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Northern and Southern European Traffic Flow Land Segment Analysis as Part of the Redirection Justification

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ABSTRACT: Natural geotraffic flows act as one of the most important factors directly affecting redirections of the world transportation routes. In terms of door-to-door multimodal transport chain, several routes from Far East toward European destinations exist, with Northern European route acting as prevailing one. The proposed paper elaborates possibilities of redirection of the traffic flow by directing cargoes to an alternative route through the Adriatic Sea. The aim is to justify realisation of mentioned possibility in terms of land transportation segment analysis, i.e. by analysing cargo transportation from ports to final destinations in Central Europe, placed in natural gravitational hinterland of ports of Northern Adriatic Port Association (NAPA). Geo-traffic and logistics' analyses of NAPA ports are presented in the paper. Container traffic and its trend as compared with Northern European ports are analysed. The development plans of inland connections are presented in function of justification of the traffic flow redirection. A model for the selection and evaluation of the optimal container transport route by using the multiple criteria analysis (MCA) has been introduced and developed. The model was applied for the selection of the representative service connecting Far East (origin) and the central Europe (destination) by detailed analysis of the land transportation segment. The PROMETHEE method was used for the model testing and evaluation. Summarised results are presented and discussed tending to confirmation of the traffic flow redirection justification.

1 INTRODUCTION

NAPA ports originated and developed primarily due to their favourable geographical position at the intersection of the traffic direction Adriatic-Danube region. The main task of the Association - comprising ports of Ravenna, Venice, Trieste, Koper, Rijeka, Monfalcone and Chioggia - is to direct the ports to operate in the international market as a single multi-port system. Among other, 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 (Perkovič *et al.* 2013, NAPA 2016). Considering their common hinterland area, NAPA ports act as mutually competitive port systems. On the other hand, they are representing common competitiveness toward other geo-traffic flows where goods from countries of Middle Europe are transported.

The aim of the proposed paper, representing the continuation of research (Kos *et al.* 2016) is to justify the redirection of the northern traffic flow by redirecting cargoes to the Adriatic Sea, i.e. through the ports of NAPA (the southern traffic flow). Structural analysis was conducted by exploring features of both traffic flows, by determining representative services for both directions: from the

Far East port of Shanghai as origin towards Central European economic centre Munich as final destination. Results are presented and discussed in terms of redirection justification. Analyses have been made by employing economical, logistic, and geographical and resource parameters representing each direction, as shown in the corresponding chapter. Findings regarding optimal transport route determination were verified with the MCA application, employing the *Preference Ranking Organisation METHod for Enrichment of Evaluations* (PROMETHEE) and *Geometrical Analysis for Interactive Aid* (GAIA) methods. For this purpose, *Visual PROMETHEE* software (Mareschal 2013) was used. The importance of certain groups of criteria and criteria respectively, determined in the model for the evaluation and selection of a container transport route, together with parameters' values of appropriate criteria for the defined variant solutions, were used as input data. Groups of criteria were defined as economic, transport and environmental, each occupying the appropriate share. Four possible transportation services (variants of both directions) were determined and analysed through the proposed model. Findings showed significant bias toward the southern lines, with both road and rail land transport component. The summary of findings represents reasonable path for further research in the proposed direction.

2 GEO-TRAFFIC AND LOGISTICS' ASPECT OF PORTS OF NAPA

In terms of operation and development of Northern Adriatic ports and corresponding traffic direction, elementary logistic advantage is their favourable geographical position. Although ports of NAPA originate from different countries, each operating under its specific conditions, geographical location and relational/respective hinterland are cause of ports' common features. NAPA ports are the main link of the southern traffic European flow, the shortest natural direction Europe is connected with Asia, Africa and Australia, linking two economically complementary worlds (Kos, Vilke & Brčić 2016).

Development of relations in the port services market has led to other traffic directions coming to the fore, accentuating the competitiveness problem towards the southern traffic flow. The Northern Atlantic traffic direction (the northern traffic flow) acts as dominant, with final points being Western-European ports of Hamburg, Rotterdam, Antwerp, Bremen and Amsterdam. In spite of longer distance, engagement of the northern route is constantly increasing. Greater distance is compensated with other logistic elements, such as contemporary roads and railway network, developed application of modern traffic technologies and cargo handling, logistic and IT network, operation organization on the overall transportation path, active ports' and railways' commercial and pricing policy, etc.

Table 1. Sea distances (in nautical miles) between ports of Rijeka (Croatia), Trieste (Italy) and Hamburg (Germany), and significant global ports

Port	Rijeka	Trieste	Hamburg
Port Said	1 254	1 294	3 551
Bombay	4 315	4 340	6 620
Shanghai	8 555	8 589	10 855
New York	4 785	4 814	3 535
Lagos	4 765	4 999	3 720
Buenos Aires	6 955	6 983	6 665
Singapore	6 275	6 308	8 585
Hong Kong	7 734	7 768	10 029

Sea distances from the Suez Channel to Northern Adriatic ports represents one third of the same distance towards North Sea European ports. Considering Northern and Western European ports, sea distance from Far East ports and Northern Adriatic ports is approximately 2 000 nautical miles shorter, resulting in shorter travel/voyage time up to ten days (Table 1). Considering economical aspect of fuel expenses, this feature is furthermore expressed. As for land cargo traffic directions, main Central European industrial and commercial centres are closer to the North Adriatic region for 400-600 km (Table 2). Despite presented facts, current traffic in Adriatic region is not suitable to its favourable geographical advantages, since the majority of cargo flows are transported through northern ports. In general, goods originating from Danube region are faster and/or with lower process transported by longer but more contemporary lowland transportation roads/lines, and slower and/or with higher prices by using mountainous transportation roads/lines towards geographically closer/nearer Northern Adriatic ports. Besides transportation price, dominant factor for selecting the traffic flow is the transport speed. Two physically different distances are becoming economically equal, even expressing an economic advantage of the longer transportation path.

Table 2. Railway distance (in km) of the Northern Adriatic and North European ports to specific Central European economic centres

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	599	527	777	876

This new logistic and economic principles lead to changes in movement of cargo flows on the global market, as well as strengthening of particular traffic directions to the detriment of others. Movement and definition of cargo flows and creation of particular traffic directions are nowadays governed by global logistics and large shipping companies according to their interests. In European and global market, the role of port systems considerably changed; certain advantages and drawbacks are evaluated by traffic and economic and political interests of individual European countries. For instance, maritime cargo transportation from Asia to Malta employing the ship of equal size and general features is more expensive than from the same origin to the port of Hamburg, nevertheless the distance of the voyage. In general, the price of the total transportation from Asia to Hungary is approximately on the same level if it is conducted through northern Adriatic or North Western European ports. In this way, competitiveness of northern Adriatic ports is hampered, while the sole selection of these ports depends primarily on large Asian carriers, as well as of European Union and other countries governments' politics.

3 AN OVERVIEW OF NORTHERN ADRIATIC AND NORTHERN EUROPEAN PORTS' CARGO TURNOVER

Reflection of business success and development possibilities of each port is the movement of its cargo. Also, in order to achieve qualitative and long-term planning of future activities and development strategy, the first step is to make detailed analysis of its cargo flows movements, as well as to investigate current and potentially future market of port services. Domestic traffic from the national foreign trade represents secure substrate of goods, subject to relatively accurate planning of quality and quantity. Transit traffic as non-commodity export which creates a foreign currency income is of invaluable importance for ports' operability and further development. Transit countries can choose between several traffic directions, therefore ports have to invest great business skills in order to preserve acquired positions and strengthening of their own business on the international port services market.

Table 3. Total turnover movement (in 000 tonnes) through North European ports and the ports of Rijeka, Trieste, Koper and Venezia (2011-2015) (PA 2017, PANW 2017, PH 2017, PK 2017, PR 2017, PROT 2017, PTS 2017, PBB 2017)

Ports	2011	2012	2013	2014	2015	diff. (%)
Hamburg	132.2	130.9	138.1	145.1	137.8	4.2
Bremen	80.6	84.0	78.7	78.3	73.5	-8.8
Amsterdam	93.0	94.3	95.8	98.0	98.8	6.2
Rotterdam	434.5	441.5	440.5	444.7	466.4	7.3
Antwerp	187.2	184.1	191.0	199.0	208.4	11.4
Total	927.5	934.8	944.0	964.9	984.9	6.2
NAPA	101.0	100.9	108.0	107.7	115.3	14.2

The gravitational hinterland of NAPA ports encompasses areas of Austria, Hungary, Slovakia and Czech Republic, South Germany and South Poland, western parts of Ukraine and Romania, eastern parts of Switzerland and partially Bosnia and Herzegovina and Serbia. In Table 3, comparison between Northern European and NAPA ports' total cargo turnover movement during recent years is presented. Container turnover is presented in Table 4.

Despite that NAPA ports are ranked as small and medium-sized ports when compared to world relations, there is evident growth of total turnover of cargoes, higher than in the North European ports.

Table 4. Container turnover movement (000 TEU) through North European ports and through the ports of Rijeka, Trieste, Koper and Venezia (2011-2015) (PA 2017, PANW 2017, PH 2017, PK 2017, PR 2017, PROT 2017, PTS 2017, PBB 2017)

Ports	2011	2012	2013	2014	2015	diff. (%)
Hamburg	9.0	8.86	9.26	9.73	8.82	-2.1
Bremen	5.9	6.12	5.84	5.80	5.55	-6.2
Rotterdam	11.9	11.87	11.62	12.30	12.23	3
Antwerp	8.7	8.64	8.58	8.98	9.65	11.4
Total	35.5	35.48	35.29	36.8	36.25	2.2
NAPA	1.13	1.52	1.65	1.79	2.01	78.5

Realized container turnover growth of North European ports in elaborated period was 2.2%, while the container traffic of NAPA ports grew by 78.5%. Considering the increase of cargo flows via other routes, especially in the proportion of Hungarian and Austrian cargoes, the necessity of joint action of NAPA ports towards the competition is imposed.

4 DEVELOPMENT PLANS OF INLAND CONNECTIONS BETWEEN NAPA PORTS RIJEKA, KOPER AND TRIESTE

As stated previously, functionality of NAPA ports as multi-port gateway system is essential. In this chapter, development plans for land interconnection of NAPA ports are presented.

4.1 *The construction of the highway Rijeka - Koper - Trieste*

Ministry of the Environment and Spatial Planning of the Republic of Slovenia published National Spatial Development Plan (NDSP) (LUZ 2011) for the connection between border-crossing Jelšane with the Koper - Ljubljana highway. After the proposal, initial highway point with the Republic of Croatia was defined, while its merging is foreseen in three possible junctions: Postojna, Razdrto or Divača. The length of the highway depends upon a specific junction, and will amount 34 to 39 km. According to the project, the highway has typical cross section with four lanes of 3.75 m in length. The project speed amounts to 120 km/h, with minimal curvature of horizontal radius being 750 m. There are nine potential corridors of the Rijeka - Trieste highway routes, which are discussed in the frame of NSDP, as presented on Figure 1. Three main and 6 additional variants are noted for further discussion. According to northern ('Postojna') variant, highway passes from Ilirska Bistrica to Postojna and the Koper - Ljubljana highway junction. The variant implying connection in Postojna consists of four additional variants. According to second variant, the junction with Koper - Ljubljana highway is situated slightly south in the Razdrto junction, while according to southern variant the highway would end in the Divača junction (near the port of Koper). The 'Divača' variant includes two additional sub-variants.

Nowadays it seems more likely (in political terms) that Slovenia will choose the highway route towards Postojna (Rupa - Postojna section), producing a highway triangle, with apex situated between Koper and Ljubljana.

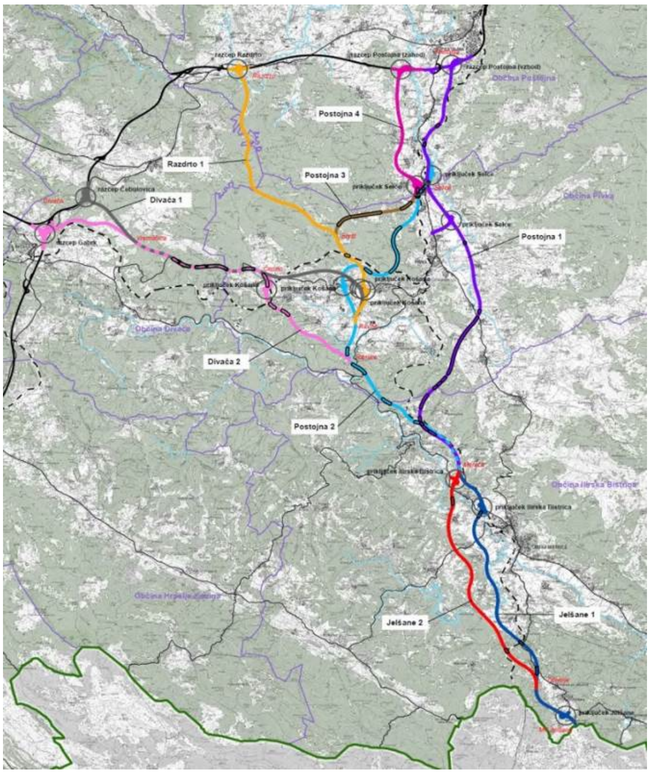

Figure 1. Jelšane – Postojna/Razdrto/Divača highway routes (LUZ 2011)

NDSP foresees two additional variants which are following the route immediately after border with the Republic of Croatia from the Jelšane junction to the Ilirska Bistrica junction. Sub-variant Jelšane 2 is more promising due to its simpler technical-exploitation features.able.

4.2 *The construction of the railway Rijeka - Koper Trieste*

Construction of high-speed railway from Northern Italy to Ljubljana has been included in Italian and Slovenian transportation policies' priorities as a part of Priority Project No.6 of the Trans-European transport network (TEN-T), or Pan-European Corridor V, respectively (Figure 2).

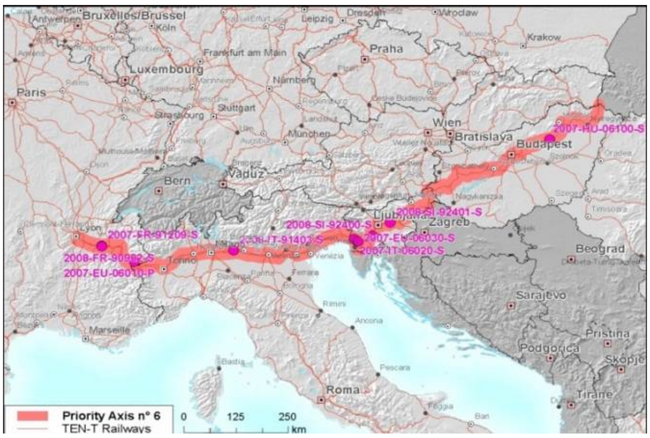

Figure 2. Venice - Trieste - Ljubljana high-speed railway route Venecija – Trst – (EC 2017)

The Venice - Trieste section of the railway should extend parallel with A4 highway and with existing railway along the coastal lowland region. Designed route envisages passing through the city of Monfalcone and through the tunnel towards plateau of Villa Opicina. The rail would extend along Vipava valley to Ljubljana. In this way, the rail corridor would completely bypassed Trieste. The proposed railway is quite demanding to construct. The most problematic section is from Trieste rising to the Ljubljana plateau. Considering terrain features, it has been accepted that the new railway station will be constructed near the existing one near Villa Opicina. This location enables simple connection with existing railway lines: two tracks towards Trieste, railway from the Venice direction and Ljubljana, and the track towards Nova Gorica and Villach. From Villa Opicina, the rail follows the highway and existing railway line, descending 300 m to Monfalcone, with an average slope of 1.5%.

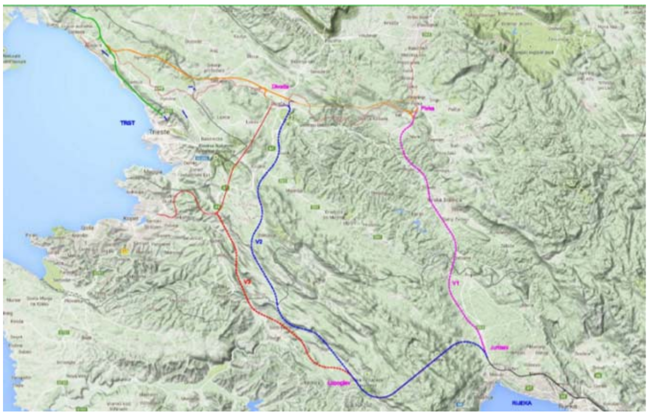

Figure 3. Rijeka – Koper – Trieste railway variants (IGH 2014)

Although not officially defined, the direction of Rijeka - Koper - Trieste railway route has three potential options/variants (Figure 3), as follows:

– Variant 1: Jurdani – Pivka train station – Divača (51.688 km),
– Variant 2: Jurdani – Divača train station (66.630 km),
– Variant 3: Jurdani – connection on new Koper – Divača railway line (66.980 km).

Construction of new double-track from the Divača train station towards Trieste is planned. New tracks from Rijeka are planned in a way that the connection on planned railway is realized. Through the planned connection of Trieste - Aurissina - Palmanova - Venezia with previously described railway variant, interconnection of ports of Rijeka, Koper and Trieste is ensured. In this way, ports are connected on 6^{th} TEN-T network corridor. As for port of Rijeka, it conjugates on a new railway Rijeka - Zagreb (EC 2017, Dundović *et al* 2010, Vilke *et al.* 2011). These new corridors' variants are, among other indices (as explained in the following text), used as parameters for further analyses.

5 THE OPTIMAL TRANSPORT ROUTE DETERMINATION

A prerequisite for the implementation of MCA in transport planning is the determination of criteria, their importance and function.

Table 5. The model for the evaluation and selection of a container transport route

GROUP OF CRITERIA (%)		CRITERIA	
		Full name	Value
Economic	29%	The freight cost	44%
		The exploitation costs	32%
		The possibility of developing logistics – business zones in the region	24%
Transport	37%	The possibility of integrating the route in the intermodal transport system	15%
		The transport route capacity	19%
		Container travel duration	18%
		The transport route length	16%
		Transport route deviation from airline	8%
		Transport safety	24%
Environmental	34%	Energy consumption	18%
		Emission of carbon dioxide	20%
		Emission of sulphur dioxide	16%
		Emission of nitrogen oxides	16%
		Emission of non-methane hydro carbons	15%
		Emission of particulate matter	10%
		The impact of meteorological conditions	5%

Since preferences are perceived as subjective factor, intentions of a decision-maker (or group of experts) are considered by definition of criterial significance depending on their weighting coefficients (Roubens 1982). The model for the selection and evaluation of the elaborated container transport route that consists of groups of criteria and criteria respectively is shown in Table 5.

For the purpose of the container transport route selection and the MCA method application, groups of criteria have been defined according to the information obtained from a number of experts in the field of traffic and cargo route planning. A coefficient of importance (weighting coefficient) has been assigned to each criteria and group of criteria, respectively, significance of which was compared and the weighting coefficients normalized. In this way, their sum amounts to 100%, as well as the weighting coefficients of criteria within a specific group.

5.1 *Analysis and evaluation of the optimization model*

Two main traffic flows were taken into consideration. Port of Shanghai was chosen as reference origin point, with Munich as a final destination. As a representative transhipment port for northern traffic flow port of Hamburg was selected, while port of Koper was chosen for the southern direction. Among specified transport corridors four representative solutions have been chosen as ranking variants, with railway and road inland transport connections applied into the model. Analysing existing and planned global container line services, the freight transportation directions (solutions) were determined as representative, each defined by group of criteria, criteria and weighting coefficients, respectively (Table 6). A corresponding object function was assigned to each criterion. The variants were chosen as follows:

- Variant I: Shanghai – Koper – Munich (Truck)
- Variant II: Shanghai – Koper – Munich (Train)
- Variant III: Shanghai – Hamburg – Munich (Truck)
- Variant IV: Shanghai – Hamburg – Munich (Train)

The economic criteria C1 is expressed quantitatively in accordance with the data received from logistics and forwarding agents. The costs of freight are the costs for the carriage of 1 forty-foot equivalent unit (FEU) through the defined transport routes expressed in USD. To criteria C2 and C3 appropriate weighting coefficients were assigned according to a rating scale from 0 to 10. The costs of exploitation include the costs of management and maintenance of road routes Koper – Munich and Hamburg – Munich and railway lines respectively. The possibility of developing logistics – business zones in the region is concerning the inland areas close to the road and rail connections.

A traffic criterion C4 evaluates interaction of road and rail tracks with other transport branches. It was assessed more favourably for northern inland routes, since they fit more efficiently in the existing traffic network.

Table 6. Criteria evaluation for variant solutions

CRITERIA GROUP (%)		CRITERIA Mark	Object function	Transport route variant I	II	III	IV
Economic	29%	C1	USD Min	3030	2520	2750	2555
		C2	Rating Min	4	4	6	6
		C3	Rating Min	4	4	5	5
Transport	37%	C4	Rating Max	4	5	7	8
		C5	Rating Max	6	6	7	8
		C6	hrs Min	412	415.5	520.5	522
		C7	km Min	16 355	16 426	20 756	20 764
		C8	Rating Min	7	6	6	5
		C9	Rating Min	6	7	5	4
Environmental	34%	C10	MJ Min	2397.180	2181.808	3134.059	2791.750
		C11	tones Min	180	157	235	205
		C12	kg Min	1810	1814	2286	2292
		C13	kg Min	2541	2468	3226	3124
		C14	kg Min	171	161	218	204
		C15	kg Min	271	271	343	342
		C16	Rating Min	7	3	7	3

Traffic criteria C6 and C7 were calculated on the basis of average speed of container carrier vessel, typical for elaborated directions/services (21 knots). Hence, time spent in navigation amounts to 21 day - 9 hours - 7 minutes with sea distance of 10 775.6 nautical miles for the northern traffic flow. As for the direction through Adriatic Sea, sea navigation time amounts to 16 days - 22 hours - 50 minutes, with distance of 8 543.4 nautical miles.

Safety of transport criteria for each variant was assessed in accordance with existing land lines' technical elements, especially data regarding total distances along with longitudinal inclination and their curvature features.

The environmental criteria (C10 - C15) were obtained using (EWI 2014) software, providing calculations of energy consumptions and emissions during each transport type, including terminal inter-operations. All environmental parameters were calculated for complete Well-To-Wheels (WTW) fuel cycles, comprising of Tank-To-Wheel (TTW) and Well-To-Tank (WTT) fuel cycle processes (EWI 2014, TIAX LLC 2007).

5.2 *Selection of the optimal transport route*

The parameters of the criteria determined in previous chapter have been used for evaluation process of transport routes, in order to select the optimal variant. The values of the weighting coefficients of group of criteria and criteria respectively were obtained by experts in the field of traffic and cargo route planning.

Rank	action		Phi	Phi+	Phi-
1	Variant 2		0,3538	0,6304	0,2766
2	Variant 1		0,1001	0,5085	0,4084
3	Variant 4		-0,0575	0,4414	0,4989
4	Variant 3		-0,3965	0,2670	0,6635

Figure 4. Results of container transport route variants' MCA

Figure 4 presents obtained values for individual variants as well as their positive and negative flows. A graphical overview of the numerical values of net flows is shown on Figure 5. The Variant 2 ranks as optimal selection with a value of the net flow of 0.35, with the Variant 1 on a second place with the net flow value of 0.1. Both variants refer to the southern traffic flow.

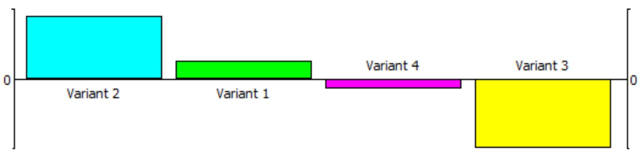

Figure 5. Overview of the conducted MCA

In selecting of potential variants of the land segment track, and in simultaneous combinations of criteria, the best solution represents the railway line Koper - Munich or Variant 2 respectively. Moreover, cargo flows which provide sea container transport from Shanghai to Koper and land transportation to final destination are evaluated with positive values, being convenient for selection. On the contrary, Northern transport routes have negative net value. More favourable results recognized in Variants 2 and 1 are a consequence of better evaluation of most of criteria as compared with other two variants. Evaluation of environmental criteria represents the crucial element for obtaining best results. Variants comprising southern traffic flow (both types of transport in land segment) achieved significantly better results. Southern traffic flows are producing considerably less harmful exhaust emissions and less energy consumption. Southern road variant produces 55 tons of CO_2 less than the northern one, while the rail variant produces 45 tons less of CO_2. SO_2 emissions are lower for 476 kg (road variant) and for 478 kg (rail variant) respectively. NO emissions are 685 kg higher in the road variant and 656 kg higher on the rail, when compared with the southern flow. Southern flow energy consumption is lower for 736.879 MJ (road variant) and for 609.942 MJ (rail variant), respectively. Summarized results are logical considering involved distances; southern transport corridor with the road component is 4 400 km shorter than the northern one, while considering the rail component, distance saving amounts to 4 338 km.

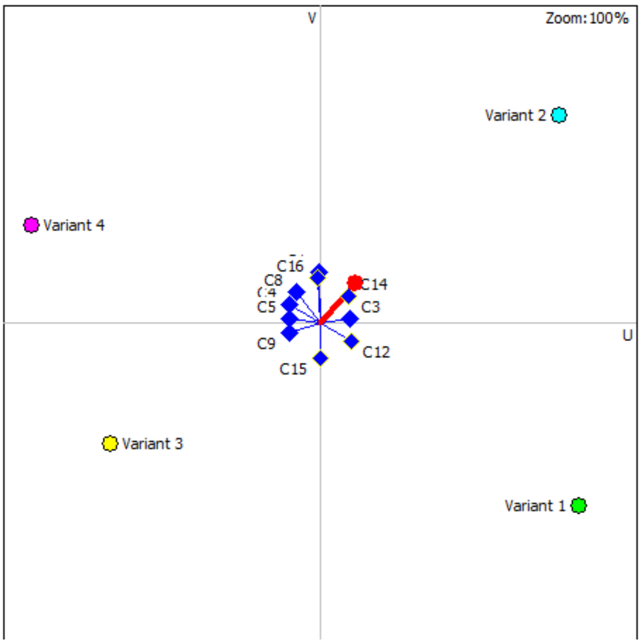

Figure 6. Overview of the MCA results in *'u, v'* GAIA plane

Direct interpretation of a multi-criteria analysis in a GAIA *'u, v'* plane is shown on Figure 6. The dispersion of variants means their diversity in terms of numerical values while clustering signifies the similarities. The same applies for the criteria: mutually closer criteria have similar numerical values. Variants 1 and 2 are directed towards right plane side giving positive results, while the direction of decision axis (C14/red vector) prioritizes Variant 2. Direction of majority of Variant 4 criteria vectors implies its domination over the Variant 3. Vector axes of individual criteria are close or are coinciding, meaning that they equally affect the respective variant. Analogously, dispersed criteria are affecting the respective variant with different intensities.

Although the Variant 2 (rail component of the southern flow) is least expensive, the final sequence of variants was not affected by freight rates. For instance, Shanghai - Koper freight per FEU amounts to 1800 USD, being 150 USD less than the Shanghai - Hamburg freight.

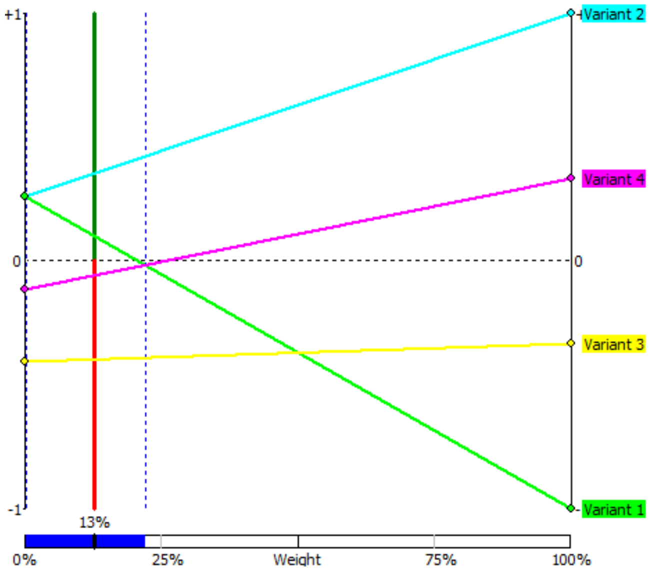

Figure 7. Overview of the sensitivity analysis of MCA results

Road transport of the same unit from Koper to Munich amounts to 1220 USD, being 425 USD *higher* than Hamburg - Munich route, nevertheless greater distance (for app. 50%). Similarly, rail transport freight per FEU is 115 USD higher on the Koper - Munich route, although the distance of this route is more than 170 km smaller. On Figure 7, alteration of ranking with different weights of costs of freight criterion is presented within the economic group of criteria. The Weight Stability Interval (WSI) ranges from 0.13 to 22.02%, meaning that Variant 1 will reach the second ranking in MCA when the weight coefficient (freight cost) exceeds the upper range value.

6 CONCLUSION

Logistic principles of the global transportation market are putting natural features of the certain area in the background in the process of traffic cargo directions' selection. The tendency of the proposed paper was to elaborate other features potentially affecting the selection of the particular transportation route. Two representative cargo directions were analysed, originating in the Far East but diverging at the exit of the Suez Channel, to finally finish in European inland: The prevailing one with Northern European ports as transhipment points, and other passing through Northern Adriatic ports. Conducted structural, comparative and MCA analyses and corresponding models showed that the possible redirection of the certain share of cargo transportation can be firmly justified by comprising economic, transportation and environmental influential factors. Several studied transportation variants which were defined in the paper. The optimal container transport route connecting the Far East and Central Europe would be the one which takes into consideration the inland railway transport Koper – Munich. This route has been named the *southern traffic flow*, with regard to the northern direction passing through North European ports. The proposed redirection represents reasonable contribution to sustainable transportation improvements, setting NAPA ports, their development and their mutual commitment at the forefront.

REFERENCES

Dundović, Č., Vilke, S. & Šantić, L. (2010) The significance of high-efficiency railway Zagreb-Rijeka for the port of Rijeka development. Pomorstvo – Scientific Journal of Maritime Research. 24(2): 165-188

EcoTransit World Initiative (EWI). (2014) Ecological Transport Information Tool for Worldwide Transports: Methodology and Data Update. Hanover: IVE mbH.

European Commission (EC 2017) [Online] Priority projects. Available at: http://bit.ly/2o5YCg6 (01 January 2017)

Institut IGH (IGH) (2014). Studija okvirnih mogućnosti povezivanja sustava sjeverno jadranskih luka željezničkom prugom visoke učinkovitosti. Zagreb: IGH.

Kos, S., Vilke, S. & Brčić, D. (2016) Redirection of the World Traffic Flow Far East – Europe via the Adriatic Sea. ATINER's Conference Paper Series, No: TRA2016-1985. Athens: ATINER

Ljubljanski urbanistični zavod (LUZ) (2011) Dopolnjena pobuda za Državni prostorski načrt za odsek AC Postojna/Divača-Jelšane. Technical Report. Ljubljana: LUZ

Mareschal, B. (2013) Visual PROMETHEE 1.4. Framingham: VPSolutions.

North Adriatic Ports Association (NAPA) (2017) [Online] Available at: www.portsofnapa.com/ (05 February 2017)

Perkovič, M., Twrdy, E., Batista, M., Jankowski, S. & Gucma, L. (2013) The Increase in Container Capacity at Slovenia's Port of Koper. International Journal on Marine Navigation and Safety of Sea Transportation (TransNav). 7(3): 441-448.

Port of Amsterdam (PA). (2017) [Online] Available at: www.portofamsterdam.com (09 February 2017)

Port of Antwerpen (PANW). (2017) [Online] Available at: www.portofantwerp.com (11 February 2017)

Port of Hamburg (PH). (2017) [Online] Available at: www.hafen-hamburg.de/ (11 February 2017)

Port of Koper (PK). (2017) [Online] Available at: www.luka-kp.si (05 February 2017)

Port of Rijeka (PR). (2017) [Online] Available at: www.lukarijeka.hr (09 February 2017)

Port of Rotterdam (PROT). (2017) [Online] Avaiable at: https://www.portofrotterdam.com (05 February 2017)

Port of Trieste (PTS). (2017) [Online] Available at: www.porto.trieste.it (03 February 2017)

Ports of Bremen & Bremerhaven (PBB). (2017) Available at: www.bremenports.de/en (01 February 2017)

Roubens, M. Preference relations on actions and criteria in multi-criteria decision making. // European Journal of Operational Research, 10 (1982.), pp. 51-55.

TIAX LLC. (2007) Full fuel cycle assessment: well-to-wheels energy inputs, emissions, and water impacts. Consultant Report. Cupertino: Tiax LLC.

Vilke, S., Šantić, L. & Glad, M. (2011) Redefining of the Rijeka Railway Junction. Promet – Traffic & Transportation. 23(6): 443-451.