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Development Status and Future Trends for Eurasian Container Land Bridge Transport

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Abstract: For decades, trade between Europe and China has grown consistently, which has resulted in increased container transportation volumes. Such transportation has been dominated by sea-based options. However, over the years, an air-based mode of transport was developed, while it has lately become increasingly popular to use railways utilizing the Trans-Siberian land bridge. This latter approach boomed amid the COVID-19 crisis in 2020. However, the railway container boom in Eurasia has deeper roots than just the COVID-19 era. As is illustrated in this research work, international trade containers (trade between Russia and other countries, mostly China) and transit containers (e.g., serving the Chinese–EU route) were already showing some significance as early as 2003–2004. In 2020, their volume was already measured in the millions, regardless of the railway data source being used. This is well above the starting period in the 1980s and 1990s, when total annual volumes were around 0.1 million twenty-foot equivalent units (TEU). Container capacity has developed over the years, first being used for international trade and only lately for transit. As a preliminary comparison to air freight, the growth rate was roughly double that in the two-decade observation period.

Keywords: container volumes; analysis; Europe; Asia; railways; air; sea

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1. Introduction

Individuals wishing to familiarize themselves with Eurasian transport and trade volumes might be disturbed by various statistics provided by different countries and regions. For example, f1or the year 2020, the Chinese state-run media stated [1] that a total volume of 1.14 million twenty-foot equivalent units (TEU) was transported between China and Europe using railways (referring to information from the China State Railway Group). However, if the same number is taken from Eurasian Rail Alliance (ERA) sources (the ERA is owned in equal parts by Kazakh, Russian, and Belarussian railways), this figure is approximately 50% lower, at 0.547 million TEU [2]. However, growth percentages do not differ that much, as Chinese sources indicate 56% growth from 2019 and the ERA in turn estimates 64%. In Europe, a common reporting body does not exist, and Eurostat figures can be delayed by several years; however, earlier research has shown that even Eurostat figures can differ from these two other sources mentioned earlier [3]. At the country level, statistics exist for railway transport. Even though these numbers give a disturbing impression and are not accurate, they still might serve a purpose. It could be that the typically highest numbers arising from China (e.g., [4]) incorporate all European container transport, also including Russia, Belarus, Ukraine, and other non-European Union (EU) member countries. As statistics are further analyzed in other countries, it cannot be excluded that countries leave out some of the calculations, as definitions do vary. Additionally, railway routes also vary—nowadays, the most popular Trans-Siberian route is through Kazakhstan to China [5]; however, in the very beginning (the 1970s and 1980s),

it was through the Far Eastern sea ports of Russia (from where it was convenient to reach Japan) [6].

If developments in other transportation modes (sea and air) are examined for the year 2020, it could be said that sea-based container transport, in terms of volume, probably declined (United Nations Conference on Trade and Development (Unctad) estimated it to be 6.9% lower than in 2019 [7]). However, freight rates at sea increased drastically—in May 2020, the rates were still below USD 750 per TEU (between Shanghai and Central Europe); however, they vary significantly, increased up to nearly USD 4100 in late December 2020 [8]. Many issues have been argued to have led to this difficult situation with sea containers. One explanation is the lack of empty containers, while other explanations are the high demand for physical products in the west (due to continued lockdowns and unavailability of services and travel), the fiscal stimulus provided in the west and the lack of resources for sea ports, sea vessels, and terminals [9]. Air freight was also on a declining path in terms of volume, due to the fact that passenger transport was so severely reduced in 2020, as much of the air freight still travels together with passengers in the same planes [10]. However, a similar upwards pricing trend was observed for air freight. Based on the International Air Transport Association's (IATA) statistics, air freight charges nearly doubled in 2020 from late 2019. On specific routes, the Baltic Air Freight index showed in December 2020 that for the Hong Kong–Europe route, prices were up 46.2% in a year [11].

In this article, we use an analytical and quantitative approach as the research method and utilize different statistics (second-hand data). Our examination approach is longitudinal. For sea container statistics, we rely on Unctad's annual Review of Maritime Transport, specifically regarding Asia–Europe route volumes [7,12–14]. For air freight, we utilize EU's Eurostat figures and take all EU airports and their freight volumes to and from China, India, Japan, and South Korea from different years [15]. For railway container transport between Europe and Asia, we base our statistics on Russian sources, such as the Coordinating Council on Trans-Siberian Transportation (CCTST) [16] statistics (currently called the International Coordinating Council on Trans-Eurasian Transportation—ICCTET). This is motivated by the fact that most of the railway volume comes through the Trans-Siberian Railway route (see Figure 1) in one form or another (either utilizing Russian sea ports in the Far East, the Manchurian hinterland connection, the Mongolian hinterland connection, or the Kazakh hinterland connection). In an earlier study by Bucsky [3], Russian statistics were at a middle ground between Chinese and European Union statistics. Using Russian statistics also gives us an opportunity to include international transport volumes (international meaning export and import to and from Russia, as well transit passing through Russian territories), as Russia for the most part (after the Ural Mountains) belongs in geographical terms to Europe.

This research work is structured as follows. In Section 2, we review the history and development of container transportation across the Trans-Siberian land bridge. As can be seen, development has progressed through Japanese, Finnish, and Chinese transit eras from the 1970s onwards. In Section 3, long-term data concerning the three main transportation modes between Europe and Asia are analyzed. As expected, volumes are dominated by sea transport; however, railway volumes and shares have increased substantially over the years. In addition, air freight shows volume growth also. The research work is concluded in Section 4, where we also propose avenues for further research.

Figure 1. Four different options of Eurasian container landbridge. Denotation: "1. Kaz", Kazakh hinterland connection; "2. Mon", Mongolian hinterland connection; "3. Man", Manchurian hinterland connection; "4. TSR", Trans-Siberian connection through Russian Far Eastern sea ports. Source (background map): © OpenStreetMap contributors [17].

2. Container Transportation in Trans-Siberian Landbridge

It took nearly two decades from the initial usage of containers in USA for this system to reach the Trans-Siberian landbridge [6,18]. In fact, the first wave of implementation was made in the midst of the Soviet era, and international transportation services provided an opportunity for the railway sector to earn "hard currencies" from abroad. There was significant transportation need outside of the Soviet Union as the Japanese economy and its foreign trade grew very strongly in the 1960s and 1970s. However, sea transportation prices for containers were too high, and there were military conflicts all over the Middle East. Then, it was natural that other different solutions were under examination, such as using the Trans-Siberian landbridge. This provided good connectivity to the Middle East for Japanese products (like reaching Iran), but also that of connecting with Central Europe and Finland. Based on Sahi [19] initial lead times of this route were rather long in 1970 e.g., from Finland to Japan, namely two months. However, with investments, new management approaches (weekly scheduled blocktrains to both directions) and experience gained resulted in lead times between Finland and Japan decreasing to 18–19 days. This huge improvement required only three years to be materialized (taking place already in 1973). Japanese volumes in the landbridge grew almost without interruptions from the early 1970s until the peak in volumes, which was experienced in 1984. At the height, container volumes were above 100,000 TEU. From this year onwards, volumes declined without much recovery, and reached TEU levels of a few thousand in the early 2000s. As Mote [6] concludes, even in this first wave of container transportation, railway border-crossing capacity and constraints became visible between Belarus and Poland. This was planned to be avoided by taking container trains to the Lithuanian sea port of Klaipeda and using it for final delivery rail ferry to reach Germany. Another weak point of this route was the Far East and the sea port of Vostochny. Mote [6] mentions that there were severe troubles due to weather and container congestion in the sea port during 1981–1982, and

it could have been the first series of events and changes leading to the declining use of this route.

After Japanese volumes started to be less and less significant, and as the Soviet Union collapsed in 1991, the entire Trans-Siberian landbridge was mostly serving the new economy of Russia and nation's foreign trade needs in container transportation. Needs were vast in Russia as there was a lot of consumption potential, and exports boomed with an increase in raw material prices. However, based on our understanding, volumes did not grow in this period that much from the highest volumes of Japanese era in the 1980s. Some new seeds of growth were sown for international container transportation as the Finnish route started to grow in the late 1990s with the same principal structure of starting from Finland and proceeding through St. Petersburg and Moscow and eventually reaching the Far East end of Russia. Sea ports in the Far East were used to take containers to and from Japan, South Korea and parts of China. According to Hilmola and Panova [20], volumes in 1998 were 10,000 TEU, and they reached 124,000 TEU in 2004. However, this very positive development was basically lost in a few months as Russia increased railway tariffs for international transports [18,20,21]. Volumes in 2006 declined by 90%, and the Finnish route (this classical route using Far East sea ports) never returned to its earlier heights. Volumes declined to a few thousand TEUs in 2008–2010. However, it should be noted that even though major transit traffic disappeared from this route, the landbridge was increasingly being used for Russia's own foreign trade purposes [22]. Therefore, in route terms, the landbridge became again more local, as it was when the Japanese-driven first wave was diminishing in its importance.

It took a few years for the Finnish-led wave to reach the Chinese wave, which we are currently living through. This new international dimension is also the main reason for the growth of container transportation in the landbridge during 2020. According to Lasserre et al. [23], China had several trials with Germany in 2008 and 2011 for container transportation in this route, and development started to take off due to the Chinese announcement of the One Belt and One Road (OBOR) program in 2013. There were several reasons for Chinese interest in this new route. One of them is the economic development of the country: regions in China other than coastal regions are increasingly the location of manufacturing and trade, and many cities would be in a difficult and expensive logistics position to develop further without international railway connections. Bucsky [3] argues that deficit in service trade of China is another difficulty—by having transports mostly arranged through Kazakhstan and Mongolia, this means that a higher amount of transportation work is done in China (in international shipping, China is a major player; however, other nations also do have an important presence, as shown in Huang et al. [24]). In addition, environmental reasons should not be forgotten—railways compete in the first place within a continental framework with airlines. It would not be possible for China to rely on air freight during times when its high-tech industry is growing—it would be simply unsustainable. On top of these reasons, the largest trading country in the world needs diversity in its supply chains and transportation modes.

What is new in the Chinese-led wave of the landbridge is the vast amount of routes used. Supply chains are no longer dependent on Far Eastern sea ports of Russia. They could be used, of course; however, this connection mostly relies on pure hinterland connection through Kazakhstan to China (with two main border-crossing points) and directly to numerous cities of China with populations in the millions. Another hinterland option is to use the Mongolian route. Typically, different research works argue that lead times in this route between Europe and China range from 12 to 19 days [23,25–28]. However, even shorter lead times are possible, such as just above 10 days [27]. In this new era, volume development has been impressive—in every year since 2013, volumes have grown in this route between Europe and China. There have been on numerous occasions doubts about volume growth, and this was especially true in 2019 as the Chinese government and local government subsidiaries [28] for railway transports were further shrinking [29]. However, in the year 2020, mostly due to the global virus pandemic, volumes grew further and very

strongly, even though subsidiaries were getting lower. In many respects, this new era of growth recalls Japanese and Finnish experiences—after the initial founding and start of use, the route has grown nearly without any interruptions. In the Japanese situation, growth continued for 13 years, and in the Finnish case for six years. In earlier situations, maximum levels have been above 100,000 TEU. The current Chinese growth wave already has volumes of more than 500,000 TEU per annum, and it has been continuously growing for seven years to the present. Similar caveats also exist that were present before—the Belarus–Polish border-crossing point has been experiencing significant challenges due to the lack of capacity, and in addition, transportation is not in balance. The latter issue, and having a balance between east- and westbound, are important for railways. This enables cost efficiency in a two-point transportation corridor.

Very few studies exist that have evaluated the long-term potential of the Europe–China landbridge railway transports. Dunmore et al. [25] estimated that there is a possibility that in the year 2040, railway volume will be as high as 3 million TEU per year. Growth would comprise a combination of long-term transportation growth and then a modal share shift from air and sea to rail (this shift is enabled with numerous investments made and planned in the Eurasian rail infrastructure).

Despite international transit of China on landbridge, over the years, local country-level container transportation needs for foreign trade have been increasing due to the increased trade between China and Russia. Even in environments with lower raw material prices, this trade has been growing in recent years, and Russia's overall trade with China is already larger than that of the UK or India [20].

3. Longitudinal Analysis of Container Transportation in Asia-Europe Route

It should be emphasized that it is a very demanding job to precisely estimate the volume and share of railway transportation in containers within the route from Asia to Europe. Nowadays, there is also exists an opportunity for container transport through the southern route, where Turkey is the main connecting country between Asia and Europe (Traceca) or through the "central route", which proceeds entirely through Kazakhstan, a relatively small stretch through Russia and then through Ukraine, eventually reaching Central Europe [30,31]. In this research, we are only concentrating on the Trans-Siberian landbridge, which has different options to reach destinations at the Far Eastern end (like the Kazakh route, the Mongolian route, the Manchurian route and the route through Far East sea ports of Russia). Therefore, in the followingm we are not taking into account any flows through Traceca and/or Central route (in overall Russian statistics, some volumes from these might be included). In Trans-Siberian volumes, we calculate together Russia's own international trade and transit containers. This might inflate total volume somewhat as some containers surely remain on Asian side of Russia; however, most of them will reach the European part. Many manufacturing units of European companies also exist in Russia, and some imported containers must serve manufacturing units (e.g., automotive or machinery), where their final products reach European markets.

For first estimates, we are using as railway container transportation data of CCTST/IC-CTET [16], which includes all northern routes of the Eurasian landbridge (classical Trans-Siberian route to Far East sea ports of Russia, Manchurian route, and Mongolian route). In the period of 2008–2020 container transportation between Europe and Asia was showing an overall increasing trend (Figure 2). Growth from 2008 to 2019 was 33.5%, and from 2008 to 2020, it will be around 25%. In 2008, total volumes were 19.5 million TEU, and in the global financial crisis year 2009, they declined to 17.5 million TEU. However, with some minor setbacks in 2012 and 2015, container transportation has in other years increased. Of course, COVID-19 in the year 2020 will lead to a similar larger loss in volumes, what was experienced in 2009; however, the overall trend is still clearly upwards. In relative terms, the expected volume drop in 2020 will be smaller than in 2009 (−10.6% vs. −6.4%); however, in volume terms, they are close to each other (−2.1 mill. TEU vs. −1.7 mill. TEU) compared to the previous year volumes.

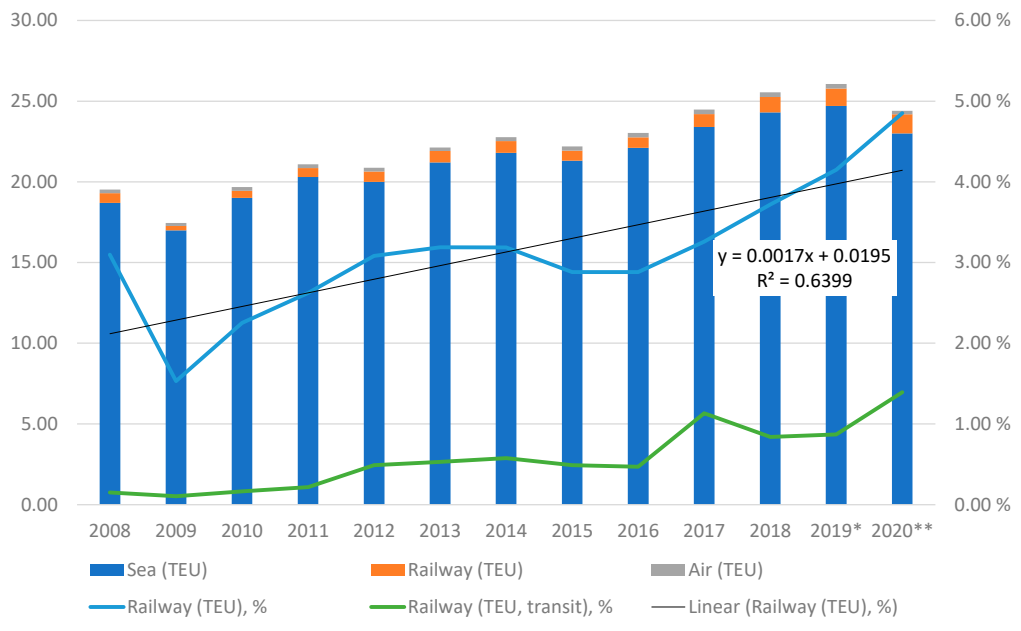

Figure 2. Container transportation volumes between Asia and Europe within three different transportation modes (air freight converted to TEU with assumption of 10 ton per TEU container; million TEU). Denotation: *, railway container volumes estimated with data ending to August 2019; **, railway container volumes estimated within international transports with an average growth in 2009–2018; railway data based on Coordinating Council on Trans-Siberian Transportation and International Coordinating Council on Trans-Eurasian Transportation (CCTST/ICCTET) [16]; air freight estimated with first three quarters of 2020 [15]; sea containers based on Unctad [7].

From examining Figures 2 and 3 further, it becomes evident that railway container transportation has been consistently increasing in the longer term within the observation periods. The current share out of overall transportation volumes is somewhere around 4–5% (estimated volume in 2020, 1.2 million TEU). If only transit containers are taken into account, the share is around one percent. The share of railway mode was lowest in 2009, when it declined to 1.5% when both international and transit containers are included, and with only transit it was 0.1%. Railways tended to behave unexpectedly in downturns, as in 2009 and 2015 its share declined, but in 2012 and 2020, it experienced notable growth in relative terms. It has been reported that in 2009, the rise of the US Dollar rate against the Russian Ruble led to the escalation of export transshipments in ports (raw materials, minerals, such as coal), which, in turn, revealed the problems of insufficient capacity of the Russian railway and its drawbacks in the logistical scheme of cooperation with the ports [22]. Partly due to this, the Government of the Russian Federation approved the federal target program "Development of transport system in Russia (2010–2020)" with the heavy investments devoted to the reconstruction of the latitudinal railway route—Baikal-Amur Mainline (BAM) stretching in parallel to the Trans-Siberian Railway [32]. However, it should be recalled that in Figure 2, the linear regression line with a rather high R^2 value shows that the average growth in railway share is 0.17% per annum—the years 2019–2020 are somewhat above this linear curve, but not abnormally so.

If indexed development from 1999 onwards is examined and compared to air freight, it becomes evident that after 2011, the growth of the Trans-Siberian landbridge (on its northern part) in containers has had a much higher rate (Figure 3). The time periods of 2003–2008 and 2011–2014 as well as also a recent period of 2017–2020 illustrate its impressive ability to grow. It is notable that growth has been taking place in two recent growth periods, when air freight has experienced growth challenges and has even declined. In the observation period of Figure 3, railways have grown 14–16 times, where air freight has shown growth of 5–6 times. Figure 3 shows equations and curves of linear regression models concerning

the indexed growth, and annual co-efficient of growth in rail is 2.4 times higher than that of air (0.607 vs. 0.2532). However, it should be remembered and emphasized that the base year of 1999 favors Trans-Siberian railways somewhat as larger development programs only began to be initiated then.

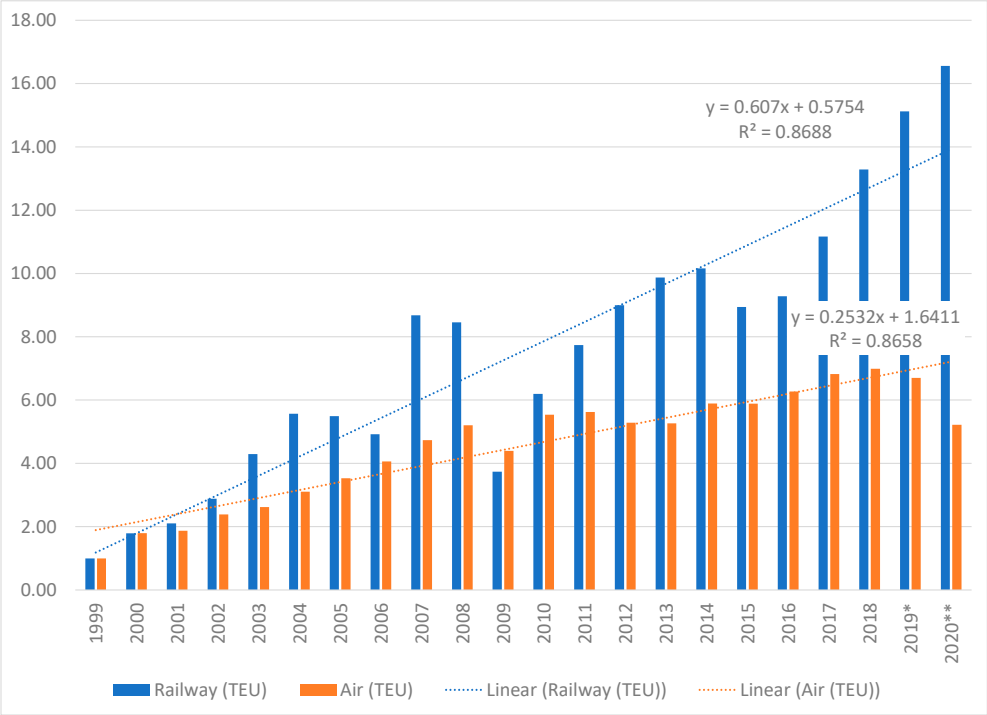

Figure 3. Container transportation volume development between Asia and Europe within transportation modes of rail and air (indexed, year 1999 = 1). Denotation: *, railway container volumes estimated with data ending to August 2019; **, railway container volumes estimated within international transports with an average growth of 2009–2018; air freight estimated with first three quarters of 2020.

For many, 2020 was the year of COVID-19 and also a year of Chinese container trains reaching European markets on a massive scale. However, as analysis illustrates, this change took place much earlier, basically from international transports of containers through Trans-Siberian landbridge. The bigger change started somewhere in 2011–2012. It is just now that this disruption and wave of change reached the European Union on a massive scale within 2020; however, there is clear evidence that railway container transports within Eurasia landbridge are on long-term growth mode. This situation is also true of Russian railways in general, as Figure 4 illustrates. Overall volumes are approaching 6 million TEUs, as they were just above 2 million TEU at the beginning of the decade.

As can be seen from Figure 4, transit container flows in 2020 exceeded 800 thousand TEU. Of the more than 500 thousand containers that passed through the route via Kazakhstan, while along the Trans-Siberian northern route only slightly more than 200 thousand containers, and through the Far Eastern ports, 74 thousand TEU. Almost all transportation through border crossings at the Eastern range reduced the volume of transit cargo [40]. About 15 years earlier, more than 50% of transit containers of Russian Railways were transported via the Trans-Siberian northern route [41]. However, since 2015, and more noticeably since 2016, the Eurasian Corridor (through Kazakhstan) volumes have begun to contribute to the overall Trans-Siberian landbridge transit container flows [42]. According to the plans of Russian government from May 2018, four times higher volumes of transit containers via Trans-Siberian landbridge should be gained by 2024 (1.656 million TEU) [43]. The International Union of Railways is less optimistic in this regard, and in 2017, the esti-

mated prospective volume of railway transit traffic between Europe and Asia at 1.5 million TEU by 2027 [44].

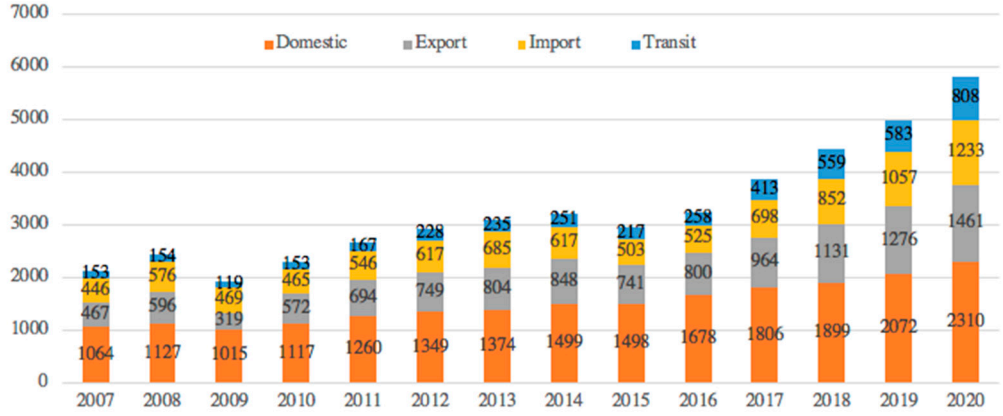

Figure 4. Overall container transportation on the network of Joint Stock Company (JSC) Russian Railways (in '000 TEUs). The data are based on the following sources [33–39].

If these Russian railway data from international and transit transports are used as an indicator of Trans-Siberian landbridge for all routes, then railway volumes and shares are of course higher (Figure 5). Development is, however, similar to what is shown in Figure 2. However, these data include all international and transit transports of Russian railways and will include some volumes from Europe, Middle East and Central Asia, and it could be considered as a somewhat biased and inflated examination approach. On this basis, the share of railway mode in container transportation would already be around 13% (est. volume of 3.5 million TEU); the linear regression model shows that railway share is increasing by 0.46% per annum, and the model also has a rather high R^2 value. If only transit containers are taken into account, the share is currently 3%. The overall market decline in 2020 would also have been somewhat lower, indicating a 4.2% decline from the year earlier (1.18 mill. TEU).

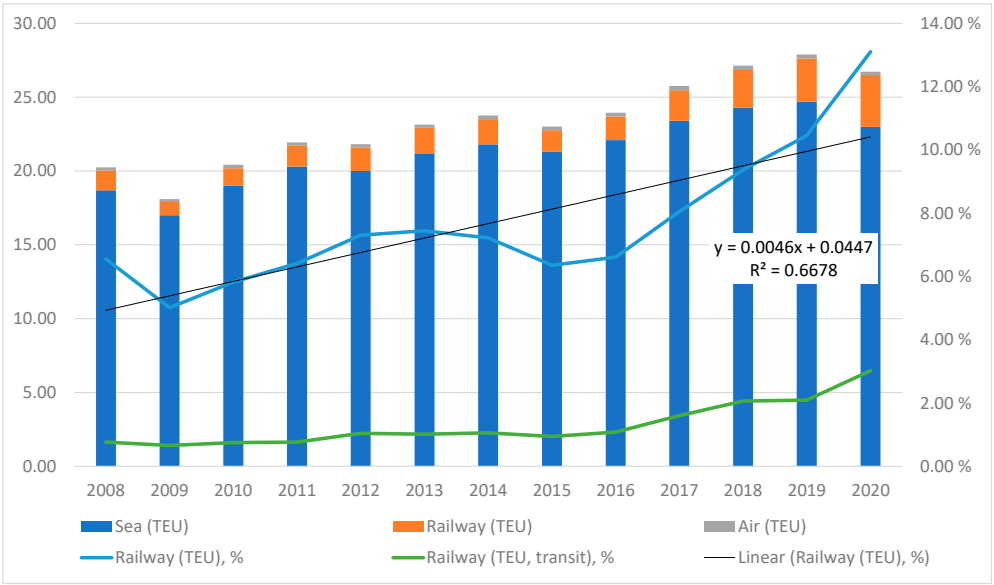

Figure 5. Container transportation volumes between Asia and Europe within three different transportation modes (air freight converted to TEU with the assumption of 10 tons per TEU container; million TEU). Denotation: Railway data based on Russian railway data [33–39]; air freight estimated with first three quarters of 2020 [15]; sea containers based on Unctad [7].

Figure 5 also resembles earlier findings that growth in the Trans-Siberian landbridge took place earlier than in the year 2020. After challenges faced in 2009, volumes already grew and the market share rose in 2010–2013. The second growth period could be identified to be originating in the OBOR program announced in 2013, and from 2016 onwards, volumes and modal share growth both have been strong and consistent. Detailed data concerning cargo groups reveal that, over the years, machines and machine tools have increased as the most important Eurasian container landbridge transport group. The share of the automotive industry is also from time to time rather high (but it fluctuates greatly).

4. Conclusions

As was revealed in this research, the Trans-Siberian landbridge in container transportation has developed through several international usage waves (Japanese, Finnish and the current, Chinese)of transit container transport from a Russian perspective. In the background, Russia's own international transport has steadily grown—in the beginning, its role was very small, but in the last two decades, its influence on overall volume has been the most significant. The year 2020 will be remembered for high growth and high absolute volume on rails between China and Europe—all taking place in an environment influenced by COVID-19. However, based on this research and longitudinal volume analysis, this is just a logical further step taken in the development of Trans-Siberian landbridge. Of course, this development was achieved not only by utilizing traditional routes and methods: landbridge nowadays offers numerous different routes, and Kazakh routes are mostly used in Chinese containers. This route, together with Mongolian and Manchurian routes, is interesting also from the perspective that routes start and end by rails. Therefore, previously used Far Eastern sea ports of Russia are not the only route for distant markets. This has changed the competitiveness of landbridge and will be a key factor in the forthcoming years. The Eurasian region is a huge economic power already, and with a significant population base, it will develop favorably in the forthcoming decades as well. As highlighted in this research work with linear regression models, railways have been shown to develop consistently within container transports of the Eurasian landbridge context. This development concerns both volumes and modal share. There is very little doubt that this linear trend will change in the other direction in the forthcoming years or decade.

For China and Eurasia in general, land transportation is increasingly becoming more important within international trade than it is for other countries or continents in global trade. In general, sea transportation holds still its cost advantage, if time and/or inventory holding is not taken into account [45,46]. However, in a situation in which time is taken into account within transportation cost estimates, then rail is equally important as sea transportation mode in container transports [45]. Air has always offered the shortest lead time over these options, but it has its price, being the highest cost option [46] and producing the highest emissions as well [47].

As further research in the area, we would be interesting to examine railway landbridge development connecting Europe and China through the perspective of different routes. Currently, the Polish and German route is the most utilized route to connect Central Europe. However, other options also exist, like those in St. Petersburg, Baltic States, Kaliningrad, and Finland. As volumes grow further and the current main route becomes more congested, it would be natural to see that development is leading to a situation where other routes are increasingly used (as many alternatives mentioned use the same gauge width with Russia, and one gauge change is saved compared to the Polish–German route). New routes of course require other modes for connectedness and for functioning supply chains (e.g., to serve Central Europe or Scandinavia), but these should be examined by, e.g., further case studies. In addition, the role of Southern Europe in Asian container flows and sea–rail intermodal transport is worth taking into account [48] as a future alternative. However, the safety of European railway network should receive caution, especially in the former Eastern European countries [49]. These mentioned routes are competing for future products, which

still have partly unknown origins and needs (as product development and factory networks are forming). One transportation product group possibly bringing additional growth to the Eurasian container landbridge is the distribution of electrical vehicles and imports of related components, which are increasingly being manufactured in China (on many occasions, within the route of current railway container flows like the Build Your Dreams (BYD) factory in Xi'an).

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