Transport research under Belt and Road Initiative : current trends and future research agenda

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Abstract

A substantial amount of transportation research has been gathered under China's Belt and Road Initiative (BRI), suggesting multi-dimensional impacts of the BRI on the transportation industry. This study identifies research trends in the BRI to elicit key agendas for future research by comprehensively reviewing 58 journal articles and applying combined methods of inductive content analysis and co-occurrence network analysis. Findings indicate that the BRI positively impacts the transportation industry by (1) building logistics capacity (2) strengthening connectivity of transportation network (3) diversifying shipping routes of oil transportation (thus enhancing energy security) (4) promoting intermodal transportation. A unified framework and four observations are presented, illustrating strategic risks and operational challenges associated with the BRI. Principal research agendas and questions are proposed, directing future research towards reconfiguration of transportation networks and healthy competition in transportation service standards.

Keywords: Belt and Road Initiative; logistics capacity building; transportation network connectivity; alternative shipping routes; intermodal transportation

1. Introduction

China's Belt and Road Initiative (BRI) has been the centre of much discussion since it was first announced in 2013. While the precise contours of the BRI have not been defined (Wang and Yau 2018), it is generally recognised that the initiative encompasses two elements: the land-based "New Silk Road Economic Belt" (the Belt) that links China with Europe via Central and West Asia through six economic corridors; and the ocean-based "21st Century Maritime Silk Road" (the Road) that connects China with countries in Southeast Asia, Africa, and Europe through various sea routes (see <https://eng.yidaiyilu.gov.cn/index.htm> for an updated list of participating countries of the BRI). As an initiative promoting international cooperation, the BRI entails a massive plan to develop and upgrade transcontinental transportation infrastructure, including highways and railway and port facilities (Ferdinand 2016). The initiative involves more than 70 countries representing roughly one-third of the world's economy, two-thirds of the world's population, and three-quarters of the known energy reserves.

With such an unprecedented scale of development, the transportation industry is expected to witness a new era of growth and changing patterns (Lam, Cullinane, and Lee 2018). The potential impacts of the BRI on the transportation industry have been examined from several perspectives. Focusing on the potential of the BRI in building logistics capacity and alleviating transportation bottlenecks, scholars have suggested that the BRI may lead to trade growth and thus create new demand for transportation service in the region (Li et al. 2018; Yii et al. 2018). Other studies recognised the potential shift of demand for transportation service due to emerging competition between certain conventional transportation routes and alternative routes promoted under the BRI (Heng and Yip 2018; Yang, Jiang, and Ng 2018). Studies also noted to a changing landscape of the transportation network due to relocation of manufacturing bases (Chen and Yang 2017) and associated changes in hinterland patterns and hub-port clusters (Jiang et al. 2018; Chen and Yang 2018).

Major journal platforms, such as *Transport Reviews*, *Transportation Research Part E*, *Maritime Policy & Management*, and *International Journal of Logistics Research and Applications* have released special issues addressing a series of challenges and opportunities presented by the BRI on the transportation industry. While the BRI is still in early stages of development, a considerable amount of academic research has accumulated in this field, suggesting complex multi-dimensional impacts of the BRI on the transportation industry (Lam, Cullinane, and Lee 2018). A comprehensive review of the relevant literature will be especially

helpful in synthesising the key research insights and unveiling major research trends in this field, which can guide the path for critical research agenda in the future. Hence, by reviewing relevant literature, this study intends to answer the following research questions:

- (1) What are the current trends in transportation research in the context of the BRI?
- (2) Based on current research trends, what are the key agendas for future research?

Notably, among articles published in the aforementioned special issues, Lee et al. (2018) provided an overview of the BRI and identified key research trends currently predominant in maritime-related research, whereas Wan et al. (2018) reviewed the concept of resilience of the transportation system in the context of the BRI. Our study does not intend to replace previous efforts nor depreciate their value, but rather, integrates essential background information provided in them.

By extending earlier review studies, this review contributes to research by investigating the impact of the BRI on both land-based and maritime-based transportation, given their interconnected nature and mutual reinforcement potential. Methodology-wise, our review study contributes by introducing a combined method of inductive content analysis and co-occurrence network analysis. By doing this, each of the selected articles was identified with a few key themes and theme clusters were automatically formed based on their associated strength, leading to identification of major research trends. Therefore, our review study also contributes with a more objective analysis of the extant literature.

The remainder of this study is organised as follows. The three-phase data collection method was discussed and a final list of 58 articles were identified, as elaborated in Section 2.1. In Section 2.2, a total of 28 key themes emerged from the identified articles by applying the technique of inductive content analysis. These key themes were further condensed into four major clusters, suggesting four principal dimensions of impacts of the BRI on the transportation system. The four major impacts are elaborated in Section 3, encapsulating the main findings of this review study. More specifically, these are the BRI's impacts on building logistics capacity (Section 3.1), strengthening connectivity of transportation network (Section 3.2), enhancing energy security (Section 3.3), and promoting intermodal transportation (Section 3.4). The conclusion discusses the research implications and research agenda.

2. Materials and method

In this review study, we aim to locate and evaluate relevant research articles based on which synthesised insights are presented and future research agenda are proposed. To ensure a

comprehensive coverage of peer-reviewed journals, Scopus of *Elsevier* and Science Citation Index (SCI) of *Thomson Reuters* were identified as ideal search databases to obtain reliable and cross-checked journal articles as review inputs (Galvagno et al. 2014). Depositories of Chinese literature such as China National Knowledge Infrastructure (CNKI, Known as Zhi Wang in Chinese) were also considered as search databases. Owing to the high volume of mainstream scholars in China publishing on English platforms, we decided to restrict our review to literature published in English. A three-phase methodology was adopted for data collection, which consisted of data mapping, data refinement, and data evaluation (Rowley and Slack 2004). A total of 58 qualified articles were selected for further analysis of the key research themes. Figure 1 provides an illustration of the review method that will be detailed in the remainder of this section.

[Figure 1: Illustration of review methodology]

2.1. Data collection method

2.1.1. Data mapping

Data mapping phase aimed to construct appropriate keywords and keyword structures. It involved several rounds of trial and error by: (1) defining the initial set of keywords based on author's domain knowledge, (2) applying keyword search, (3) scanning search results and identifying additional keywords overlooked in previous rounds, (4) updating keywords and restarting from step 1. Based on this four-step process, the keyword structure was finalised as ("belt and road" OR "maritime silk road" OR "one belt one road" OR "BRI" OR "OBOR") and (transport* OR logistics). Using the finalised keyword structure, search requests were run in the search databases. At this stage, a total of 216 publications were identified including journal articles, conferences papers, editorial notes, and book chapters.

In addition to keyword searches, we also extracted journal articles published in various special issues on the topic of the BRI, which contained 18 articles from *Maritime Policy & Management* (two special issues including two editorial notes), 8 articles from *Transportation Research Part E* (including one editorial note), 7 articles from *Transport Reviews* (including one editorial note), and 6 articles from *International Journal of Logistics Research and Applications*. It is worth pointing out that 16 of these articles were picked up twice (appearing in both keyword searches and special issues), and were thus removed. Combining the two

streams of publications (from the keyword search and from the direct extraction from special issues), a total of 239 publications were obtained.

2.1.2. Data refinement

Phase consists of two steps. First, we restricted the sources of publications to peer-reviewed journal articles as they were expected to disseminate the most recent findings and represented the most credible research. It should be highlighted that the editorial notes were also included for analysis as they provided a good summary of the respective special issue and rich insights on the subject matter from the editors' perspective. Accordingly, 183 articles were retained after applying the source filter. Second, article titles and journal platforms were evaluated; articles with clear emphasis on non-transport related issues were deselected. By screening abstracts, research objective statements were analysed and research focus of articles was identified. Articles that mainly provided political, legal, environmental, or economic implications were excluded (Yu and Chang 2018; Malle 2017; Zhang, Luo, et al. 2018), and only articles with a key focus on transportation or logistics were retained. After the two-step data refinement, a total of 68 articles were selected.

2.1.3. Data evaluation

Data evaluation is the most critical phase of this review study, which involved reading articles in their entirety. Based on a holistic understanding of each article, we identified the following disqualifying characteristics: (1) articles that claimed to address the BRI but no specific implications were drawn (2) articles that failed to effectively address the objective due to unclear presentation or inadequate communication. While this phase of evaluation was more subjective, it was considered a necessary measure to ensure reliability of the review data and quality of review findings. A final list of 58 articles for further analysis (see Appendix A for a summary of the selected articles) was generated.

As seen in Table 1, it was found that all selected articles had been published in the last five years. A sharp increase in terms of research output was observed in 2018. While the increase could be linked to various special issues released in 2018, it could also indicate growing interest in the field of the BRI research. Such an emerging field justifies a timely review study that contributes to revealing current research trends and proposing future research agenda. Table 2 lists the main sources of the selected articles. The top two contributors were *Maritime Policy & Management* and *Transportation Research Part E*, followed by

Sustainability and *Transport Reviews*. Collectively, these four journal platforms contributed the majority (32 out of 58) of the articles reviewed in this study.

[Table 1: Publication year of reviewed articles]

[Table 2: List of sources of reviewed articles]

2.2. Analysis of key research themes

After selecting the 58 articles, an inductive content analysis was conducted to identify key themes in the field (Elo and Kyngäs 2008). The process involved open minded analysis of main texts of articles to identify meaningful subjects that reflected aims of the studies, which were presented in the form of keywords or phrases to enable the drawing of conclusions. More specifically, by reading through selected articles, researchers obtained an overview of contents and identified phrases as an indication of the themes that might emerge. After reading through all 58 articles, key phrases with similar meanings were compiled, sorted, and thus condensed to reveal key themes in the research field.

Phrases such as *port facilities*, *consolidation centres*, *transport infrastructures*, were identified in a few articles. Given their similar connotations, they were compiled into one research theme termed logistics infrastructure. On the other hand, some similar phrases were purposely categorised under different themes despite their similarity. For example, *land bridge* and *high-speed railway* were listed as separate themes. While land bridge is essentially high-speed railway, it was often examined as an integrated part of intermodal transportation. High-speed railway, on the other hand, is often evaluated as a stand-alone mode of transportation. Table 3 lists key research themes that frequently appeared in articles selected. Based on their occurrences, *logistics infrastructure*, *alternative route*, and *China-Europe* emerged the most popular themes investigated by researchers. A total of 28 themes appeared in at least two of the articles reviewed. These 28 themes as well as their associated strengths were used as a basis for co-occurrence network analysis. The next section provides detailed elaborations on the four research trends based on co-occurrence network analysis.

[Table 3: List of key research themes]

3. Results

We employed VOSviewer to perform co-occurrence network analysis (see Figure 2 for details). VOSviewer (www.vosviewer.com), a computer programme that constructs and views bibliometric maps, was selected as it pays special attention to graphical representation and displays bibliometric maps in an easy-to-interpret manner (see van Eck and Waltman (2010) for a detailed review of VOSviewer). Using 28 key themes identified as input, a co-occurrence map was produced as shown in Figure 3. The size of the circle and the font size of the label reflect the number of links the theme has with connected themes; the more links the theme has, the larger its font size. The thickness of the curved lines reflect link strength between any two connected themes.

[Figure 2: Illustration of co-occurrence network analysis]

Notably, the theme *alternative route* which is positioned at the centre of the map appeared to be strongly interconnected with surrounding themes (such as Malacca dilemma, China-Europe, and Environmental consideration). It might suggest a fundamental impact of the BRI on transportation systems by establishing alternative routes which greatly amend transportation patterns in different manners. Each theme was assigned to a cluster as indicated by different coloured circles. The result displayed a clear four-cluster mapping, indicating four major research trends in this field that corresponded to the four impacts of the BRI on the transportation industry—building capacity of logistics structure (green cluster), strengthening connectivity of transportation network (red cluster), enhancing energy security (yellow cluster), and promoting intermodal transportation (blue cluster). The four distinct yet interconnected dimensions formed the basis for this review study.

[Figure 3: Results of co-occurrence network analysis of key themes]

3.1. Green cluster: building logistics capability

As an initiative promoting regional connectivity, the BRI's primary agenda aims to ease bottlenecks for cross-border trades (Herrero and Xu 2017), and improve infrastructure connectivity (Wang and Yau 2018). The deficiency in logistics capacity among the BRI countries presents pressing issues. Many countries face hindrances due to underdeveloped and

ageing infrastructure (Chhetri et al. 2018), which lead to inferior roads, incomplete railway links, and inadequate port infrastructure and facilities (Chia 2016). To this end, the BRI provides financial, technological, and policy support in building logistics capacities for partner countries. Therefore, the first cluster of studies addresses fundamental objectives of the BRI in this regard.

Evaluation of the current status of logistics capacity revealed imbalanced development among the BRI countries. For example, Chhetri et al. (2018) evaluated the competitiveness of key logistics cities in Asia based on their capacity of logistics infrastructure (road, rail, port, and air transport) and logistics service responsiveness. Results suggested that competency levels varied significantly. Cities like Shanghai and Hong Kong attained maturity as global gateways for international commerce, whereas others like Jakarta, Bangkok, and Ho Chi Minh City, suffered serious inadequacy of logistics infrastructure and struggled to improve service levels (Chhetri et al. 2018). Focusing on port infrastructure of 51 countries along the BRI, Peng et al. (2018) found that development of port infrastructure was markedly polarised where competitive ports were mainly located in the Mediterranean, the Suez Canal, and the Hormuz Strait, and most ports in South Asia and East Africa were severely handicapped. There is an urgent need to address imbalance in logistics capacity development to facilitate unimpeded trades under the BRI (Mou et al. 2018).

Researchers have rationalised the infrastructure-led development strategy embedded in the BRI. While the development of transportation and logistics infrastructure is generally recognised as the main driving force shaping economic pattern (Shao et al. 2018; Yii et al. 2018), the underlying rationales should be highlighted. In particular, Chia (2016) explained the benefit of physical connectivity in relation to regional trade integration. On the one hand, improved logistics connectivity reduces distance to markets and promotes trades. It also facilitates participation in regional and global supply chains, which leads to access to resource advantages in local environments and hence, trade integration. Li et al. (2018) went a step further to present a “Chinese model” and unveiled the relationship between logistics infrastructure development and economic growth. It is suggested that investments in logistics infrastructure may lead to economic growth by (1) contributing to Gross Domestic Production (GDP) and generating employment opportunities, (2) enhancing regional accessibility and labour mobility, (3) creating spill-over efforts on upstream and downstream industries, and (4) attracting foreign direct investments (FDI) and promoting diffusion of technologies (Li et al. 2018). In the context of coastal and inland China, the same authors demonstrated differentiated impacts of logistics investments (in telecommunication, air transportation, rail transportation,

storage facilities, etc.) on economic growth (Li et al. 2018). Studies also identified a coordinated development path of logistics and economy where impacts are bidirectional and reciprocal (Yang, Lan, and Tseng 2019; Yii et al. 2018). For example, by conducting causal chain analysis, the coordinated logistics and economic development path is identified as follows: investment in logistics infrastructure would lead to enhancement in logistics network accessibility, which eventually contributes to development of the logistics industry and coordinated development of economy and logistics (Yang, Lan, and Tseng 2019). Notwithstanding the disparities in the rationalisation, the infrastructure-led strategy seems to be well regarded. To this end, the BRI contributes to trade integration and regional cooperation by actively building up logistics capacities of participating countries.

However, large scale infrastructure development comes with controversies, especially considering the transnational nature and geopolitical sensitivity of many infrastructure projects under the BRI (Shao et al. 2018). Recognising these controversies, Andrić, Wang, and Zhong (2019) identified potential risks associated with general railway projects under the BRI, among which geopolitical risks and threats related to cooperation with China were considered intrinsic to the BRI and ranked as most critical. Other scholars focused on specific railway projects and proposed a prioritisation strategy of project implementation (Shao et al. 2018). Projects with high priorities are generally found to be located in regions with stable political environments (Shao et al. 2018). In addition to the political risks, it is worth noting that environmental risks were also a recurring theme in the literature. Among others, carbon emission, soil pollution and site contamination, noise pollution, and habitat loss are often attributed as negative impacts of infrastructure construction projects and associated logistics activities (Andrić, Wang, and Zhong 2019; To and Lee 2018). The environmental risks become an even more controversial issue in the transnational context, as differentiated environmental standards among the BRI countries may result in inter-country relocation of polluting industries, turning certain countries (with relatively lower environmental standards) into “pollution havens” and propelling a regional “race to the bottom” in terms of environmental standards (Tracy et al. 2017; Cai et al. 2018).

The empirical evidence, however, reveals contradictory findings. Cai et al. (2018) tested the Pollution Haven Hypothesis (PHH) by comparing carbon emission embodied in imports and exports of the BRI countries. Among the 31 developing countries under examination, the PHH was found to hold true between China and 19 developing countries, partially supporting the theory. Han et al. (2018), on the other hand, examined effects of the BRI on energy efficiency convergence and found that trade integration and regional

cooperation, the two major functions of the BRI, may have a positive influence on the convergence process especially among middle-and low-income countries. This means that lagging countries may catch up in terms of energy efficiencies and environmental standards by participating in the BRI. Indeed, logistics infrastructure projects under the BRI may facilitate trans-border information sharing, knowledge spill-over, and technology transfer, which ultimately lead to desirable environmental outcomes. Therefore, based on preceding discussion, the following observation is proposed (see Figure 4 for graphical representation):

Observation 1: The BRI impacts the transportation industry by contributing to logistics capacity building. However, geo-political and environmental risks associated with construction projects of logistics infrastructure may cause controversies and hinder smooth implementation of the BRI.

[Figure 4: Graphical illustration of Observation 1]

3.2. Red cluster: strengthening connectivity of transportation network

Closely related to logistics capacity building, the BRI may also contribute to a better-connected regional transportation network (Cullinane et al. 2018). From an evolutionary perspective, the transportation system has witnessed the initial phase of growth followed by hierarchical developments. A stage of networking is emerging characterised by multi-hub agglomeration, integrated connectivity beyond spatial proximity, and functional differentiation among ports (Wang et al. 2018; Mou et al. 2018). Studies that fall into this cluster address impacts of the BRI that facilitate the formation of such an integrated transportation system. Special attention was paid to two aspects.

First, as an export-oriented strategy, the BRI would benefit the inland region (especially in China) by improving its logistics connectivity to the coastal region as well as the rest of the world (Wei and Sheng 2018). In this regard, one stream of literature examines the development of port-hinterland networks by stressing the critical role played by inland dry ports. A dry port often refers to a hinterland intermodal freight terminal where supporting services such as customs clearance, bill of lading issuance, and cargo inspections are provided. With intermodal transit capability, the dry port acts as an extension of seaports and facilitates convenient cargo operations (e.g. drop-off and pick-up) for shippers and carriers in the hinterland (Wei, Sheng,

and Lee 2018). In this regard, inland dry ports serve as an effective intermediate connecting inland regions with seaports, thus activating the development potential of inland regions.

Against this background, Wei and Sheng (2018) investigated the accessibility of 15 inland provinces of China (including 136 dry ports) in relation to 127 sea ports. Results indicated that development of dry ports in China has started to “take shape” as clusters in three regions: the Circum-Bohai-Sea region, the Yangtze River Delta region, and the Pearl River Delta region. However, based on the closeness centrality, the logistics connectivity of China’s inland province is relatively low in the overall BRI network (Wei and Sheng 2018). Researchers attempted to design an optimised dry ports-sea ports networks based on a hub-and-spoke system (Wei, Sheng, and Lee 2018). It was found that some dry ports emerged as inland hub ports which connect directly to the seaports. Factors such as local logistics demand, logistics service costs, and governmental policies, greatly influence the logistics gravity shaping the network configuration. In addition, some scholars recognised the capacity constraints often faced by major seaports and proposed a capacity sharing scheme by way of a port service network (Ruan, Feng, and Pang 2018). The network consists of an international seaport and the nearby inland ports (not necessarily dry ports), where inland ports not only share the capacity with the seaport, but also specialise in diversified port services. The integrated port system is branded under the same umbrella to compete in the global port market, reinforcing competitiveness of both the seaport and the inland ports.

The second aspect is in relation to the global trend of industry transfer and manufacturing relocation. Due to rising costs of labour and production, emerging regions which used to be ideal manufacture bases (such as China and India) are losing their attractiveness (Mohiuddin et al. 2019). As a result, many firms are exiting these emerging countries and reallocating manufacturing activities to less developed countries such as Cambodia, Vietnam, and Bangladesh. In this respect, the BRI may catalyse the relocation process by actively investing in the much-needed logistics infrastructure in those regions. This is further coupled by the domestic industry transfer which is currently underway in China as embedded in the BRI, where the country plans to gradually spin off a relatively low-value-added manufacturing industry (Mohiuddin et al. 2019). From these two perspectives, the BRI facilitates the process of manufacturing relocation, which may create major impacts on the transportation industry.

From the perspective of the manufacturers, studies investigated the firms’ relocation strategies along the BRI countries. Transactional efficiency, institutional advantage, and learning opportunities were identified as some of the key motivations of relocation decisions

(Mohiuddin et al. 2019; Chan and Reiner 2019). More importantly, from the perspective of port developers, Chen and Yang (2017, 2018) conducted studies to examine the influence of manufacturing relocation on port investment strategy along the BRI. Using the Port of Colombo as a case study, authors posited that there would be positive feedback between port investment and returns due to relocated manufacturing activities from China to Colombo. However, positive feedback would reach an equilibrium when manufacturing costs became so high that both ports and manufacturers are unwilling to further increase the scale (Chen and Yang 2017). Considering diminished returns on investment, an optimal port investment strategy was suggested. Chen and Yang (2018) further explored a cooperative development mechanism of port clusters in Southeast Asia and South Asia given the trend of manufacturing relocation. While the status of hub ports would not change, most ports would experience a surge in shipping volume—except for the Port of Singapore, whose catchment area would be relocated to nearby ports (Chen and Yang 2018).

Despite the positive prospect of the strengthened transportation network, studies have highlighted the vulnerability of the network. In particular, the concept of resilience of the transportation network is often presented (Wan et al. 2018; Chen, Lam, and Liu 2018; Twumasi-Boakye and Sobanjo 2018). While no universal definition has been agreed upon, resilience normally refers to the level of reliability, redundancy, robustness, and recoverability of the transportation system, i.e. how long it can perform without failing, actions it will take in response to disruptive events, functionality after disruption, and how it reaches a new equilibrium (Wan et al. 2018). In the context of the BRI, given the strengthened connectivity of the transportation network, more precaution should be taken to ensure resilience of the network in the early formation stage. Chen, Lam, and Liu (2018)'s work reveals alarming signs in this regard. For a port-hinterland transportation network, it is found that a complementary business relationship demotivates players to invest in necessary preventative measures, which may increase vulnerability of the network. Instead, the existence of competition among players encourages investment in network resilience. Findings are attributed to the free-rider or peer phenomenon. A strong business connection of network players may result in high vulnerability and an intensive business cooperation is not constantly recommended in the context of the transportation industry. Hence, we propose the following (see Figure 5 for a graphical illustration):

Observation 2: The BRI impacts the transportation industry by strengthening connectivity of transportation networks focusing on inland regions (via port-hinterland network development)

and under-developing regions (via manufacturing relocation). However, the resilience of the integrated transportation network may be a critical concern for its sustainable development.

[Figure 5: Graphical illustration of Observation 2]

3.3. Yellow cluster: enhancing energy security

This stream of literature largely concerns the vulnerability of the transportation system in relation to maritime chokepoints, such as the Malacca Strait. Chokepoints are strategic locations that limit movement yet cannot be easily bypassed and are commonly noticed in transportation geography (Cheng et al. 2018). The Malacca Strait is a shortcut route connecting major oil exporting and importing regions; nearly a third of global petroleum and other liquid products—equivalent to approximately 16 million barrels of oil per day—transit through this busy sea route (Heng and Yip 2018). Its heavy dependency is coupled with challenges of territorial disputes, pirate attacks, and geopolitical sensitivity in the region, leading to grave concerns of energy securities especially for oil importing countries (Shaikh, Ji, and Fan 2016).

Such is the case of China and one of the key considerations of the BRI. As the world's largest net importer of oil, China relies on transit through Malacca Strait for nearly 80% of its oil supplies (BP 2019; Hellenic Shipping News 2019). Indeed, China's over-reliance on the Malacca Strait is widely recognised as the "Malacca Dilemma" that potentially threatens national energy security in case of an unexpected blockage in the region (Brewster 2017). To this end, the BRI, with the proposed China-Pakistan Economic Corridor (CPEC) and China-Myanmar Economic Corridor (CMEC) (as part of the Pan-Asia Railway Network), is often considered a diversification strategy that enhances national and regional energy security (Li and Jin 2018; Sheu and Kundu 2018). To illustrate, the CPEC would connect the Arabian Sea and China's Xinjiang province through Pakistan by way of pipelines and road/rail links, while CMEC would link Yangon and China's Kunming province via road routes, river routes, as well as pipelines (Brewster 2017). In both cases, by "unlocking" the landlocked western part of China, the proposed economic corridors enable oil supplies from the Middle East and Africa to bypass the Strait of Malacca. In assessing prospects of the CPEC, Shaikh, Ji, and Fan (2016) concluded that energy transport routes via the CPEC could represent better alternatives with shorter transport distances, decreased transport costs, and reduced greenhouse gas emissions. Sheu and Kundu (2018) state that the CPEC and the CMEC complement each other as oil transport routes. The CPEC transit route could be more cost-effective for transporting oil from

the Middle East, whereas in transporting oil from West Africa, the CMEC oil pipeline route could be more cost-effective (Sheu and Kundu 2018).

However, it remains to be seen if the proposed oil transport routes under the BRI will become a competitive alternative and thereby divert transport volumes from conventional routes. Researchers have remained rather pessimistic in this regard. Brewster (2017) pointed out that almost half of the pipeline in the CMEC passes through Shan State, a highly politically unstable area. The CPEC also traverses regions in Pakistan that suffer from adverse security environments (Brewster 2017). The concerns on domestic instability in Pakistan and Myanmar were also shared by Shaikh, Ji, and Fan (2016) and Li and Jin (2018). It will require years of investments in the proposed economic corridors before project completion, during and concurrently, the Malacca Strait will also undergo certain changes (Sheu and Kundu 2018; Kundu and Sheu 2019). On an optimistic note, the construction of transportation infrastructure can boost socioeconomic development in the region and provide opportunities for local manufacturing industries (Shaikh, Ji, and Fan 2016). As a result, it may further generate new demand for the transportation service with considerable significance. While the two alternative oil routes are unlikely to have any real impact on the transport industry in the short term, their competitiveness in the long run remains to be seen in terms of diverting shipping traffic from the Malacca transit and generating new transportation demand.

Studies also examined the feasibility of the Thai Canal proposed under the BRI (alternatively called Kra Canal or Carat Canal, which connects Songkhla in southern Thailand with Satun) as an alternative transit route in competition with the Malacca Strait (Heng and Yip 2018; Zeng et al. 2018). It is worth mentioning that while the canal is commonly referred to as the Kra Canal, it is not located within the area of the Isthmus of Kra (Heng and Yip 2018). In its present design, the canal is planned to be 102 km long, 400 m wide, and 25 m deep, and will allow smooth transit even for Very Large Crude Carriers (VLCC). Depending on origins and destinations, transit via the canal will shorten shipping distances by several hundred miles (Heng and Yip 2018), thus attracting shipping traffic from the Malacca Strait.

By modelling the impact of the canal on the evolution of the nearby hub ports, Zeng et al. (2018) suggested that the comparative advantage of the traditional Malacca Strait route will eventually dwindle. The transit-trade volume of hub ports near the Malacca Strait (e.g. Singapore, Klang, and Tanjung Pelepas) would be gradually transferred to Shanghai, Hong Kong, Busan, and Thai Newport (to be developed) to a certain degree (Zeng et al. 2018). However, while there has been intermittent discussion on the canal, a concrete timeline has not yet been established. With relatively short distance saving, it seems unlikely that the Thai Canal

will overtake Singapore to be the new regional shipping centre, especially considering gaps in port infrastructure and service qualities of both routes. Nonetheless, the canal will experience decades of development after its completion through stages of germination, growth, and maturity (Zeng et al. 2018). Different competition patterns between the Malacca strait and the Thai Canal are expected at different stages of development. Based on this discussion, the following observation is put forth (see Figure 6 for a graphic illustration):

Observation 3: The BRI impacts the transportation industry by diversifying energy transportation routes (which bypass the Malacca Strait), intensifying competition among port operators, and restructuring hub-port patterns, which ultimately enhance energy securities of the region. However, construction of infrastructure (e.g. pipelines for CPEC and Thai Canal) requires long-term investment, which causes uncertainties in future competitiveness.

[Figure 6: Graphical illustration of Observation 3]

3.4. Blue cluster: promoting intermodal transportation

The dependency on the Malacca Strait is also manifested in the container transportation of Asia-Europe trades. Research that falls under this cluster mainly addresses alternative transport routes proposed under the BRI for Asia-Europe trades. The value of China-Europe trade reached USD 54.7 billion in 2016 (Zhang, Ruan, et al. 2018), which translated into a substantial transportation demand. The freight volume of Asia-Europe trade reached approximately 3.6 million TEUs in the same year (Jiang et al. 2018). More than 90% of these freights are dependent on seaborne transport, which typically sail a remarkable distance of more than 20,000 km for 40 to 50 days across the South China Sea, the Malacca Strait, the Indian Ocean, the Red Sea, the Mediterranean, and finally to destination countries in Europe (Wen et al. 2019). On the other hand, land-based routes, which are supposed to be more direct and much faster, are currently underutilised due to geographical and infrastructural constraints (Jiang et al. 2018).

To unlock the potential of land-based alternatives, the BRI has proposed various economic corridors that connect Eurasian countries by constructing or upgrading land-based transportation infrastructure. Noticeably, various express railways, branded as China Railway (CR) express, have been deployed to connect logistics centres in China and Europe (Wen et al. 2019). By the end of 2017, a total of 57 routes of CR express opened, linking 35 cities in China

with 34 cities in Europe (Jiang et al. 2018). Depending on origins and destinations, transport distances of CR express trains vary from 8,000 to 13,000 km with an average transport time of 15 days—significantly shorter than ocean-based alternatives (Chen et al. 2017). Land-based routes serve as an effective land bridge that is in direct competition with deep-sea shipping. While the topic of the Eurasian land bridge has been well acknowledged in logistics literature, added features of the BRI bring new insight into this field. Some studies systematically evaluated competitiveness of land-based routes from a multi-criteria perspective. Factors that are commonly taken into consideration include cost, transit time, commodity nature, governmental support, and infrastructural reliability (Wen et al. 2019; Yang, Jiang, and Ng 2018; Wang and Yeo 2018).

Based on the comparative analysis of freight cost structures, Jiang et al. (2018) estimated that the CR express can attract an average of 5% market shares of IT products. It should be highlighted that the estimation was made based on heavily subsidised freight cost (covering about 60% of freight cost) of the CR express. In fact, the cost factor is often considered the most important criterion when evaluating alternative routes (Wang and Yeo 2018). The normal freight cost of the CR express is about 4 times higher than ocean freight, which makes it unfeasible in most cases. However, with continued governmental subsidies, it is likely that the manufacturing base would be gradually attracted along the routes (Jiang et al. 2018). The accumulated cargo mass may eventually lead to a decent profit margin that ensures sustainable development of the CR express. The trend of manufacturer relocation has been witnessed to a certain extent. For example, some PC manufacturers such as HP, Acer, and Asus, have chosen to relocate production lines to Chongqing, which is one of the origin cities of the CR express (Jiang et al. 2018). In another case, Samsung chose the railway alternative for transporting semi-finished or end products from Korea to Eastern Europe, which has resulted in significant reduction of lead time from 50 days to 18 days (Wiegmans and Janic 2018). The shortened lead time is especially critical for high value-added and time-sensitive products, which could cause considerable reduction in inventory-holding cost and enhance customer responsiveness. In some situations, land-based routes could be ideal intermodal alternatives (e.g. river-rail, truck-rail, or coastal shipping-truck-rail) to their deep-sea counterparts (Wiegmans and Janic 2018).

Regarding the level of infrastructure development, land-based routes also suffer from poor logistics infrastructure compared to well-established deep-sea transportation. As critically demonstrated by Vinokurov and Tsukarev (2018), the containerisation level of inland transit regions is distinctively lower than coastal regions. Some routes would require substantial

modernisation in terms of cargo-handling tools, storage facilities, and information systems to enable smooth cargo operations as well as efficient administrative processes (Vinokurov and Tsukarev 2018). The inadequacy in “hardware” is also coupled with the lack of competent human capitals, both of which require massive investments from local governments and financial support from the BRI. Wen et al. (2019) stressed the importance of the reliability of the infrastructure in a political sense given the wide geographical spread of the routes (hence the involvement of many countries). It is found that infrastructure reliability becomes a dominant consideration for the purpose of route selection when time constraint is lifted (Wen et al. 2019). It is of great importance for governments along routes to establish close collaboration in order to provide a stable and reliable political environment (Wen et al. 2019). Governments should act collaboratively to enhance the technical capacity of infrastructure internally and ensure the reliable operating environment of infrastructure externally.

In addition, scholars stressed the issue of empty container repositioning due to trade imbalance between China and Europe. More specifically, trade imbalance results in a considerable number of empty containers for eastbound transportation. They require the same storage spaces as full containers, yet no added values can be generated from transporting empty containers. While the issue has been thoroughly investigated (Kuzmicz and Pesch (2019)), the context of the BRI with the proposed intermodal transportation poses new challenges in this field. Unlike in transportation where one carrier is mainly involved, intermodal operators in charge of different legs of transportation have to collaborate and agree on one strategy for returning empty containers. The agreement is especially difficult to reach given the sensitivity of commercial data and conflicts of interests. As a result, decision makers are often reluctant to collaborate, which makes repositioning especially challenging for intermodal transportation (Kolar, Schramm, and Prockl 2018). Against this context, studies attempted to solve the problem by considering foldable containers where four or six empty containers can be folded into one standard-size container (Zhang, Ruan, et al. 2018; Moon, Do Ngoc, and Konings 2013). Notwithstanding the potential of foldable containers, it is recognised that a huge amount of fixed investment is required before significant operational benefits can be demonstrated (Zhang, Ruan, et al. 2018). Based on the aforementioned discussion, we propose the following (see Figure 7 for a graphical illustration):

Observation 4: The BRI impacts on the transportation industry by promoting intermodal transportation, yet there exist significant challenges regarding high freight costs, poor transportation / logistics infrastructure, and complex repositioning issues of empty containers.

[Figure 7: Graphical illustration of Observation 4]

4. A unified framework: research trends and agenda

Based on a comprehensive review of 58 journal articles, this study identifies four clusters of research themes that correspond to four principal trends of transportation research in the context of the BRI. By synthesising the review findings under each trend, four observations are presented, stressing the major impacts of the BRI on transportation industry and associated uncertainties and challenges. In this section, we propose two key agenda along with a list of research questions for future research. A unified framework is thus provided as shown in Figure 8.

[Figure 8: Unified framework of review findings and proposed research agenda]

With reference to Figure 8, the first two trends address impacts of the BRI from a strategic perspective. As an infrastructure-led initiative, it is found that the BRI actively finances infrastructure projects in partnering countries, which contributes to both hardware (infrastructure capacity) building and software (transportation network) upgrading. Impacts are expected to be especially prominent on inland regions (e.g. landlocked countries) and / or less developed countries. On the one hand, they are effectively connected to regional / global transportation hubs by participating in the BRI. On the other hand, they become potential destinations of the next manufacturing base by surfing the wave of the global-wide re-shoring.

To this end, the BRI may strategically reconfigure global transportation networks by bringing new entrants into the competitive field whose potentials are yet to be unlocked with enhanced infrastructure capacity. The new entrants may be a disturbance that further stimulates the growth potential of the system. In this regard, we may expect the BRI to contribute to a new equilibrium of the transportation system with enhanced infrastructure capacity and transportation network connectivity. We invite future researchers to explore the dynamic reconfiguration process and characteristics of the transportation network under the new equilibrium. Importantly, the process may suffer from multiple uncertainties.

As identified in our review findings, certain infrastructure construction projects under the BRI are considered highly controversial in terms of environmental and geopolitics risks. In addition, resilience of transportation networks may also be at risk due to deep interdependency

among players involved and difficulties in implementing a coordinated disaster prevention plan. Given various uncertainties in the reconfiguration process, we proposed the following research questions:

(1) What are the contextual risk factors (in addition to environmental and geopolitical risks) and to what extent would those factors influence the reconfiguration process of the transportation networks?

(2) How does the resilience level of transportation networks evolve during the configuration process?

(3) To what extent would deep dependency among transportation players influence decisions on preventive investments?

(4) How would deep dependency among transportation players contribute to or hinder the development of a resilient transportation network during the reconfiguration process?

With an operational focus, two trends of research highlight potential changes of business operation patterns of the regional / global transportation industry due to the impacts of the BRI. To illustrate, the current transportation network depends heavily on the Malacca Strait. To alleviate the transportation bottleneck, review findings suggest that a series of infrastructure projects are planned / implemented under the BRI that diversify sea-based shipping routes and promote land-based intermodal transportations. Changes have been especially exemplified in infrastructure projects such as the Thai Canal, the New Eurasian Land Bridge, and various over-land transit pathways, which provide alternative routes with different transportation modes bypassing the chokepoint of the Malacca Strait.

In this connection, we predict that introduced alternatives would intensify competition among transportation players (especially port operators), leading to upward competition in terms of quality of transportation services. A virtuous development cycle may be anticipated in the transportation industry that strengthens service reliability, availability, and diversity. We propose a research agenda on modes of future competitions in the transportation industry as intensified by the BRI. Essentially, our review studies identify several critical concerns that influence competitiveness of transportation routes and create operational challenges. In particular, our review suggested that the influence of locational advantage seems to dwell gradually considering the availability of well-established alternative routes. Instead, it is route reliability, cost competitiveness, and overall ease of operations (such as empty container repositioning) that matter. Taking various concerns into consideration, we propose four specific research questions:

- (1) What are the response strategies for transportation players who used to enjoy a locational advantage in the face of a global upwards competition in transportation standards due to the BRI?
- (2) What are the levels of reliability of alternative routes as promoted under the BRI (compared to conventional routes), and how does upwards competition influence reliability?
- (3) What are the optimal subsidy schemes that lead to competitive freight costs of intermodal transportation (compared to sea-route alternatives) and sustain long-term profitability of land-based routes in the context of the intensified competition under the BRI?
- (4) What are potential emerging / disruptive technologies that may solve operational challenges in intermodal transportation and how does technology influence competition between land-based and sea-based long-distance transportation?

5. Conclusion

This study systematically reviews key research trends of transportation research under China's BRI and makes several contributions in this regard. First, we contribute to the research with a unified framework of various impacts of the BRI on the transportation industry. With synthesised insights from 58 journal articles, the framework reveals multi-dimensional impacts of the BRI. More specifically, by applying combined methods of inductive content analysis and co-occurrence network analysis, four principal clusters of transportation research are obtained, which correspond to the four major research trends in the field. Respectively, the four trends address the BRI's impacts on the transportation industry in relation to building logistics capacity, strengthening transportation network connectivity, enhancing energy security (by diversifying shipping routes), and promoting intermodal transportation.

More importantly, notwithstanding the potentially significant impacts of the BRI, its future prospects suffer some drawbacks. Our contribution lies in the identification of strategic risks and operational challenges of the BRI in the context of transportation research (as summarised in the four observations). To begin with, the unprecedented scale of transportation infrastructure construction gives rise to controversies, among which environmental and geopolitical risks are the most critical considerations that may influence the successful implementation of infrastructure projects (Observation 1). Strengthened connectivity of transportation networks may increase vulnerability of the system due to deep involvement of transportation players (Observation 2). Further, while diversified shipping routes and

transportation modes alleviate overall dependency on the Strait Malacca, alternative routes have a long way to go before they become operationally competitive as compared to established counterparts in terms of route reliability, freight costs competitiveness, etc. (Observations 3 & 4).

In view of prospects and challenges, we further contribute by proposing two research agendas and a series of specific research questions for future research. Recognising the BRI as a potential game-changer in the transportation industry by building both the necessary hardware and software, we propose to investigate the reconfiguration process of the transportation network due to the impact of the BRI. Specific research attention may be directed to contextual factors such as environmental and geopolitical risks and internal factors concerning network resilience, which collectively shape the reconfiguration process. Given the intense competition in the transportation market caused by the BRI, this study also proposes exploring potential upward competition in transportation service standards. We invite future researchers to revisit operational issues in transportation by considering added impacts of the BRI on market competition and evolution of service standards.

This review study also offer some managerial implications for both public and private transport players. Our findings suggest that the BRI may lead to reconfiguration of transportation network by contributing to infrastructure capacity building and enhancing transportation network connectivity. During the reconfiguration process, investments and resource integration are required which provide cooperation opportunities for public agencies and private business players. For example, the business players can establish strategic alliances (e.g. between major shipping liners and terminal operators) by investing in “hardware” and “software” along the BRI economic belt, while public agencies can facilitate the cooperation by providing favourable policies to attract more private investors from other BRI countries. Thus, a smoother reconfiguration process may be achieved through the collective actions of public and private actors. Furthermore, our study suggests that the BRI may promote an increasingly competitive market of transportation industry, where the competition is no longer within the same mode of transportation, but among sea-based, land-based and multimodal transportation (Baykasoğlu et al. 2018). The changed competition pattern provides development opportunities for landlocked regions which were placed in a particular disadvantage in the conventional sea-based transportation. Thus, both the public agencies and private players should realise the emerging role of these regions. The initial supports from both public and private actors in land-based transportation are essential in promoting healthier competitions in alternative transportation modes in the long run. For public agencies, financial

aids such as tax subsidies may be required to support the initial development of these regions; For private players (such as shippers), they may respond by relocating their manufacturing base to these regions, which shortens the lead time and lowers the shipping costs due to the faster and subsidised transportation service by land.

The contribution of our research must be interpreted with certain limitations. To the best of our knowledge, no clear contour of the BRI has been defined. The BRI is open to participation from any region and country as long as there is a mutual interest and the overall coverage of the BRI is constantly expanding. As a result, extant research often focuses on high-profile BRI programmes that are well-established, such as the China-Pakistan Economic Corridor and New Eurasian Land Bridge Economic Corridor, whereas other components of the BRI receive less attention. In particular, the BRI has been recently extended to the Arctic region due to the developing shipping lanes opened up by global warming. A proposed “Polar Silk Road” has been integrated into the BRI as a strategic component (Tillman, Yang, and Nielsson 2018). The Polar Silk Road may create major impacts on all four trends of transportation research identified in this review study, yet only limited research can be found that thoroughly investigates the issue. The omission of the Polar Silk Road may be a limitation of this study. Additionally, as part of the Pan-Asia Rail Network, Malaysia’s East Coast Rail Link has resumed after months of negotiations. The rail network would contribute to the re-distribution of regional traffic upon completion. We expect more research to be conducted on the continuously expanding landscape of the BRI.

In addition, with a primarily objective to identify the key research themes, this review study does not distinguish studies with a qualitative or a quantitative focus. Special attention was paid to research motivations and implications, whereas distinctive methodologies as adopted by different studies are de-emphasised. Among the 58 articles covered in our study, a variety of methods have been applied in this field, such as case studies (Wang and Yau 2018), multi-criteria decision analysis (Yang, Jiang, and Ng 2018), gravity model (Wei, Sheng, and Lee 2018), game theory (Liu et al. 2018), and mixed integer programming (Zhao et al. 2018). While a comprehensive review of research methodologies is out of the scope of this study, such a review would complement our study from a different perspective (see Lee et al. (2018) for a brief discussion). We encourage future researchers to devote efforts towards a methodological review of transportation research under the BRI.

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Appendix A: A summary of studies under review (see supplementary material)

Tables

Table 1: Publication year of reviewed articles

Publication year	2015	2016	2017	2018	2019
Number of articles	1	4	4	42	7

Table 2: List of sources of reviewed articles

Source of article*	No. of article
<i>Maritime Policy & Management</i>	13
<i>Transportation Research Part E</i>	11
<i>Sustainability</i>	4
<i>Transport Reviews</i>	4
<i>International Journal of Logistics Research and Applications</i>	3
<i>Area Development and Policy</i>	2
<i>International Journal of Shipping and Transport Logistics</i>	2
<i>Transportation Research Part A</i>	2
*Sources with two or more articles covered are listed	

Table 3: List of key research themes

Occurrence of key themes*			
Logistics infrastructure	11	Economic growth	3
Alternative route	10	Port competitiveness	3
China-Europe	10	Carbon emission	3
Environmental consideration or impact	8	Energy security	3
Hub port	7	Manufacturing relocation	3
Transportation network	7	High value-added product	2
Strait of Malacca (Malacca dilemma)	6	Hinterland connectivity	2
Intermodal (multimodal) transportation	6	Thai Canal (Kra Canal)	2
Regional cooperation	6	Hub-and-spoke	2
High-speed railway	5	Port cluster	2
Energy	4	Complex network	2
Land bridge	4	Inland dry port	2
Oil transportation	4	Empty container repositioning	2
Trade integration	3	Resilience of transport system	2
*Only themes appearing in two or more articles are listed			

Figures

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Figure 2: Illustration of co-occurrence network analysis

Figure 3: Results of co-occurrence network analysis of key themes

Figure 4: Graphical illustration of Observation 1

Figure 5: Graphical illustration of Observation 2

Figure 6: Graphical illustration of Observation 3

Figure 7: Graphical illustration of Observation 4

Figure 8: Unified framework of review findings and proposed research agenda

Figure captions (list):

Figure 1: Illustration of review methodology

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Figure 4: Graphical illustration of Observation 1

Figure 5: Graphical illustration of Observation 2

Figure 6: Graphical illustration of Observation 3

Figure 7: Graphical illustration of Observation 4

Figure 8: Unified framework of review findings and proposed research agenda