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RATIONAL AREAS OF COMBINED TRANSPORT TECHNOLOGIES APPLICATION FOR CONTAINER DELIVERY ON THE CASPIAN-BLACK SEA ROUTE OF THE NEW SILK ROAD

Abstract

The article analyzes the main routes for delivering goods from China to the EU countries. The main transit flow in this direction is cargo in containers. The competitive Caspian-Black Sea route of the New Silk Road through Ukraine with the use of combined rail and sea transportations has been analyzed. Two delivery options are considered – using ferry ship and feeder ship lines. Simulation was used to evaluate the route parameters. Recommendations on the rational areas of combined transport technologies application on this route are given.

Keywords: new silk road, combined transport, ferry lines, feeder lines, simulation Java SE

Introduction

Today, shipments from China's inland areas to Europe are delivered first by land transport to sea ports. The most commonly used scheme is the transportation to the port in China by road transport, as well as the car removes cargo from ports in Europe. This is a transport-logistic scheme of "road-sea-road" (Figure 1).

The diagram shows the route segments – container transport from inland origin point to the sea port of Shanghai and its land transportation from the destination port of Hamburg, as well as the maritime section of the route, via Suez Canal and Gibraltar.

Figure 1. Carriage by road-sea-road scheme (by sea from the port of Shanghai to the port of Hamburg)
Source: (own elaboration based on: SeaRates, 2018)

An alternative to such route, which carries more than 95% of container shipments between China and the EU, is the transportation by rail, the Trans-Siberian route (Figure 2). On this route there are two overloads of the container due to changes in the gauge of the track – on the border of China with Kazakhstan (station Dostyk) and on the border with Belarus and Poland (station Brest).

In comparison to sea freight the rail transportation from China to Europe via TransSib offers a lower transit time at a higher price (Wagener, 2016). Main clients of this route are shippers of electronics (from China to Europe) and of automotive parts (from Europe to China) (Wagener, 2016).

As of today, the delivery of a 40-foot container (two TEU, twenty foot equivalent) door to door from a Chinese sender, for instance, in Lanzhou to a German consignee in Frankfurt-am-Main under the scheme of "road-sea-road" (sea from Shanghai port to the port of Hamburg) will cost 6414 US dollars. The container will be delivered within 35–38 days (SeaRates, 2018).

Rail transit through the Trans-Siberian route with a total distance of more than 8847 km will last 16 days, will cost 12757 dollars. Before 2011, this route's total transit time was typically 25 days (Seo, Chen, Roh, 2017). Seven countries are on this route. In 2013 Chinese President Xi Jinping in Kazakhstan was promoting a plan aimed at the bilateral relations of China and its neighbors; however, the initiative had since then traversed the region's borders and become a global project (Sárvári, Szeidovitz, 2016).

Figure 2. Scheme of railway transportation by Trans-Siberian route
Source: (own elaboration based on SeaRates, 2018)

1. Background

The related article (Mathematical model for assessing the reliability of cargo delivery on the Caspian-Black Sea route of the New Silk Road) provides an analysis of Ukraine's participation prospect in the New Silk Road in general, not specifying actual points of the route.

All alternative routes must meet the requirements set for the Silk Road route, such as speed, safety, reliability, and cost-effectiveness. The route with better performance will have geopolitical and economic advantages in terms of making a final decision on the part of the Silk Road route. Some assessments were made for the route via the ports of Poti and Batumi to the EU countries (Toropov, Myronenko, 2017).

In our opinion, the most perspective and well-positioned route of the New Silk Road through Ukraine is Caspian-Black Sea route (Figure 3). It is descripted in terms of mathematical model proposed in the related article.

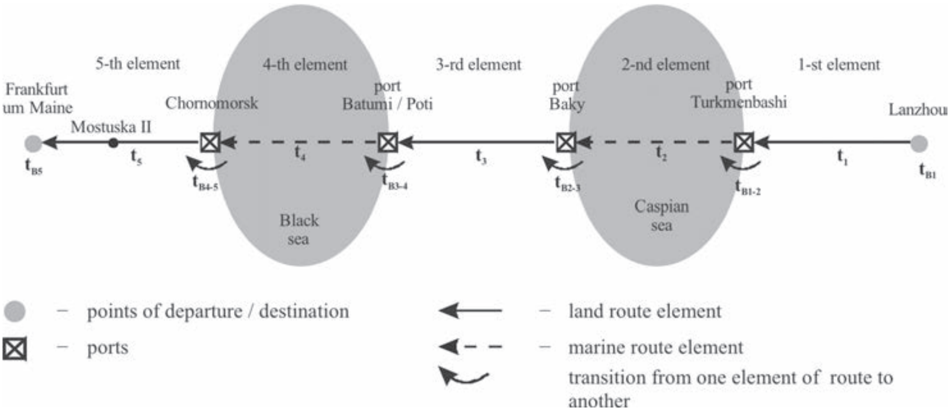

Figure 3. Caspian-Black Sea route through Ukraine
Source: (own elaborations)

2. Main part

The implementation of the cargo delivery chain within the proposed route of New Silk Road is possible only with the usage of inland and maritime modes of transport. The process of container delivery may be implemented in one or several options for combined rail and sea transportation.

If there is lack of alternatives to rail (especially high-speed) transport in the part of the land route, then in the part of the Caspian and Black Seas route, it is possible to apply several delivery options. Ways of organizing maritime connections:

1. Using *ferry lines*, in which railway wagons and cargo are transported by sea as single cargo modules. In this variant, rail cars (providing technical interoperability of the railways of all countries of the route) will rotate between the point of departure of the goods and the destination, that is, within the entire route of delivery.
2. Using *feeder lines*, in which the containers are overloaded at the junction points of rail and sea transport. In this case, the railway units will be rotated in isolation within the limits of the first, third and fifth technological elements of the route (Figure 3).

The key task of organizing any transport-technological line is to establish its rational parameters. With known running speeds, throughput and processing capacity of line elements and cargo terminals, capacity of ships and railways, required fleet of rolling stock units remains unknown.

Analytically the requirement of rolling stock units is determined by the time of route traffic, the required number of runs and the total time of the certain period (commonly – a day). However, due to the stochastic, probabilistic flow of goods it is impossible to avoid fluctuations and inter-operational downtime.

In order to assess the technological capabilities in providing the necessary delivery time for freight, we will conduct a research for using *ferry lines*. Since the delivery process is the interaction of five elements (rail – marine – rail – marine – rail) with stochastic formation of cargo flows, imitation modeling will be applied. Output parameters of the line are presented in Table 1, the requirement of rolling stock (defined analytically) in Table 2. The intensity of the receipt of containers at 275 per day corresponds to an annual volume of 100 thousand. Approximate investments in the new high-speed railways are 21 million USD per 1 km.

Table 1. Output parameters of the transport-technological line using the railway ferry

Route element	China – Caspian Sea	Caspian Sea	Caspian Sea – Black Sea	Black Sea	European part
Mode of transport	railways	marine	railways	marine	railways
Approximate distance, km	2000	400	750	1100	1500
Intensity, containers per day	275				
Average speed throughout the route, km / h	200	25	200	25	200
Time in motion, hours	10	16	3.75	44	7.5
Time in turnover point, hours	1.5	1.5	1.5	1.5	1.5
Movement time in one direction, hours	11.5	17.5	5	45.5	9
Time of turnover, hours	23	35	10	91	18
Approximate investments in the new high-speed railways, billions USD	42	–	15.7	–	31.5

Source: (own elaborations)

Table 2. The requirement of rolling stock units

Type of rolling stock	Time of turnover, hours	Capacity	Required number of trips per day	Rolling stock units
Railway units	177	30 TEU	10	75
Ferry (Caspian Sea)	35	135 wagons	2	3
Ferry (Black Sea)	91	135 wagons	2	8

Source: (own elaborations)

The simulation model is implemented using Java programming language and AnyLogic class library (Matsiuk, 2017). The flow of goods in containers is random (in exponential distribution) in both directions (China – EU and EU – China). The model did not take into account the decrease in the reliability of sea and rail lines operations due to the influence of external factors – weather, seasons, technical failures, human factors, etc.

In the implementation of the model with the parameters established by analytical calculations (Table 1 and 2), there is an extremely long delivery time of containers and significant delays in the promotion of goods at points of overload.

Therefore, a series of experiments with a gradual increase in the number of rolling stock units have been conducted. For ease of carrying out of measurements, the entire rolling stock fleet (Table 2) equally increased by a certain percentage. The criterion for evaluating the efficiency will be the average (in both directions) container delivery time. The results of experiments are presented in Figure 4 and 5.

It is logical that with the increase of rolling stock units of the time of container delivery decreases, but the delivery time of 88 hours (the sum of the graphs "Time of movement in one direction, hours" of Table 1) cannot be ensured even with substantial (three times!) increase of rolling stock units: the average experimental time is 154 hours (6,4 days) (Figure 5).

In addition, with a gradual increase in the number of rolling stock units (over 120 railway units), there is no decrease in time. Further rationalization of the delivery period is not possible due to an increase in rolling stock units.

Conclusions

Ukrainian railways, due to their well-developed infrastructure, can be a reliable partner in mastering mass traffic flows within the framework of the New Silk Road between China and Europe.

Even in spite of several overloads in combined transport (with the option of a route through the Caspian and Black Seas) it is technologically and technically possible to provide competitive terms for the delivery of goods between China and Europe (for example, between Lanzhou and Frankfurt) within 150 hours (approximately 6–7 days).

Of course, results can only be achieved if there are high-speed rail freight lines and a sufficient number of rolling stock units. Sufficient amount is a volume exceeding the calculated values for 1.5 times.

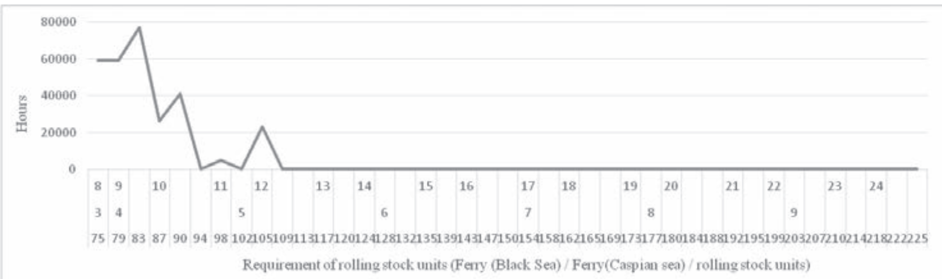

Figure 4. Dependence of the average term of goods delivery on the number of available rolling stock units (model time 20 years)
Source: (own elaborations)

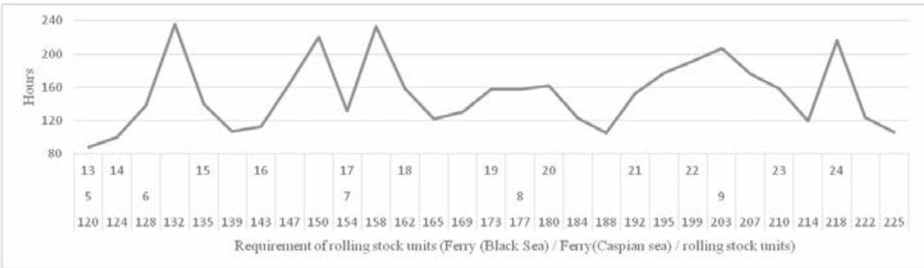

Figure 5. Dependence of the average goods delivery time on the number of available rolling stock units (in the range of 120–225 units)
Source: (own elaborations)

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