Intermodal freight transportation network analysis: The China-Singapore International Land-Sea Trade Corridor

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Abstract

The China-Singapore International Land-Sea Trade Corridor (C-S-ILSTC) was officially proposed in 2018, under the government-to-government framework of the China-Singapore (Chongqing) Demonstration Initiative on Strategic Connectivity. The C-S-ILSTC is expected to play an important role in the international trade and connectivity between Western China and Southeast Asia, where Chongqing serves as the logistics hub that covers surrounding provinces in Western China, and Singapore is a transshipment hub for ASEAN region. This paper aims to analyse the newly formed intermodal freight container transport network in the context of C-S-ILSTC and China-Singapore/ASEAN region quantitatively from both supply and demand sides, and identify the bottlenecks hindering the increase in C-S-ILSTC utilisation rate. For the demand side analysis, the results show that stable economic growth in China and ASEAN can be expected, and the trade volume between China and ASEAN countries is forecasted to consistently increase in the future. The most commonly traded cargo types between China and ASEAN have also been identified. For the supply side analysis, the ports infrastructure and services, the inland transport along C-S-ILSTC, and the connection with China Railway Express have been analysed and compared. In addition, the advantages and disadvantages of C-S-ILSTC in comparison with the conventional intermodal container transport routes connecting Western China and Southeast Asia have been investigated and discussed. The result of this study could provide policy implications for the development of C-S-ILSTC and the cooperation between China and ASEAN region.

Keywords: Chongqing, International Land-Sea Trade Corridor, ASEAN, Intermodal Transportation, Bottlenecks

1. Introduction

Regional Comprehensive Economic Partnership (RCEP) was signed on 15 November 2020, serving as a free trade agreement among Asia-Pacific countries. 15 member

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countries have been involved in RCEP, accounting for approximately 30% of world's population and global GDP value, such that it forms the largest trade bloc in history (Nikkei Asian, 2020). The introduction of RCEP has unified the pre-existing bilateral agreements among the ten-member Association of Southeast Asian Nations (ASEAN) and its five major trade partners, namely, China, South Korea, Japan, Australia and New Zealand (CNA, 2020). Thereby, RCEP is expected to open up the market among its member states and promote the growth of trade. Under the regional cooperation environment and Belt and Road Initiative (BRI) which improves the transportation infrastructure and alters the spatial properties (Lin, 2019; Liu et al., 2020), the trade and intermodal freight transportation between Western China and Southeast Asia as well as the other countries has been solidified.

With the government-to-government framework of the China-Singapore (Chongqing) Demonstration Initiative on Strategic Connectivity, the Chongqing Connectivity Initiative - International Land-Sea Trade Corridor (CCI-ILSTC) or the China-Singapore International Land-Sea Trade Corridor (C-S-ILSTC) was officially proposed in 2018. The corridor connects eight Western China provinces including Chongqing municipality, Guangxi province, Guizhou province, Gansu province, Qinghai province, Xinjiang province, Yunnan province and Ningxia province and Southeast Asia. Under C-S-ILSTC, Chongqing serves the logistics hub that covers surrounding provinces via the domestic rail and highway systems of China, whereas Singapore serves a transshipment hub for ASEAN region. As a critical cargo transportation corridor, C-S-ILSTC provides several major benefits: it plays a key role in the international trade between Western China and ASEAN/Oceania countries; it improves the connectivity between Western China and ASEAN/Oceania countries through rail-sea or intermodal freight transport operations; it elevates the potential of western ports of China (namely, Beibu Gulf Ports); it enhances the hub port status of Singapore.

The development of C-S-ILSTC is expected to provide more cargo transportation route choices for freight forwarders and shippers, attract more commodities to utilise C-S-ILSTC, and re-distribute the international trade flows. In 2019, the National Development and Reform Commission of China has formulated the master plan for developing the international land-sea trade corridor, consisting of the overall strategic plan, guiding principles, and the goals for a planning period of 2019-2025 and looking forward to 2035. In addition, many strategic and political guidelines are being actively formulated and implemented by the Party Central Committee, the State Council, and various levels of regional or local government bodies.

In addition to boost the trade between China and ASEAN countries, C-S-ILSTC could also affect the ASEAN-Europe freight trade by integrating with the China Railway Express (CRE). As pointed out by Zhou et al. (2017); Hung (2020); Chen (2021), CRE can provide a new transportation corridor for Southeast Asia-EU trade where cargoes can be shipped from Southeast Asia to coastal region in China, with trade-off between cost and timeliness. Wei and Lee (2021) suggested that China inland ports can improve their efficiency and service to enhance their radiation capability of shipping Southeast Asian cargoes to Europe via a combination of shipping and CRE. In particular, Jiang et al. (2020) argued that connecting C-S-ILSTC & CRE can provide an alternative route for the ASEAN-EU transportation, while the traditional ASEAN-EU freight transportation is mainly seaborne.

We have reviewed the related research works on C-S-ILSTC, and two research papers in English (Chan, 2019; Jiang et al., 2020) and 175 papers in Chinese on C-S-ILSTC have been identified as of Apr 2021, after searching major databases, including Web of Science, Scopus, and China National Knowledge Infrastructure (CNKI). The majority of the research papers have been funded by the local governments of Guangxi province and Chongqing municipality in China, and many Chinese papers have been published Western China's local journals. In general, C-S-ILSTC is a hot research topic among Western China academic institutions at present. The existing research papers can be classified into three categories, namely, transportation and logistics, economy and trade, development status and the significance of C-S-ILSTC, as illustrated in Table 1[1]. However, the previous research on C-S-ILSTC mainly focused on the qualitative study of ILSTC such as the policy analysis, whereas the quantitative study was rarely found. In addition, there was a lack of systematic research on C-S-ILSTC from the perspective of supply and demand.

Table 1: Categorisation of related research works on C-S-ILSTC

No.	Category	Topics
1	Transportation and logistics	Guangxi province
		Chongqing municipality and Sichuan province
		General transportation industry
2	Economy and trade	Policies, opportunities and challenges regarding regional trade in Western China
		International trade between China and ASEAN
3	Development and significance	The development status and significance of C-S-ILSTC

This paper aims to analyse the newly formed intermodal container transport network in the context of C-S-ILSTC and China-Singapore/ASEAN region quantitatively from both the supply side and the demand side, and investigate the bottlenecks that hinder the increase in C-S-ILSTC utilisation rate. The results of the study could provide policy implications to the development of C-S-ILSTC container transportation network. The remainder of the paper is organised as follows: Section 2 overviews the contextual setting of C-S-ILSTC. Sections 3 and 4 illustrate the demand side and supply side analysis of C-S-ILSTC respectively. Section 5 draws the conclusion, addressed the limitations of the current work and future work directions.

2. Contextual investigation

In this section, we investigate the contextual background of C-S-ILSTC, in terms of its geographical transportation connection within China, as well as its international connection with ASEAN countries and Europe.

2.1. C-S-ILSTC within China

For the part of ILSTC within China, the key long-haul freight transportation mode is railway. Three major railway transportation lines (as shown in Figure 1) from Chongqing and Chengdu to Beibu Gulf Port (including Qinzhou Port, Beihai Port, Fangcheng Port) via Guiyang, Huaihua, and Baise respectively, have been established to ensure the daily

[1]As the majority of the research papers on C-S-ILSTC were in Chinese, these papers are not presented in this paper in detail.

operation of container trains, and to maintain the effective connection with China-Europe trains.

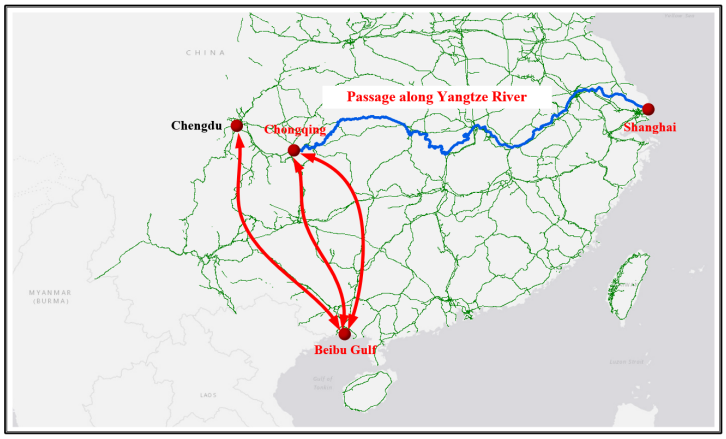


Figure 1: Major railway transportation lines from Chongqing and Chengdu to Beibu Gulf Port

2.2. Connection with ASEAN

ILSTC enables Chongqing's connection to several ASEAN countries, and the major available freight transportation routes connecting between Chongqing and ASEAN region is depicted in Figure 2. The transit time of ILSTC has been compared with conventional routes connecting Chongqing and ASEAN ports via Yangtze River and Shanghai port , as summarised in Table 2, where 10-20 days transit time saving can be achieved.

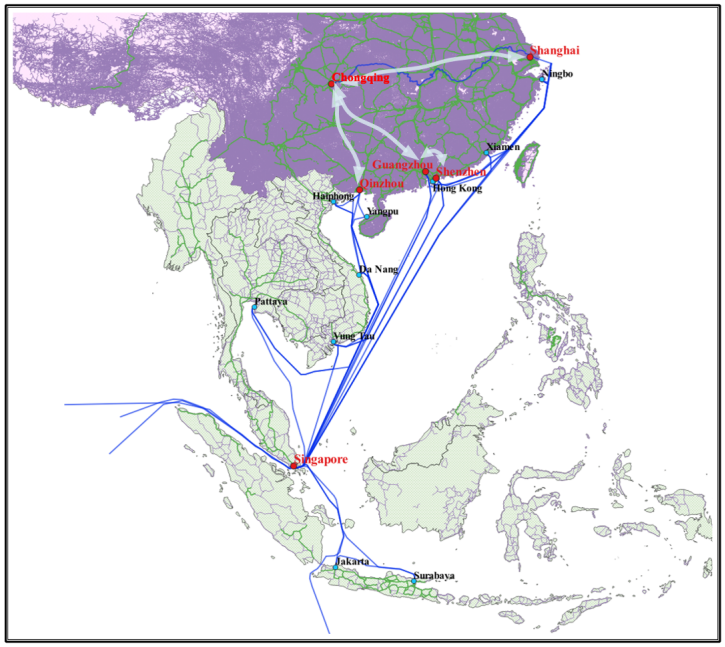


Figure 2: Major routes connecting Chongqing and ASEAN countries

In particular, for the connection between Chongqing municipality and Singapore, there are mainly four intermodal container transport routes via Shanghai, Shenzhen, Guangzhou and Beibu Gulf Port (C-S-ILSTC) respectively, with different transportation

Table 2: Transit time of ILSTC and conventional routes for some ASEAN ports

Routes	Transport Time (days)		Time saving
	ILSTC	Conventional route	
Chongqing – Beibu Gulf – Klang Port (Malaysia)	10	20	10
Chongqing – Beibu Gulf – Bombay (India)	20	30	14
Chongqing – Beibu Gulf – Jakarta Port (Indonesia)	20	21	12

modes, lengths, time and costs (as shown in Figure 3). The details will be discussed in Section 4.

Figure 3: Main intermodal container transport routes between Chongqing municipality and Singapore

2.3. Connection with EU

The impact of ILSTC on the transit time to Europe (EU) has also been analysed. Taking the example of the route between Chongqing and Rotterdam, the transit time from Chongqing to EU via ILSTC has been compared with conventional routes such as railway, shipping, inland waterway, and airline, as summarised in Table 3. We collected data on transportation costs after the COVID-19 pandemic, and compared them with data before COVID-19 (Seo et al., 2017), where it can be observed that the container freight rates has increased by at least 180%.

The surge in container freight rate after COVID-19 pandemic can be explained by the increase in shipping demand due to the changes in consumers' shopping patterns, for instance, the prosperity in electronic commerce. On the other hand, the supply capacity is in sufficient, which has further caused container repositioning issue and shipping capacity imbalances (UNCTAD, 2021)[2]. Before COVID-19 pandemic, the railway-shipping route

[2]As the freight rates during COVID-19 outbreak are much higher and unrepresentative, the freight rates before the pandemic has been utilised for further analysis in the remainder of the paper.

by ILSTC provides relatively low cost, merely higher than the inland water-shipping route via Shanghai, whereas transit time savings of around 12 days by ILSTC can be achieved. After the outbreak of the pandemic, China Europe Express also appears to be a competitive container freight transportation alternative, in terms of both transit cost and time.

Table 3: Transit time of ILSTC and conventional routes for Chongqing – Rotterdam

Routes	Mode	Cost (USD/TEU)		Transit time (days)
		Before COVID-19	After COVID-19	
Chongqing – Qinzhou – Rotterdam (ILSTC)	Highway-Shipping	1,461	10,914	34
	Railway-Shipping	1,333	9,382	33
Chongqing – Shanghai – Rotterdam	Inland Waterway-Shipping	1,177	8,288	45
	Highway-Shipping	1,819	11,890	37
	Railway-Shipping	1,581	9,809	36
Chongqing – Alashankou – Rotterdam	China Railway Express	2,218	6,250	15
Chongqing – Rotterdam	Airline	4,465	54,700	3

3. Demand side analysis

In this section, we present an analysis of the demand side of C-S-ILSTC. First, the trade between China and ASEAN countries have been analysed, where the GDP values and the international trade volume between China and ASEAN countries over the years are collected and the future trade volume between them are predicted. We then study the cargo types traded between China and ASEAN, in terms of bulk cargo and non-bulk cargo. Lastly, the trade between Chongqing municipality and ASEAN has been investigated, where significant growth in trade volume can be observed.

3.1. China-ASEAN trade volume

Generally, the GDP of China and ASEAN has been increasing over the years, as demonstrated in Figure 4a. The GDP values from 2021 to 2025 are extracted from the 'World Economic Outlook' database of World Bank (Oct 2021), which is an authoritative data source for GDP forecast, considering numerous theoretical and practical influencing factors in the forecast (Huang et al., 2020). It can be observed that despite the COVID-19 pandemic, the GDP values of China and ASEAN are expected to continue to consistently grow, providing a stable macro-economic environment for China-ASEAN cooperation.

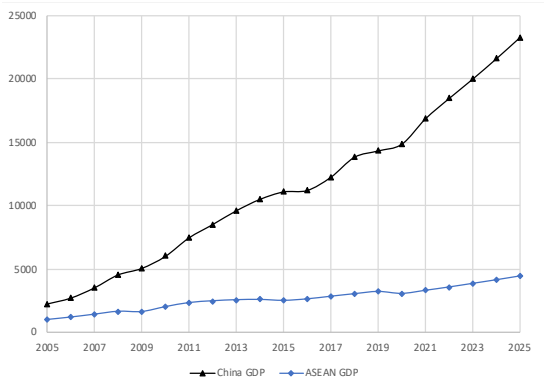
In addition, the trade volume between China and ASEAN has been consistently growing in recent years, as shown in Figure 4b. The China-ASEAN Free Trade Area (CAFTA) has been fully launched since 2010, such that the average tariff on the cargoes from ASEAN countries to China dropped from 9.8% to 0.1%, and around 90% of the goods can be traded at zero tariff, covering a market with around 2 billion people (MFA, 2010). In 2019, ASEAN has surpassed the US to become China's second-largest trading partner. Thereby, the benefits provided by CAFTA has deepened the cooperation and triggered the high trade volume between China and ASEAN countries. In the first three months of 2020, ASEAN became China's largest trading partner surpassing both the EU and US.

The Regional Comprehensive Economic Partnership (RCEP) among Asia-Pacific countries has further been signed in 15 Nov 2020. Until 2021, China has been the largest trading partner of ASEAN for the previous 12 years (FMPRC, 2021).

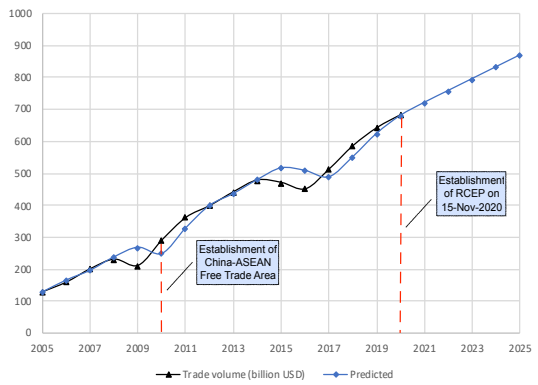
The trade volume between China and ASEAN from 2021 to 2025 are predicted based on the automatic autoregressive integrated moving average (ARIMA) forecasting algorithm. The ARIMA model has been widely used in the previous research works, such as supply chain demand forecast (Gilbert, 2005), container shipping freight rate forecast (Munim and Schramm, 2017), container throughput forecast (Rashed et al., 2017), etc. The non-seasonal ARIMA(p, d, q) model is applied in this study, where p denotes the number of autoregressive terms, q denotes the number of moving average terms, and d denotes the non-seasonal difference in order:

$$\phi(B)(1 - B^d)Z_t = \theta(B)\epsilon_t, \tag{1}$$

where Z_t which denotes the trade volume between China and ASEAN at year t; B represents the backshift operator, such that $BZ_t = Z_{t-1}$, hence $B^n Z_t = Z_{t-n}$; $\phi(B)$ and $\theta(B)$ are polynomials of order p and q respectively; $\{\epsilon_t\}$ denotes the white noise series, with mean value as zero and variance as σ_ϵ^2. Then the automatic ARIMA model adopted in this paper follows an iterative approach within the order constraints, and the best ARIMA model is selected based on the AIC value. The results show that ARIMA(0,1,0) with drift is the optimal model, with AIC value as 150.01 and the mean absolute scaled error (MASE) as 0.49. The details on the deduction process of ARIMA can be found in Hyndman and Khandakar (2008). As shown in Figure 4, the results show that stable economic growth in China and ASEAN can be expected, and the trade volume between China and ASEAN countries is also forecasted to consistently increase in the near future.



(a) Total GDP value of China & ASEAN countries (billion USD)



(b) Trade volume between China and ASEAN (billion USD)

Figure 4: China & ASEAN economy

3.2. Cargo types traded between China and ASEAN

As demonstrated in Figure 5, we have extracted the trade volume of the commodities between ASEAN countries, Australia, and New Zealand and China between 2015 and 2019 based on the United Nations Conference on Trade and Development (UNCTAD) database (UNCTAD, 2019); the trade values on 2025 have also been predicted based on

automatic ARIMA model and depicted accordingly, where the average MASE values for the southbound and northbound trade value prediction are 0.65 and 0.84 respectively.

It can be observed from Figure 5a that the potential southbound bulk cargoes using C-S-ILSTC include mineral fuels, iron and steel and articles thereof, chemical products, vehicles and parts thereof (break bulk), aluminium and articles thereof, organic chemicals; while the potential southbound non-bulk cargoes using CCI-ILSTC include electrical products/equipment, machinery and mechanical appliances, plastics and articles thereof, furniture and bedding, and optical, photographic or medical instruments.

On the other hand, from Figure 5b, it is shown that the potential northbound bulk cargoes using C-S-ILSTC may include ores, mineral fuels, rubber and articles thereof, precious stones and metals, and organic chemicals; while the potential northbound non-bulk cargoes using C-S-ILSTC include electrical products/equipment, machinery and mechanical appliances, plastics and articles thereof, optical, photographic or medical instruments, and fruit and nuts.

In general, bulk cargoes such as iron and steel, metal, mineral fuels cannot be shipped by containers. Singapore, as a typical endpoint of C-S-ILSTC, does not process or smelt the bulk cargoes like iron ore either. For these cargoes, Singapore mainly performs the role as a transhipment hub, instead of earning other profits in manufacturing.

3.3. Trade between Chongqing and ASEAN

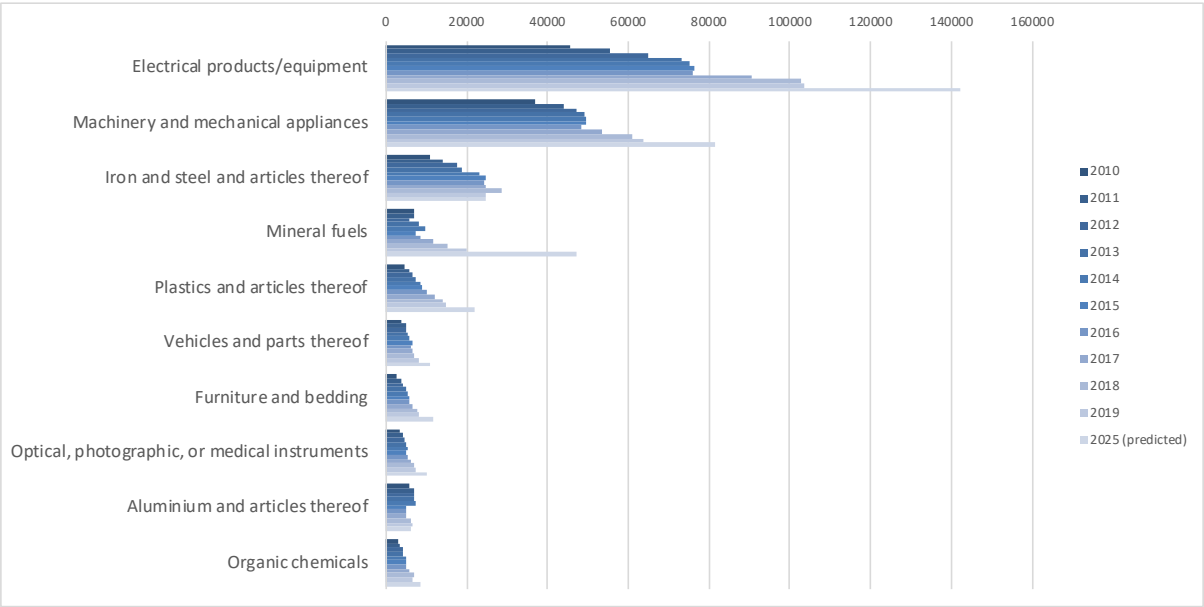
In particular, we have also examined the trade characteristics between ASEAN countries and Chongqing municipality which is a typical endpoint of C-S-ILSTC. According to the data from Chongqing Statistical Yearbooks (Chongqing Government, 2020a), trade volume between Chongqing and ASEAN countries accounted for 14.5% of Chongqing's total export and import trade in 2018, and this number has increased to 18.7% in 2019, demonstrating the huge trade potential between Chongqing and ASEAN. Based on Xinhua (2019), we have also compared the foreign trade volume from Chongqing to the ASEAN and other countries along BRI, as shown in Table 4, where the important role of ASEAN state members could be observed.

Table 4: The trade volume of Chongqing to the ASEAN and other countries along BRI

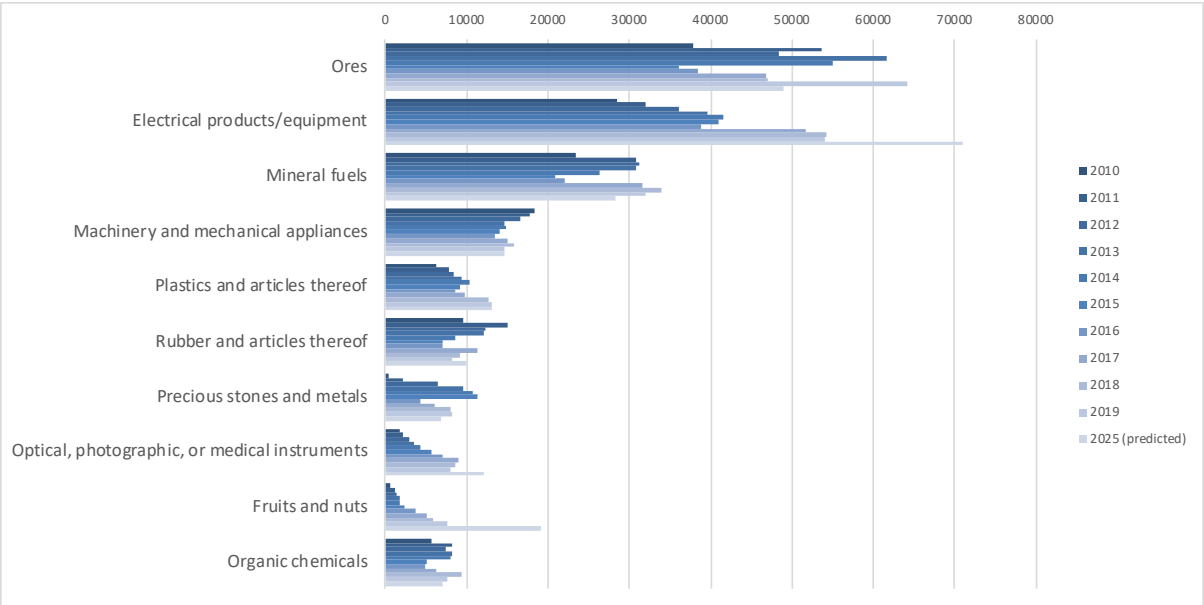
Trade direction	Trade volume and growth	The first three quarters of 2018 (billion USD)	The first three quarters of 2019 (billion USD)	Growth rate
Countries along the Belt and Road and C-S-ILSTC	ASEAN state members	7.6	11.1	46.1%
	Other members	4.6	5.2	13.0%
	Subtotal	12.2	16.3	34.1%
Other countries		39.9	42.2	5.8%
Total		52.1	58.5	12.3%

4. Supply Side analysis

In this section, we investigate the supply side of C-S-ILSTC. First, we examined the ports infrastructure and services at the essential nodes of the corridor, namely, Chongqing municipality, Singapore, and Guangxi Beibu Gulf port, and we also provide a comparison of the intermediate ports of the intermodal container transport routes between Chongqing



(a) Southbound trade value (million USD)



(b) Northbound trade value (million USD)

Figure 5: Commodities traded between China and ASEAN

and Singapore. In addition, we explored the Inland transport of C-S-ILSTC by overviewing the intermodal railway services along C-S-ILSTC, comparing the available inland transportation modes, and comparing C-S-ILSTC with conventional intermodal container transportation corridors connecting Chongqing and Singapore.

4.1. Ports infrastructure and services

4.1.1. Chongqing

As an essential node connecting the 'Belt and Road' with the Yangtze River Economic, Chongqing has railway and inland waterway connections to major ports in China, such as Shanghai port, Guangzhou port, Shenzhen port and Beibu Gulf port (as shown in Figure 6). In addition, Chongqing has completed the construction of five major logistics centres, including Chongqing International Logistics Park, Chongqing Aviation Logistics Park, Guoyuangang Intermodal Transportation Hub, Fuling Longtou Port and Logistics Park, Nanpeng Commerce and Logistics Base, and Jiangjin Luohuang Logistics Park, which form the main logistics hub of Chongqing. Among these logistics centres, Guoyuangang Intermodal Transportation Hub is the largest inland water, railway, and highway intermodal hub port in China. Based on Chongqing Mid-term and Long-term Railway Network Plan (2016-2030), as a freight transportation hub, Chongqing municipality will accommodate 2 national railway logistics centers, 4 regional railway logistics centers and 9 regional railway logistics centers. The key container transport centers in Chongqing such as Tuanjiecun Container Central Station and Yuzui Railway Freight Station are being upgraded.

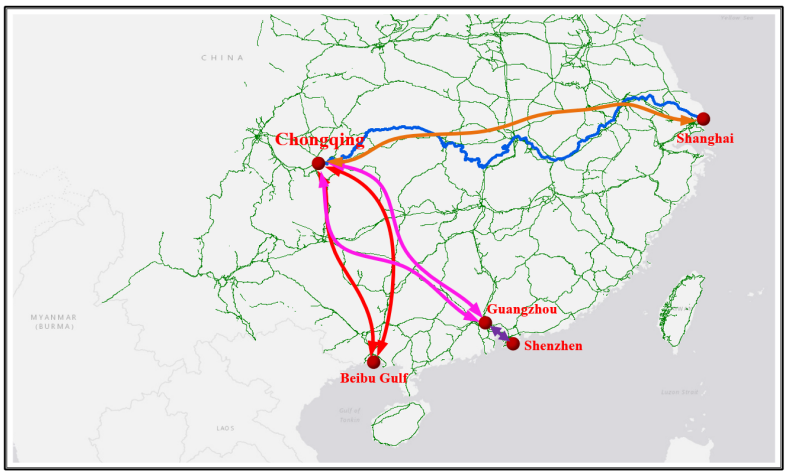


Figure 6: Chongqing's railway and inland waterway connections

To contribute to the development of C-S-ILSTC, the local government of Chongqing municipality has formulated a plan in April 2020 to promote and implement the master plan for C-S-ILSTC published by the National Development and Reform Commission of China, named as Chongqing's implementation plan to promote the development of C-S-ILSTC (Chongqing Government, 2020b). The implementation plan of Chongqing has aimed to increase number of rail-sea intermodal trains and cross-border highway shuttles by more than 15% annually; to develop railway refrigerated transport and reefer container multimodal transport; to increase the railway trains from Chongqing to Beibu

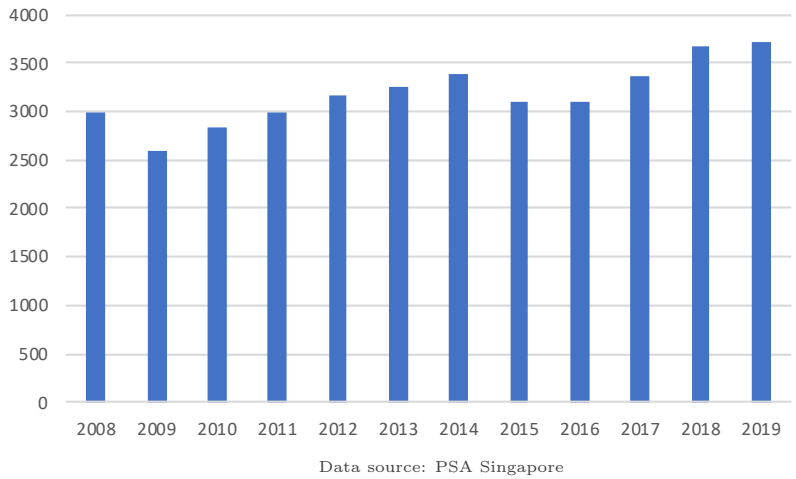


Figure 7: Total container throughput of Singapore port (in '0000 TEU)

Gulf Port; and to develop value-added services and integrated logistics business (e.g., constructing overseas distribution centers, overseas warehouses and container return points in Singapore, Vietnam, Laos, Cambodia, Thailand and other ASEAN regions), etc.

4.1.2. Singapore

Located at the center of trade routes web, Singapore port is a global hub port, international maritime center and a key maritime gateway to key Asian markets, which has connection to around 600 ports in more than 120 countries, providing various users reliable, value-added and cost-efficient marine services and facilities (MPA, 2021). According to World Shipping Council, Singapore is the second busiest container port in the world regarding container throughput, which has been summarised in Figure 7. In addition, Singapore is one of the top refuelling ports and bunkering ports in the world. Currently, Singapore is the busiest port in Southeast Asia, while it is also faced with emerging competition from the neighbouring ports in the region, including port Klang in Malaysia, port Laem Chabang in Thailand, etc. (Nguyen et al., 2020).

4.1.3. Beibu Gulf port

The Guangxi Beibu Gulf port consists of three port areas, namely, Qinzhou port (the largest one), Fangcheng port and Beihai port. Until 2020, the port infrastructure and equipment include 18 container ship berths capable of serving vessels of up to 100,000 DWT, 28 quay cranes, 84 gantry cranes, and the port capacity up to 5.6 million TEU/year. For international connectivity, Beibu Gulf port has 31 international shipping services, covering Southeast Asia, Northeast Asia, South Africa and South America, etc. We have also examined the container port throughput data published by the Ministry of Transport of China, and the top fifteen ports in China in terms of container port throughput in 2019 are summarised in Figure 8. Guangxi Beibu Gulf port is ranked as the fourteenth, while it has has demonstrated the highest year-on-year growth rate (over 30%).

As shown in Figures 9a and 9b, we have also examined the total cargo throughput and the container throughput of Guangxi Beibu Gulf port in recent years, with the average annual growth rate as 11.88% and 28.62% respectively (bbwport, 2021). It is depicted

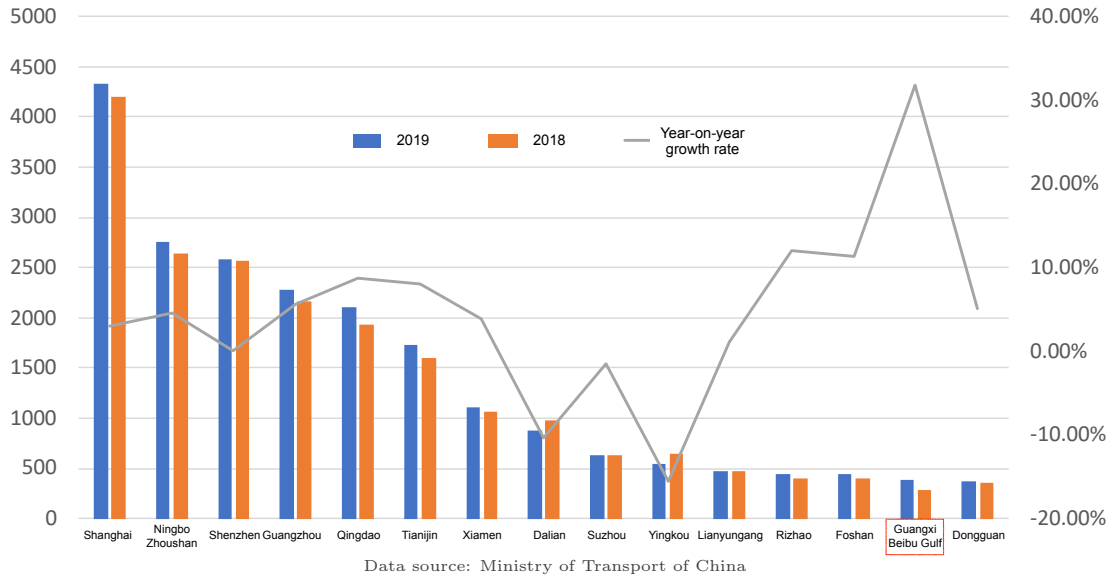
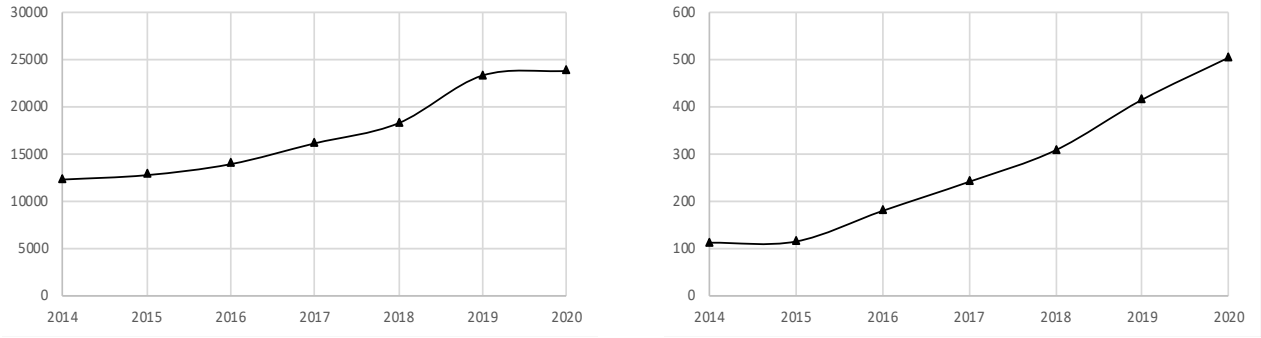


Figure 8: China top 15 ports' container throughputs (in '0000 TEU)

that the container throughput has maintained a robust growth even under the COVID-19 pandemic, demonstrating the consistent development potential of the port.



(a) Total cargo throughput ('0000 ton)

(b) Container throughput ('0000 TEU)

Figure 9: Annual throughput of Guangxi Beibu Gulf Port

Furthermore, for the port's railway connection, Table 5 shows the train frequency between Qinzhou Port East station and the regional hubs in Western China, including Chengdu, Chongqing and Kunming. From 2017 to the first quarter of 2020, the train frequency at the port has also been observed to consistently increase over the years.

Table 5: Train frequency between Qinzhou Port East station and Western China regional hubs

Hub/Year	2017		2018		2019		2020(Q1)	
	train No.	train/day	train No.	train/day	train No.	train/day	train No.	train/day
Chongqing	17	0.04	314	0.86	515	1.41	118	1.29
Chengdu	0	0.00	33	0.09	249	0.68	64	0.7
Kunming	0	0.00	29	0.08	18	0.04	14	0.15
Total	17	0.04	376	1.03	782	2.36	196	2.15

4.1.4. Comparison of ports

In this section, the shipping services from Qinzhou Port, Shanghai Port, Shenzhen Port, Guangzhou Port to Singapore Port have been further compared and analysed, as summarised in Table 6. In 2019, Qinzhou port achieved the container throughput of 3.016 million TEUs with a year-on-year increase of 29.8%. Compared with ports of Guangzhou, Shenzhen and Shanghai, the throughput of Qinzhou port is quite low even though its growth rate is the highest. On the other hand, the number of international shipping services called at Qinzhou port is only 42, which is only about 1/5 of Guangzhou port, 1/6 of Shenzhen port and 1/7 of Shanghai port. Therefore, the seaward hinterland of C-S-ILSTC is limited compared with the three conventional routes. In other words, the shipping services in Qinzhou port are not ready to accommodate a large volume of containers for international shipping. On the other hand, we have also observed that the shipping frequency between Qinzhou and Singapore is the highest compared to the other three ports.

Table 6: Comparison of shipping services to Singapore

Port	Throughput 2019 (million TEU)	Increase of throughput (year on year)	Number of shipping services (international & feeder)	Service frequency
Shanghai	43.3	3.1%	281	4-7 ship/day
Shenzhen	25.7	0.1%	238	3-5 ship/day
Guangzhou	22.8	0.2%	217	3-5 ship/day
Qinzhou	3.0	29.8%	42	1-3 ship/day

Furthermore, the size of vessels called at Qinzhou port is small compared with those vessels called at Guangzhou, Shanghai and Shenzhen ports. For example, Pacific International Lines (PIL) operates two 900-TEU vessels in Singapore and Qinzhou Shuttle (SQS) service, and the capacity for PIL's largest ship that calls at Qinzhou port is 1,728 TEUs. In comparison, Guangzhou port, Shanghai port and Shenzhen port can handle mega-ships with the capacity exceeding 10,000 TEUs. Hence, these ports could attract more transhipment containers from Western China.

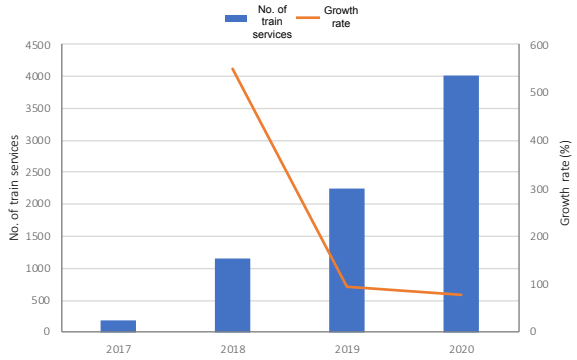
4.2. Inland transport of C-S-ILSTC

4.2.1. Intermodal Railway Services

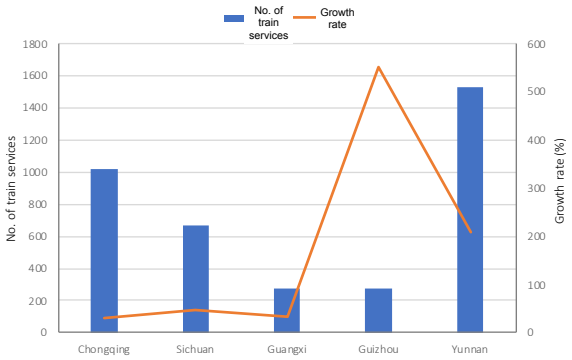
The intermodal train service frequency along the C-S-ILSTC has been increasing during the past few years. The number of train services along the C-S-ILSTC increased from 178 to 4020 from 2017 to 2020 (as shown in 10a), where over 100% year-on-year growth rate can be observed since 2018. In addition, all western China provinces, especially Guizhou province and Yunnan province, have experienced fast growth in the capacity of intermodal service used by cargoes, as shown in Figure 10b.

4.2.2. Comparison of inland transportation modes

The transit time and cost for the inland transport of C-S-ILSTC and conventional corridors are compared in Table 7. The inland waterway transport via Yangtze River has the longest transit time at 12-20 days from Chongqing to Shanghai, but the lowest cost at only 282 USD/TEU. The railway transport time for Chongqing-Beibu Gulf and Chongqing-Shenzhen (or Guangzhou) are all within 3 days, but the cost of the former is



(a) Number of train services along the C-S-ILSTC (2017-2020)



(b) Intermodal train services used by Western China provinces (Jan-Nov 2020)

Figure 10: Intermodal Railway Services

less than that of the latter. To sum up, C-S-ILSTC railway service is the most competitive choice in terms of transit time, while inland waterway transport is the most competitive choice in terms of cost.

Table 7: Transit time and cost for inland transport for C-S-ILSTC and conventional corridors

Corridor	Modes	Length(km)	Time(days)	Cost($/TEU)	Service frequency
Chongqing – Beibu Gulf	Railway	1230	2	796	1 train/day
Chongqing – Shenzhen	Railway	1848	3	1088	1 train/day
Chongqing – Guangzhou	Railway	1709	3	1088	1 train/day
Chongqing – Shanghai	Waterway	2300	12-20	282	1 ship/day

4.3. Comparison among C-S-ILSTC and conventional corridors

Lastly in this section, the length, time and cost of C-S-ILSTC are compared with the main conventional intermodal container transport routes between Chongqing municipality and Singapore, as summarised in Table 8. Among the four routes, the route via Shanghai port (water to water) is the cheapest one, whereas the route via Qinzhou port is the shortest one, whose cost is around 2 times of the cost of Chongqing-Shanghai-Singapore route. Thereby, the cost issue could be the reason why shippers do not want to transport the low-value time-insensitive cargoes via C-S-ILSTC. On the other hand, C-S-ILSTC could be potentially attractive to the carriage of time-sensitive reefer containers.

Table 8: Comparisons among intermodal container transport routes between Chongqing and Singapore

Routes	Mode	Length(km)	Time(days)	Cost(USD/TEU)
Chongqing – Qinzhou port – Singapore port	Railway – Shipping	4219	6	1071
Chongqing – Yantian port – Singapore port	Railway – Shipping	5276	7	1173
Chongqing – Guangzhou port – Singapore port	Railway – Shipping	5137	7	1173
Chongqing – Shanghai port – Singapore port	Inland waterway – Shipping	7284	23-21	365

4.4. C-S-ILSTC and China Railway Express

As mentioned in Section 1, connecting C-S-ILSTC with CRE can provide an alternative freight transportation route between ASEAN and EU. Based on the literature on Asia-Europe trade lane (Zhang et al., 2016; Notteboom, 2012; Wang et al., 2018), the typical conventional routes include the ones via Suez Canal and the Cape of Good Hope, which are demonstrated together with C-S-ILSTC with CRE in Figure 11.

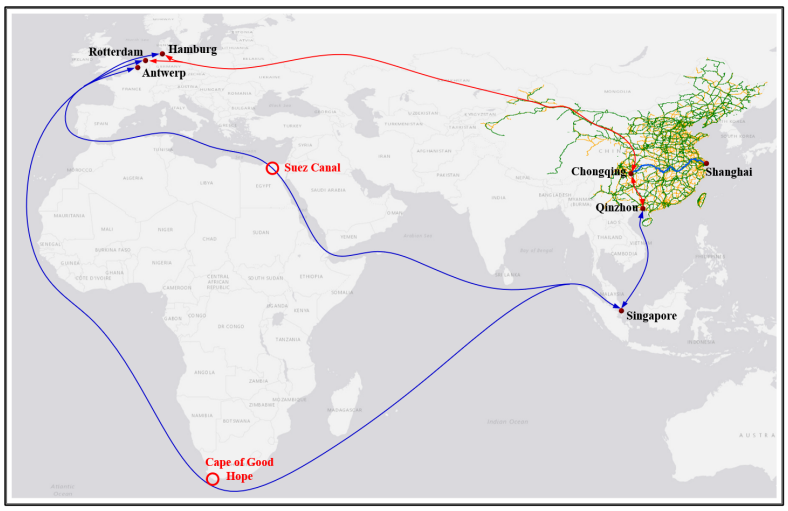


Figure 11: C-S-ILSTC and China Railway Express

Table 9 has further summarised the current service frequency information between Singapore and the top three ports in EU by throughput, namely, Rotterdam, Antwerp and Hamburg. Generally, the service frequencies from Singapore to the three destination ports are similar, and the route via Suez Canal has the highest service frequency, followed by the route via The Cape of Good Hope (CGH), and the newly formed route along C-S-ILSTC & CRE.

Table 9: Singapore-EU service frequency

Origin	Destination	Route	Mode	Service frequency
Singapore	Rotterdam	SG-Chongqing-Rotterdam	Shipping-China Railway Express	3-5 ship-train/day
		SG-Suez Canal-Rotterdam	Shipping	8-12 ship/day
		SG-CGH-Rotterdam	Shipping	2-6 ship/day
	Antwerp	SG-Chongqing-Antwerp	Shipping-China Railway Express	3-5 ship-train/day
		SG-Suez Canal-Antwerp	Shipping	8-12 ship/day
		SG-CGH-Antwerp	Shipping	2-6 ship/day
	Hamburg	SG-Chongqing-Hamburg	Shipping-China Railway Express	3-5 ship-train/day
		SG-Suez Canal-Hamburg	Shipping	8-12 ship/day
		SG-CGH-Hamburg	Shipping	2-6 ship/day

5. Discussion and conclusions

The new intermodal container transport network based on C-S-ILSTC enriches the choice for the intermodal transport in the import and export trade between the western provinces of China and the Singapore/ ASEAN & Oceania countries. With the development of C-S-ILSTC and a series of preferential transport/trade policies on it, more

freight forwarders/shippers would be attracted by the new C-S-ILSTC freight corridor. Thereby, it is necessitated to investigate the demand side and supply side of C-S-ILSTC systematically, and identify the bottlenecks hindering the increase in C-S-ILSTC utilisation.

In terms of the demand side, stable economic growth in China and ASEAN can be expected, and the trade volume between China and ASEAN countries is forecasted to consistently increase in the future 5 years based on the automatic ARIMA forecasting model. The most imported bulk commodities and non-bulk commodities by ASEAN countries, Australia, and New Zealand from China have been identified as iron and steel and articles thereof, and machinery and mechanical appliances respectively; the most exported bulk commodities and non-bulk commodities from ASEAN countries, Australia, and New Zealand to China have been identified as ores, and electrical products/equipments respectively.

From the perspective of the supply side, in comparison with the conventional corridors connecting Western China and Southeast Asia, the C-S-ILSTC provides relatively short transport time, high transit reliability compared to inland shipping on Yangtze River, high level of railway service, relatively lower cost than other rail-sea intermodal transportation routes, and it could be suitable for transporting time-sensitive cargoes (e.g. reefer containers). In addition, C-S-ILSTC can be connected with CRE, providing an alternative freight transportation route between ASEAN and EU, even though the current service frequency is relatively low. On the other hand, C-S-ILSTC has several disadvantages including limited number of shipping services via Beibu Gulf port, low service capability of railway freight station, low container service capability at Beibu Gulf port, small capacity of ships called at Beibu Gulf port compared with that of Guangzhou, Yantian and Shanghai, and higher cost compared with inland waterway transport via the Yangtze River. To overcome C-S-ILSTC's shortcomings at present, several policy implications are raised to increase the utilisation rate or competitiveness of C-S-ILSTC: (1) To develop cold chain logistics and time-sensitive cargo deliveries; (2) To improve cooperation with shipping companies and launch more international shipping services; (3) To enhance the container service capability at railway freight station and Beibu Gulf port.

In the future, we could further model the route choice behaviour between C-S-ILSTC and other available routes, and investigate the connection between C-S-ILSTC and China Europe Railway Express.

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