Problems in Eurasian Container Supply Chains

Katarzyna Anna Kuzmicz

Abstract Transportation of goods exchanged between China and Europe is performed mainly in containers. Due to economic reasons, most of the containers are transported by maritime corridors. Within the frame of the Chinese initiative One Belt One Road (OBOR), often referred to as the New Silk Road (NSR), substantial investments are made to develop rail connections between China and Europe. In this paper, major challenges in container transportation on the route China-Europe on strategic, tactical and operational level are analysed. Among others they include infrastructure design, location problems, container handling, allocation of resources, service network design, routing and scheduling as well as adjustments deriving from dynamic changes in environment. The main focus is on empty container repositioning problem.

Keywords Container transportation · Supply chains · Optimisation · One Belt One Road · New Silk Road

1 Introduction

The Chinese undertaking to develop a land bridge and maritime route linking Europe with China entitled One Belt One Road (OBOR), also referred to as the New Silk Road (NSR), raises public attention and is reflected in the current research studies (Sahbaz 2014; Herrero and Xu 2016; Nazarko and Kuźmicz 2017; Seo et al. 2017, Kuzmicz and Pesch 2017; Sheu and Kundu 2018; Ejdys 2017; Nazarko et al. 2017). The idea behind is to create economic growth by developing logistic infrastructure enabling seamless flow of goods throughout a network of corridors on the Eurasian route. The name One Belt embraces a rail and consequently intermodal corridor. The name One Road refers to the twenty-first century maritime route. There is no one

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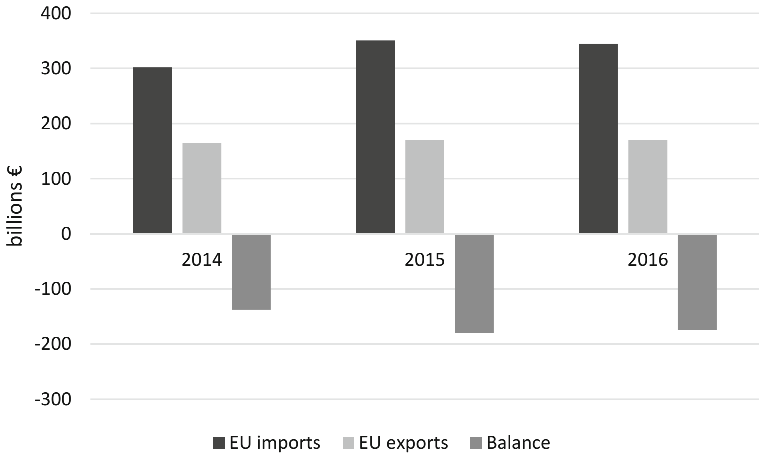

Fig. 1 EU—China trade imbalance in the years 2014–2016. Source: European Commission (2017)

defined route of the NSR, it should be rather perceived as a network of corridors. Taking into consideration the viability of the NSR project the corridor through Russia, Belarus and Poland as a gate to Western Europe prevails. The Asian Infrastructure Investment Bank and the Silk Road Fund are funding the infrastructure development within the frame of the NSR. Many countries are willing to take part in this endeavour expecting economic benefits.

Reduction of transport time and cost as well as overcoming the bottlenecks in transportation, are going to be the main factors facilitating trade exchange. The Chinese exporters will definitely benefit from the facilitation of the goods transportation, however some European producers are concerned by the possibility of big flow of the Chinese products. European importers look for niches in Chinese market that they have a potential to fill in.

The European Union is the most significant trading partner for China and China is the second important partner for the EU after the United States (European Commission 2017). The trade deficit between EU and China (Fig. 1) is substantial. The structure of mutual trade seems to contribute to this outcome, the EU imports from China mostly include industrial and consumer goods: machinery and equipment, furniture and lamps, footwear and clothing, and toys. In the EU exports to China food, pharmaceuticals, chemicals and agricultural products dominate (Nazarko et al. 2016).

Transportation of goods exchanged between China and Europe is performed mainly in containers. Due to economic reasons, most of the containers are transported by maritime corridors but within the frame of the NSR a significant shift to the rail and intermodal route may be expected. Containerised transport is developing. The biggest exporters of containerised cargo are China, USA, South Korea and Japan. The only European country in the first 10 of these exporters is

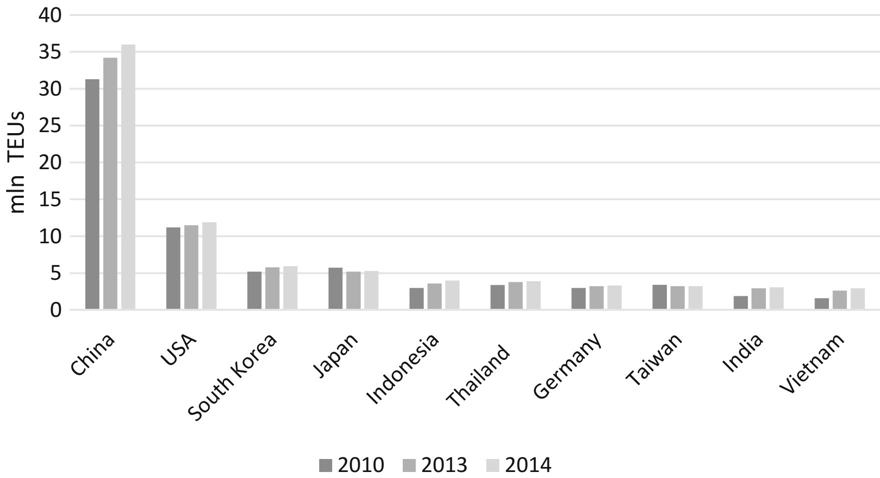

Fig. 2 The 10 biggest exporters of containerised cargo in the world (in mln TEUs) in the years 2010, 2013, 2014. Source: IHS Global Insight, World Trade Service, World Shipping Council (2017)

Germany (Fig. 2). In most of these countries the trend of exporting cargo export is growing.

USA is leading in importing containerised cargo, followed by China and a considerably lower share of South Korea, Indonesia, Germany, Great Britain, Taiwan, Australia and Vietnam (Fig. 3). The difference between the countries' export and import of containerised cargo points to the problem of empty container repositioning.

The big surpluses of containers emptied from the loads exported from China and waiting for future demand is a problem of cost and no revenue. Since import to China from European countries is much lower the problem is significant. In this paper importance of container transport as a research field is underlined, later major challenges on strategic, tactical and operational level in the field of container transportation on the route China-Europe in the light of the NSR initiative are indicated. They include infrastructure design, location problems, container handling, allocation of resources, service network design, routing and scheduling as well as adjustments deriving from dynamic changes in environment. The special focus is on empty container repositioning problem.

2 Intermodal Transport in China

The rail part of the NSR relies on the idea of The New Eurasian Continental Bridge (NECB), also referred to as The Second Eurasian Continental Bridge (SECB). Seo et al. (2017) indicate that based on NECB China opened Yuxinou (YXO) rail line

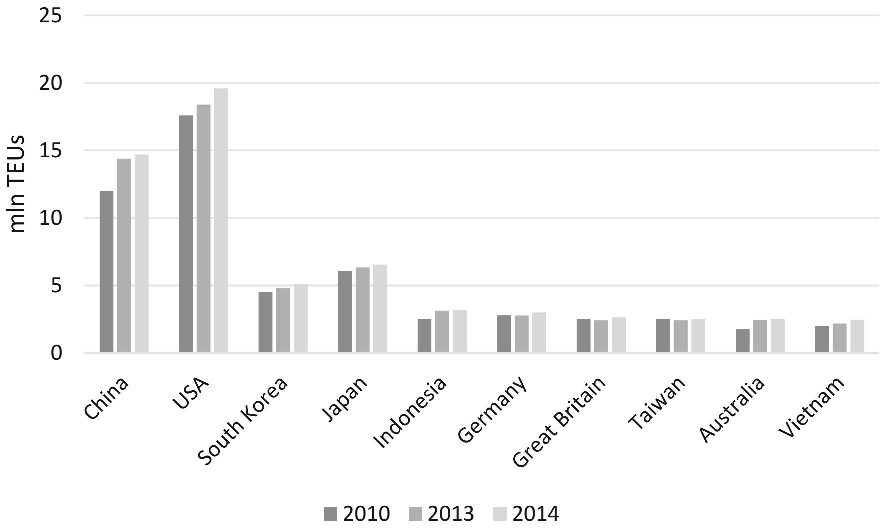

Fig. 3 The 10 biggest importers of containerised cargo in the world (in mln TEUs) in the years 2010, 2013, 2014. Source: IHS Global Insight, World Trade Service, World Shipping Council (2017)

starting from Chongqing in China running through the Yulan and Yuan railways, Sinkiang Alataw Pass to Kazakhstan, Russia, Belarus, Poland leading to Duisburg and Rotterdam in Germany. This line exemplifies the realisation of the Chinese policy to enhance export trade and to internationalise the logistics framework of the southwest region of China.

The rail transport on the Eurasian route is considered as the middle option in terms of cost and lead time between faster but more expensive air transport and cheaper but more time-consuming maritime transport. It is an attractive option for companies with: high value cargo, non-perishable goods or those to be shipped between inland locations.

The Chinese government consolidated trains within the NSR frame under the China Railway Express brand. Rail connections with Europe are highly supported in China, currently 16 Chinese cities have developed active rail freight services to 15 cities of Europe (Shepard 2017). This number is systematically growing. For example DB Schenker (2015) has an already well developed network of connections with China linking for example: Chongqinng–Dusiburg; Chengdo–Lodz; Zhengzhou–Hamburg; Wuhan–Hamburg; Suzhou–Warshau; Leipzig–Shenjang. The lead time on this route is up to 23 days, for instance for Leipzig (Germany)—Shenjang it is 19 days. The consolidation of the trains takes place in Shanghai and Chengdu. Deconsolidation in Malaszewicze (Poland) from where the goods are transported by transit to different European countries.

Intermodal transport brings benefits from the seamless transport during the rehandling process. Usage of standardised containers: 20-foot (TEU), 40-foot

(FEU) and standard handling equipment safes time and cost of rehandling cargo. In this way intermodal transport contributes to lowering cost of delivery. In China intermodal transport has been intensively developed in recent years. China's railway network was insufficient and in comparison to the well developed countries like US or Germany the volume of intermodal transport was much lower (Seo et al. 2017). For example in such countries the ocean-rail mode usually is about 20–40% of the total port container throughput, in China is was about 1.5%. Therefore in China road-ocean transport still prevails. The current achievements like the intensive development of railway network system and national express lines help China to reduce their national intermodal bottlenecks. China also invested in widespread usage of 20-foot and 40-foot standard containers and 40 high cube containers as well as information technologies necessary for seamless intermodal transportation. They also use double-stack trains and electronic customs clearance (Seo et al. 2017).

3 Container Transportation Research Areas

Container transportation is a relevant issue as a subject of current scientific research. We analysed matchings of a usage of a term *container transportation* in scientific papers and books between this term and the often related terms. A bibliographic base comprising papers listed in Web of Science database was compiled and used. To perform the analysis the publications were limited to articles, proceedings papers, chapters of books and books recently published in the years 2013–2016. To construct a map we used a VOSviewer programme developed by Van Eck and Waltman (2007, 2010). The abbreviation VOS stands for visualization of similarities. Terms were extracted from titles and abstracts of the publications. The minimal number of occurrence of a term to be included was determined as 10 and most relevant 274 out of 14,400 terms met the threshold. For each of the 274 terms the relevance score was calculated and on this basis the default choice of 60% of most relevant terms was made. Then the author verified the selected terms by rejecting pronouns, articles and words concerning methodology of writing a paper such as "author", "research problem", "aim".

The developed map is a distance-based map which means that the distance between two items reflects the strength of the relation between the items. A smaller distance illustrates a stronger relation (Van Eck and Waltman 2010). The size of the item's circle depends on the weight of the item. The weight of an item can be determined by the weight (or normalized weight) column in a map file. When a network is available, two weights are provided automatically (Van Eck and Waltman 2016). One weight is the number of links of an item, the other weight is the total strength of the links of an item. Colours of the circles mark clusters.

The developed map (Fig. 4) illustrates co-word network analysis. It indicates main clusters—fields of research in the area of container transportation. Additional loops have been used to provide visibility of clusters in black and white printout. The first cluster is operational research and optimisation problems related to container

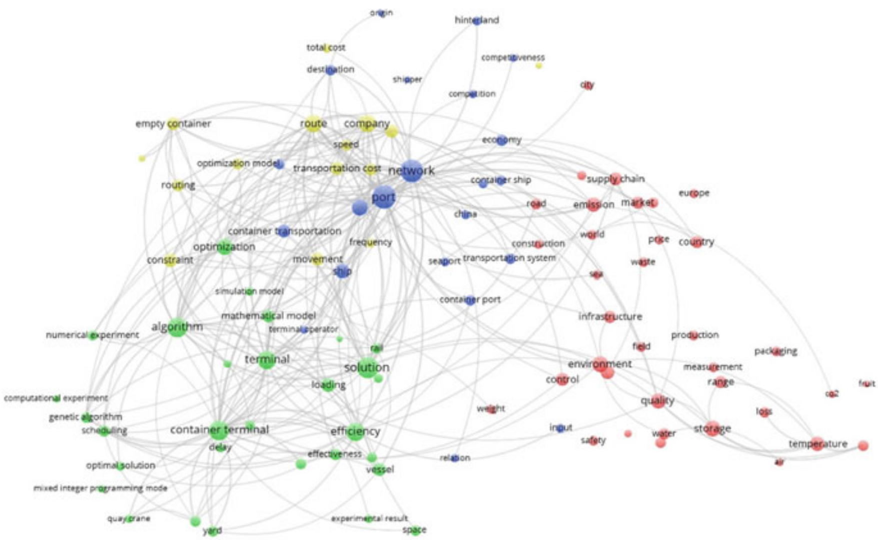

Fig. 4 Container transportation—co-word network analysis. Source: Author's elaboration in VOSviewer programme

terminals including efficiency issues, quay crane operations and in general yard operations and loading problems. The second cluster includes problems of container transportation and shipping related to sea transportation and in this context shipping networks and competitiveness, with particular indication on China and Europe as shipping destinations. The third cluster includes optimisation models of empty container repositioning and routing problems. The fourth cluster refers to papers on container transportation in the light of supply chains and environmental issues and problems with storage policies.

4 Major Challenges in the Container Supply Chains

The expected rise in rail container transport within the frame of the NSR raises attention to the strategic, tactical and operational problems that need to be solved. The examples of such problematic areas are presented in Table 1. They include cooperation strategies in intermodal chain, location problems, transport network design, intermodal terminal design, layout planning, infrastructure development, service network design, pricing strategies, decisions about consolidation network, routing problems, resource allocation, scheduling of jobs and staff and problems with empty containers. To solve the mentioned logistic problems solutions based on operations research are proposed. In the table the example areas for optimisation on different levels of problems in container transportation are presented.

Table 1 Problems for optimisation in container transport on strategic, tactical and operational level

	Level of problems in container transport		
	Strategic	Tactical	Operational
Example areas for optimisation	Cooperation strategies in intermodal transport chain	Service network design	Vehicle or cargo routing
	Location of hubs, terminals, etc.	Pricing strategies	Resource allocation
	Terminal design	Decisions about capacity levels of equipment and labour	Scheduling of services
	Intermodal transport network design	Redesign of operational routines and layout	Redistribution of railcars, load units etc.
	Regional strategic development of intermodal transport	Decision between a type of consolidation network (point-to-point network, a line network, a hub-and spoke network a trunk-collection-and-distribution network)	Scheduling of jobs
	Intermodal infrastructure development planning	Decisions about frequency of service, train length, allocation and capacity of equipment	Scheduling of staff
	Strategies of empty container balancing	Empty container relocation	Empty container storage and reshuffling

Source: Authors own study based on Cranic and Laporte (1997), Macharis and Bontekoning (2004), Caris et al. (2008)

Sheu and Kundu (2018) in the context of the NSR propose a spatial-temporal logistics interaction model integrated with Markov chain to asses real-time logistics distribution patterns. They consider political and trading uncertainties triggered by the NSR as well as the objectives of this project referring to the development of international logistics along the corridors. The aim is to investigate the logistics distributions flows of the freight and forecast time-varying logistics distributions patterns along different corridors within the frame of the NSR. The study embraces finding the optimal distribution flow path from a set of potential paths so that the total relevant cost and flow time are minimized and the service level requirements are satisfied (Sheu and Kundu 2018; Klose and Drexl 2005). The model is tested on the example of Chines oil supplies from West Africa and the Middle East within the frame of the NSR.

Among the problematic areas mentioned in Table 1 there are strategies of empty container balancing on global level (between the regions of big surplus and those with shortage of containers) and relocation of empty containers indicated as tactical problem which can be considered as relocating containers between importers, exporters and depots located in the close geographical location. On an operational level empty container storage and reshuffling moves also require optimization in terms of storage space and avoiding unnecessary reshuffling movements deriving from poor planning and forecasting of future container movements. Due to the

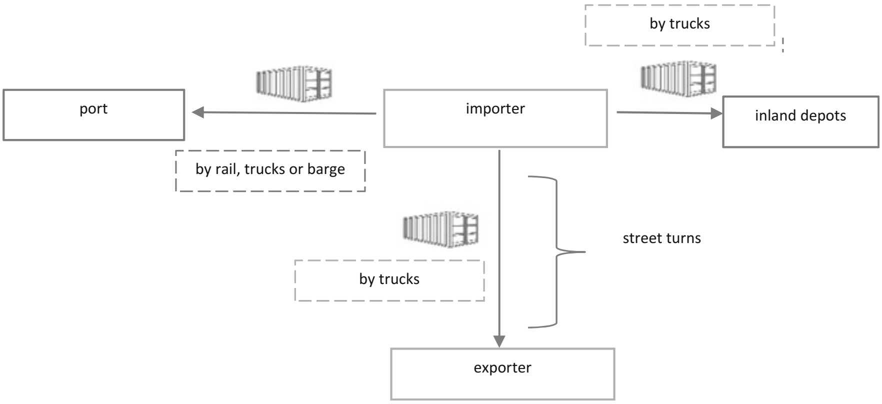

Fig. 5 Empty container movements. Source: Author's elaboration based on shipping container icon by Asa (2017)

substantial imbalance of the flow of full and empty containers between Europe and China, deriving from substantial trade imbalance, this problem is vitally important.

Empty containers after being unloaded by an importer either come back to the port transported by trucks, rail or barge or they are transported by trucks to inland depots where they wait for future demand. Another option is transportation of empty containers directly to exporters, which is referred to as street turns. It requires a knowledge about available containers at importers and meeting various criteria matching with exporter's needs like times windows, type of containers etc. The possible movements of empty containers are illustrated in Fig. 5.

Empty container repositioning is widely studied in the literature. The attempts to solve this problems include technical solutions and optimization methods application (Kuzmicz and Pesch 2019). Mathematical models of mixed integer programming are developed considering the problem from different perspective. Some models analyze empty container repositioning as network design problem (Huang et al. 2015), service network design (Braekers et al. 2013a), inventory sharing game (Xie et al. 2017), location problem (Mittal et al. 2013), routing problem (Braekers et al. 2013b), routing and assignment problem (Nossack and Pesch 2013), inventory control problems (Dang et al. 2012). Technical solutions include foldable containers (enabling folding 4 or 5 containers into one to save transport and storage space) and connectainers (a type of containers that can be joined into one 40-foot container or disjoined into two 20-foot containers) (Kuzmicz and Pesch 2019).

Empty container relocation is a significant problem in Eurasian transport because it generates costs in transport and in storage not generating revenue. Therefore attempts are made to model the problem with the aim of solving the global strategic problem of diminishing the big surpluses of containers in China for instance and provide them in regions where there is a demand and to solve the problem on tactical and operational level. Models presented in the literature address container allocation problem, trade imbalances, scheduling problems, distribution planning, fleet management, uncertainties of demand and environmental aspects of empty container transport.

5 Conclusions

The NSR raises public attention and researches interest as a trigger of changes in global supply chains in a consequence of broadening transportation possibilities. Smooth transport on the long route requires solving many logistic and transportation problems on strategic, tactical and operational level. These problems are mostly addressed by the application of optimization methods.

The dynamics of the grow of rail connections between China and Europe allow to anticipate that there will be a shift of some type of cargo transport that needs faster transport than maritime. Lead time is an important component of logistic costs and shorter lead time provides more flexibility to the supply chain. Therefore rail container transport will be an interesting option for those goods transportation for which time is an important factor.

One of the main problem in Eurasian container transport is management of empty containers. Since they generate cost and do not generate revenue all the stakeholders are interested in reducing the problem. In the study possible movements of empty containers and different approaches to reducing the problem were indicated. An interesting research field would be therefore studying cooperation relations among the stakeholders in the empty container supply chain. Another direction of further studies are pricing strategies in container lease in the context of solving empty containers problem.

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