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Eurasian Rail Freight in the One Belt One Road Era

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Abstract
This paper presents an overview of the recent development of Eurasian rail freight in the One Belt, One Road Era and further evaluates its service quality in terms of transit times and transport costs compared to other transport modes in containerised supply chains between Europe and China. A trade-off model of transit time and transport costs based on quantitative data from primary as well as secondary sources is developed to demonstrate the market niche for Eurasian rail freight vis-a-vis the more established modes of transport of sea, air, and sea/air. In a scenario analysis, further goods attributes influencing modal choice are employed to show for which cargo type Eurasian rail freight service is favourable.

According to our calculations, Eurasian rail freight is about 80% less expensive than air freight with only half of the transit time of conventional sea freight. Our scenario analysis further suggests that for shipping time sensitive goods with value ranging from 1.23 USD/kg to 10.89 USD/kg as well as goods with lower time sensitivity and value in a range of 2.46 USD/kg to 21.78 USD/kg, total logistics costs of Eurasian rail freight service beat all other modes of transport. Hence, Eurasian rail freight seems to be an option beneficial in terms of transport cost, transit time, reliability and service availability, which enables shippers to build up agile and sustainable supply chains between China and Europe.

Keywords
One Belt, One Road; Belt and Road Initiative, container block train; quality of service; transport cost; transit time

1. Introduction
In 2013, the term ‘One Belt, One Road’ (OBOR) came into the spotlight as China’s masterplan initiative to revive the Ancient Silk Road was announced by Chinese president Xi Jinping. The OBOR initiative (or shortly BRI following NDRC, 2015) is often communicated as a “national vision” and “foreign strategy” towards regional cooperation, and it is also mentioned in relation to infrastructural project construction and investments (van der Leer and Yau, 2016).

Basically, the BRI includes two major parts - the New Silk Road Economic Belt and the 21st-Century Maritime Silk Road (hereinafter referred to as the Belt and the Road respectively).
Both represent a network of ports, railways, roads, pipelines, and utility grids connecting China with Central Asia, West Asia, and parts of South Asia, Europe, and Africa (NDRC, 2015; Tian, 2016). Though, the BRI is more than just physical connections (Tian, 2016), it provides a blueprint framework for Chinese diplomatic, commercial, and foreign infrastructure policies to get access to new markets for trade and investments (van der Putten and Meijnders 2015). The aims of the BRI are to (1) promote connectivity of Asian, European and African continents via land, sea and air, (2) establish and strengthen regional cooperation and partnerships among the countries along these routes, and (3) facilitate flow of economic resources and integration of markets (Song, 2015). Currently, the Eurasian rail freight only take a small share of the total transport volume between China and Europe (Kaplan, 2016). However, with a rapid growth of freight transport on the rail routes along the Belt, the Ancient Silk Road trading routes are coming back to life again as container block trains, have emerged as an alternative transport mode there in recent time (see Figure 1).

![Figure 1: China-Europe rail freight continues to soar](source: CRCT (2018))

In terms of transit time, a typical container block train from e.g. Chongqing to Western Europe takes at present 14 to 20 days on the Belt route, which is half of the time than shipments spend on the Road route with 31 to 48 days (Kaplan, 2016; Kuester, 2017; Seo et al., 2017). In terms of transport costs, rail is regarded to be much cheaper than pure air transport (Davies, 2017). Therefore, with a speed advantage against sea and price advantage against air, Eurasian rail freight seems to fit a market niche in modern supply chains with great potential to grow its market share in the future. It is expected, that the potential rail freight volume on the Belt routes will grow 50 times from 2012 to 2020 (Luica, 2013) and according to the five-year development plan issued by the Chinese National Development and Reform Commission (NDRC), the number of trains is expected to reach 5,000 by 2020 (Luo, 2017).

Although these really impressive figures circulating, research in Eurasian rail freight between China and Europe is so far subject to merely anecdotal empirical evidence, consultancy work or policy studies (Davydenko et al., 2012; UNECE, 2012, 2017; Galushko, 2016; Jakóbowksi et al., 2018; Vinokurov et al., 2018) and only a few recent scholarly contributions are worth mentioning like Rodemann and Templar (2014), Chen et al. (2017), Besharati et al. (2017), Seo et al. (2017), or Panova et al. (2018), as well as some in Chinese language discussed in Liu et al. (2018). Other recent works like Song and Na (2012), Regmi and Hanaokab (2012), Tsuji (2013) or Moon et al. (2015) focused on transports via Trans-Siberian Railway with a short sea leg from China, South Korea and/or Japan to Russian Far East.
The aim of this paper is to provide an objective overview of the present Eurasian rail freight market. Therefore, desk research of sources available in English, Russian and Chinese language are complemented by interviews with main players being active on this market. In the following, common routings, major players, present bottlenecks and service quality issues of Eurasian rail freight are discussed in Sections 2, before the trade-off between transit times and transport costs compared with other modes of transport followed by a scenario analysis based on cargo type to demonstrate the market nice for Eurasian rail freight services in Section 3. The paper concludes then in Section 4 with a discussion of the results in a wider context, followed by managerial implications, limitations and suggestions for further research.

2. Eurasian Rail Freight Transport in the OBOR Era

Dating back more than 3,000 years, the Ancient Silk Road emerged between Asia and Europe, it ran 15,000 km between the old capital city Xi’ an in China and the Roman Empire, connecting China, India, Persia, Arabia, Egypt and Rome along the route (Otsuka, 2001; Lin, 2011). Commodities such as silks, gems, gold, silver, carpets, tea, paper, spices were carried by camels or donkeys transporting between Asia and Europe (Otsuka, 2001), as Marco Polo recorded in the late 13th century, it took him four years to travel along the entire Ancient Silk Road by foot (Woods, 2015). Later in the 17th century, as European voyagers thrived the maritime trading route, this land route faded out due to its overall longer transport time (Otsuka, 2001).

However, the emerging Eurasian land bridge revives the Ancient Silk Road as a land route for trading between east and west – not by camel or donkey but by railway (Otsuka, 2001), and goods remain in the same container for the entire intermodal journey (Rodrigue, 2017). It connects cities in Europe with Russian Far East and China by railway lines running through East Asia, Central Asia, Southern Russia, Eastern Mediterranean, Arabian Peninsula and Europe (Lin, 2011). Given that at least some parts of the Eurasian land bridge follow the same track with the Ancient Silk Road, thus it is also called “New Silk Road” or “Modern Silk Road” (Zhang, 2013; NDRC, 2015). This New Silk Road includes two major rail land bridges between Europe and Asia as shown in Figure 2, namely:

- **The Trans-Siberian Railway** (TSR, or First Eurasian Land Bridge) served as the main land bridge between Russian Far East and Western Europe from the late 1960s until the early 1990s (Lilliopolou et al., 2005; Pieriegud, 2007). The TSR starts from the Russian Far East Pacific seaports Vladivostok and Nakhodka running west through Russian Federation to Moscow, and further reaches European countries such like Finland, Latvia and Poland through different rail routes (Zhang, 2013; OSJD, 2017), at the east end, maritime links connecting the aforementioned Russian seaports with China, South Korea or Japan are also considered as natural extension of the intermodal transport routes of this traditional Eurasian land bridge (Zhang, 2013).

- **The New Eurasian Land Bridge** (NELB, or Second Eurasian Land Bridge) originally spans from the pacific port of Lianyungang in China running through China, Kazakhstan, Russian Federation, Belarus to Rotterdam in the Netherlands (Islam et al., 2013; OSJD, 2017) with a variety of intermodal terminals as points of origin and destination in between.
Figure 2: Route of the Trans-Siberian Railway (red) and the New Eurasian Land Bridge (green), Source: http://en.osjd.org/dbmm/download?vp=68&load=y&col_id=121&id=258

2.1. Present Eurasian Rail Freight Main Route Characteristics

The abovementioned TSR and NELB are the current two main routes connecting Asia to Europe (Sárvári and Szeidovitz, 2016). Notably, these two major Eurasian land bridges consist of several train routings across various countries with individual branch lines that partially share the same main line sections as well (Rodemann and Templar, 2014). They can be described as follows:

**The Northern Corridor** provides three alternative branch lines connecting China and Europe via TSR (Islam et al., 2013, Galushko, 2016), namely:

- China – TSR via Alashankou/Dostik and transit through Kazakhstan (Kazakh route)
- China – TSR via Erenhot/Zamyn-Uud and transit through Mongolia (Mongolian route)
- China – TSR via Manzhouli/Zabajkalsk (Manchurian route)

Trains on this route start somewhere in China, head via one of the three border crossings for the TSR toward west and enter European Union at Brest/Malaszewicze, Chop/Dobra or (but to much less extent) via Estonia, Latvia, Lithuania, and/or the Russian exclave of Kaliningrad (OJSD, 2017). However, it is noted that the classic TSR line starting in Vladivostok or Nanchodka is not considered in the BRI development strategy (Sárvári and Szeidovitz, 2016).

**The Central Corridor** provides an alternative east-west route through Kazakhstan and Russian Federation to connect China and Europe called NELB. Trains on this route cross the Chinese-Kazakh border at Alashankou/Dostik or Altyndol/Khorgos and usually run further west via railway lines south to the TSR towards the aforementioned border crossings to European Union. This route is the main target of the Belt in the BRI (Sárvári and Szeidovitz, 2016).

Meanwhile, it is worth to mention that there is **the Southern Corridor** called the Trans-Caspian International Transport Route (TITR, http://titr.kz/en) upcoming which runs through Kazakhstan, the Caspian Sea, Azerbaijan and Georgia further to Turkey, Ukraine or European countries. However, this routing requires at least one ferry trip across the Caspian Sea, and transcends Caucasus towards the Black Sea or Turkey to reach Europe and these multiple border crossings, ferry trips and current geopolitical issues in the Caucasus region make it rather unattractive at present (Sárvári and Szeidovitz, 2016).

2.2. Current Development of Eurasian Rail Freight Services

In March 2011, China launched the China Railway Express (CRE) freight service with the aim to enhance connectivity with markets in Central Asia and Europe along the Belt of BRI (Luo, 2017). Originating from different parts of China, these container block trains have different
routings: trains starting in the western part of China like Urumqi, Chongqing, Chengdu and Wuhan go via Alashankou or Altyndol to Europe, whereas trains from the east coastal and northern region such as Putian, Suzhou and Zhengzhou leave China via Manzhouli or Erenhot and follow the TSR to Europe (Luo, 2017; OSJD, 2017; CRCT, 2018). By end of 2017, the main intermodal terminals on the European side were Malaszewicze, Warsaw, Duisburg or Hamburg, with some dedicated block trains also end at Budapest, Klaipeda, Lodz, London, Madrid, Muuga, Nuremberg, Pardubice, Riga, Rotterdam, Schwarzheide or Tilburg (OSJD, 2017; CRCT, 2018).
<table>
<thead>
<tr>
<th>Market Player</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Container operator</strong></td>
<td>Container carrier, organises dedicated block trains or single container transports</td>
<td>InterRail Services, Russkaya Troyka, Hupac International Logistics, Far Eastern Transport Group (DVTG)<em>, Far East Land Bridge (FELB)</em>, China Railway Express (CRE)<em>, Sino Railway</em>, Hunan Xiang Ou Express Logistics*, Hao Logistics*, YuXinOu Logistics*, Yiwu CF Intl. Logistics*, HLT Intl. Logistics Ningbo (H&amp;T)<em>, Wuhan Asia-Europe Logistics (WAE)</em>, etc.</td>
</tr>
<tr>
<td><strong>National railway company</strong></td>
<td>Provision of traction, infrastructure, wagons, tariff policy</td>
<td>Russian Railways (RZD), Belarussian Railways (BC), Kazakhstan Railways (KZH)<em>, Chinese Railways (KZD)</em>, Deutsche Bahn (DB)<em>, Polish State Railways (PKP)</em>, Latvian Railways (LDZ)<em>, Railcargo Austria</em></td>
</tr>
<tr>
<td><strong>Affiliated company for container transport</strong></td>
<td>Organises and operates intermodal transport on behalf of railways</td>
<td>DB Intermodal, TransContainer, KTZ Express*, United Transport &amp; Logistics Company (UTLC)<em>, CRIntermodal</em>, China Railway Container Transport (CRCT)<em>, Trans Eurasia Logistics (TEL)</em>, YuXinOu Logistics*</td>
</tr>
<tr>
<td><strong>Container owners</strong></td>
<td>Owns containers for own transport and/or leasing; shipping companies, leasing companies</td>
<td>Maersk, Evergreen, Seaco, China Railway Express*, Far East Land Bridge (FELB)<em>, TransContainer</em>, Far Eastern Transport Group (DVTG)<em>, Pantos Logistics</em>, China Railway Container Transport (CRCT)*, etc.</td>
</tr>
<tr>
<td><strong>Terminal operator</strong></td>
<td>Handling of containers on behalf of container transport companies and container owners</td>
<td>Deutsche Umschlaggesellschaft Schiene-Strasse (DUS), TransContainer, Duisport*, Russian Railways (RZD)<em>, Far Eastern Transport Group (DVTG)</em>, CRIntermodal*, China Railway Container Transport (CRCT)<em>, PKP Cargo</em>, KTZ Express*</td>
</tr>
<tr>
<td><strong>Railway agency</strong></td>
<td>Books transport on behalf of train operator</td>
<td>Kaztransservice, Transrail, Belintertrans*</td>
</tr>
<tr>
<td><strong>Customs agents</strong></td>
<td>Customs clearance on behalf of forwarders</td>
<td>Far Eastern Transport Group (DVTG)<em>, PKP Cargo</em>, United Transport &amp; Logistics Company (UTLC)<em>, TransContainer</em>, Pantos Logistics*, Belintertrans*</td>
</tr>
</tbody>
</table>

Table 1: Principal market players in Eurasian rail freight container transport

Source: Davydenko et al., (2012), Pieriegud (2007), updates by the authors indicated with “*”

Currently, most of the goods transported on these Eurasian rail freight routes between China and Europe are mainly household appliances, machinery and equipment, automotive vehicles and spare parts, food and beverages, garment and electrical products (Wang, 2017). The type of cargo transported by rail gradually shifted to higher value-added goods (Sárvári and Szedovitz, 2016), whereas the types of cargo on the return trips from Europe to China are high-value automotive products and luxury products as well as foodstuff and beverages.

Furthermore, it is important to understand who the major players in this container block train market are. As there is no central organization or an integrated corridor management platform, these Eurasian rail freight corridors comprise a variety of different market players due to the railway systems spanning multiple countries and operators, which forms a complex contractual network (Davydenko et al., 2012; UNECE, 2017; Jakóbowski et al., 2018). Table 1 shows principle market players in Eurasian rail freight container transport as identified by Davydenko et
al., 2012), Pieriegud (2007), and updated based on author’s desk research and interviews with main players in the Eurasian rail freight market.

2.3 Bottlenecks in Eurasian Rail Freight Operations

With its obvious advantage over traditional sea freight and air freight between Asia and Europe, Eurasian rail freight has been witnessed a growing trend of popularity in recent years. However, operating long-haul container block trains across multiple countries in short time is not easy, as complex legal environment, technical limitations, physical constrains, capacity limits, and political issues post bottlenecks in Eurasian rail freight operations (Islam et al., 2013). In the following, some current bottlenecks in Eurasian rail freight operations will be elaborated.

Complex legal environment: As these block trains cross various countries, consequently, political and legal differences occur which has been identified as the primary bottleneck in Eurasian rail freight operations (Rodemann, 2013). From the operation perspective, differences in transport and customs law lead to arbitrary transport documentation and border crossing procedures (Kallas, 2012, Galushko, 2016, Jakóbowski et al., 2018; Zhu and Filimonov, 2018) which slows down transit time and heavily affects service reliability. But at least some recent improvements can noted: (1) the International Rail Transport Committee (CIT, https://www.cit-rail.org) established a combined CIM-SMGS consignment note as a commonly accepted transport document along the Belt route (Galushko, 2016), (2) the foundation of the Eurasian Customs Union (EACU, http://www.eurasiancommission.org) including Russian Federation, Belarus, and Kazakhstan in 2010 eased at the same time transit through these countries and (3) China joined the TIR Carnet transit framework in 2017 which will allow soon end-to-end transit operations (UIBE and IRU, 2017). However, along the Eurasian rail freight routes, national monopolies in railway operations are still common so that no free market entry is possible. This is again a major inhibitor, too, especially due to the fact that at present, almost all container block trains between China and Europe have to pass through Russian territory (Rodemann, 2013; Jakóbowski et al., 2018).

Technical limitations: Along the New Silk Road, railway technology lacks unified standardization which hinders interoperability of railway systems (Galushko, 2016, Panova et al., 2018). For example, Russian Federation, Kazakhstan, Belarus as well as other Commonwealth of Independent States (CIS) countries have broad gauge (1,520 mm), while China and most European countries use standard gauge (1,435 mm). Automatic gauge change technologies are existing but not in wide-spread use, so that either boogies of wagons have to be exchanged or cargo have to be trans-loaded onto wagons with the correct gauge wide at least two times between China and Europe. However, the wide-spread use of 40’ containers (FEU) ease these interoperability issues considerably - but it still takes about two to four hours to complete the trans-load for a container block train. Beside this, technical infrastructure of railways en route such as double track lines or electrification cannot taken for granted, which will also hinder an uninterrupted transport (Liu, 2014).

Physical constrains: Rail operators always tend to use longer trains to make transports, customs and documentations process more efficient (Woods, 2015). However, in China, a block train can carry around 55 FEUs, on the TSR up to 75 FEUs, while in Europe, they are usually limited to max. 44 FEUs, and also all freight trains have to give priority to passenger trains. Besides, there is also limit on the structure gauge (or minimum clearance outline), in line with height and width of tunnels and bridges that allow a train to access. Due to limited clearance for two FEUs put on each other, container block trains running between China and Europe cannot run double-stacked to add on capacity. What’s more, extreme weather condition with minus 40°
Celsius in Siberia can be a challenge for many sensitive goods. But according to Woods (2015) and InterRail (2017), nowadays containers for such block trains are equipped with thermal insulation and active temperature control systems whenever necessary.

**Imbalanced cargo volume:** In general, demand for goods exported from China to Europe is higher than the other way around. Accordingly, the number of westbound block trains are about three times of the eastbound ones (InterRail, 2017; Besharati et al., 2017; Vinokurov et al., 2018, Jakóbowski et al., 2018). Reasons for this discrepancy are that (1) unlike in maritime shipping, intermodal terminals in China are not co-located with distribution hubs and onward carriage to final destinations may add up costs (Sárvári and Szeidovitz, 2016), (2) many Chinese companies still hesitate to use the Belt route (Seo et al., 2017), and (3) it is not easy to fill eastbound containers with European goods demanded at China as Russian Federation has imposed a ban on both import and transit of certain European food stuff through its territory and so containers and wagons leave Europe quite often empty (Brinza, 2017; Jakóbowski et al., 2018). However, a trend towards a more balanced ratio of westbound and eastbound cargo volumes has been witnessed by major players such as DB Schenker (Woods, 2015) and InterRail (InterRail, 2017).

### 2.4 Service Quality

It is commonly agreed that service quality is characterised by customer’s perception on service (Shainesh and Mathur, 2000), so that it can be defined as “the difference between customer expectations of service and perceived service” (Shahin, 2006). Accordingly, when service quality is to be evaluated, the difference between the services that customers expect and the services perceived has to be examined. There are an array of factors and determinants to measure service quality (Prasad and Shekhar, 2010). The most common used metrics for measurement of service quality is called SERVQUAL, firstly proposed by Parasuraman et al., 1988). There, five dimensions - tangibles, reliability, responsiveness, assurance and empathy are used as basic instruments for service quality measurement in order to examine gaps between expectations and perceptions (Parasuraman et al., 1988; Zeithaml et al., 1990). Although the SERVQUAL instruments has been widely used, proven to be valid and reliable in different service contexts, they still need to be modified and adapted to reflect specific service settings (Prasad and Shekhar, 2010). Based on the SERVQUAL metrics, RAILQUAL has been developed as a service quality scale to measure the rail service quality passenger transport with three additional dimensions - convenience, comfort and connection - added to the basic five SERVQUAL metrics (Prasad and Shekhar, 2010). To understand the service quality of freight transport, there are an array of variables proposed by researchers in investigating shippers’ freight service decision choice between different transport modes. Matear and Gray (1993) applied principal components analysis to explore the underlying structure of the service choice decision for shippers and freight suppliers when choosing between sea and air modes of transport (see Table 2). Five principal component - carrier, route, timing, price characteristics and control over other parties have been considered as important factors in modal choice.

Among these five principle components, Matear and Gray (1993) pointed out that frequency, reliability (i.e. punctuality concerning time of arrival) and capacity (i.e. the availability of freight space) are the most important ones. Later on, Rodemann (2013) as well as Seo et al., 2017) confirmed that transport cost, transit time, as well as transit time reliability are the major modal choice decision criteria concerning goods transports between China and Europe.
### Table 2: Service attributes for service choice decision

*Source: Adapted from Matear and Gray (1993)*

<table>
<thead>
<tr>
<th>Principal Component</th>
<th>Service Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier characteristics</td>
<td>Arrival time; Fast response to problems; Handle special requirements and urgent</td>
</tr>
<tr>
<td></td>
<td>deliveries; Good relationship with carrier.</td>
</tr>
<tr>
<td>Route characteristics</td>
<td>Proximity to origin and destination; Optimised route choice.</td>
</tr>
<tr>
<td>Timing characteristics</td>
<td>High service frequency; On time collection and delivery; Short transit time;</td>
</tr>
<tr>
<td>Price characteristics</td>
<td>Low price; Value for money price; Special offer or discounts.</td>
</tr>
<tr>
<td>Control over other parties</td>
<td>Transport preference of trading partner; Documentation completed carrier.</td>
</tr>
</tbody>
</table>

#### 3. Comparison of Transport Modes

Now we want to examine the service quality of rail freight compared to the other current existing transport solutions carrying containerised cargo between China and Europe, namely sea, air and sea/air transport modes. As mentioned before, transport cost and transit time have been identified as the two major components contribute to the service quality of freight transport. To achieve this purpose, a trade-off model and a scenario analysis will be constructed based on transport costs and transit time, to compare the cost and time differences of sending a containerized shipment from China to Europe by sea, air, sea/air, or rail respectively.

#### 3.1. Data Collection

Quantitative data obtained in this study includes quotes of transport, transit time, distance of each routes for each mode on each route (see Table 3). In order to maintain the integrity and reliability of data collection process, freight rates for rail and sea/air were requested from major container operators or forwarders through direct contacts in Austria, Germany, China and Kazakhstan and average freight rates for sea and air were retrieved from Freightos (http://www.freightos.com) and SeaRates (http://www.searates.com). Both freight rates and transit times presented are averages based on a sample of quotations for each transport leg.

Furthermore, a set of assumptions have been made to make the different modes comparable:

- Transport routes are all terminal-terminal intermodal, excluding local cartage service at both origin and destination. Accordingly, ancillary costs (i.e. fees for customs clearance, security checks, agency, insurance, document and container handling) are not included.
- Freight rate quotations for all modes of transport are for a FEU full container load (FCL) freight-all-kinds. The cargo transported in a FEU by sea and rail is assumed max. 20 tonnes, and for air and sea/air max. 10 tonnes. Concerning transport capacity, it is assumed that max. 45 FEU can be transported per block train, max. 3 FEU per plane (Rodemann, 2013; Woods, 2015) and 9,000 FEU or more per vessel by sea (Rodemann, 2013).
- Transit times stated were as indicated by the freight operators or forwarders. However, delays caused by congestions at intermodal terminals, border crossing points, documentation handling processes still occur on a regular basis (Galushka, 2016).

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1 The sea/air concept is a multimodal transport of cargo by sea on its first leg followed by air which comes along with „half the time half the cost“ (Raguraman and Chan, 1994).
<table>
<thead>
<tr>
<th>Data Collected</th>
<th>Data Type</th>
<th>Source</th>
<th>Collection Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>FEU FCL freight rate for all possible routes from Asia to Europe, transit time along major corridors</td>
<td>European and Central Asian block train operators, Chinese and Central Asian rail freight forwarders</td>
<td>Direct contacts, online enquiries, site visits, skype call meetings</td>
</tr>
<tr>
<td>Sea</td>
<td>FEU FCL freight rate from China to Germany, Transit time for the routes Route distance</td>
<td>Freightos.com, SeaRates.com, Drewry container freight rate monthly report</td>
<td>Online enquiries, secondary data collection</td>
</tr>
<tr>
<td>Air</td>
<td>Unit rate (per kg) and transit times from China to Germany</td>
<td>Freightos.com, SeaRates.com</td>
<td>Online inquiries</td>
</tr>
<tr>
<td>Sea/Air</td>
<td>Unit rate (per kg) from China to Germany, Transit time for the routes</td>
<td>European freight forwarder, Sea/air freight operator</td>
<td>Direct contacts, Emails, Secondary data collection</td>
</tr>
<tr>
<td>Distance</td>
<td>Separate distance of each transport leg and total distance of each route</td>
<td>SeaRates.com, Ecotransit.org</td>
<td>Online enquiry</td>
</tr>
</tbody>
</table>

**Table 3: Data collection summary**

It is noted as all the primary data from direct contacts were collected during the period from 1st June to 31st July 2017, freight rate quotations and transit times stated may be subject to change due to the volatility of the freight rates in the marketplace. In this sense, the freight rates and transit times presented here reflect a “snapshot” of current market situation and need to be considered in a more general context.

### 3.2 Transit Times and Costs Comparison Results

To build up a realistic and at the same challenging scenario, Shanghai in China and Hamburg in Germany were selected as the origin and destination points, as both cities have a seaport serving as a major container hub with direct connection on the China-Europe trade lane and are quite often used when it comes on freight rate benchmarking.

Table 4 summarises the transport costs and average transit times of shipping a single FCL shipment of one FEU from Shanghai to Hamburg for four modes of transport on a terminal-terminal basis for 2017 compared to figures raised by U.S. Chamber of Commerce (2006) with sea/air calculated separately based on historical freight quotations available to the authors.

By freight rate, sea was and is still the cheapest option and air is very much higher than the other modes. Sea/air transport costs are around half of air, whereas Eurasian rail freight is about 80% less costly than air and ranked next to sea as the second cheapest option. In terms of transit time, which includes the actual time of transport plus time when a container is waiting at terminals or borders crossings for customs clearance or trans-loading gauge changes etc., air (3 to 5 days) is by far the fastest transport solution from China to Europe, and rail (14 to 16 days) or sea/air (18 to 20 days) are about half of the time than sea (usually 30 to 34 days, but could be much longer when a container is subject to transhipment en route).
Table 4: Transport costs and transit times for different transport modes in 2006 and 2017


Furthermore, these different modes of transport come along with different routing, so that the distance of each mode travelled varies and cost per kilometres is in line with the total transport cost of each mode. In terms of average transport speed, sea/air (about 843 km/day) is faster than rail (about 704 km/day), but due to its slower sea leg (about 627 km/day), the total transit time of sea/air is still higher than Eurasian rail freight.

Finally, most striking is a significant shift of transit times in the past decade from 45-50 days to 16 days on average with now only 1 or 2 days of variation due to different routing. While rail freight rates have shown a slightly decreasing trend in recent years as well, the transport costs decreased from 8,450 USD to nowadays 6,350 USD for a FEU from Shanghai to Hamburg. On some specific routes from inland China cities (i.e. Chongqing or Changsha) to Germany via Kazakhstan, these transport costs can be even lower with around 3,700 to 4,500 USD due to subsidies granted by Chinese government (Bresharati et al., 2017; Qiwen and Xianliang, 2017; Vinokurov et al., 2018).

3.3 Scenario Analysis Based on Cargo Type

In the previous section it has been discovered that rail comes along with much shorter transit time than sea and much lower cost than air which qualify it to be an alternative mode of transport to fit into the market niche of shipping high-value and time-sensitive goods. But goods transported by Eurasian rail freight cover a wide range from high value goods such as luxury products, machinery and equipment, automotive vehicles and spare parts, time-sensitive goods such as food and beverage, to general commodities such as textile and construction material.

Goods are considered to be time sensitive when they are subject to depreciation and uncertain demand due to “inventory holding costs, perishability, rapid technological obsolescence, and uncertain demand” (Hummels, 2007; Hummels and Schaur, 2013). Furthermore, inventory holding costs include capital cost of the goods in transit, cost of buffer stock at destination warehouse to accommodate variation in arrival time. In addition to this, depreciation costs include spoilage of perishable goods or rapid technological obsolescence. Hence, time of goods spend in transit will impose a combination of inventory holding and depreciation costs on consumers.

Moreover, Hummels and Schaur (2013) defined estimated value of time per day transit time which depends mainly on the value of cargo and expressed these time costs in tariff equivalents.
by calculating the estimated value of one day saved in transit for each product. To reflect how much consumer’s value of timely delivery for the full range of product categories being traded and shipped, it was estimated that each day of goods in transit is equivalent to a tariff of about 1% per day levied on value of cargo for most goods employing trade and shipping data from U.S. imports of merchandise database. This estimation varies over the type of goods, as bulk products and raw materials are less time sensitive than complex manufactures and perishable goods are subject to rapid depreciation, such as fresh fruit and vegetables (Hummels, 2007). As the daily depreciation rate of goods with high time sensitivity and high value can be as high as about 2%, one day in transit translates into a tariff equivalent of 2%.

When combining these findings with transit times and transport cost figures as shown in Table 4, estimated values of time per days in transit can now be employed for scenario analysis to include time sensitivity and value of cargo transported. Then the value of time in transit (defined as a combination of inventory holding and depreciation cost) allows to assess the relations between transport costs, transit time and total logistics costs for goods of high versus low time sensitivity between different modes of transport. Or more strictly defined:

- Inventory holding and depreciation costs are incorporated in form of a tariff equivalent as a proxy. In line with the estimations of Hummels and Schaur (2013), this tariff equivalent is set to 1% per day of cargo value for goods with lower time sensitivity, and 2% per day for goods with higher time sensitivity.
- Calculation of total logistics costs only include the direct transport costs and indirect inventory holding and depreciation costs during the transit expressed in this tariff equivalent.
- An average shipment is assumed to be 10 tons per FEU, so that cargo value in USD per kg can be easily calculated and compared over all four modes of transport.

Results of the scenario analysis are shown in Figure 3 and can be summarized as follows: Whenever goods shipped have a low time sensitivity, and cargo value is around 2.55 USD/kg, rail is almost equal to sea and after around 21.78 USD/kg, air gets cheaper than rail. If goods shipped have a high time sensitivity, rail is already cheaper than sea for cargo values of higher than 1.23 USD/kg and air is then cheaper when cargo value is higher than 10.89 USD/kg. Hence, in both scenarios, sea is the cheapest mode of transport when cargo value is low. Then rail fits into the niche and becomes the cheaper solution for cargo values ranging from relative

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**Figure 3: High time vs. low time sensitivity scenario**

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low value to average and high value goods with sea/air always coming along with higher total logistics costs.

To interpret these results, it is important to understand value/weight ratios and carrier liability for cargo. According to own calculations based on EUROSTAT COMEXT dataset DS-016890 from 2000-2013, the export price of goods traded between China and European Union (EU) ranges from around 6 USD/kg to 23 USD/kg, and the majority share of the products have a value under 6 USD/kg. Moreover, it is important to note, that carriers on all transport modes have certain liability limits for loss or damage of goods being transported. For example, air carrier liability is limited to about 26 USD/kg (or max. 19 SDR/kg following to Montreal Convention of 1999 or IATA Resolution 600a), in rail freight it is max. 22 USD/kg (or max. 17 SDR/kg according to CIM of 1999 and SMGS of 2015 with no limitation other than value of cargo) and in sea freight usually max. 3 USD/kg (2.5 SDR/kg in Hague-Visby Rules of 1968, see e.g. https://www.ivt-int.org/en/basics/).

Based on the above findings, preferred modal choice can be split in 2x2 scenarios as follows:

**Scenario I: High-value cargo with high time sensitivity:** Whenever cargo value is above 12 USD/kg (120,000 USD per FEU), it can be generally considered as high-valued (U.S. Chamber of Commerce, 2006). This is especially true for automotive spare parts and high-tech products, which may require frequent weekly replenishment. In this scenario, air with the shortest transit time of less than one week and most of the time lowest total logistics costs is the most favourable solution. However, whenever special space and weight limitation occur for air, rail with less restriction on cargo type and much larger capacity available might be an alternative solution at least in some cases.

**Scenario II: High-value cargo with low time sensitivity:** High-value cargo with low time sensitivity can be luxury garments and leather goods. In this scenario, rail with about 2 weeks transit time is able to cover a wide range of goods from 2.46 USD/kg to 21.48 USD/kg with the lowest total logistics costs in comparison to all other modes of transport.

**Scenario III: Low-value cargo with high time sensitivity:** When the average cargo value is around 6 USD/kg (60,000 USD per FEU) or less, this can be considered as low-value cargo. In this scenario, for goods with short lead-time demand (e.g. high-fashion apparel, electronic appliances), rail continues to be the favourable option with half of the transit time than sea and much lower transport cost and larger capacity than air. Rail is able to provide cheapest total logistics cost for a range from 1.23 USD/kg to 10.89 USD/kg.

**Scenario IV: Low-value cargo with low time sensitivity:** For the majority share of transport goods with low-value of less than 2.46 USD/kg, sea with by the far largest shipping capacity available is the cheapest solution closely followed by rail.

### 3.4 Discussion of Results

BRI must be considered as a major enabler to the rapid development of Eurasian rail freight within the last decade and it can be regarded favourable for three reasons:

**Faster than sea and cheaper than air:** In Section 3.2, a general comparison based on the costs and transit times among rail, sea, air and sea/air was conducted, which pointed out that Eurasian rail freight is about 80% cheaper than air with only half of the transit time of sea. Besides, a historical shift of its positioning in the market has also been captured - its transit time has significantly shortened from one month (or more) to only two weeks or even less. The driving force behind this significant improvement of its service in recent years can be traced back to two main factors. On one hand, BRI focuses on the Central Corridor rather than the traditional
Northern Corridor, which helps to boost domestic economy in the rural west part of China, as well as avoids to deal with Russian monopoly on the TSR. Therefore, new railway infrastructure projects and dedicated container block train services launched under BRI have greatly revived Eurasian rail freight. On the other hand, changes to global trading patterns and increasing demand for the speed to market also drive the development of intermodal logistics solutions both within Europe and along the New Silk Road (Davies, 2017).

**Alternative to air for time-sensitive goods:** Certainly, a pure transport cost comparison is not sufficient, as other costs occur during the transport process like inventory-holding and depreciation cost are worth to take into consideration. Therefore, in Section 3.3, they have been incorporated to compare the total logistics costs of rail, sea, air as well as sea/air where rail stands out as the most favourable transport solution when it comes on time sensitive goods with a cargo value ranging from 1.23 USD/kg to 10.89 USD/kg. In the past, air used to be the only option when shipping high-value, time-sensitive goods. But as transit time shortened and transport service got more reliable, rail becomes a perfect alternative for time-sensitive goods, especially for those with average cargo value not necessarily worth to be transported by air. Besides, rail freight with higher capacity than air can accommodate almost all kinds of containerized cargo, which again demonstrates higher service availability.

**Alternative to sea for low-value goods:** Again, our scenario analysis found that when shipping goods with low time sensitivity, rail would be the cheapest option for cargo ranging from 2.46 USD/kg to 21.78 USD/kg. Sea used to be the best option for low-value goods. However, present short-term flexibility tactics executed by liner shipping companies like slow steaming and rerouting of vessel as well as blanking of sailings results in longer and less reliable transit times (Munim and Schramm, 2016) and this cannot fulfill the requirement for today’s agile supply chains. In this case, rail with a speed advantage over sea can also cover a wide range of goods from low to high value. Instead of to upgrade from sea to air (or sea/air), rail gives the customer a window of opportunity to meet deadlines without bearing full expense of air (Davies, 2017).

Since the global economy continues to slow down, the world searches for new engines to drive trade growth, the BRI offers “a major development framework and opportunity for connectivity, international trade and economic development” (Davies, 2017). The momentum of Eurasian rail freight has already been witness to enhance connectivity and trade growth between China and Europe. Implications of this on supply chains can be summarized as follows:

**Not competition, but another option:** Our calculations in Section 3.2 clearly demonstrate that Eurasian rail freight service is an emerging competitive solution - faster than sea and significant cheaper than air. However, rather than being seen as a threat, it provides a potential alternative for companies that no longer like to consider air (or sea/air) as the only options when shipping high-value and/or more time-sensitive goods. This offers a cost-efficient option to tailor freight lead time relevant to production (Davies, 2017).

**The value of short transit time:** Matear and Gray (1993) suggested that when shipper and freight forwarders making the decision on freight service choice, transit time is frequently considered as more important than a low freight rate. As shown in Section 3.3, a substantial amount of inventory holding and depreciation costs will add up to the total logistics costs during transport if transit time of a shipment is too long. This is especially critical for perishable or time-sensitive goods with frequent changes in consumer preferences (U.S. Chamber of Commerce, 2006). Eurasian rail freight with shorter transit time than conventional sea and higher reliability is able to help shippers to reduce total logistics costs and gain more flexibility on cash flow and liquidity.
**Bring agility to supply chains:** Shorter and more reliable transit times give Eurasian rail freight advantage of higher accountability. On one hand, this will allow companies have more control over their logistics operation and production forecasting (Zhang, 2013); on the other hand, it will encourage companies conduct “just-in-time” business practices with timely delivery in order to reduce production costs by minimising inventory (U.S. Chamber of Commerce, 2006). In addition, with more frequent scheduled container block trains and adding more terminals of origin and destination, the Eurasian rail freight service is able to offer a variety of end-to-end routing options, which again gives shippers more flexibility than sea and air. Moreover, high reliability of service delivery and flexibility of service availability will bring agility to company’s supply chains, which potentially offer companies a chance to tailor made their supply chains based on different product categories.

4. **Conclusions**

This paper examined the service quality of Eurasian rail freight based on transit times and transport costs, and a scenario analysis with a special focus on cargo type and associated total logistics costs has been used to identify its market niche. Taking a transport of a FEU from Shanghai to Hamburg as an example, we found that present Eurasian rail freight service fits into the sweet spot between the sea and air; it is about 80% cheaper than air with only half of the transit time of conventional sea. Our scenario analysis further suggests that when shipping time sensitive goods with cargo values ranging from 1.23 USD/kg to 10.78 USD/kg, rail is cheaper than all other modes of transport and much faster than sea - the same is valid for goods with lower time sensitivity ranging from 2.46 USD/kg to 21.78 USD/kg.

Moreover, some practical recommendations on the way forward for Eurasian rail freight service development in the OBOR era should be noted. On strategic level, high-level collaborations among government of countries and railway stakeholders along the Belt of BRI are required to establish favourable legal and technical agreements to facilitate Eurasian rail freight operations. On operational level, keep rail freight rates low to maintain competitiveness, optimise routing to lower transit times, target market to seize profit, improve public awareness to gain business are recommended for Eurasian rail freight operators to keep developing in this new OBOR era. Reflecting research process and findings, some limitations have to be remarked. First, this paper intends to examine the service quality of Eurasian rail freight and compares it with other modes of transport. By doing this, it focused on two quantifiable attributes – transport costs and transit time. However, there are other important attributes that contribute to service quality as well, such as transit time reliability, service availability, environmental impact etc., which were mentioned in the paper but not included in the comparison model. Second, given that the Eurasian rail freight market is still in its infancy state (Sárvári and Szeidovitz, 2016), rail freight quotes collected by the authors may not fully reflect long-term competitive freight rates that companies get in the markets, as freight quotes obtained e.g. from freight forwarders might be already being bundled with other value-adding services on top of bare costs of rail transport. Moreover, Chinese government is providing subsidies to Eurasian rail freight operations under BRI (Bresharati et al., 2017; Qiwen and Xianliang, 2017), which may to some degree hide real costs of transport service provision. Beside this, costs of local cartage service at both origin and destination as well as other ancillary costs were not included in our calculations. In sum, this study does not intend to provide a pricelist for individual business decisions, however it does offer guidance for assessing transport options available for shippers. Last but not least, much larger data samples, specific cost models and detailed market insights are required to get the full picture. Accordingly, further research could investigate traffic volume on the different rail routes as shown in Section 2.1. to capture the Eurasian rail freight market landscape, thus to identify
market demand for rail and to provide recommendations for further route optimisation. Moreover, some key attributes of service quality briefly outlined in Section 2.4, such as transit time reliability and service availability not explicitly included here may be subject to surveys to capture full aspects of service quality. Finally another direction for further research would be to collect more detailed data of freight costs and transit time which enables to compare total logistics cost of shipping goods from specific origins to destinations by rail, sea, air and sea/air respectively.

References


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