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Evaluation of consolidation center cargo capacity and loctions for China railway express

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ABSTRACT

To solve problems of China railway express such as low load factor and profit margin, high pressure upon the government to subsidize the trains, this paper selects 27 cities as pre-candidate consolidation centers considering government policy and CRexpress operation experience, then evaluates the significance each node in Chinese railway, highway and national road networks using complex network theory. With the TOPSIS model and cargo rates to comprehensively evaluate the networks, 10 cities are identified. Of them, Taiyuan, Xi'an, Zhengzhou, Wuhan, Suzhou are selected as the optimal consolidation centers by a mixed integer programming.

1. Introduction

"One Belt and One Road" (OBOR) initiative was first proposed in 2013, when China's president Xi Jinping visited Kazakhstan. In 2015, China's National Development and Reform Commission, Ministry of Foreign Affairs, and Ministry of Commerce jointly issued the "Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road" document, confirming the importance of China Railway Express (CRexpress) for constructing an international land cargo route under the OBOR policy. The "Vision and Actions" document has created new opportunities for development of the CRexpress service.

At present, there are three main international rail corridors stretching from China to central, western, and southern Asia, and even as far as to Europe (Fig. 1). The western route departs China and continues towards Europe via the Alatwa and Khorgos passes, and travels through Kazakhstan, Russia, and Belarus. The central corridor leaves China through the Erenhot pass and continues to Europe by crossing Mongolia, Russia, and Belarus, whereas the eastern route departs through the Manzhouli pass or the Suifenhe pass and crosses Russia and Belarus on its way to Europe. At the end of 2015, more than 20 Chinese cities, including Chongqing, Chengdu, Xi'an, Wuhan, and Suzhou, had opened their own rail cargo freight lines to Asia and Europe, amounting to a total of 32 lines and 820 trains. It generally takes 6 to 23 days for trains to travel from these cities to their destinations, which is half of the time required for sea cargo. However, because of a lack of holistic planning and optimization for the overall train network, problems such as insufficient cargo supply, low load factor, low profit margin, and high pressure upon the government to subsidize the CRexpress occur. In this paper, we propose cargo consolidation to mitigate or solve these problems and satisfy the transportation needs from all Chinese provinces. Some Chinese railway experts have suggested that it would be efficient to place CRexpress consolidation centers in western cities such as Urumqi or Xi'an, but this approach would cause uneven competition between the three CRexpress corridors. Therefore, we choose the location of consolidation centers for the three corridors based on an analysis to find the most efficient flows through the overall rail network. Our results suggest that Xi'an, Taiyuan, Zhengzhou, Wuhan, and Suzhou represent the best

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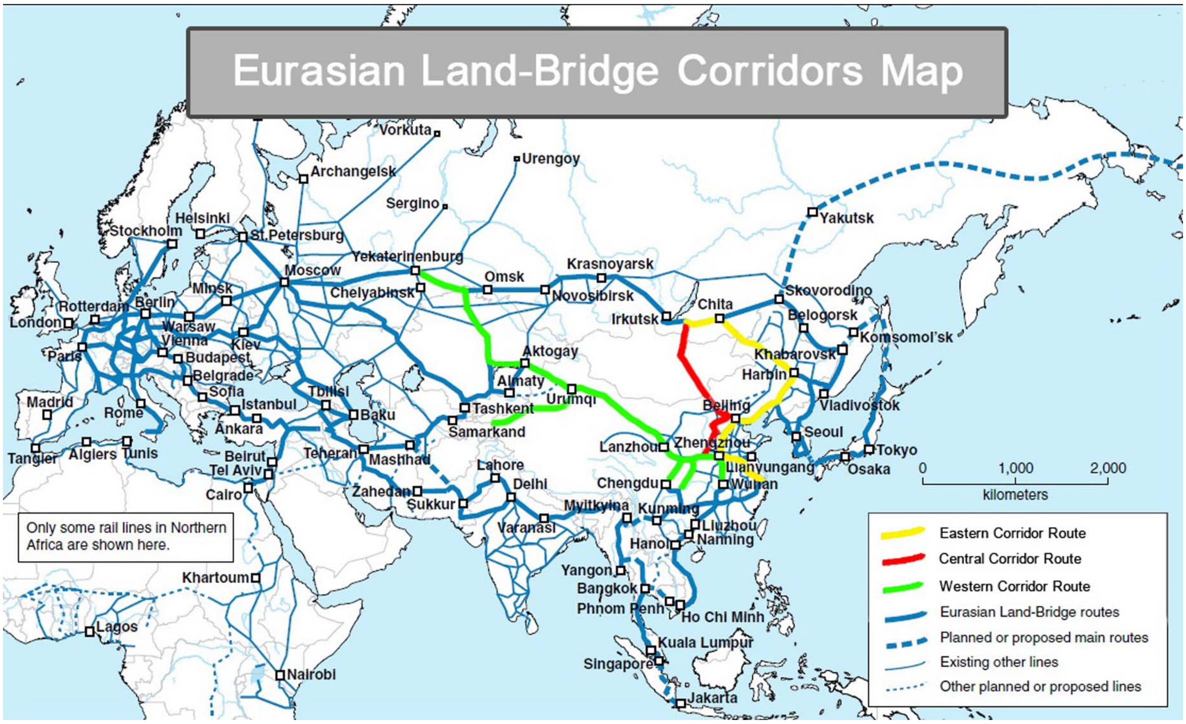

Fig. 1. Outline of the paths of the three trans-Eurasian rail cargo routes.

combination of consolidation centers. All of the consolidation centers send cargo through three corridors, except Xi'an only uses the western and central corridors.

As the cargo hub for China and foreign countries, the proposed CRexpress consolidation centers will be multimodal, since they can combine railway and road transportation, and even ocean shipping at some locations. Thus, the selection of consolidation sites should involve the logistics network and node planning.

In the field of multimodal transportation research, Zhang (2000) discusses theories of multimodal transportation and recommends measures to enhance multimodal transportation management. Nijkamp et al. (2004) analyze the logistics optimization and prediction ability of a multimodal transportation network using logit and probit discrete-choice models and a neural network. SteadieSeifi et al. (2014) define the differences between multimodal, intermodal, co-modal and synchromodal transportation. Bontekoning et al. (2004) identify the characteristics of the intermodal rail-truck freight transport. Beuthe et al. (2001) analyze the coefficients of direct and cross-elasticity for railway, road, and ocean transportation modes. Ballis and Golias (2002) design and evaluate parameters of train and truck freight transport behavior/patterns. Wang (2010) studies the factors that influence site selection in his research about consolidation node layout for multimodal transportation through the Eurasian Land Bridge (the "new silk road"). Furthermore, he introduces a network layout and the associated planning theory for use in solving related problems. For the fields of logistics and node planning, many researches have been done on site selection of distribution centers and vital logistics nodes (Hakimi, 1964; Aikens, 1985; Holmberg, 1999; Wang, 2009).

OBOR initiative research involves not only qualitative analysis about of economy and policy (Huang, 2016; Cheng, 2016; Clarke, 2016), but also the quantitative aspects about network planning. Sheu and Kundu (2017) consider the forecast of time-varying logistics distribution flows in the OBOR strategic context. Ye et al. (2014) propose cargo consolidation for the China-Europe rail cargo network and mathematically prove the effectiveness of consolidating cargo in Urumqi. Jiang et al. (2015) build a mixed integer programming model for CRexpress which only consider the western route to look for the best consolidation center. Even though Ye et al. (2014) and Jiang et al. (2015) use mathematical method to solve the CRexpress consolidation problem allowing for factors such as distances, costs and train speed, they only focus on one of the three possible corridor routes and do not think about Chinese governmental policy on the layout of logistics nodes and the cargo capacity of the consolidation center, thereby making it difficult for the calculation results to reflect the actual situation of CRexpress.

To systematically analyze the operations of CRexpress and rank the candidate consolidation cities, factors such as government policy, experience of CRexpress operation, and cargo capacity should all be taken into account. The cargo supply wields significant influence on a multimodal transportation system, since it must be compatible with the system's cargo capacity. Thus, the cargo capacity of possible hubs is a vitally important criterion in choosing optimal locations for consolidation centers. System science and social network theory currently are the main theories used to quantitatively evaluate node importance (Yu et al., 2013). The former approach generally uses methods such as node deletion (Corley and Sha, 1982; Nardelli et al., 2001) and node contraction (Tan et al., 2006), whereas the latter considers the node's importance within a network from different perspectives using indices such as the