Volume XXIII 2020
ISSUE no.2
MBNA Publishing House Constanta 2020

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

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To cite this article: Filip Nistor and Catalin Popa, Scientific Bulletin of Naval Academy, Vol. XXIII 2020, pg.102-107.

Available online at www.anmb.ro

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-20-I2-014

Modal Split of Inland Freight Transport. Study Case: Romania

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Abstract. Starting from the fact that over 80% of the global freight transport is using seas and oceans, it's interesting to know how is splitting the inland freight transport on rail, road and inland waterways. Inland freight transport is dominated by road transport but attempts are being made, by various means, to increase the share of rail and inland waterway transport. The objectives proposed by EU for limiting greenhouse gas emissions require using of less polluting means of transport. The transformations in logistics chains cause by Industry 4.0 impose permanent adaptations of the transport modalities to the market requirements. The present paper proposes an analysis of the share of inland transport modes in the case of Romania and the influence of different factors for each mode of transport.

Keywords: freight, transport, rail, road, inland waterways

1. Introduction

Statistics shows that more than 80% of world freight transport takes place on the seas and oceans. Anyway, maritime transport is one of the five existing modes of transport. Maritime transport, compared to other modes of transport, has gained so much due to the main advantage it offers: large quantity of goods per transport unit resulting lower price per ton transported.

Also, the unequal distribution of raw material resources worldwide as well as the relocation of production for certain goods in areas where labor costs are low, have led to need of transport significant quantities of goods between continents and maritime transport was first choice.

Each mode of transport has its importance depending on the position occupied in the supply chain of goods. For example, petroleum products are transported by sea from export areas to importing countries. For inland transport, oil companies can choose pipelines for faster and in larger quantities transportation. But at the same time, significant quantities of petroleum products are transported by rail and then distributed by road to customers.

In the supply chain, there are very few cases of goods that are using for transport a singular mode. We often talk about intermodal transport, ie using at least two modes of transport to send goods from the place of production to the customer's place of unloading.

Intermodalism was implemented helped by the introduction of freight unitization in maritime transport. Freight unitization helps for a better freight flowing in port operations and in the transfer of goods from one transportation unit to another.
Over the last decade, has increased the importance of reducing the carbon footprint, globally and in the EU. Thus, certain targets have been set for the level of greenhouse gas emissions to be achieved in 2030 and 2050, applicable in the EU to all modes of inland freight transport. In the North Sea and the Baltic Sea there are emission control areas since 2015, where sulfur oxide emissions must be at 0.10% for ships that are passing through these zone.
EU has sought to impose measures to reduce emissions from maritime transport since 2012. However, EU and IMO in a joint effort, were successful in limiting the sulfur in marine fuel to 0.5%, measure that is taking effect since 2020. Need to reduce emissions of air pollutants was confirmed by shipowners since 2016 and represents a commitment of the maritime industry. Let's not forget that, reduction of sulfur content leads to increased fuel costs or need for ship retrofitting, both solutions meaning costs for shipowners.

2. Literature review

An important aspect regarding the evolution of transport modes is that any transformation in the transport system is closely related to the changes of transport demand. This can be used to identify the further evolution of multimodal transport. [1]
De Jong (2014) underlines that selection of transport mode must take into account other variables such as service availability, transport time reliability in addition to time, cost and service level. [2]
An analysis made by Wiegmans (2015) highlights that it's a higher efficiency using road and inland waterway transport for transporting 20' containers. In the case of transport of 40' containers, the exclusive use of road transport is recommended. [3]
There may be factors that influence the modal split of inland freight transport, like climate change. Thus, a dry year will lead to problems for inland waterways transport. Low water levels cause transport of goods by rail or road instead of inland waterways transport. This can determine a loss of about 5% of the annual quantity of goods transported by water. [4]
Each mode of transport has its own carbon footprint depending on different factors. For a sustainable transport, can be identified a market share model that determines the optimum mix of transport modes that leads to the smallest impact on air quality. [5]
Estimating externalities for each mode of transport is important because it can conduct to the use of one mode of transport instead another based on the analysis of noise, emissions, accidents or congestion. [6] All these analyzes can help autorities to establish an appropriate framework for carrying out the freight transport activity in accordance with the factors that influence each mode of transport.

3. Romania: modal split of inland freight transport

The inland transport modes are rail, road, inland waterway and pipeline. As pipeline transport does not cover the full range of goods, this mode of inland transport will not be considered in the following analysis.

Table 1. Split of goods transport performance by transport mode [%], selected years [7,8]

Mode of transport		2005	2008	2010	2015	2016	2017	2018
Railway	RO	21.66	18.97	23.54	20.76	18.08	17.02	15.55
	EU	17.9	18.1	17.4	18.2	18.2	17.7	18.0
Road	RO	67.32	70.21	49.23	59.25	64.35	67.53	69.87
	EU	75.6	75.4	75.7	75.3	75.6	76.3	76.5
Inland waterways	RO	11.02	10.82	27.23	19.99	17.57	15.45	14.58
	EU	6.5	6.5	6.9	6.5	6.2	6.0	5.5

The split of the inland transport modes according tonne-kilometre variable for Romania and European Union (28 countries) is presented in table 1. The year 2008 was included in the analyzed period because the highest rate of GDP growth was registered in this year. Further, each mode of transport will be analyzed in detail.
In Romania, rail freight transport accounted 15-23% of the total inland freight transport in the analyzed period, lowest value being in year 2018 and the highest in year 2010. If we compare the values registered in Romania with those in EU, approximately same percentages are calculated in 2008, 2016 and 2017, largest difference, over 6%, was recorded in year 2010.
In EU zone, countries such as Latvia, Lithuania, Austria, Slovenia, Slovakia and Switzerland recorded values between 30-75% for rail freight transport in 2018. The lowest percentages was recorded in Ireland and Greece.
Imports and exports of goods transported by rail can be an important indicator for national economy because it's shows importance of transport mode for carriers, Romania's values be seen in table 2.

Table 2. Imports and exports by railway in mil euro, selected years [7]

Romania	2005	2008	2010	2015	2016	2017	2018
Imports	2273	3297	1426	1512	1437	1952	2083
Exports	1033	1787	1775	1983	1888	2059	3060
Total	3306	5084	3201	3495	3325	4011	5143

As can be seen, the highest value of imports plus exports was recorded in 2018, when rail freight transport accounted 15.55% of the total inland freight transport, the lowest value of analyzed period. Dividing total value of imports and exports to quantity of goods transported by rail in a year, obtain the value of 0.0108 euros per ton on year 2018.
Coal, lignite, crude petroleum and natural gas represented goods category transported in the largest quantity by railway (27.71%) in year 2018. On second place was coke and refined petroleum products with a percentage of 24.32%. Some of this goods could have been transported through pipelines. The reasons that some goods are transported by railway and not pipelines are related to costs and the supply chain positioning to the customer.
Average commercial speed of freight trains registered a decrease of approximately 25% in the period 2011-2018. In Romania, the average commercial speed for freight transport was 18 km / h in year 2018. The continuous degradation of the railway infrastructure was effect of constant decrease of the allocated amounts for railway maintenance and repair.
But, the average speed of freight trains is not very high even in EU. Thus, the average commercial speed of freight trains in the EU was about 18 km / h in 2016, which means higher with 1 km / h than average speed in Romania. [9]
If we take a look at the railway transport infrastructure in Romania, we notice that railways network length under operation decreased by about 2% in year 2018 compared to year 2005. Electrified railways represent 37.4 % from total railways length in 2018, being an increase of 1% compared to year 2005. [7]
Taking in consideration desire of an environmentally friendly transport, a required lower energy by 50% is one of the reasons that freight railway transport is preferred to road transport. [10]
Road transport holds supremacy in inland freight transport. Road transport is present in all countries and is mainly used for short-haul routes.
In EU, road freight transport accounted 75.3-76.5% of the total inland freight transport in the analyzed period, the highest value being recorded in 2018 and the lowest in 2015 (see table 1). Due to lack of precipitation in 2018, road transport take some percentages from market share of inland waterways transport being known carriers problems with low water levels.
In Romania, road freight transport varied between 49.23% of the total inland freight transport in 2010 and 70.21% in 2008, respectively. There is an increasing trend starting with year 2010, being recorded

in 2018 a value close to the maximum of the analyzed period. One cause may be the increase of number of goods road motor vehicles with over 200% in 2018 compared to 2005.
As can be seen from Table 3, the length of public roads had an increasing trend by 7.9% in 2018 compared to 2005.

Table 3. Length of public roads by type of road, development regions in kilometers, selected years, [7]

Development region (Romania)	2005	2008	2010	2015	2016	2017	2018
NORTH - WEST	11855	12084	12322	12679	12678	12713	12738
CENTER	10182	10714	10801	11356	11458	11352	11459
NORTH - EAST	13387	13502	13672	14840	14830	14890	14892
SOUTH - EAST	10856	10966	10763	10973	10972	10971	10982
SOUTH - MUNTENIA	11982	12574	12672	12939	12940	12931	12933
BUCHAREST - ILFOV	890	890	890	878	874	889	898
SOUTH - WEST OLTENIA	10460	10675	10838	11254	11287	11293	11299
TOTAL	79904	81693	82386	85920	86080	86099	86234

In the North-East region can count 17.27% of the total length of public roads and in the South-East Region about 13%, these regions being boundaries, which conduct us to say that in Romania is a fair distribution of public roads between the regions. Dividing the total value of imports and exports to total quantity of goods transported by road in a year obtain the value of 0.0021 euro per ton on year 2018.
But, for an efficient transport, it's needed highways. In Romania, the length of highways had an increasing trend but under-expectations during the analyzed period. Thus, the increase of highways length was 360% in 2018 compared to 2005, but highways represent just 2% of the length of modernized road infrastructure in year 2018.
In EU, Spain has the most kilometers of highway, followed by Germany and France in 2018. Highways have become important once reconfigurations taking place at the level of the TEN-T network due to changes in the freight supply chains.
Inland waterway transport (IWT) is the least used mode of transport for freight inland transport. In the case of Romania, IWT registered variations between 10.82% -27.23% of the total inland freight transport, the highest value being registered in year 2010.
Freight transport by inland waterways has a decreasing trend since 2015. Thus, IWT does not register increases even if it has the lowest price per ton transported of all three transport modes and the external costs are the lowest.
The percentage of goods transported on inland waterways is maintained by the number of ships registered in Romania being a support to the development of the transport activity (see table 4).

Table 4. Inland waterways vessels, number of ships registered at the end of the year in Romania, selected years [7]

Types of ships	2005	2008	2010	2015	2016	2017	2018
Goods carrying vessels not self-propelled	1184	1221	1208	1134	1145	1139	1123
Tugs and pusher craft	241	256	239	286	294	295	296
Total	1425	1477	1447	1420	1439	1434	1419

As can be seen in table 4, the number of inland waterways vessels is relatively steady in the analyzed period, Romania having approximately 20% of the total goods carrying vessels not self-propelled registered in EU, being on second place after Netherlands. Traffic of goods transported by inland waterways represents 37.7% of total traffic in Romanian ports, in 2018, which can be a effect of high number of ships. Dividing the total value of imports and exports to the total quantity of goods transported on inland waterways in a year obtain the value of 0.0331 euro per ton on year 2018.

In EU, IWT recorded values between 5.5% -6.9%, reinforcing the fact that inland waterway transport cannot be done in all european countries and there are factors that leads to a decrease in freight transport by inland waterways. The most important disadvantage of IWT is the speed, being the lowest of all three inland transport modes. If we add the climatic factors that can occur in a year, there are periods of total stop of IWT, which is not satisfactory for customers.
EU Strategy for the Danube Region was creating a framework for an environmentally friendly transport on inland waters, one of the solution being implementation of LNG as fuel for inland waterways vessels.
The aspect of climatic factors that influence the freight transport does not only apply to IWT. Any change in climate may influences any mode of transport. Thus, rain can lead to a decrease of road freight traffic from 1.35% to 2.11%, and if the amount of precipitation is higher, the decrease can reach 3%. [11]
The most important inland waterways transport corridor is the Rhine-Main-Danube connecting the east to west of European continent. The existence of this corridor should contribute to the development of multimodal transport, by combining more efficiently the three modes of inland freight transport.
For better planning of logistics modules for each transport segment of multimodal transport, national authorities have tried to implement freight transport models. Thus, France has introduced the MODEV model since 2006, applied to at least 10 commodities, for all three inland transport modes. Netherlands has developed a model (SMILE +) valid for inland transport but also for air, pipeline or sea transport. At the same time, EU tried to implement models (Worldnet, Transtools, LOGIS) for logistics solutions suited to inland freight modes. [12]

4. Conclusions

Industry 4.0 produces changes in the inland freight transport. Digital transformation that will occur in every transport mode represents a key to a more efficient logistic chain.
Road transport is the most flexible of all inland transport modes. Over short distances, road transport is convenient by cost and because it can distribute goods directly and quickly between two points. Cost aspect is valid if external costs are not taken into account. So, from point of view of national economy, road transport becomes expensive if you take into account cost with maintenance of infrastructure, air pollution, congestion, etc. IWT is at the opposite pole in terms of these costs.
In Romania, IWT could gain ground over road transport because it benefits from its location on pan-European Corridor VII and the large number of registered inland waterway vessels. The important obstacle in the development of IWT is the inland ports infrastructure.
Among the factors that can change the option of the carrier for a transport mode it can be mention: service availability, reliability of service, cost and security of the goods.
EU aims to transfer on railway or IWT some of the goods transported by road, having targets set for 2030 and 2050. These targets cannot be achieved without carrier support. It will be very difficult to achieve these targets. For rail transport, one of the reason is low commercial speed of rail freight transport. Also, because of interruptions of IWT due to ice or low water levels lead carriers to stay away of this mode of transport.
The implementation of electrical solutions for freight transport can lead to reduction of road transport emissions. Thus, carriers can applied last-mile solutions to be electric eco-friendly, key to a sustainable and green transport.

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