Analysis of the Possibilities of Using VI Corridor of Transport for the Alternative Export of Bulk Cargo from Upper Silesia (Poland) to the Mediterranean Countries

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The article assesses the possibility of activation of transport and logistics services in relation Silesia – Trieste - Alexandria and by continuation towards India. The increasing demand for transport on this route, where the section will be located onshore in the sixth (and part of fifth) transport corridor and the forecast of traffic on the route for transportation of bulk materials, justify launching intermodal connections there. It is expected that the market for transport in the analyzed route will have significant bulk loads (coal, coke) in the area of Silesia, in the direction to the south of Europe and further by maritime transport to customers in Egypt and India (coke plants, steel mills).

Keywords: intermodal, transportation corridors, bulk materials, transportation costs.

1. INTRODUCTION

The European Union, since taking into account the alleviation of traditional transport route: west - east (in terms of the intensity of the carriage and CO_2 emission), subsidies for a number of international research programs to assess the possibility of transferring part of these operations on the axis: north - south. One of them was a program named SoNorA (*South North Axis*), the largest strategic program for Central Europe, implemented in six Central European countries in the years 2008-2012, to accelerate the development of infrastructure and multimodal transport services in the area which was connecting the Baltic countries (from Scandinavian side to the port of Szczecin - Swinoujscie) with the Adriatic Sea. The second project is BATCo (*Baltic - Adriatic Transport Cooperation*), implemented in the years 2010-2013, which had the task to activate the ports in Gdańsk / Gdynia in the intermodal transport, including the transport using the north –south axis.

The primary objective of the programs SoNorA and BATCo was the activation of transport and logistics services in the North - South direction, which is heavily dependent on the possibility of launching intermodal connections in the direction from Scandinavia to the ports of the Adriatic Sea, with transit through Polish ports and by using Polish railways going to southern directions.

The increasing demand for transport in the north-south axis, which from the land will be located in the sixth (and in the part of fifth) transport corridor and the forecasts of traffic of bulk materials on this route justify the launch of the intermodal connection. It is expected that the transport market in the analyzed route will have significant bulk loads (coal, coke) in the area of Silesia with the destination to the south of Europe and further by maritime transport to the customers in northern Egypt and India (coke plants, steel mills).

Such intermodal transport of bulk materials is not known to us, especially of the large amounts of cargo (about several hundred thousands, and even millions of tons per year), which in the case of the sixth transport corridor can be competitive with the “conventional” currently used, which means the transportation of these materials from mines (or coke plants) in Silesia to the ports (Gdańsk, Świnoujście) by using coal wagons and than by bulk vessels around Europe to the port of Alexandria (or Port Said – towards India).

The article presents the analysis of the internal costs of transport (shipping charges) and external costs (primary energy consumption, air pollution, noise and occupancy of the land) of rail and maritime transport for conventional bulk materials transport and intermodal variant using VI European corridor: (Helsinki) Stockholm - Gdańsk - Katowice - Žilina - (Budapest - Athens), with a branch of VI B for the route: Czestochowa - Ostrava - Brno (Vienna - Triest / Rijeka / Venice).

In terms of railway density area of the Silesian province is the clear leader in Poland. The density of the railway network in the region is 17.4 km per 100 km^2 and it is almost twice higher than the density ratio of the second province in the country - Opole (9.2 km per 100 km^2) [7]. The region carries out about 50% of the national rail transport. All the rail lines included in the international system are the State importance lines, and are covered by AGC (European agreement, which defines a network of railway lines of international importance, which should be adapted to the speed of 160 km/h in passenger traffic and 120 km/h in freight traffic, with the axle load up to 225 kN) and AGTC agreement (which defines a network of railway lines for the international container transport by rail and container terminals, located on this network).

Implementation of an intermodal transport system on the north-south axis will include the Silesia province rails. Countries along the corridor VI apply for TEN verification and the combination of Poland and the northern parts of Italy (or Croatia) for the usage of high bandwidth and capacity trains. Availability is a prerequisite for economic development and growth of these areas, therefore, the main objective of the actions should be (as stored in the projects SoNorA and BATCo):

- to improve intermodal transport connections, in particular, the acceleration of the establishment of connections for high-speed rail along the north - south axis ("Ecological transport " - the so-called "Green corridor"),
- to protect the environment by reducing the negative effects caused by transportation.

2. THE POSSIBILITIES OF INTERMODAL TRANSPORTATION OF BULK MATERIALS

Transport technology often uses the concept of *combined transport* which is included in intermodal transport, where the unit load, for a substantial portion of the route, is transported (without reloading) between the terminals by rail, inland waterway or sea, and its delivery and drop-off take place by road, where it is characterized by separateness and independence of the services provided by different transport operators [2]. The definition of intermodal transport refers to the integrated intermodal transport units. In fact, these are the different types of containers or swap bodies. Universal containers (*ISO*) are the most common integrated load units in intermodal transport. In their case, as in the case of pallets, we have to deal with dimensions which are internationally standardized.

In Poland, bulk is the most often transported (using coal wagons) such as coal, coke, aggregates and other bulk materials. Transportation of such materials in universal containers (normalized) is difficult and inefficient. Such containers are not suitable for the transport system *Lo - lo* (*lift on - lift off*), due to the fact that transshipment vertical system is used here (*spreaders*) and maritime transport (*on-board storage in piles and the impossibility of the strapping*).

Shipping containers for the transport of the bulk materials should have a specific construction, lighter than typical 1A - 1D, with the walls made of flexible materials, easily folding, and the double doors on their narrow side that can open full width or tilt, due to the need for a simple loading of bulk material at the clients plant.

As a possible technology of intermodal transport of bulk materials (coal, coke) using rail-sea transport, from Silesia to a recipient located in Middle Egypt (Steel Plant and Coke Plant Al – Nasr) about 250 km from the port of Alexandria), and the VI transport corridor may be the technology of the *shuttle train* (Fig.1).

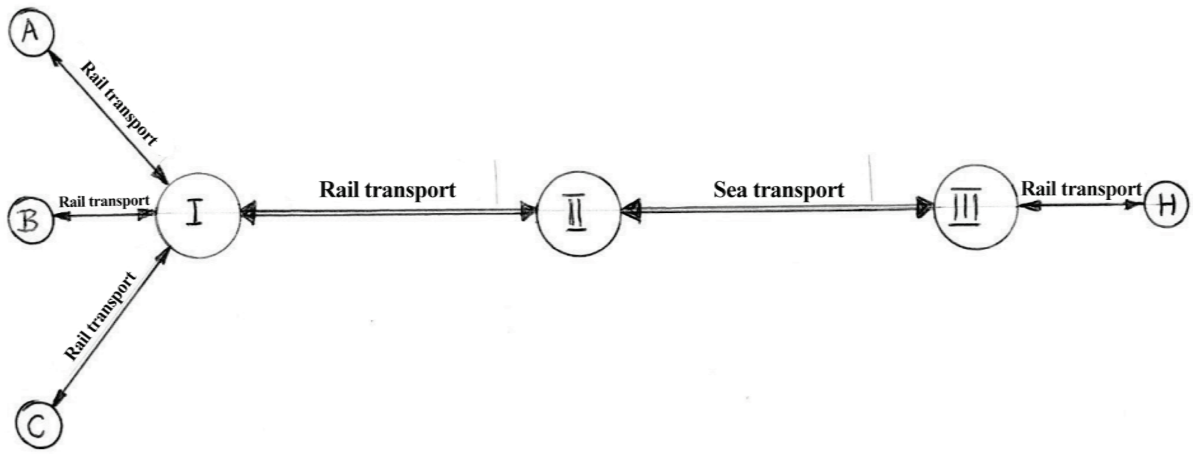
In the above technology the shuttle train is compiled directly into the main terminal and runs directly between the sender (e.g. terminal in Dąbrowa Górnicza – Upper Silesia, Poland) and the recipient (the port of Trieste or Rijeka), without shunting operations, handling or additional picker (Fig. 1). The main terminals (I, II and III) have high efficiency, but their number in the system is smaller. Individual wagons of the shuttle train mostly transport loads of the same type from and to fixed recipients.

Functioning of the shuttle trains consists of:

- combination of compact train sets with the intermodal transport units, carrying the loads on a fixed route from different countries or regions of the world,
- constant composition and the number of wagons in the train,
- a minimum of 5 train trips a week,

- the train cannot be shunted along the route and at the points of origin and reception,
- transport operator acquires the traction services from the owner of the rail infrastructure, taking on the full risk of the train load.

In the international transport, a large shipping company is mostly the logistics operator (e.g. PKP Cargo, Maersk, Schenker, etc.), because it has the necessary experience and capabilities of organization for this kind of transport. Figures 2 and 3 show the principle of the intermodal supply chain for bulk materials from the Silesian region (JSW mines and coke plants, for example "Przyjaźń") to a recipient located in central Egypt, made in variants A and B.



where: I – rail terminal in Dąbrowa Górnicza or Sławków – Upper Silesia, Poland,; II – seaport terminal (Triest/Rijeka); III – seaport terminal (Aleksandria); A, B, C – mine plant/coke plant on Upper Silesia; H – steel plant/coke plant in Egypt

Fig. 1. General principle of intermodal chain for delivery bulk materials from Upper Silesia region to purchaser localized in the Middle Egypt.
Source: own study

3. COMPARISON OF THE INTERMODAL TRANSPORT ROUTES WITH THE CONVENTIONAL TRANSPORT OF THE BULK MATERIALS

We have analyzed two variants of transportation of bulk materials from Silesia to the Northern Egypt:

A. using intermodal transport through sixth corridor and the northern Adriatic ports and then on container vessels to Alexandria,
B. currently used system involves the carriage of materials from mines (or coke plants) in Silesia to the port of Gdansk by using rail wagons (coal, coke) and then on bulk vessels around Europe to the port of Alexandria.

The following parameters will be defined for these options:

- differences in the length of the route between the variants,
- the calculated cost of transport at the annual contract for the carriage of 1 million tons of coal or coke,
- the estimated travel time,
- the impact of transport on the environment.

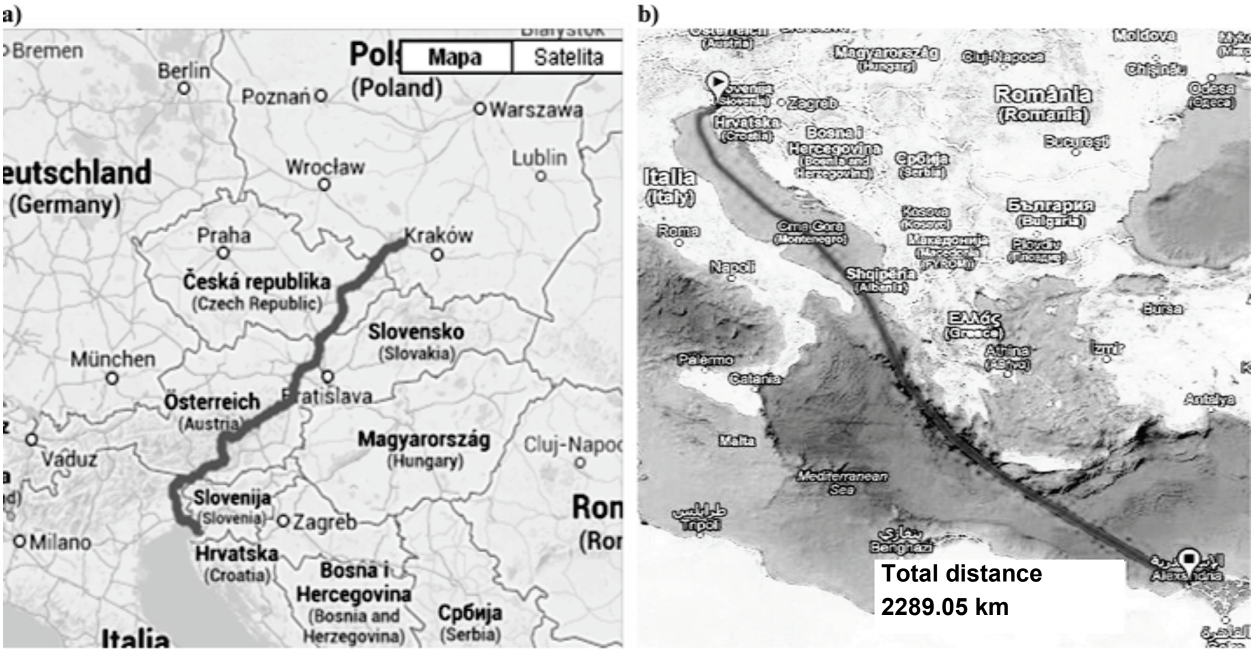


Fig. 2. Transportation variant A: a- railway route Upper Silesia – seaports in North Adriatic; b- sea route to Alexandria.
Source: own study

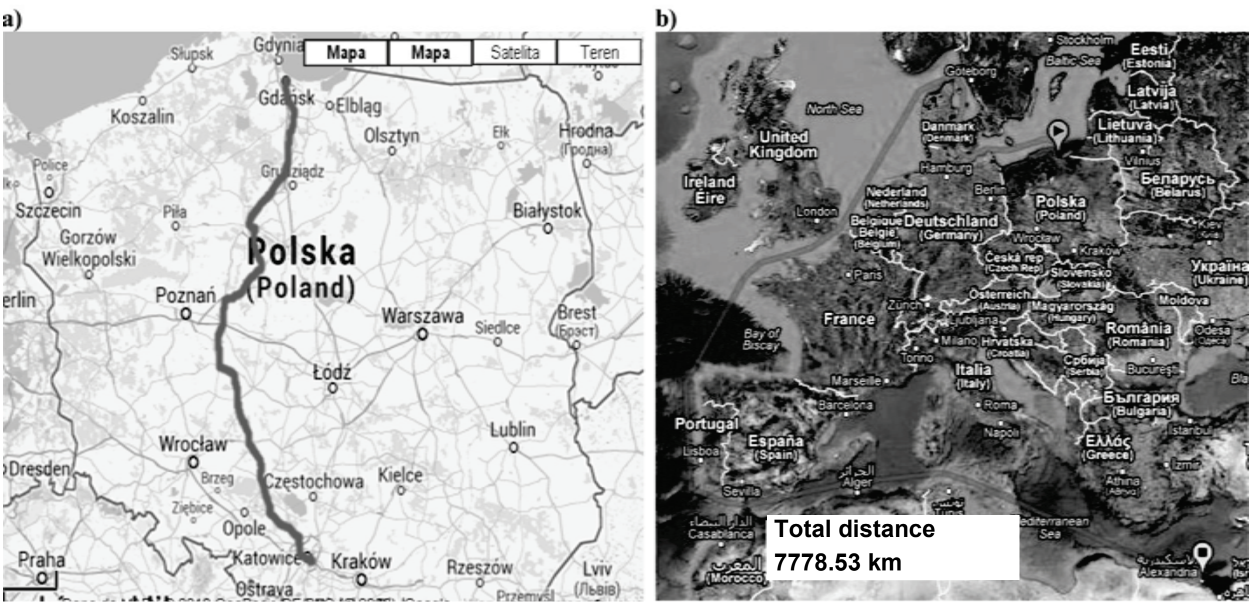


Fig. 3. Transportation variant B: a- railway route Upper Silesia – Gdansk; b- sea route from Gdansk to Alexandria.
Source: own study

Table 1. The input data for the railway route in the compared variants.

The input data	Railway route	
	Variant A	Variant B
	Katowice-Triest	Katowice – Gdańsk
length of railway track [km]	931	550
average speed of transport on this route [km/h]	50	25
time needed for transport [h]	32	22
type of wagon	Sgs 412Z	Eanos 415W
wagon load capacity [t]	62	60
loading volume [m^3]	82.5	82.5
number of wagons in the train	28 (84 TEU)	38
the number of shipments per year, with the total mass transported 1 million Mg/year	577	435
maximum weight of a train [t]	1,750	2,300

Source: own study

Table 2. Analysis of internal costs on the railway transport in two variants.

Railway route	Variant A	Variant B
	Katowice-Triest	Katowice – Gdańsk
the number of shipments per year, with the total mass transported 1 Million Mg/year	577	435
the number of shipments per month	48	37
the number of shipments per week	12	9
cost of railway transport of one train [EU]	100,000	125,000
annual cost of rail transport [EU]	57.7 million	54.4 million

Source: own study

In Table 1 a comparison of the basic parameters of the railway for both variants of transportation has been shown. Table 2 shows a comparison of the cost of transport for both A and B variants of rail carriage.

Table 3 summarizes the input data on the maritime route in the compared variants of each transport A and B.

Table 3. The input data for the maritime route in the compared variants of transport.

Input data	Sea route	
	Variant A	Variant B
	Triest - Alexandria	Gdańsk - Alexandria
the distance between ports [km]	2,290	7,778
the average speed of the vessel [km/h]	45-65	35- 55
maximum load capacity of the vessel	12,000-14,000 TEU	100,000 Mg
the number of courses of vessel per year	5	10
time needed for transport [h]	85	200

Source: own study

Table 4 shows an analysis of internal costs, in two variants of transport, of the maritime transport.

An important element in the comparison of two alternative routes is the amount of CO_2 emissions. In comparisons of routes (Variant A and Variant B) the following assumptions are used: Unit of CO_2 emissions in rail transport is 22 g / Mg / km, while emissions of maritime transport is equal to 17g/Mg/km (Fig. 4) [15].

Table 4. Analysis of internal costs, in two variants of transport, of the maritime transport,

Sea route	Variant A	Variant B
	Triest-Alexandria	Gdańsk - Alexandria
transport costs	1 TEU - 500 EU	1 Mg of bulk material - 165 EU
annual shipment costs [EU]	31 million	724.5 million
the additional charges at the handling terminals [EU]	1 TEU- 66 EU	1 Mg- 346 EU
the additional charges for customs clearance [EU]	1 TEU- 29 EU	1 Mg - 168,5 EU
documentation charges [EU]	1 TEU- 45 EU	1 Mg- 45 EU

Source: own study

4. ANALYSIS OF EXTERNAL COSTS OF TRANSPORT

External costs of transport requires to be referred to the costs of primary energy sources. The primary energy source is one that is taken directly from nature. It is, for example, coal, oil, gas, wind or sunlight (but not electricity). External costs of transport should also include accidents and intensity of noise, however the comparison of these factors for rail and sea transport does not have any sense. In determining the external costs of transport in the analyzed variants of carrying of 1 million of tons of bulk material per year primarily taken into account should be the costs of CO_2 emissions, which designation is relatively simple (Fig. 4).

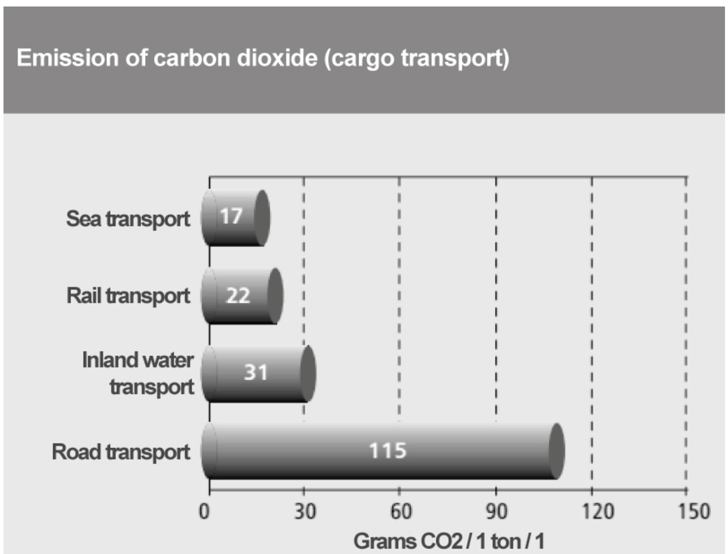


Fig. 4. Emissions of carbon dioxide by individual modes of transport.
Source: Own calculations based on [16].

Figure 4 shows that CO_2 emissions in transport by rail is lower than by marine transportation. Independent issue is the European Union preference to relieve the major European routes and transport streams and shift them into less environmentally burdensome maritime routes (Fig. 5).

Table 5 presents the CO_2 emissions in the carriage of 1 million Mg per annum of the bulk materials. These emissions are calculated basing on the input data (route length, number of shipments per year, the load carried on one transport) assuming the units of CO_2 emissions of the mode of transport. The calculations are made as follows:

Table 5. The total CO_2 emissions in transport by rail and sea in two variants.

Transport type	Variant A	Variant B
	Katowice - Triest - Alexandria	**Katowice - Gdańsk - Alexandria**
railway transport [t]	20,482	12,100
maritime transport [t]	38,930	132,226

Source: own study

This calculation shows that the route around Europe (Version B) is much more environmentally burdensome which especially in the conditions of continuous usage in the busiest seaways (by North Sea, English Chanel and Bay of Biscay) (Fig. 5) suggests the necessity of the intermodal transport.

Total Emissions = Individual emissions *[g/Mg/km]* * Number of shipments per year *(weight of 1 mln/Mg/year)* * Load capacity *[t]* * Route length *[km]*

Fig. 5. Emissions of CO_2 (kg/ TEU) from vessels in maritime transport around Europe – increasing from Port Said, Egypt [6].

Table 6 shows a comparison of the total cost of both variants (A and B) of the transport of bulk materials from Silesia to ports in northern Egypt. Assuming that the results are subject to errors resulting from rounding and inaccurate data provided by transport companies, clearly it can be concluded that all the compared parameters are much more favourable for variant A where the intermodal transport is used.

Table 6. Comparison of routes variants A and B.

Compared parameters	**Variant A Intermodal: Katowice – Triest - Alexandria**	**Variant B Conventional: Katowice – Gdańsk - Alexandria**
length of route [km]	**3,221**	**8,328**
transport time [h]	**117**	**233**
The total cost of transport [mln EU]	**88.7**	**778.9**
CO_2 emissions [t]	**59,412**	**144,326**

Source: own study

5. CONCLUSION

- If you even evaluate that the adapted data for the presented calculations (especially the internal costs of transport) are subject to errors, arising from inaccurate (or unreliable) information collected in transport companies, the most important in this comparison is the magnitude of the obtained results, which are clearly favourable for the intermodal route version.
- From the analysis of Variants A and B it is concluded that it would be also possible to transport the materials in version C, which can use the corridor VI to the export of bulk materials from areas of Silesia to the south, in the conventional system by using coal wagons, with unloading and storage the goods at the terminal II (Triest / Rijeka) and further transport by bulk carrier vessels to the port of Alexandria.
- It should, however, be realized that the intermodal transport of bulk materials will be basically deprived of freight transport on the route back.

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