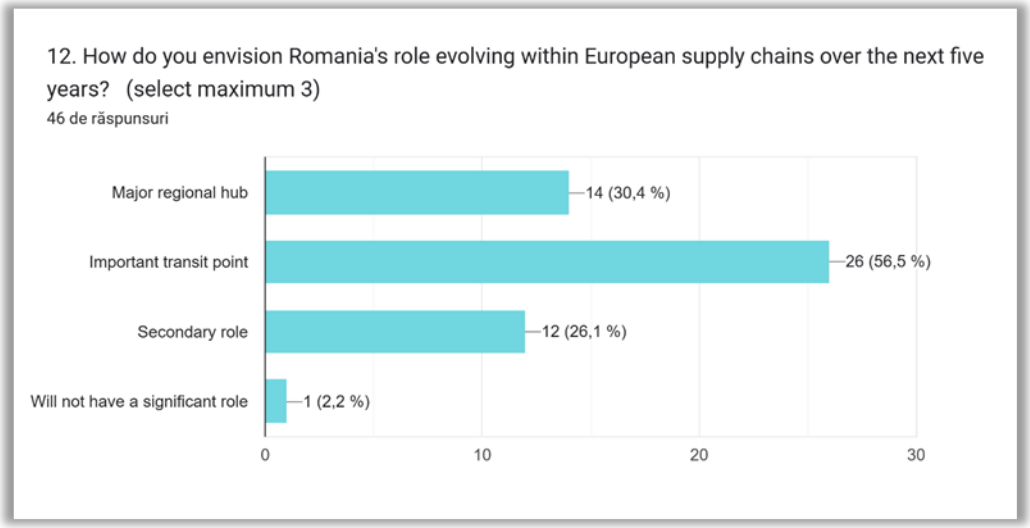
This concept aims to provide a comprehensive and adaptable approach to accelerate Romania's regional development in the supply chain, the implementation of this framework will depend on the active involvement of all stakeholders, as well as constant adaptation to changes in the global and regional logistics environment, to current challenges.

5.1 Europe's Strategic Logistics Hub

The defined concept would propose Romania, emerging as a major European Strategic Logistics Hub, where Romania is increasingly recognized as a strategic supply chain key actor within Europe, leveraging its geographic position at the crossroads of Central, Eastern, and Southern Europe, its integration into pan-European transport corridors, and its recent accession to the Schengen Area for land transport. These developments, combined with accelerated investments in road, rail, and port infrastructure, largely supported by EU funds and public-private partnerships, are transforming Romania into a key distribution and consolidation point for goods originating from Asia, the Middle East, and Africa, as well as a nearshoring partner in production, to support EU manufacturing growth.

Following the questionnaire answers, the role of Romania, evolving within the European supply chains, during next 5 years, is perceived as an important transit point and major regional hub ***Error! Reference source not found.***.

Figure 8. Answers to question No. 12



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5.2 Digital harmonization with EU standards

Romania is aligning its national digital logistics systems with European frameworks, enhancing cross-border interoperability and regulatory compliance:

e-Transport – eFTI (EU-Commission, n.d.)**:** Romania's e-Transport system integrates with the EU's Electronic Freight Transport Information (eFTI) platforms, enabling automated data exchange and harmonized inspections across member states.

e-CMR - European e-CMR: Adoption of standardized electronic consignment notes (e-CMR) ensures interoperability with systems in countries such as Germany, France, and Poland, with digital signatures and timestamps recognized EU-wide.

e-Seal - EU Customs Systems: Smart seals used in Romania are now compatible with European customs platforms (e.g., ICS2, NCTS), allowing real-time GPS tracking and alert sharing across borders.

CID - EDIH Network: Romanian Digital Innovation Hubs (DIHs) are integrated into the European Digital Innovation Hub (EDIH) network, fostering collaborative testing and development in logistics, AI, blockchain, and robotics.

Cybersecurity - ENISA Standards: Romanian systems are audited and certified according to ENISA protocols, ensuring robust data protection and coordinated incident response across the EU.

5.3 Projected Outcomes in an Optimistic Scenario

Under favorable conditions, Romania is well-positioned to evolve into a leading regional logistics hub in Europe, considering 3 main pillars, that can boost the efficiency and agility for EU supply chain:

- ✓ Transit times could decrease by 30- 40%, with digitalization driving cost optimization.
- ✓ International companies may increasingly select Romania for distribution, warehousing, and production operations.
- ✓ Job creation is expected across logistics, IT, automation, and cybersecurity sectors, reinforcing Romania's role in the European supply chain ecosystem.

6. Conclusion

Romania's evolution from a peripheral transit country to a strategic actor in Europe's smart supply chain architecture reflects a convergence of geographic advantage, infrastructure modernization, and digital harmonization with EU standards. The country's accession to the Schengen Area and its integration into key TEN-T corridors have significantly enhanced its role in regional logistics, enabling faster and more secure movement of goods across borders.

The adoption of interoperable digital systems, such as e-Transport, e-CMR, e-Seal, and SAF-T, has positioned Romania as a digitally aligned logistics partner within the European Union. These systems facilitate real-time data exchange, regulatory compliance, and cross-border coordination, reducing administrative burdens and improving supply chain transparency.

Romania's Digital Innovation Hubs (DIHs), integrated into the European EDIH network, further support the development of advanced logistics technologies, including AI, blockchain, and robotics. Coupled with ENISA-certified cybersecurity protocols, Romania is building a resilient and secure digital logistics ecosystem.

Under favorable conditions, Romania should become a regional consolidation and redistribution center for goods originating from Asia, the Middle East, and Africa. Optimized transit times, reduced logistics costs, and increased foreign investment in warehousing and production facilities are expected outcomes. This transformation is likely to generate significant employment opportunities in logistics, IT, automation, and cybersecurity, reinforcing Romania's strategic importance in the European supply chain landscape.

7. Future outlook and research directions

With Romania's recent accession to the Schengen Area for land transport, future research could quantify the impact on cross-border freight flows, customs clearance times, and logistics costs. Comparative studies with other Schengen-border countries could offer valuable benchmarks, in evaluation of the impact assessment of Schengen integration on freight efficiency

While large enterprises are advancing in digital adoption, SMEs face barriers. A focused study on the digital readiness, adoption gaps, and support mechanisms for

small logistics firms could inform targeted policy and funding strategies, for the identification of digital maturity of Romanian SMEs in logistics.

Green Logistics and Carbon Footprint Modeling, can play the content for future research, as Romania expands its electric vehicle infrastructure and green logistics initiatives, future research could model the carbon reduction potential of these investments. This includes lifecycle analysis of EV fleets, smart warehouses, and multimodal transport systems.

Given Romania's proximity to conflict zones and its role in rerouting Ukrainian exports, a resilience-focused study could evaluate how Romanian logistics networks adapt to geopolitical disruptions, supply shocks, and energy volatility, analyzing the resilience of Romanian supply chains to geopolitical shocks.

AI and Automation in Romanian Logistics Operations, can be as well the base in exploring the integration of AI, robotics, and predictive analytics in Romanian logistics hubs, especially within Digital Innovation Centers, could reveal productivity gains, workforce transformation, and operational efficiency improvements.

Public-Private Collaboration Models for Infrastructure Development, thru a comparative analysis of successful PPP models in logistics infrastructure across Europe could help Romania refine its investment strategies and accelerate project delivery in highways, rail, and port modernization.

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Annex

Trade openness impact

Methodology: Panel regression based on data from 2013- 2024, between Digital adoption and LPI (Logistic Performance Index)

Year	Country	Digital adoption (%)	LPI (score)	Predicted LPI	Residual	Residual^2
2013	Romania	19.00	2.90	2.93	(0.02940)	0.00086
2014	Romania	20.18	2.91	2.93	(0.02236)	0.00050
2015	Romania	21.36	2.92	2.94	(0.01531)	0.00023
2016	Romania	22.54	2.94	2.94	(0.00827)	0.00007
2017	Romania	23.72	2.95	2.95	(0.00122)	0.00000
2018	Romania	24.90	2.96	2.95	0.00582	0.00003
2019	Romania	27.68	2.97	2.97	0.00614	0.00004
2020	Romania	30.46	2.98	2.98	0.00647	0.00004
2021	Romania	33.24	3.00	2.99	0.00679	0.00005
2022	Romania	36.02	3.01	3.00	0.00712	0.00005
2023	Romania	37.36	3.02	3.01	0.01349	0.00018
2024	Romania	38.54	3.03	3.01	0.02053	0.00042
2013	EU	23.00	3.60	3.61	(0.00910)	0.00008
2014	EU	24.56	3.61	3.62	(0.00365)	0.00001
2015	EU	26.12	3.62	3.62	0.00180	0.00000
2016	EU	27.68	3.64	3.63	0.00724	0.00005
2017	EU	29.24	3.65	3.64	0.01269	0.00016
2018	EU	30.80	3.66	3.64	0.01814	0.00033
2019	EU	35.36	3.67	3.66	0.01099	0.00012
2020	EU	39.92	3.68	3.68	0.00384	0.00001
2021	EU	44.48	3.70	3.70	(0.00332)	0.00001
2022	EU	49.04	3.71	3.72	(0.01047)	0.00011
2023	EU	53.60	3.72	3.74	(0.01762)	0.00031
2024	EU	58.02	3.73	3.76	(0.02418)	0.00058

Formulas:

Predicted LPI = Intercept + (Slope * Digital adoption) + Country Effect (if Romania)

Intercept = 3.5125, Slope = 0.0042, Country Effect (Romania) = -0.6629

R^2 Calculation: $R^2 = 1 - (SSR / SST)$

SSR = SUM(Residual^2) = 0.004275531024000006

SST = SUM((LPI - Mean LPI)^2) = 2.9811840000000016

R^2 = 0.998566