DEVELOPMENT OF RAILWAY TRANSPORTATION BETWEEN CHINA AND THE EUROPEAN UNION COUNTRIES

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***Abstract**: European and Chinese economies belong to the largest economies in the world. These economies are also heavily intertwined into bidirectional supplier-customer chain. Bilateral trade between European countries and China was in the nineties of the last century relatively weak. Development of the Chinese economy caused an increase in the volume of foreign trade. Chinese leaders began to promote the development of the New Silk Road. This trade route in addition to maritime has two railway routes - northern and southern. Since 2008 there has been significant development of connections and transport volumes on these routes. This article will deal with the analysis of the development of rail to rail routes, the New Silk Road.*

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1 Introduction

The main means of transport on the historic Silk Road were caravans that crossed from China through Persia and Arabia to the east coast of the Mediterranean Sea. Overland transport route was secured for a first time by the Roman Emperor Augustus, who negotiated peace with the Parthians in the year 20 BC. As the end of the original Silk Road is considered the year 1453 when the Ottoman Empire conquered Constantinople and refused to promote European trade.

The second mean of transport were ships that sailed from China past Indonesia, India and the Red Sea. The first regular naval links with China were introduced by the Portuguese in 1514. The third mean of transport was a train. In 1905 was completed a comprehensive rail line known as the Trans-Siberian Railway, which joined the Russian Far East and northern China with the European railway network.

The European Union and China are the biggest exporters and importers in the world (Eurostat 2016). For the effective functioning of foreign trade it is essential to ensure smooth logistics chains.

TAB. 7: Table of main export and import partners of the EU in 2015

	Main	Share (%)	Second main	Share (%)	Third main	Share(%)
Export partner of EU Member states in 2015	United States	21	China	10	Switzerland	8
Import partner of EU Member states in 2015	China	20	United States	14	Russia	8

(Eurostat 2016)

As is evident from TAB. 1, China ensured 10% of total exports of the EU countries in 2015. On the other hand, the EU imported from China 20% of the total imported products. It is therefore obvious that the material flows between these economies are enormous.

At the end of the last century the transport between the European Union and China was provided almost only by a ship or by a plane. But in the nineties Europe launched the Pan-European railway corridors project (TEN-T). Central Asia started to build a network of TRACECA (Transport Corridor Europe Caucasus Asia) and China began to modernize its railway network.

Nowadays it is possible to provide transport of goods between Europe and China not only by ships or planes but also by trains. These transport means are different in lot of aspects such as speed, costs, safety or environmental impacts.

Each kind of products has its own characteristics that must be considered in selected type of transport. Products which quickly become obsolete must be transported quickly to have been placed on the market as soon as possible. On the contrary, products that have a high density and their application is not urgent take advantage of low transportation costs. The main subjects of EU trade are machinery and transport equipment (42% of exports. resp. 31% of imports.) The second largest chapter is other manufactured goods. In this group are electronic components and products (23% of exports and 26% of imports) (Eurostat 2016). Electronic components and products often belong to a group of products which could become obsolete very quickly and slow transport could make them less competitive.

2 Literature review

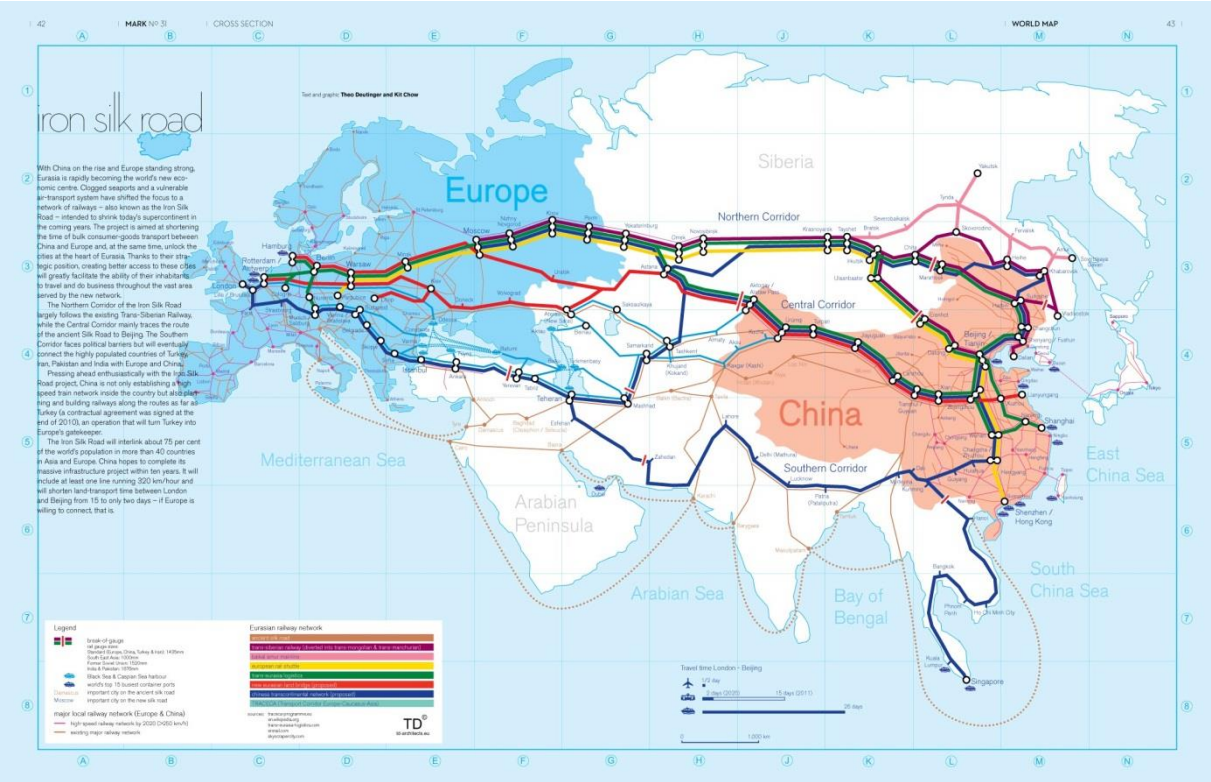
2.1 Development of Eurasia railroad

In 2008 the Deutsche Bahn and Russian Railways created a project of Trans Eurasia Logistics GmbH (TEL). Deutsche Bahn has prepared the first train Beijing - Hamburg. In 2010 began testing of usability of the Northern Route (via the Trans-Siberian Railway) and of the Southern Route (via Kazakhstan). A map of these corridors is can be seen in PIC. 1. In 2011 the first regular train between Germany and China was launched.

China launched the Project Silk Road economic belt in 2012. Aim of this project is to develop a modern silk route and support the international trade of China. The project aims to create three new

high speed rail corridors named The Iron Silk Belt. The first two corridors copy corridors that TEL is nowadays using. The third corridor (in the PIC. 1 the southern blue one) should be built in future linking Indonesia, China, India, Pakistan, Iran, Turkey and join the European network of corridors TEN-T.

PICT. 8: A map of train corridors between Europe and Asia (Strategic Demands 2016)



On both of current corridors there is a problem with rail gauge. China and Europe use same rail gauge (1.435 m) But Kazakhstan, Russia and Belarusian use broader gauge (1.520 m). Either the shipping containers have to be transloaded from one train to another or the bogies have to be exchanged on boarders.

The first regular route between the EU countries and China was Chongqing - Duisburg in 2011. In 2012 followed the routes Wuhan - Pardubice (for Foxconn), Chengdu to Lodz (Poland), Zhengzhou - Hamburg. All these routes are on the Southern Route via Kazakhstan. The first route on the Northern Route was opened Suzhou - Warsaw in April 2014 and later Changsha - Duisburg. The line Yiwu – Madrid was launched in 2014. Yiwu has thus become the first Chinese city with the classification of Tier 3, which opened regular rail link to Europe (Elsinga 2014).

2.2 Current situation and possibilities in railway transport

Fastest version of freight train is a blocktrain. It could be a company train for one customer or a public train for multiple customers. These trains can travel at top speed due to blocktrain prioritization. There is no shunting (only technical stops and transshipment stops at the border) (Schenker 2015).

Since 2015 it is possible to use other services than blocktrains. It is possible to transport a single container or container groups but there is a longer lead time due to train consolidation in open

intermodal system of railways. Next service is Less than Container Load (LCL) services. This service is provided by DB Schenker on blocktrains e.g. from Suzhou (Northern Route) or Chengdu (Southern Route) to Malaszewice. Door to door time is 20 – 23 days (Schenker 2015).

Hewlett Packard (HP), Acer and Foxconn began to look for an alternative of the transportation of the computer components from China to European factories. Hewlett Packard moved production from China's coastal areas inland to the city of Chongqing, where it produces components for the production, which takes place in Duisburg, Germany. Transport to the coast and the subsequent transport ships would be time consuming and therefore these components have been transported throughout Southern Route since 2011. DB Schenker was a pioneer of traffic on this route, which uses the rail network of Kazakhstan (Knowler 2014).

Kazakhstan is part of a customs union agreement with Russia and the European Union and once the block trains are cleared at the Kazakhstan border, which takes four hours, there are no further inspections, or delays, required until destination. Due to the procedure of preliminary customs information under the "electronic train" container train was made for 90 minutes(Kazakhstan temir zholy 2012).

DB Schenker operated about 800 trains in both directions in 2015. Westbound is approximately 70% (10 – 11 trains per week on westbound and about 15 trains per week on eastbound). These trains hauled 30, 000 shipping containers. Estimate of DB Schenker for the year 2016 is 1500 trains. TEL plans an increase up to 100, 000 containers per year by 2020 (Kemp 2016).

DHL 150 TEUs were transported by train between Europe and China. The company uses this type of transportation when there is a risk of delay of the delivery and transport ships would cause complications. DHL in 2015 established a regular rail connection between Zhengzhou and Hamburg, which runs twice a week (Knowler 2015).

Government of Hubei province announced that Europe - Wuhan freight trains ran a total of 164 shifts in 2015 (98 shifts of Outbound trains a 66 shifts of Inbound trains), carrying 14912 TEUs of container cargos. Cargos travel from Wuhan including electronic equipment, automobiles, clothes, general merchandise of companies such as Foxconn or Dongfeng. Cargos which came from Europe were plastic products, auto parts, cosmetics, timber, etc. Government of Hubei province expects 537 trains in 2016 only for this province (Huifang 2016).

If cargos are transported by ship from China to Europe, the transit time would be approximately 42 or 45 days and the price per one 40-ft container would be over 5,000 to 5,500 US dollars. Moving cargo by train, the transit time significantly decreases. Depending on the destination in Europe, it might take between 16 and 25 days. Unfortunately the speed comes with a price. The approximate price would be between 8,600 and 8,900 US dollars per container. And by air, at price of $3.85 per kg would cost $37,000 (Knowler 2015).

In the time before running rail connection was available almost all goods between China and the EU were transported by ships. Only smaller volumes were sent by air. Choice of transport mean depends on the characteristic of the cargo and how urgently it is required. Heavy, low-value cargo is sent by ships while high-value and time-critical cargo is flown by aircrafts.

Rail freight will compete mainly with air transport. Electronics and automotive manufactures are interesting in rail freight because the value loss on goods during the longer sea journey is high.

Schenker (2015) published the following information for transporting High Value Good (in this case it was a notebook) from Chengdu to Rotterdam in 2015. These data are shown in TAB. 2. Data were compared with data from other sources and has been found to be authentic.

TAB. 2: Table with data about transport of one notebook from Chengdu to Rotterdam in 2015

	Door to door lead time (days)	Cost of freight (USD/ one pcs of notebook)	Pollution (kg CO2 / ton)
ocean	38	1,9	391
blocktrain	22	3,8	270
air	4	18	5727

(Schenker 2015)

The alleged costs in TAB. 2 include only freight costs. The goods are the property of company and as such they have to be financed. During transport of goods capital is fixed in it. If the goods are being transported for a long time, then such transport may cause significant rise in capital costs. In the case of consumer electronics and other precious commodities, capital costs can reach a higher value than the cost of transporting goods. In the case when the capital costs are higher than 7% and one container contains goods worth more than USD 2 mil, cumulative freight costs and capital costs for transport by rail are lower than for transport by ship (Schenker 2016). For these goods, the transportation by rail is more economical than the transport by ships. In addition to these purely economic parameters, there can be other benefits found in rail transport. For the products that rapidly become obsolete, it is possible to better exploit market opportunities as the products reach the target markets sooner. If the semi-products are transported for further processing and shipment by rail it reduces the risk of subsequent stop in production due to failure of delivery of semi-finished products to the factory on time.

2.3 Risks

Goods in transit are exposed to various risks. Transport by air exhibits the lowest risk. It is the way of carriage with the bottom failure rate. There is not so high risk of theft of goods, of its loss or damage. Such services may be influenced by the weather.

Goods transported by sea are exposed to risks caused by adverse weather conditions, which can cause a delay in delivery of goods. According to the Maritime Riskmap (Control Risk Group 2016) goods must pass risk areas in the South China Sea and Malacca straight and risk areas off the Somali coast. South China Sea is risky due to dispute about ownership of area which is rich in natural resources.

Railway transport is the least dependent on the current weather. But all existent railroad corridors lead across Russia and there are some political tensions between Russia and EU. Escalation of these tensions could lead to problems with transport.

3 Methodology

The aim of this paper is to prepare a table for Multi-criteria decision making about modus of transport between EU and China.

In the literature review the following criteria were mentioned: Door to door lead times, Cost of freight, Pollution, Capital costs and Risks. In this article, the multi-criteria analysis will be performed only for the first three criteria mentioned above. Capital costs are negligible for certain products and the current risks of transport on the roads are relatively low so these factors are not included in the analysis. If necessary, the user can add other criteria following the described procedure and include it in the decision-making process.

Weight Sum approach will be used as a decision method. The reason for this choice is the quantification of the criteria. Another reason is the user's ability to adjust the weighting of the criteria based on current conditions (launching new products, increasing consumer pressure on environmental behavior, etc). The choice of weights will be based on recommendations of an expert in the field of transport for the standard product, not based on a product that could become obsolete as a consequence of longer transportation time thus binding larger amount of capital during transport and increasing its cost. The most important objective is the perceived costs of transportation (60%), followed by transport time (30%) and then the last one is the environmental impact of transportation (10%).

The decision process will be designed for transport of one notebook from Chengdu to Rotterdam in 2015.

In this article the weighted sum will be used according to (Jakob, W. &, Blume, Ch. 2014). The result of this method will be one non-dominated solution with highest utility.

This method is suitable because there are objectives functions with different scales. These scales will be normalized by functions:

$$f_i^{norm} = \frac{\max(f_i) - f_i}{\max(f_i) - \min f_i} \quad \text{for objectives to be minimized} \qquad (1)$$

$$f_i^{norm} = 1 - \frac{\max(f_i) - f_i}{\max(f_i) - \min f_i} \quad \text{for objectives to be maximized} \qquad (2)$$

The bounds of all criteria can be identified by a user. In this article will be used maximal value in each objective in this case study. Calculation of utility (weighted sum) is shown in the next equation. Weight wi has to be selected for each objective.

$$\max \sum_{i=1}^{k} w_i f_i^{norm} \; where \; w_i \rangle 0 \; for \; all \; i = 1,...,k \; and \; \sum_{i=1}^{k} w_i = 1 \qquad (3)$$

The type of transport with maximal utility will be recommended as a best choice for this case.

4 Analysis

As it was mentioned above the analysis will be carried out from data of DB Schenker for transportation of one notebook from Chengdu to Rotterdam in 2015 see TAB. 2.

A user can adjust the bounds of every objective according to their present needs. For example they know that the product needs to be imported to Europe in 45 days - then the maximum value (max fi) of the first objective is substituted by 45. In this analysis values of max fi and min fi will be substituted with the real limit values for each objective. By combining the table TAB. 2 and the limit values we obtain table TAB. 3. The table also shows specified weights wi, as suggested by experts (0,3; 0,6; 0,1). The sum of the weights must be equal to one and size of the weight indicates the importance of the given criterion.

TAB. 3: Table with data about transport, limit values and weights

	Door to door lead time (days)	Cost of freight (USD/ one pcs of notebook)	Pollution (kg CO2 / ton)
ocean	38	1,9	391
blocktrain	22	3,8	270
air	4	18	5727
Max fi	38	18	5727
Min fi	4	1,9	270
wi	0,3	0,6	0,1

Each value must be normalized. All criteria in this case are minimized so we use the formula (1). Calculation for a normalization of the first criterion for blocktrain will be as follows:

$$f_i^{norm} = \frac{4-22}{4-38} = 0{,}4706 \tag{4}$$

In the same way we normalize all values and we get table TAB. 4. The last calculation is the calculation of a weighted sum as shown in the following equation (5) for ship transportation. These values are also shown in Table 4 too. On the basis of these values the order of the variants is determined.

$$\sum_{i=1}^{k} w_i f_i^{norm} = 0*0{,}3+1*0{,}6+0{,}9778*0{,}1 = 0{,}6978 \tag{5}$$

TAB. 4: Table with normalized values and with values of aggregated value of the utility

	Door to door lead	Cost of freight	Pollution	Utility	Order

	time (days)	(USD/ one pcs of notebook)	(kg CO2 / ton)	(Σ wi*fi)	
ocean	0	1	0,9778	0,6978	2.
blocktrain	0,4706	0,882	1	0,7704	1.
air	1	0	0	0,3	3.
wi	0,3	0,6	0,1		

From the aggregated value of the utility it is clear that for the setting of the decision making process of this case study transportation by rail has the highest total utility value. This type of transportation wins despite it is best only in one criterion (pollution). Furthermore, this criterion has very little weight (wi= 0.1). However, this variant reached balanced results in more important criteria and thus ultimately obtained greater value of aggregate utility than other types of transport. On the second place is the transport by ship. This transport is very slow, causing zero utility value of this criterion.

As an option with the lowest value of utility is in this case air transport. Which is indeed very fast modus, but also it is very expensive and has strong negative impact on the environment.

Conclusion

International trade between the EU and China is and will be very important for both economies. Modernization of transport infrastructure in China and Kazakhstan being in progress in recent years can therefore raise expectations in further development. Every commodity and every commercial transaction has unique characteristics which influence the choice of transportation modus. The aim of this article was to propose a simple methodology for preparing data for the decision-making managers. In this case study, according to the data available for 2015, rail transport appears to be the best type of transport. However, if the user changed the setting of weights, or range of limits, then the results will be different. Likewise, the results would be affected by involvement of other criteria, such as capital costs or risk elements. The author, however, believes that in most settings of the decision-making process the rail transport will still be the best choice. This opinion is supported by a relatively significant annual increase in the volume of railway traffic between the EU and China. This development thus supports the economic growth of all countries involved.

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