Intermodal Transportation Challenges in Eastern Europe: Case Study of Romania

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Abstract. *The purpose of this paper is to analyze data from the Romanian intermodal transportation sector and provide an overview of its main terminals (sea, river, road and rail) and the operational challenges faced by its most important logistics service providers. Intermodal transportation (by rail) is encouraged at EU level as a sustainable alternative to current predominant truck haulage. Most research articles outline issues with connectivity, terminal handling infrastructure and cost efficiency as factors hindering large scale adoption. Other authors tend to emphasize the more reliable delivery schedules, reduced road congestion and emissions as drivers of cost competitiveness on medium term. Relevant cargo volume traffic (tons, TEU and ITU) is analyzed at Romania's main intermodal hubs in the last 10 years (2014-2023) using quantitative and qualitative data to provide a comprehensive overview of its overall competitiveness in this sector. Most Eastern European countries are faced with the same challenge in terms of intermodal transportation: the shortcomings of their supporting network due to insufficient public investment, highlighted by the results from Romania (case study method). Main results show Constanta Port had record cargo traffic in 2023, but its throughput is hindered by constant congestion issues, similar to the highly competitive road sector where intense truck traffic creates bottlenecks on the major roads leading to Western Europe. Cargo is also shipped via the Danube and freight trains, but to a limited extent due to low average speeds and inconsistent reliability along most sectors. The paper highlights the importance of a country's strategic hubs and their connectivity (sea and/or river ports, main railway lines and road sectors) as a source of future growth and development perspectives, for terminal operators as well as neighboring regions (EU and EEA) through increased business activity.*

Keywords: intermodal transport, intermodal terminal, shipping container, freight train, inland waterways, cost-effectiveness, digitalization.

Introduction

The overall performance of an intermodal transportation system is related to the quality of its terminal's infrastructure, range of interconnectivity alternatives and strategic placement of logistic hubs (Tufano et al., 2023). Recent sustainability policies, market volatility and the need to increase process digitalization have emphasized the demand for private terminal operators and local authorities to improve their collaboration (Maslaric et al., 2024). Intermodal transportation can help balance out cargo traffic and volumes over time through contracted services and occasional spot quotes by providing increased capacity and service predictability (Gharehgozli et al., 2020). Transit times are however longer than by road, but not all types of cargo need JIT delivery (e.g. automotive industry suppliers). Generally, the longer the distance hauled, the more efficient intermodal transportation is compared to trucking by road (20-30% more cost efficient,

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on average), but it also depends on volumes and the geographical area where it is shipped (and its infrastructure specifics).

A recent EC report shows 66% of intermodal transport operations are intra-EU, 19% national and 15% international. Rail/road (48%) and water/road (45%) are most common, each accounting for nearly half of the overall combined transport (CT) choices, while 39% of shipments even use more than 2 modes. Short sea shipping (SSS/road) accounts for 27%, whereas inland waterways transport (IWW/road) represents 18% for total water/road options mentioned above (Kirichek et al., 2024).

In Romania, 40-60% of intermodal transportation costs are road-related (trucks) and intermodal is cost-efficient only for optimum loads (TEU, UTI, bulk) hauled along longer distances (Paridaens and Notteboom, 2022). Otherwise, even including trucking fees and parking, local road transportation/distribution by truck (within Romania) and intermodal overall costs are more or less matched. Rail solutions are mostly applied until reaching the intermodal terminals in the West of Romania (1300-1700 km by freight trains) and then mostly by road (600-800 km) with trucks (80% of incoming freight is shipped towards Bucharest), only a small amount stays in the Banat-Crisana region or is distributed to other parts of the country (Transylvania, North and/or South of Romania) other than the capital.

The lack of modern rail terminals in other parts of the country, low average freight train speeds (14-16 km/h) and small incoming cargo volumes mean that trucks (up to 35-40% cheaper on spot quotes, compared to certain EU countries) are the still the most effective choice for corresponding domestic delivery (Parola et al., 2021). Domestically, road transport is more flexible (and faster than trains), comparable in terms of cost (more competitive for distances up to 300-450 km) and more practical, overall as there are not enough freight volumes to make intermodal/train transportation viable (Tadic et al., 2020). In Romania, price is still the leading criteria for most customers and LSP choices are made on either a higher profit margin (with less volume) or on higher volumes (with less profit margin), balancing out more business contracts won and a higher share in sales.

Literature review

Current research studies and EU-level policies highlight the strategic importance of infrastructure investments in improved connectivity throughout Europe. Road traffic is a major source of CO_2 emissions and intermodal solutions are sought on intra-EU level to improve connectivity and reduce traffic congestions, while also investing in durable infrastructure projects, mainly targeting railways, inland waterways, and short-sea shipping (Kaack et al., 2018). The crucial role of intermodal connectivity with adequate supporting infrastructure in attracting cargo flows is also outlined by Wiegmans and Janic (2019).

Intermodal terminals and associated logistics infrastructure located in the proximity of the Trans-European Transport Network (TEN-T) will be of strategic importance, enabling better connectivity and increased efficiency of cargo traffic throughput, as shown by Horvath and Szabó (2018). Efficient infrastructure investment is correlated with increased freight volumes, subsequent reduced transport costs and more environmentally friendly transportation alternatives, enabling a more interconnected, competitive, and sustainable intermodal and logistics network (Tanasuica, 2022).

Strategic placement of intermodal terminals (rail, IWW, SSS) and supporting industrial parks (intermodal freight hubs) facilitate efficient cargo handling and consolidation, developing efficient logistics hubs (Oszter and Kövesdi, 2014). These hubs may additionally offer typical value-added services like customs clearance and warehousing, further streamlining the process through specialized LSPs, as anticipated by Wagener (2014).

Collaboration between LSPs, transport operators, and public authorities is essential for an effective, operational and efficient intermodal system, as recently shown by Pineda-Jaramillo and Viti (2022). Planning, implementing, and continuously improving intermodal system solutions require a reliable partnership to source win-win strategies and an active engagement to fund and manage infrastructure projects (Burciu et al., 2015).

Intermodal terminals are incentivized by EU policies as they are aligned with more environmentally friendly alternative solutions prioritizing freight shift from road/rail and from road/water (Tadic et al., 2021). Focusing on sustainability will thus encourage more investments in greener technologies (reducing carbon emissions) and modal shift terminals (towards rail, rivers and seas) while also improving cost competitiveness (reducing overall cost, improved delivery predictability and reliability, faster connections on medium-term) as is presented by Beskovnik (2023).

Investing in multiple types of innovative technologies (automated solutions), more environmentally friendly facilities (certified warehouses, lower energy-consumption, prosumers) and increased digitization (blockchain, EDI interfaces, online communication) is increasing in recent years, driven by the pandemic as is highlighted by Krstic et al. (2023). Freight information platforms, real-time tracking systems, and intelligent transport systems are some of the digital solutions used in intermodal transportation (Krüger et al., 2023) to improve transparency, efficiency, and visibility across the intermodal network.

Methodology

The research paper analyzes data from the last 10 years to provide a comprehensive overview upon the scale and recent development of intermodal transportation in Romania.

Relevant intermodal transportation data was sourced from company annual reports, official press and marketing releases as well as sector-specific associations, official European statistics databases and the authors' own private sector experience (work, consultancy and research contracts) conducted with logistics service providers (LSP). No sensitive or confidential information was disclosed within this paper by the authors in order to maintain trade secrets and uphold the trust invested in them by their business partners to gain a more broad insight on actual issues and challenges faced by the intermodal sector. Leaving out such specific data (qualitative and quantitative) might be subject to certain limitations for the reader.

Relevant data (tons, TEU and ITU units) is compared on a year-to-year basis within a period of 5-10 years, ranging from absolute values to relative values (year-to-year dynamic, in percentages), variations from the overall average (absolute and relative, for 5 years and/or 10 years) to the overall variation (absolute and relative) within the entire period for the sets of data. An average level is calculated for a 5-year and/or 10-year timespan and the dynamic (absolute and relative variation) is determined in relation to both the 5-year and 10-year timespans. Data availability and aggregation from several business partners was an issue due to different company disclosure policies, as well as the overall economic setting (specific macroeconomic and external factors) during the carried out analysis (up to 10 years) and the changing interdependency of the concurring means of transportation add complexity to analysis, adding further limitations in terms of study replicability and relevance of findings.

The objective of the paper was to analyze the current state of intermodal transportation in Romania, its challenges and perspectives and to provide an overview of its most relevant issues. A selection of quantified data and results is provided in the Results and discussions section, as well as comments and interpretations to each set of data, whereas the main research outcomes are outlined in the paper's Conclusion section.

Results and discussions

Constanta is the largest Black Sea port (located on its western coast) and the 7th largest in Europe (2023) in terms of tons/year handled, being constantly ranked in the top 20 and more recently in the top 10 European ports. Constanta is one of the most important maritime cereal hub ports in Europe, along with its Northern European counterparts in Germany, Belgium and The Netherlands. The Black Sea port in Romania has one of the largest operating capacities for individual cereal types (can handle about 8 million tons per year) and serves as a crucial export point for Eastern European wheat, as is outlined by table 1. It is outdone only by Rotterdam which handles over 12 million tons of cereals (wheat, barley, maize, and rice), as of 2022, whilst Amsterdam and Ghent have more dedicated cereal terminals (10 and 8) and specialized handling capabilities. Marseille, operating Mediterranean cereal trade (3.5 million tons, 2022) and Hamburg, specialized in barley (capacity of over 5 million tons) are other important such ports.

Table 1. Gross weight of goods handled in the port of Constanta

year	**2013**	**2014**	**2015**	**2016**	**2017**	**5-year average (2013-2017)**	
ktons	55,138	55,641	56,336	59,424	58,379	**56,983.6**	
dynamic [%]		*0,91*	*1,25*	*5,48*	*-1,76*	*5.88*	
TEU	661,124	668,349	689,066	711,339	696,438	**685,263.2**	
dynamic [%]		*1,09*	*3,10*	*3,23*	*-2,09*	*5.34*	
ship traffic	4,833	4,771	4,605	4,331	4,093	**4,526.6**	
dynamic [%]		*-1,28*	*-3,48*	*-5,95*	*-5,50*	*-15.31*	
year	**2018**	**2019**	**2020**	**2021**	**2022**	**5-year average (2018-2022)**	**10-year average (2013-2022)**
ktons	61,303	66,603	60,375	67,483	75,537	**66,260.2**	**61,621.9**
dynamic [%]	*5,01*	*8,65*	*-9,35*	*11,77*	*11,93*	*23.22*	*37.00*
TEU	668,016	666,036	643,725	631,946	776,590	**677,262.6**	**681,262.9**
dynamic [%]	*-4,08*	*-0,30*	*-3,35*	*-1,83*	*22,89*	*16.25*	*17.47*
ship traffic	4,139	4,176	4,031	3,985	4,498	**4,165.80**	**4,346.2**
dynamic [%]	1.12	0.89	-3.47	-1.14	12.87	*8.67*	*-6.93*

Source: Port of Constanta – Annual report.

A record 92.5 million tons were handled by the port in 2023 (22% increase year-on-year), over a third of cargo being cereals (36 million tons and a 50% year-on-year increase) with an important amount (38%) coming from the Ukraine (14 million) by barges, trains and trucks. If cereals from Ukraine would only be hauled by road transportation, this would account for 800,000 trucks. Over 40% of cereals from Constanta port were destined for export (towards South Korea, Morocco, Jordan, Spain) in 2023 with sea traffic accounting for over 70 million tons (76% of total cargo and an 18% increase year-on-year), whilst the other quarter transited through the Danube (40% year-on-year increase in river traffic). 40% of the total navigable sector of the Danube is in Romania (1,075 km) across 20 river ports. Only 8 of these ports are located on the central TEN-T railway network and only 4 ports (Braila, Galati, Tulcea and Sulina) can operate maritime vessels, limiting the intermodal options across the Danube. In addition, some ports have important issues (indicators are not visible, wrecks at the bottom of the water, low depth in summer), making them unsuitable for traffic 3-4 months a year. A low absorption of the allocated 600 million euros for projects and works from the Large Infrastructure Operational Programme (LIOP 2014-2020) meant modernization effects were scarce. The outdated infrastructure, the lack of connections with the railway and roads, but also the slow procedures for handling goods reduce the attractiveness of the Danube ports for potential users.

Modernization is needed in all 20 river ports to increase cargo volumes, reduce loading-unloading times, increasing the safety of ships during operations. Since 2018 over 60 million tons of cargo were handled by the port every year (2018-2021) with important growth in the last 2 years (12% in 2022 and 22% in 2023), representing an overall 37.07% (since 2021) or 53.21% increase (since 2020). ISO container traffic has been more stable in the last decade (under 700,000 TEU), with a record level in 2023 of 776,590 units (23% year-on-year increase). The increase in cargo volumes (as shown in Table 2) has also brought about congestion and the need for port infrastructure to be extended to further handle the upcoming traffic in the port's terminals.

Table 2. Top 3 cargo types handled in the port of Constanta

year/cargo [ktons]	**2018**	**2019**	**2020**	**2021**	**2022**	**average (2018-2022)**	**dynamic (2018-2022)**
cereals	17,963	21,329	21,893	25,174	24,010	**22,074**	**+6,047**
share [%]	*29.30*	*32.02*	*36.26*	*37.30*	*31.79*	*33.31*	*33.67*
crude oil & oil products	13,373	14,323	11,680	12,153	16,714	**13,649**	**+3,341**
share [%]	*21.81*	*21.51*	*19.35*	*18.01*	*22.13*	*20.60*	*24.99*
iron ores, scrap & metal products	6,809	7,718	5,822	7,268	10,227	**7,569**	**+3,418**
share [%]	*11.11*	*11.59*	*9.64*	*10.77*	*13.54*	*11.42*	*50.21*
top 3 share [%]	**62.22**	**65.12**	**65.25**	**66.09**	**67.45**	**65.34**	**+5.23**

Source: Port of Constanta – Annual report.

Bulk is the main type of cargo handled in the port of Constanta (cereals and oil) with an overall share of 53.91%. Cereals have an average share of 33.31% in the last 5 years and a matching dynamic (+6.05 million tons and a 33.67% increase). Oil has an average share of 20.60% in the last 5 years and an even higher dynamic (+3.35 million tons and a 24.99% increase). Iron and metal products also have important share (an average of 11.42%) and 50.21% dynamic in the last 5 years (+3.42 million tons between 2018-2022).

Constanta focuses on bulk cargo (cereals and oil products), but also handles containerized shipments (16.8% increase in first semester of 2023 in TEU traffic), both being supported by connections with Pan-European transport corridors IV (high speed railway and highway) and VII (Danube), Europe, Caucasus and Central Asia (TRACECA corridor). The port currently handles most of the cereal flow from Ukraine and the import of Russian and Caspian oil to Central Europe through its pipe system connection. The port's South breakwater needs extension investment in Pier III and IV (oil, containers and cereals), quays and berths are partially built and could be finished in 3-4 months (up to a year) along with roads and 2 bridges (road and railway) to increase the capacity on the South breakwater. Traffic management (200 trucks per day carrying 25-27 tons are unloaded) is performed by an automated AI software with RFID (owned by a terminal operator), but no such port-owned software is currently operational (contract termination in progress with current supplier).

The average speed for passenger trains was 44.71 km/h (2023) and for freight trains 15.86 km/h, according to CFR. Based on their technical condition and age more than half (55%) of the wagons and locomotives (1,450 units) owned by CFR should be scrapped and either modernized or replaced and 85% of the railway lines should be rehabilitated (some are in advanced state of damage). The last trains bought (120 "Blue Arrow" trains) were in 2006 whereas the last wagons (603 units) were bought in 2011. CFR owns around 1,000 wagons (60% need modernizing), but would need at least 1,200 for regular use. Only 57 of the total of 450 locomotives were modernized (13%), the remaining 393 should be repaired or replaced (87%). In terms of infrastructure, of the 10,615 kilometers of railway, 9,000 need repairs (84.7%) and of the 9,000, under 638 are planned for modernization (7% of the total) in 2024. Trains thus mostly travel with difficulty and restrictions (1,562 mapped areas where trains reduce speed to 10-15 km/h, as of 2022) due to deteriorated and fissured railway lines, meaning lower speeds and delays along the network, especially in summer and winter. A maximum speed of 160 km/h is possible only on M800 Bucharest-Constanta (225 km) and on M200 Sighisoara-Curtici (186 km), so on a total of 411 km of the network length (3.87% of total), subject to railway transport operators having appropriate rolling stock.

Last year 125 km of railway lines were rehabilitated (1.17% of total network) and only 34% of the intermodal terminals (9/26) owned by CFR Marfa were active. 409 km of railway lines (owned by CFR) within the port area and its outside connections need repair, less than 25% being currently executed (work in progress on 100/409 railway lines), the rest await launching of their FS (ETC: 60 months). In the port area there are currently 780 stationary train cars (300 beyond repair, 38% of total) blocked on railway, mostly having complicated legal issues (sequestration by Finance Agency). These train cars are taking up important rail capacity which could be used for improved intermodal shipments and operations flow and would reduce the port's current congestions and lengthy waiting times (20-34 hours to reach Curtici intermodal terminal at Hungarian border). Only one of the port's marshaling yards (Palas, Valu lui Traian) for traffic management is functional (Palas), with a limited 20% capacity (only 5/25 lines are operational), all others are closed (since 2011) and currently useless, as are the port's 2 train ferries.

Road connectivity (A4) is lagging capacity requirements, slowing down throughput, creating congestions (waiting queue: over 300 trucks and/or more than 10 km of blocked lane) and excessive waiting times (2-3 days) prior to port access (Gate 10). 39% of cargo operations are with cereals, capacity being mainly designed for Romania, Hungary and Serbia (shipments from Ukraine have increased regular activity by 63% in 2023, generating congestion issues). A private Ro-Ro terminal operated by Romcargo Maritim for Dacia (storage capacity: 6,000 automobiles) with destinations in Europe (Italy, France, Spain, Greece and Turkey) and Africa (Algeria and Morocco) is operational in breakwater North, in addition to 2 other terminals in breakwater South (capacity of 5,400 and 1,500 vehicles).

Table 3. Main road connections and their economic importance in Romania

Name (road category)	**starting point**	**terminus point**	**length [km]**	**remarks**
A0 (highway)	-	-	101	By-Pass (Bucharest) – in execution (18%)
A1 (highway)	Bucharest	Pitesti	110	Dacia manufacturing plant (Mioveni) Automotive industry suppliers (region)
A1 (highway)	Timisoara	Nadlac II	80	Automotive industry suppliers (region) Romania-Hungary border crossing (highway) Railport Arad intermodal terminal (Curtici)

Name (road category)	starting point	terminus point	length [km]	remarks
A2 (highway)	Bucharest	Constanta	203	Port of Constanta (Black Sea and Danube) Petromidia refinery (Rompetrol, Navodari)
A3 (highway)	Bucharest	Ploiesti	66	Petrobrazi (OMV) & Petrotel (Lukoil) refineries
DEx12 (expressway)	Craiova	Pitesti	122	DEx12 connection (to A1) – in execution (59%) Ford manufacturing plant (Craiova) Automotive industry suppliers (region)

Source: Pro Infrastructura Association.

The longest highway in Romania is the A1 which connects the capital city, Bucharest, to the border with Hungary and serves car manufacturer Dacia (near Pitesti), the automotive industry (Western Region) and the country's largest intermodal terminal (near Arad), among others (see Table 3). The A1 lacks a connection between Pitesti and Sibiu (called "the Dacia highway", 140 km) along the Olt valley (DN7) and 15 km between Margina and Holdea (DN68A, mountainous national twisty road) which both source high congestion and risk of accidents and complete road blocks in case of such events occurring due to single carriageway traffic passing through towns (lights, pedestrians, schools), dangerous curves and high amount of trucks using the road (no alternative once on it). Another option is the use the Prahova valley (DN1) through Brasov which is 40 km (and 40 minutes) longer, but traffic conditions are similar (again, no alternative once on it). The DEx12 expressway between Craiova and Pitesti (called "the Ford highway", 122 km) would allow faster traffic between the Oltenia region (A6, Craiova-Lugoj is only planned with 4% being open of the 260 km) and the capital city. Bucharest is also only now building its by-pass (A0) which would ease its huge traffic congestion rate and provide better access to A2 (leading to Constanta port) and A3 (oil refinery companies).

Table 4. Oil products sourcing and distribution

brand	internal refinery	external refinery	refinery location (s)	maximum capacity [mtons/year]	nearest storage facility [km]	gas stations	Storage facilities
OMV (Petrom)	1	-	Petrobrazi	4.5	-	793	6
Lukoil*	1	1	Petrotel Burgas (Bulgaria) and import (Port of Constanta)	2.4 7.5 40.6*	-	318	7
MOL (Slovnaft) (INA)	-	4	Szazhalombatta (Hungary) Bratislava (Slovakia) Rijeka and Sisak (Croatia)	8.1 6.1 4.5 and 2.2	299	241	2
KazMunayGas (Rompetrol)	1	-	Petromidia	6	-	158	6
SOCAR	-	-	import (Port of Constanta)	6.5*	-	66	4
Gazprom (NIS*)	-	2	Pancevo and Novi Sad (Serbia)	4.8 2.6	-	19	0

Source: Company official press and marketing releases and annual reports.

Romania has 3 main refineries (as outlined by Table 4), owned by 3 different multinational oil companies that ensure almost a third of its national consumption. Petrobrazi refinery is owned by OMV (Austria), Petrotel refinery by Lukoil (Russian Federation) and Petromidia by KazMunayGas (Kazakhstan). Petromidia is the most modern of the 3 facilities and ensures around 40% of Romania's refining capacity. Lukoil has a refinery in Bulgaria as well, the only of the three to have a second refinery so close to Romania, whereas all other brands import their own products from elsewhere to their own storage facilities (or intermediate storage facilities) or directly to their network of gas stations. MOL has its main refinery in Hungary, but also has facilities in Slovakia (bought from Slovnaft) and Croatia (bought from INA), where it still uses the local brand names for its products. Gazprom, although being a multinational company from Russia, has transferred its operations to NIS from Serbia and can thus legally avoid current imposed sanctions since Serbia is not part of the EU. Lukoil similarly imports crude oil through intermediate companies outside Russia and refines it in Romania, thus also avoiding sanctions. SOCAR imports its own products through tankers in the port of Constanta from Azerbaijan and then distributes it throughout its local network (storage facilities and gas stations) in Romania. Only 30% of oil products are sourced locally (3.32 million tons), the rest (crude oil, but also refined products such as diesel fuel) is imported (7.98 million tons) from Asia (30%), the United States (20%) or countries such as Kazakhstan, but 80% of imports pass through pipes belonging to the Russian Federation prior to being shipped to Constanta. Before EU sanctions, after the invasion of Ukraine (2022), over half of oil imports were sourced from Russia (53%). Petrobrazi (OMV and Petrom brands) sources two thirds of its production locally, but 33% comes from import at higher prices (extra shipping and insurance costs). Rompetrol (owned by KazMunayGas) sources 58% locally and has its own oil terminal in Midia for its imports, whereas Petrotel (Lukoil) sources 50% locally and 50% is imported. Both OMV and Lukoil bring their products through a company called Oil Terminal (located in Constanta), but their capacity is limited to 900,000 cbm (own terminal, Port of Constanta) and 400,000 cbm (central storage facility, city of Constanta) and the company is not digitized.

Table 5. Internal production figures of Dacia and Ford in Romania

year/internal production [units]	**2013**	**2014**	**2015**	**2016**	**2017**
Automobile Dacia, Mioveni plant	342,620	338,593	339,204	320,457	313,883
dynamic [%]		*-1.18*	*0.18*	*-5.53*	*-2.05*
Ford Otosan, Craiova plant	68,377	52,841	47,973	38,849	45,367
dynamic [%]		*-22.72*	*-9.21*	*-19.02*	*16.78*
total	**410,997**	**391,434**	**387,177**	**359,306**	**359,250**
dynamic [%]		*-4.76*	*-1.09*	*-7.20*	*-0.02*
year	**2018**	**2019**	**2020**	**2021**	**2022**
Automobile Dacia, Mioveni plant	335,262	349,528	259,099	257,405	314,678
dynamic [%]	*6.81*	*4.26*	*-25.87*	*-0.65*	*22.25*
Ford Otosan, Craiova plant	141,507	140,884	179,008	163,350	195,237
dynamic [%]	*211.92*	*-0.44*	*27.06*	*-8.75*	*19.52*
total	**476,769**	**490,412**	**438,107**	**420,755**	**509,915**
dynamic [%]	*32.71*	*2.86*	*-10.67*	*-3.96*	*21.19*

Source: Dacia and Ford press releases.

Dacia's production levels (see Table 5) have constantly been above 90% of its maximum capacity (peaking at 99.87% in 2019) in the last decade, with Ford only being at 20% before assembling 2 new models starting 2017 (Puma and Transit Courier). In the last 2 years the plant in

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Craiova has come close to an 80% production level and capacity will be increase by a further 10% soon. Last year Dacia produced 322,086 units (2.35% year-on-year increase) with Ford sourcing 190,964 cars, their combined output exceeding half a million units (513,050 cars made in Romania) for the second year in a row. Dacia is market leader in Romania (33% share with 46,124 units sold in 2023), but both carmakers sell less than 10% on the local market as most of their production is shipped to export destinations. Besides assembling vehicles, Dacia also makes SKD (up to 10% on top of production) and CKD units (up to 35% on top of production) that are shipped by its Alliance ILN (International Logistic Network), adding to the complexity of its logistics operations. Inbound, Dacia has 651 suppliers (108 from Romania) delivering to Mioveni and manages over 21,000 different references (including Renault-Nissan) of which around 50% are Dacia-specific parts. Outbound, every week Dacia ships more than 8,000 cars by truck or train. On average 4,400 cars are sent with 550 trucks (6-8 cars/trailer, 53% of total) by road (a total of 12-16,000 cars per month) and 3,800 units with 14-15 trains (224-294 cars/train) to either Valenton (France) or the Port of Constanta (360 km, but transit time is 12-24 hours) for further distribution. A truck reaches Germany within 2-4 days of departure from Mioveni (including border crossing waiting times). Once arrived in the port of Constanta (private Ro-Ro terminal operated by Romcargo Maritim) 4,000 cars are loaded for shipping in around 30 hours (140 cars/hour or around 1,500 cars per 12 hour shift) for export destinations (to ports in Turkey, Morocco or France). A further 600 trucks leave the manufacturing plant with containers of CKD kits (loading time: 30 minutes) for a total of 25-33% of total production (around 85,000 units per year) to be assembled elsewhere in Renault Group plants (Africa, South America or Asia). Every year, on average, 30% of internal production (Dacia and Ford, combined) is shipped via the Port of Constanta.

Ford also ships 90% of its production abroad, most of it (70%) by train and the rest via road (25%) and sea (only 5% is shipped through the port of Constanta). Every day 2 trains (up to 300 cars, each) leave the Ford plant in Craiova towards Curtici, at the Romanian-Hungarian border (400 km usually take 26 hours + 9 hours for border crossing). Border crossings in Curtici may take anywhere between 6 (ideally) and 24 hours (worst case). After entering Hungary the trains need 36 hours to reach Neuss, Germany (1,400 km), before their distribution to Ford dealerships throughout Western Europe. On average, freight trains in Romania travel with 14 km/h (Ford data, 2023), even less than in 2022 (average speed: 15.6 km/h), the lowest speed in the region (Hungary, Bulgaria, Greece, Serbia, Croatia, Slovenia, Austria). According to Ford, 400 km can be traveled in Hungary in 6-8 hours, whilst in Romania the same distance could even take 24 hours (4 times longer) due to constant safety and speed restrictions (maximum speed allowed: 60 km/h), as of 2023.

Table 6. Annual cargo volumes at Timisoara and Bucharest International Airports

year/cargo handled [tons]	**location**	**2013**	**2014**	**2015**	**2016**	**2017**
Traian Vuia International Airport	Timisoara	1,600	1,937	2,606	3,887	4,586
dynamic [%]	(TSR)	*9.4*	*21.06*	*35.54*	*49.16*	*17.98*
Henri Coanda International Airport	Bucharest	28,432	29,193	31,421	34,125	37,415
dynamic [%]	(OTP)	*7.31*	*2.68*	*7.63*	*8.61*	*9.64*
		2018	**2019**	**2020**	**2021**	**2022**
Traian Vuia International Airport	Timisoara	5,939	5,167	5,147	6,068	7,817
dynamic [%]	(TSR)	*29.50*	*-13.00*	*-00.39*	*17.89*	*28.82*
Henri Coanda International Airport	Bucharest	39,534	38,607	31,186	29,391	34,094
dynamic [%]	(OTP)	*5.66*	*-2.34*	*-19.22*	*-5.76*	*16.00*

Source: Romanian Airport Association (AAR).

In the last decade airfreight volumes in Romania have increased considerably and are now above 50,000 tons yearly. Bucharest has a 70% share of all airfreight, but Timisoara is an important second with its current volumes (6,639 tons and 15% year-on-year decrease) being more than 3 times higher than in 2014 (see Table 6). Despite an overall 5.7% industry drop (from 53,877 tons in 2022 to 50,786 tons in 2023) Cluj International Airport managed to increase its cargo volumes to 7,417 tons (6.9% year-on-year increase) and overtake Timisoara in this traffic segment as well. Timisoara's main advantages are its highly developed automotive industry, highest amount of highways per county (106 km, 10% of total highway length) and by-pass (partial), as well as the planned investment of connecting the airport with a main railway line (CFR 200) that could further be developed into an intermodal terminal in the upcoming future. The logistic development in the Western Area, especially the number of warehousing spaces and LSPs would most likely generate important terminal traffic, in addition to the completion of the entire city by-pass (currently in execution).

Table 7. Annual goods transported by rail in intermodal transport units

year	**2013**	**2014**	**2015**	**2016**	**2017**	**5-year average (2013-2017)**	
ktons	2,094	2,324	2,053	1,856	2,617	**2,188.8**	
dynamic [%]		*10.98*	*-11.66*	*-9.60*	*41.00*	*24.98*	
TEU	233,409	260,706	328,126	328,850	418,049	**313,828**	
dynamic [%]		*11,69*	*25,86*	*0,22*	*27,12*	*79.11*	
year	**2018**	**2019**	**2020**	**2021**	**2022**	**5-year average (2018-2022)**	**10-year average (2013-2022)**
ktons	2,601	2,114	2,164	2,154	1,735	**2,153.6**	**2,171.2**
dynamic [%]	*-0.61*	*-18.72*	*2.37*	*-0.46*	*-19.45*	*-33.29*	*-17.14*
TEU	406,683	344,212	296,830	279,891	227,691	**311,061.4**	**312,444.7**
dynamic [%]	-2,72	-15,36	-13,77	-5,71	-18,65	*-44.01*	*-2.45*

Source: Eurostat.

The main challenge of intermodal transportation is the state of its infrastructure (especially its connections to the railway network). After reaching its peak in 2016-2017 with over 400,000 TEU (and over 2,600 tons), the lack of investment in strategic hubs and their connections (especially railways) has reduced average freight train speed to below 20 km/h. Besides the increasing safety concerns (increased number of train breakdowns, derailing incidents, railway accidents and collapsing bridges) reduced speed also means longer transit times and reduced throughput. TEU traffic declined by 45% in the following 5 years (2017-2022) with a slightly lesser drop for weight (33%) both being currently below their corresponding volumes from 2013 (see Table 7). This drop is due to the traditional small margins in railway transportation (which is also high energy consuming) being coupled with rising energy costs, pressures on raising salaries and high inflation in recent years. The Covid-19 pandemic also brought about uncertainty, unbalanced volumes and supply chain fluctuations between 2020-2021. The mix of these market features thus enabled a part of freight to be shifted towards road transportation (30%) for improved reactiveness and increased shipment turnover.

Despite major infrastructure shortcomings, especially on the Romanian railway network, many projects for new intermodal terminals are developed in regions where there is a competitive advantage (location, access to highway network and/or local economy factors favoring investment). Such investments are Bucharest Intermodal Terminal, Bucharest-Ilfov Multimodal

Hub or Aiud Intermodal Park in the central part and Episcopia Bihor Intermodal Terminal and Intermodal Vest Terminal in Oradea.

Table 8. Freight volumes by rail at Railport Arad

year/cargo handled [TEU]	**2013**	**2014**	**2015**	**2016**	**2017**
Railport Arad – Curtici (corridor VII)	32,000	54,000	82,000	81,000	83,000
dynamic [%]		*68.75*	*51.85*	*-1.22*	*2.47*
	2018	**2019**	**2020**	**2021**	**2022**
Railport Arad – Curtici (corridor VII)	85,000	86,000	87,357	96,052	79,937
dynamic [%]	*2.41*	*1.18*	*1.58*	*9.95*	*-16.78*

Source: Railport Arad – Annual reports.

Railport Arad (part of Curtici Cargo Center) is an intermodal terminal in Western Romania at the border crossing with Hungary and has a 25-30% share of all TEU hauled by rail due to its location and nearby road infrastructure connection (Arad by-pass and A1 highway). The intermodal terminal (handling both ISO containers and other ITU) connects freight from Western Europe to Eastern Europe (Bulgaria, Turkey) as well as local deliveries to customers throughout Romania. Railport Arad is on the Pan-European railway corridor Orient/East-Med (Rail Freight Corridor VII) with recent investments in the railway section leading to the intermodal being made and improving safety and speed of transit (up to 140 km/h). The only other modernized railway section in Romania is between Bucharest and Constanta (CFR 800), where the train can speed up to 160 km/h within safety conditions (255 km in 2 hours for passenger trains). Railport Arad is the biggest and most modern inland terminal in Romania and also one of the largest in Central and Eastern Europe (CEE) with a handling capacity of 200,000 TEU/year and a storage capacity of 3,000 TEU (full or empty). Multiple regular trains are scheduled every week for destinations in the CEE region, such as Budapest (Hungary), Lambach (Austria), Hamburg (Germany), the Czech Republic and Belgium. Increasing the terminal's capacity also saw volumes rise by more than 50% in consecutive years (2013-2015), after which growth was more marginal in the next years (6.53% between 2015-2020), before peaking in 2021 at almost 100,000 TEU after a 10% year-on-year growth (see Table 8). In 2022 Railport Arad handled 1.88 million tons of cargo, double the amount of 2016 and 66% more TEU than the national freight railway company CFR Marfa (48,217 units). Curtici Cargo Center has attracted other intermodal investments nearby, such as Rail Hub Transylvania (storage capacity: 1,300 TEU and over 100, 000 tons of cereal handled, 2020) in Vladimirescu with connections to Slovenia (port of Koper), Germany (port of Duisburg and Hamburg), Belgium (port of Antwerp) or Turkey (transit through the port of Constanta) and Arad South Terminal (storage capacity: 500 TEU) in Sagu. The terminals' main issue is the low average freight train speed across Romania's railway network (14 km/h in 2023) which is continuously declining (the average speed in 2010 was 26.6 km/h). LSPs operating in Romania see transit times for cargo flows from Northern Europe (e.g. Belgium) to Romania match those from East to West (Constanta-Curtici) within Romania, despite double the distance traveled.

Main results thus show an important activity increase in the port of Constanta in the last 5 years (16% in TEU and 38% in tons) driven by cereals (33% increase), oil products (25% increase) and iron ores (50% increase) between 2019-2023. Dacia and Ford's production output has neared and recently even exceeded 500,000 units (2022 and 2023), but with more than 90% vehicles being exported there are also intermodal solutions supporting shipments. Dacia delivers 45% of its vehicles from Mioveni via rail (two thirds towards a DC in France and a third towards

Constanta port) with Ford's proportion reaching 75%. From Craiova only 5% of production is shipped towards the port of Constanta, the rest reaches a DC in Germany (as it mainly targets European customers). The A1 highway is incomplete (missing the Pitesti-Sibiu section), causing slower truck haulage, but the road rates are still very competitive in Romania compared to the EU setting. Average freight train speeds are around 15 km/h (2023), making intermodal rail solutions for distances shorter than 300-450 km and longer term contracts (based on volumes) comparable to conventional truck haulage. The declining average speeds have also affected intermodal traffic volumes (46% decline in TEU and 18% in tons) between 2018-2022, this decrease being seen at Railport Arad as well (17% TEU contraction in 2023). Other studies cited in this paper either focus on partial intermodal topics (sea, rail or road) and their specifics either broaden the issues into more general (theoretical or mathematical models) or aggregated results (macroeconomic or regional conclusions). The current paper's attribute is that it uses quantitative and qualitative data to improve understanding of the intermodal transportation sector in Romania (case study) and how deeply it is interconnected with the country's main industries (oil companies, automotive industry, port and rail terminal activity) by analyzing actual figures gathered from the private sector. The comprehensive analysis gives more insight into why certain intermodal hubs (Constanta Port, Railport Arad) are performing better than others (Danube inland ports) despite similar road-rail connectivity competitiveness issues. The performed case study thus adds value through its figure-driven approach and limits knowledge, data and practical gaps to a higher extent (subject only to non-disclosure agreements), enabling it to be fairly conclusive within its consented framework.

Conclusion

Overall data confirms an increase in cargo traffic, but network shortcomings cause congestions on all types of infrastructure (sea, road, railway) used for intermodal transportation in Romania. 92.5 million tons (22% year-on-year and 53.21% increase since 2020) and a record 776,590 TEU units (22.89% year-on-year, first increase since 2016) of cargo were handled by Constanta port in 2023. Bulk cargo (liquid and dry) represents more than two thirds of cargo traffic at the Romanian Black Sea terminal: cereals (31.79%), oil (22.13%) and metal products (13.54%). Road (A4), river (Danube) and railway (M800) connections for intermodal transport management (both inbound and outbound) exist but are poorly developed thus leading to high congestion and smaller throughput of port operations. Investments in Constanta's features are needed to process incoming traffic faster, improve handling, management and efficiency of the port's operations.

Road connections are incomplete (A1 highway) and create congestion around the capital city (no by-pass) or at the highway terminus points (Olt valley on A1, Bucharest-Pitesti and Prahova valley on A3, Bucharest-Ploiesti), generating longer transit times for carmakers Dacia and Ford (and their suppliers) and the distribution of oil products (refined locally or imported) by local petrol or intermediary companies across the country. Nevertheless local cargo hauling by road with trucks in Romania still remains very competitive compared to EU average.

Intermodal transportation is challenged by the state of the Romanian railway infrastructure, affecting speed and reliability. Lack of investment in strategic hubs and railway connections has reduced average freight train speed by 47% in the last 15 years (to 14 km/h, 2023), as well as TEU traffic (by 45%) and cargo volumes (by 33%) in the last 5 years. Slower transit times, weary completion of modernization projects and increasing number of railway incidents have reduced cargo traffic by more than 35% in the last 20 years according to OPSFPR.

The EU's strategy to reduce carbon emissions seeks the transition of long-distance transport (greater than 350 km) from road to rail encouraging investment projects targeting intermodal solutions, a more balanced share between the different transportation options and sustainability. Some regions have better set-ups, attract more investments (Bucharest and Ilfov, Transylvania, Western Romania) further sourcing economic development (warehousing, LSPs, intermodal terminals) and enabling a more dynamic, competitive and attractive local business environment. This does however lead to a more unbalanced socio-economic setting (very well developed vs. isolated regions) and an increased role of local authorities to work together with the private sector and design sustainable infrastructure development projects in line with both regional and European priorities.

This paper bridges the gap between Romania's intermodal transportation sector and its interconnected industries using actual figures, in-depth public and private data (gained through consultancy and research contracts) and explains performance disparities among intermodal hubs (sea, road and rail), offering valuable insights and challenges faced within Eastern Europe.

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