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Redirection of the World Traffic Flow Far East – Europe via the Adriatic Sea

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Abstract

Natural geographic directions – cargo flows represent the shortest natural traffic route connecting origins and destinations. When redirecting the world's traffic flow, these directions become the most important advantage only when preconditions of provision of competitive technical, technological, organizational and economical services on the specific traffic route are satisfied. The basic aim of the paper is the analytical elaboration and scientifically founded necessity for the redirection of the geo traffic flow from the Far East to Europe. Instead of having its destination in northern European ports (such as Antwerp, Rotterdam, Amsterdam and Hamburg) – the northern traffic flow, the flow should have to be redirected through the Adriatic sea to the ports of NAPA (North Adriatic Ports Association), that are Ravenna, Venice, Trieste, Koper and Rijeka. This route represents the southern traffic flow. During the research, reference destination in the center of Europe was chosen (Munich, Germany). The conducted analyses and calculation results showed that by the proposed redirection, significant shortening both in sea and land transportation can be achieved. Apart from distance and time thus fuel consumption savings, emissions can be significantly reduced in all related transport branches, especially in maritime transportation. The proposed redirection of the elaborated route represents reasonable contribution to sustainable transportation improvements.

Keywords: Far East – Europe Line, Maritime transportation, Multimodal transport, Ports of NAPA, Sustainability, World traffic routes.

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Introduction

In maritime transportation, world traffic flows or directions are global changeable trajectories of goods and passengers movement between continents, connected with sea routes. They act as dynamical elements which represent the world trade jugular veins. In liquid cargo transportation their driving force are VLCC and ULCC vessels, while containerization stands for solid cargo transportation.

During the last 30 years, global directions are constantly changing, passing through new geographic areas. It can be expected that even greater changes in their structure and dynamics will occur. Variety of internal and external factors govern mentioned changes: creation of new world economic areas, infrastructure and superstructure investments focused on new continental and intercontinental railroads construction including waterway (river-lake-channel) systems, new sea routes, construction and expansion of a number of international, national and regional ports, inland terminals, seaport systems, etc.

Out of numerous factors directly and indirectly affecting redirections of the world transportation flows in international goods exchange, several exceptionally important factors can be pointed out:

- economic potential and development of particular regions of the world,
- development of science, technique and technology and associated transportation technologies,
- extension, reconstruction and building of capital transportation infrastructure and superstructure objects,
- specificities of competitive technological, organisational and economic services provision,
- natural geographical traffic directions or cargo transportation (geotraffic) flows.

Regarding economic potential, it is necessary to underline the pronounced expansion of Chinese economy with a high rate of annual growth (9%) and therefore its involvement in the world economic and trading scene. Mentioned occurrences caused redirection of global traffic flows. Furthermore, the emergence of the oil crisis, Suez channel issues and other recent events in the Middle East are directly affecting the redirection process.

In the field of science and technologic development, regularities in the transportation engineering are observed, together with the expansion of new transportation technologies application in the maritime transport, which are becoming the backbone of the world's major ports for cargo attraction. Important factors herein are block-train dynamics between inland and port terminals, as well as road and inland-waterways connectivity.

As for capital infrastructure and superstructure, major changes are occurring in the European region, but also in the area of the Far, Middle and Near East. In the emerging field of competing technological and organisational-economic services provision, enormous force is hiding, evident in many practical examples.

Geotraffic directions of cargo transport are representing the shortest natural traffic pathway which connects origin and destination. They are becoming the most important advantage in the redirection of the world traffic flows, however only when a prerequisite of competitive services provision on a specific direction is satisfied. Exactly these elements are discussed in the paper. The aim of the proposed research is the confirmation of justification of one of the most influential European traffic routes redirection. Conducted analysis and research results are discussing the redirection in terms of shortening of cargo transportation time and distance, as well as the reduction of environmental impacts, found for all engaged transportation branches.

North Adriatic Transport Route

North-Adriatic transport route, or *the southern traffic flow*, is the shortest natural thus the most economical way Europe is connected with the Mediterranean and, by sailing through the Suez Canal, with most of the countries in Asia, Africa and Australia. This route connects two economically complementary worlds: the industrially developed countries of Western Europe and the Asian and African developing countries. In the period of 1996/2011, container import to Europe and Mediterranean Basin rose for 130% from countries east of the Suez Channel. For the same period, the import from the United States rose for 10% (MDS 2011). As for Central-European destinations, land transport distances are measurably shorter than from Northern-European ports, as presented in Table 1.

Table 1. *Railway Distance (in km) of the North Adriatic and North European Ports to Specific Central European Economic Centers*

Railway	Rijeka	Koper	Trieste	Hamburg	Rostock
Budapest	592	634	626	1406	1166
Bratislava	602	650	639	1022	980
Prague	806	854	810	686	644
Vienna	580	599	584	990	984
Linz	557	549	517	911	923
Munich	563	579	527	777	876

Important transportation links from landlocked Central European countries to seaports on the Adriatic coast intersect on the territory of Croatia, Slovenia and Italy with other important traffic flows which move from Western and Central Europe to South-eastern Europe and the Middle East. Therefore, countries in the Northern Adriatic region act primarily as transit ones. Transport connection of the Danube and the Adriatic geographical area represents the connection of national areas with the Mediterranean area and its hinterland, which connects the continental countries of Central Europe with Mediterranean.

Integration of the North Adriatic Ports

Within the narrow catchment area the ports of Venice, Trieste, Koper and Rijeka act as competitors. All ports have the same natural gravitational fields, but there are certain differences in operating on the market.

In order to improve their position on the global trade, the Northern Adriatic Ports Association (NAPA) was established, including ports of Ravenna, Venice, Trieste, Koper, Rijeka, Monfalcone and Chioggia (NAPA, 2016).

The main task of the Association is to direct the ports to operate in the international market as a single multi-port system. Among other, the harbour members agreed upon strengthening the links between transport infrastructure of the North Adriatic transport route and the Pan-European transport corridors, supporting inclusion of the Central European Transport Corridor in the TEN - T network (NAPA, 2016).

In order to achieve complete connection between ports of Rijeka and Trieste highway section through the Republic of Slovenia (section Jelšane – Postojna) needs to be constructed. Interest in the completion of this road corridor, in addition to strengthening the position of the port of Rijeka but also the entire system of the North Adriatic ports, lies certainly in the ability of routing freight traffic to Croatia or increasing it (LUZ, 2011).

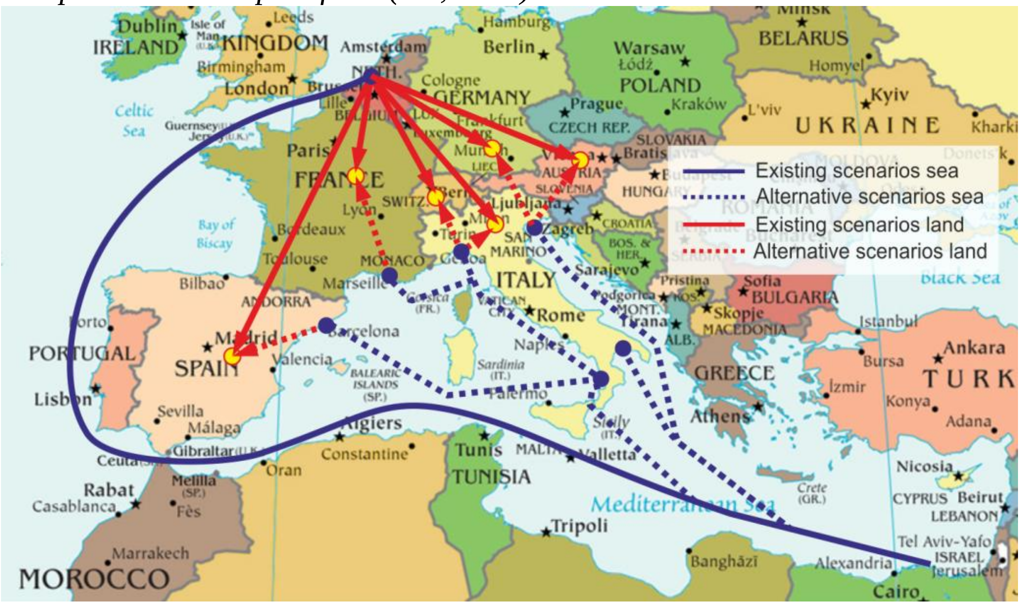
The new railway line that will link the ports of Rijeka, Koper and Trieste, with respect to comparable technical specifications, conjugates on a new high-efficiency lowland railway Rijeka – Zagreb (Dundović *et al.* 2010).

The North Adriatic transport route and the corresponding ports connected by a highway and by high speed and lower elevation railway become an integral part of the transport network of the Pan-European Corridor V. Construction of new high efficiency railway line Rijeka - Zagreb tracing the Corridor V_B and the Danube - Sava Canal reinforces the importance of the Danube Corridor VII and the Pan-European Corridor X (Vilke *et al.* 2011).

Distribution of Traffic Flows Europe - Far East

According to (EC 2007), container traffic achieved the highest growth in the maritime industry through the past two decades, with an annually average growth of 11.5%. The major proportion of the container traffic is concentrated in the ports of North West Europe, or *the northern traffic flow*, which has a share in turnover of nearly 60% of the total European container traffic.

Figure 1. *Existing and Alternative Scenarios of Traffic Flows Distribution, as Interpreted and Adapted from (EC, 2007)*



In Figure 1, the unfavorable situation of the North Adriatic ports and associated transport route is noted. North European ports are serving areas such as Austria and Northern Italy and even Hungary, despite their natural geographical location which gravitates towards the Northern Adriatic region. Proposed alternative scenarios are shown as dotted lines. The implementation of an alternative scenario depends on investments in port and transport infrastructure. Table 2 shows existing and alternative distances between the ports of the Far East and EU destinations.

Table 2. *Maritime, Road and Railway Distance between the Ports of the Far East and Destinations in the EU for Existing and Alternative Scenario, according to (EC 2007)*

Transport	Scenario	Switzerland	Italy	Austria	Spain	France
Maritime (M)	Existing	10,234	10,234	10,234	10,234	10,234
	Alternative	8,645	8,645	8,459	8,940	8,739
	Difference	- 18%	- 18%	- 17%	- 16%	- 16%
Road (km)	Existing	614	950	975	1,650	579
	Alternative	239	142	354	618	505
	Difference	- 61%	- 85%	- 64%	- 63%	- 13%
Railway (km)	Existing	594	925	990	1,545	560
	Alternative	239	140	350	600	500
	Difference	- 60%	- 84%	- 65%	- 61%	- 11%

Calculating the costs of container transport by different modes of transport between the Far East and various destinations in EU countries, comparative analysis of two scenarios are presented, as shown in Table 3.

Table 3. *Savings according to Alternative Scenarios in relation to the Existing, according to (EC 2007)*

	External costs (€)	Transport costs (€)
Maritime transport	- 313,458.783	49,353.774
Road transport	- 260,133.009	- 170,315.229
Railway transport	- 47,099.862	- 106,983.638
Total	- 620,691.654	- 227,945.093
Tons	18,682.864	18,682.864
TEU-s	1,868.286	1,868.286
Average savings per TEU	332	122

The average saving in containers transport is € 122/TEU and taking into account the external costs, it amounts to € 332/TEU. The total savings in the external costs amount to more than € 600 million and observing their structure by traffic branches it reveals that they are the largest in maritime traffic, followed by savings in road traffic as a result of shorter itineraries (EC, 2007).

Economic Environment and Potential Market of the North Adriatic Ports

For Central-European countries, Northern Adriatic region provides shortest access to the sea through the Gulfs of Trieste and Rijeka. At the narrower Central European area there is significant existing and possible potential economic and demographic market that could use the North Adriatic transport route as the optimal route for the flow of goods from the Mediterranean and the rest of the world.

The economic impact of closer European environments on the North Adriatic transport route is as follows:[1]

- the territory of the Republic of Hungary, which covers nearly 10 million people who earn over 196.6 billion US$ gross domestic products (purchasing power parity) and whose total foreign trade amounts to 182.5 billion US$;
- the territory of the Czech Republic, with a population of approximately 10.6 million residents, the gross domestic product of more than 286.5 billion US$, and foreign trade of 264.9 billion US$;
- the territory of the Republic of Slovakia that covers 5.48 million residents who earn 133.4 billion US$ of gross domestic product and which the total amount of imports and exports is at a level of 160.6 billion US$;
- The territory of the Republic of Austria, which covers about 8.2 million people with 361 billion US$ gross domestic product and whose total foreign trade amounts to 333.5 billion US$.

[1] Population, gross domestic product and foreign trade of all the above states are estimated data for the year 2015 according to (CIA 2016)

Competitiveness of North Adriatic Traffic Direction Compared to North European Ports

Central European countries that do not have direct contact with the sea but are distinctly maritime trade oriented have an independent opportunity choice between individual ports taking into account the efficiency of their operations, price and speed of transportation through the entire transport route with the aim of seeking the most favorable routes for the transport of certain goods.

Central-European countries can choose from a number of maritime transport routes to the Mediterranean, and to the countries of the Near, Middle and Far East, and on to Australia, as follows:

- The Atlantic sea route from northern ports: Hamburg, Rotterdam, Antwerp, Amsterdam, Bremen,
- The route from Black Sea ports: Braila, Ismail, Constanta,
- The route from Baltic ports: Gdynia, Gdansk, Szczecin, Rostock.
- The route from Mediterranean ports: Marseille, Genoa.
- The North Adriatic route, comprising ports of Ravenna, Venice, Trieste, Koper and Rijeka.
- The inland waterway system Rhine - Main - Danube.

Table 4. *Total Turnover Movement (in 000 Tonnes) through North European Transport Route Ports and through the Ports of Rijeka, Trieste, Koper and Venezia (2011th-2015th Years) (PA, 2016; PANW, 2016; PH, 2016; PK, 2016; PR, 2016; PROT, 2016; PTS, 2016; PBB, 2016)*

Ports	**2011**	**2012**	**2013**	**2014**	**2015**	**diff**(%)
Hamburg	132,22	130,94	138,12	145,14	137,81	4.2
Bremen	80,59	83,98	78,73	78,26	73,45	- 8.8
Amsterdam	93,01	94,261	95,75	97,79	98,83	6.2
Rotterdam	434,5	441,53	440,46	444,73	466,36	7.3
Antwerp	187,15	184,136	190,97	199,02	208,42	11.4
Total (North-West)	927,52	934,84	944,04	964,94	984,87	6.2
Rijeka, Trieste, Koper, Venice	101,0	100,9	107,96	107,67	115,33	14.2

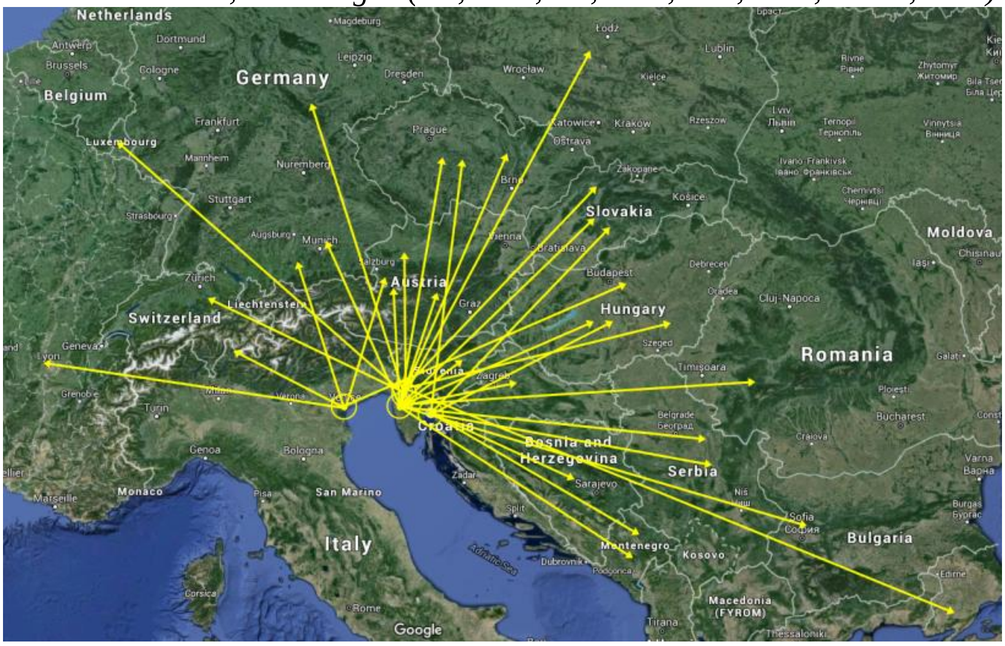
According to European and world relations, the ports of Rijeka, Koper, Venice and Trieste are ranked among small and medium-sized ports. Looking at the total turnover (Table 5) of North-European and North Adriatic ports, an increase of 8.5% in 2015 is evident. The traffic movement analysis shows that the total turnover through the North Adriatic ports grew at higher relative terms than in the North-European ports.

Table 5. *Container Turnover Movement (000 TEU) through North European Transport Route Ports and through the Ports of Rijeka, Trieste, Koper and Venezia (2011th-2015th Years) (PA, 2016; PANW, 2016; PH, 2016; PK, 2016; PR, 2016; PROT, 2016; PTS, 2016; PBB, 2016)*

Ports	**2011**	**2012**	**2013**	**2014**	**2015**	**diff.** (%)
Hamburg	9,01	8,86	9,26	9,73	8,82	- 2.1
Bremen	5,92	6,12	5,84	5,80	5,55	- 6.2
Rotterdam	11,88	11,87	11,62	12,30	12,23	3
Antwerp	8,66	8,64	8,58	8,98	9,65	11.4
Total (North-West)	35,47	35,48	35,29	36,8	36,25	2.2
Rijeka, Trieste, Koper, Venice	1,127	1,522	1,647	1,785	2,012	78.5

During a five-year period the North European ports realized the container turnover growth of 2.2 % while the container traffic of four Adriatic ports grew by 78.5 % (Table 4). It must be emphasized that the container growth was presented at the ports of Koper and Venice while the throughout put at the ports of Rijeka and Trieste didn´t change significantly. On Figure 2, NAPA ports cargo transit directions and final destinations are shown.

Figure 2. *Most Significant Current Transit Cargo Directions and NAPA Ports Final Destinations, according to (PK, 2016; PR, 2016; PTS, 2016; NAPA, 2016)*



Stated facts indicate cargo transportation growth in the Northern Adriatic region. As defined in the Introduction chapter, one of most influential factors which govern traffic flows is natural geographical direction of certain cargo reaching its final destination. In the next chapter, the Northern Adriatic transport route was analysed and compared to the North-Europe transport route, and the analyses results were summarized as follows.

Comparison of Northern and Southern Traffic Flow

This chapter presents the results obtained by elaborating features of the northern and the southern traffic flow. Calculations were made using (EWI, 2014) software, providing environmental impacts calculations in accordance with (BSI, 2012). Environmental impacts were rendered possible to obtain in terms of energy consumption and emissions during each (truck/train/vessel) vehicle operation during the transport (EWI, 2014), comprising both direct and indirect parameters. Considering existing and planned global container line services between the Far East and Europe (CMA CGM, 2016; MAERSK, 2016, COSCON, 2016; UASC, 2016; HANJIN, 2016), the following freight transportation directions were defined as representative, defining two directions.

The port of Busan (KR) was chosen as a reference origin point, with Munich (DE) as a final destination. The port of Hamburg (DE) was chosen as a representative transshipment port for the Northern Europe traffic flow (NE). For the Northern Adriatic direction (NA) – the southern traffic flow, port of Venice (IT) was selected.

The emphasis of the transportation chain was on the sea segment, given that the majority of calculated parameters' amount, as well as geotraffic flow in general, refers to distances and consumptions between ports. However, land transportation parameters were calculated as well for both directions, in a way that from European ports to the final destination road (Transport Service 1 – TS1) and rail transportation service (Transport Service 2 – TS2) were engaged.

Energy consumption and emissions were calculated for the Tank-To-Wheel (TTW) and Well-To-Tank (WTT) fuel cycle processes, enabling calculation of total energy consumption and total emissions for each transport mode (Well-To-Wheels - WTW) (EWI 2014, TIAX LLC 2007)[2]

Calculation Algorithm/Rules/Steps

Final energy consumption was differentiated for each of the carrier's downstream process:

$$ECF_{tkm,i} = \frac{ECF_{km,i}}{CP \cdot CU} \tag{1}$$

where:
$ECF_{tkm,i}$… final energy consumption (TTW) per net tonne km for each energy carrier i [MJ/tkm], i… index for energy carrier, $ECF_{km,i}$… final energy consumption of vehicle or vessel per km [MJ/km], CP… payload capacity [t], CU… capacity utilization [%]

[2] TTW – Energy consumption and emissions from vehicle operations (downstream processes); WTT – Energy consumption and emissions from upstream processes (primary energy and/or fuel production, transportation, storage and distribution); WTW - Energy consumption and emissions from vehicle operation and upstream processes (EWI 2014, Wang & Huang 1999, TIAX LLC 2007)

Energy related vehicle emissions were calculated as follows:

$$EMV_{tkm,i} = ECF_{tkm,i} \cdot EMV_{EC,i} \tag{2}$$

where:
$EMV_{tkm,i}\ldots$ vehicle emissions (TTW) per net tonne km [g/tkm], $EMV_{EC,i}\ldots$ energy related vehicle emission factor (TTW) [g/MJ]

Calculation of combustion related emissions were calculated an expressed as energy related emission factors:

$$EMV_{tkm,i} = \frac{EMV_{km,i}}{CP \cdot CU} \tag{3}$$

where:
$EMV_{km,i}\ldots$ combustion related vehicle emission factor (TTW) of vehicle or vessel per km [g/km]

Emissions of each vehicle during upstream processes were calculated as follows:

$$EMU_{tkm,i} = ECF_{tkm,i} \cdot EMU_{EC,i} \tag{4}$$

$$ECU_{tkm,i} = ECF_{tkm,i} \cdot ECU_{EC,i} \tag{5}$$

where:
$EMU_{tkm,i}\ldots$ upstream emissions (WTT) [g/tkm], $EMU_{EC,i}\ldots$ energy related upstream energy consumption (WTT) [MJ/MJ], $ECU_{tkm,i}\ldots$ upstream energy consumption (WTT) [MJ/tkm], $ECU_{EC,i}\ldots$ energy related upstream energy consumption (WTT) [MJ/MJ]

The total energy consumption and emissions of each transport mode, comprising both upstream and downstream processes were calculated as follows:

$$EMT_i = D_i \cdot M\left(EMV_{tkm,i} + EMU_{tkm,i}\right) \tag{6}$$

$$ECT_i = D_i \cdot M\left(ECF_{tkm,i} + ECU_{tkm,i}\right) \tag{7}$$

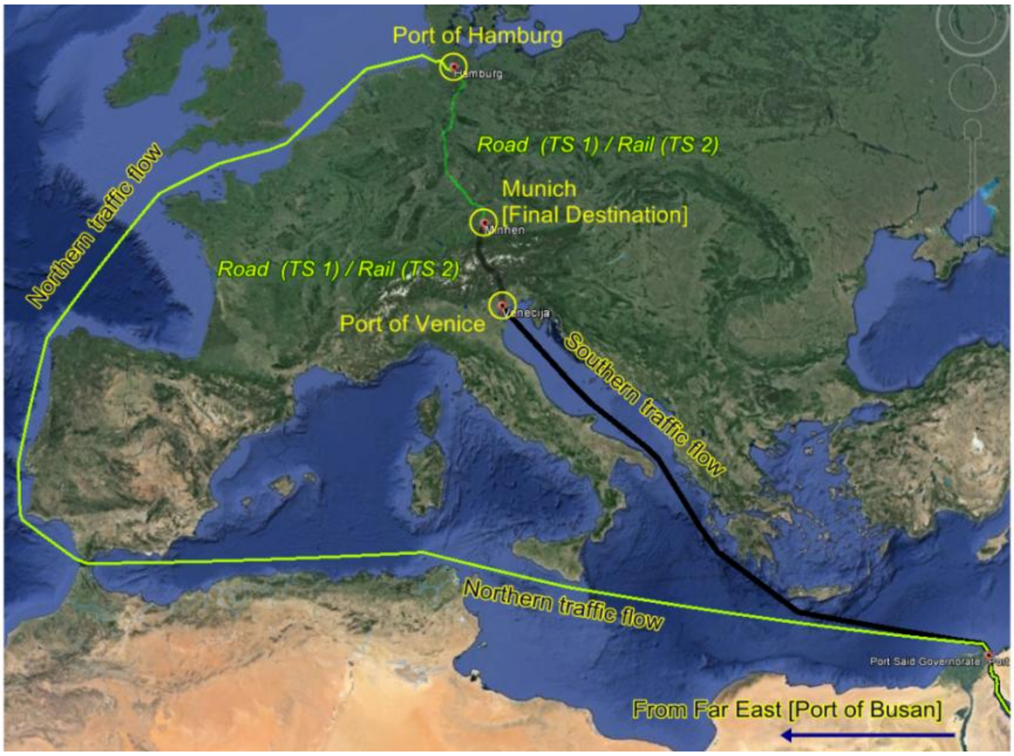
where
$EMT_i\ldots$ WTW emissions of transport [kg], $ECT_i\ldots$WTW energy consumption of transport [MJ], $D_i\ldots$ distance of transport performed for each energy carrier i [km], $M\ldots$ mass of freight transported

Results were obtained for each transportation mode, comprising *internal* transport operations (e.g. transportation from terminal to port and vice versa, port transfers etc.), sea transportation and land transportation to the final destination, with both TS 1 and TS 2 variations.

Structural Analysis of Elaborated Directions and Comparison Results

The main segment of traffic flows (including redirection point) is presented on Figure 3, showing Mediterranean and North European sea route.

Figure 3. *Northern (NE) and Southern (NA) Traffic Flow Segment from the Mediterranean Entrance to the Final Destination*



In Tables 6-8, the total travel length and distance savings are presented for both directions, comprising road and rail variations for the land transportation.

Table 6. *Total Travel Length (km): TS 1 (Land Transport to Munich)*

Route	Busan (Truck)	Sea transport	Hamburg/ Venice (Truck)	Munich (Truck)	Total
NE Route	8.47	20,528.07	5.01	769.08	21,310.63
NA Route	8.47	16,389.12	4.76	450.11	16,852.46

Table 7. *Total Travel Length (km): TS 2 (Land Transport to Munich)*

Route	Busan (Truck)	Sea transport	Hamburg/ Venice (Truck)	Munich (Rail)	Total
NE Route	8.47	20,528.07	5.01	777.01	21,318.56
NA Route	8.47	16,389.12	4.76	549.26	16,951.61

Table 8. *Distance Savings (km): TS 1 (Road) & TS 2 (Rail)*

Route	Sea transport	Hamburg/ Venice (Truck)	Munich	Total
TS 1	4,138.95	0.25	318.97	4,458.17
TS 2	4,138.95	0.25	227.75	4,366.95

Sea segment distance is shorter for 4,138.95 km on the NA route, what makes distance saving of app. 20%. Comprising all transportation segments (including inter-distances and port cargo transfers), total distance saving is 4,458.17 km (20,92%) for TS1, and 4,366.95 km (20,48%) for TS 2, respectively. Considering sea transportation segment and average container vessel speed (21 kts), rough estimation of time saving via the southern traffic flow is 4.5 days.

The following environmental parameters were calculated further for both directions and land transport variations: energy consumption (EC), emissions of carbon dioxide (CO2), greenhouse gases (measured as CO2 equivalents), nitrogen oxides (NOx), sulphur dioxide (SO2), non-methane hydro carbons (NMHC) and particulate matter (PM). All parameters were calculated for both downstream (TTW) and final (WTW) fuel cycle processes.

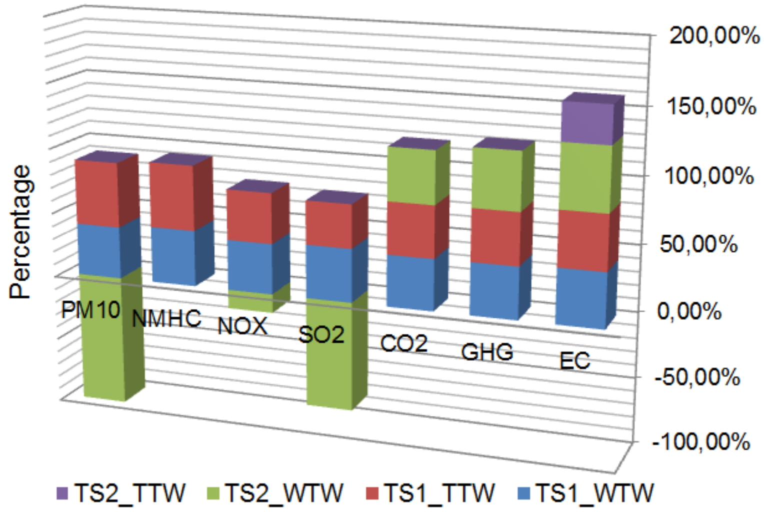
In Table 9, land transportation energy consumption and emissions are presented for both land segments of elaborated traffic flows.

Table 9. *Energy Consumption and Environmental Impact Parameters (Emissions) for Both Land Routes Comprising Road (TS1) and Rail (TS2) Transportation Service, and WTW and TTW Fuel Cycles*

Route	Fuel Cycle	Energy consumption and environmental impact						
		EC (MJ)	**GHG (T)**	**CO2 (T)**	**SO2 (Kg)**	**NOX (Kg)**	**NMHC (Kg)**	**PM10 (Kg)**
Hamburg - Munich	**TS1 WTW**	687.56	48	46	54	127	21	5
	TS1 TTW	556.62	38	38	0.3	101	2	2
	TS2 WTW	308.5	16	15	12	14	2	1
	TS2 TTW	99.86	0	0	0	0	0	0
Venice - Munich	**TS1 WTW**	401.4	29	28	32	78	12	3
	TS1 TTW	324.96	23	23	0.2	62	1	1
	TS2 WTW	161.02	9	9	22	16	2	2
	TS2 TTW	71.51	0	0	0	0	0	0

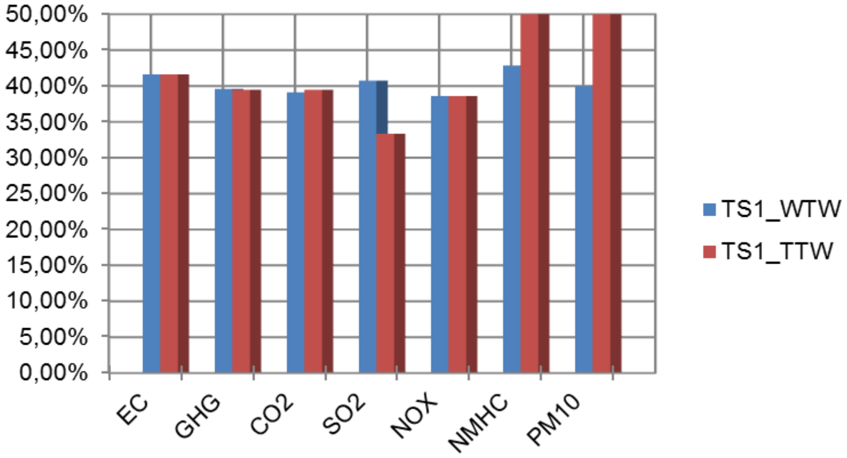
On Figure 4, calculated differences are presented for both transportation services and for both types of fuel cycles. Results are showing savings mostly in favor of Venice – Munich route, except Well-To-Wheel fuel cycle and TS2 Tank-To-Wheel emissions, which are the same for both sections. Savings derived from road transportation on route Venice – Munich as compared to Hamburg – Munich Route are shown on Figure 5.

Figure 4. *Energy Consumption and Emissions' Differences (in %) between TS1 and TS2 (Port – Final Destination)*



As for road transport (TS1), distance from Venice to Munich is shorter for 318.97 km (41%) in comparison with the Hamburg – Munich route, while the rail distance on the same section is shorter for 227.75 km (29%).

Figure 5. *Energy Consumption and Emissions' Differences (in %) for Road Transportation (Port – Final Destination)*



Although significant, described distance and emission savings are negligible when compared with the sea navigation segment. On Table 10 the total absolute results are presented, comprising the total energy consumption and emissions for both fuel cycles and considering both land transportations services.

Table 10. *Environmental Impact as Calculated for the Northern (NE) and Southern (NA) Traffic Flow with Road (TS1) and Rail (TS2) Land Transport Variations*

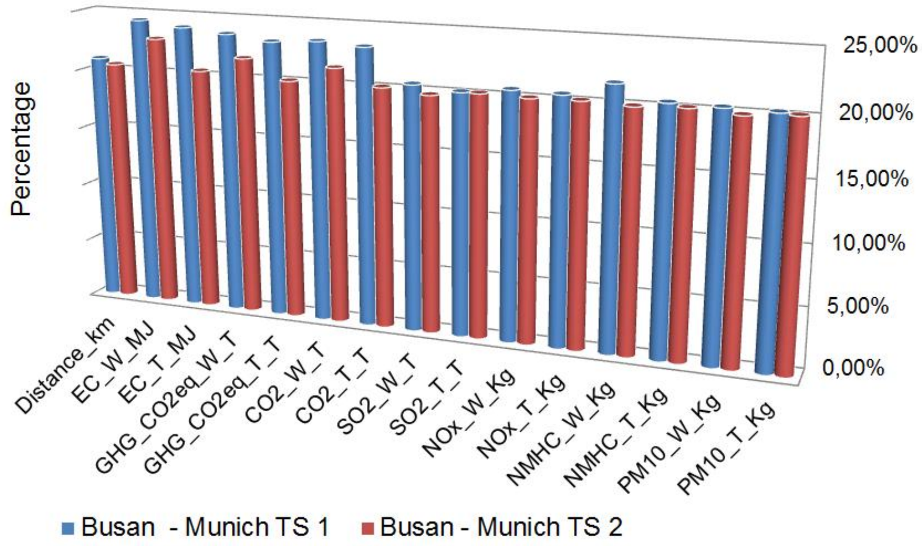
Parameter	Fuel cycle	NE Route		NA Route	
		TS1	TS2	TS1	TS2
Energy consumption (MJ)	WTW	3,451.24	3,072.18	2,610.055	2,369.68
	TTW	3,093.57	2,636.80	2,352.211	2,098.76
GHG emissions (CO2 eq.) (T)	WTW	261.9	229.9	200	180
	TTW	235.1	197.1	180.5	157.5
Carbon dioxide (CO2) (T)	WTW	257.9	226.9	197.3	178.3
	TTW	233	195	178.8	155.8
Sulfur dioxide (SO2) (Kg)	WTW	3,156	3,114	2,508.7	2,498.7
	TTW	2,862.83	2,862.53	2,285.58	2,285.38
Nitrogen oxides (NOx) (Kg)	WTW	5,044	4,931	4,004	3,942
	TTW	4,917	4,816	3,908	3,846
Non-methane hydrocarbons (NMHC) (Kg)	WTW	313.7	294.7	245.8	235.8
	TTW	206.5	204.5	164.27	163.27
Particulate matter (PM10) (Kg)	WTW	469.08	465.08	373.53	372.53
	TTW	453.4	451.4	361.39	360.39

The final comparison results are presented in Table 11 and Figure 6, respectively. Derived savings are presented as percentages, including previously presented distances, showing both land transportation variations.

Table 11. *Savings' Calculations Results Comparing Northern and Southern Traffic Flow for Land Transport Service 1 (Road) and Transport Service 2 (Rail), Respectively, in Percentages*

	Well to Wheel		Tank to Wheel	
Parameter	TS1	TS2	TS1	TS2
Distance (km)	20.92%	20.48%	20.92%	20.48%
Energy Consumption (MJ)	24.37%	22.87%	23.96%	20.41%
GHG/CO2 eq (T)	23.63%	21.71%	23.22%	20.09%
CO2 (T)	23.50%	21.42%	23.26%	20.10%
SO2 (kg)	20.51%	19.76%	20.16%	20.16%
NOx (kg)	20.62%	20.06%	20.52%	20.14%
NMHC (kg)	21.64%	19.99%	20.45%	20.16%
PM10 (kg)	20.37%	19.90%	20.29%	20.16%

Figure 6. *Southern Traffic Flow Total Environmental Impact Reduction and Distance Savings as Compared with the Northern Route*



Presented results are justifying the redirection proposal from the northern to southern traffic flow of container cargo. Differences in almost all elaborated parameters are indicating savings over 20% when looking at a whole transportation pattern. Moreover, land section and corresponding distances connecting Northern Adriatic with Central Europe are not negligible.

Conclusions

In the past 15 years, geographical aspects of container transport between Europe and other continents experienced dramatic changes. The first reason was the increase of the relative importance of the Far East regarding factory products import, accelerated with the entrance of the Republic of China in the World Trade Organization in 2001. Second, with the integration of Central and Eastern-Europe countries, with their dynamical economics, origins and destinations of container freights gravitated from the inland toward the south and the east of the continent.

Two significant routes were elaborated in the proposed research: the northern traffic flow, directed toward Northern European ports and the southern traffic flow, passing through Northern Adriatic region. Both flows are connecting Far East origin with the Central Europe final destination. The possibility and justification of traffic flow redirection in favor of southern traffic flow was discussed in terms of practical and environmental impact features. Results showed significant shortening of distance and therefore travel time and fuel consumption for over 20% when compared to the northern traffic flow. Savings were observed in all related transportation modes constituting the transportation chain. Emission reductions were identified as well, additionally justifying proposed redirection in terms of sustainable transport and development. Considering geo traffic flow as one among most important factors governing global traffic redirection, it can be stated that suggested proposal is qualitatively and scientifically justified.

The need for cooperation between Northern Adriatic ports lies in the fact that their geographical and traffic position is still not sufficiently exploited, and that their role in the transport to the Central European Market is in secondary position in relation to North-European ports. The ultimate goal of cooperation between ports should be the creation of a single area of North Adriatic port system. Several limitations have to be considered: port and hinterland connectivity infrastructure development (full implementation of block-trains and traffic network enhancements), port terminals expansions (providing access to larger vessels), to mention some. However, *mutual tendency* of these relatively small, transit ports could positively influence the competitiveness and the size of the gravitational area, and therefore the transit cargo amount for European heartland countries.

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