Pandemic Effect on Multimodal Transport Operation: Border Trade Between Thailand and Southern China

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***Abstract*—This paper explores the various alternative routes and methods available from Bangkok to Yunnan, a province in southern China. Cross-border trade has always been one of the main catalysts for Thailand's economy. However, ever since the pandemic, COVID-19, freight transport has been heavily affected due to lockdowns, quarantine, the suspension of production and border closures. Furthermore, it has created complications for the performance and profitability of most industrial sectors. This research investigates the pandemic effect on multimodal transport operations with focuses on five routes: R3A, R3B, R9, R11, and R12, which are the transport routes of agricultural products from Thailand to Yunnan. Delphi method was used to establish a sub-criterion of transport across borders, followed by the Time-Cost Distance method which are used to investigate the operational changes. The result has shown that with the increased process of cross-border freight services, transport costs and time was substantially increased causing changes in route selections.**

Keywords—multimodal transport, COVID-19, Cost Model, Thailand

I. INTRODUCTION

At present, it is undeniable that cross-border transportation (CBT) is an essential criterion in developing the international trade economy. CBT drives growth through international trade results in a better economy growth. Multimodal transport is critical to international cross-border trade in the global economy, particularly in the movement of commodities, since it allows for the efficacy of foreign and domestic trade, the development of industrial linkages, and the transportation of passengers and cargo. However, during the pandemic, COVID-19, several logistics service providers providing multimodal transport services has been affected. In order to reduce the number of infectious cases, several governments have closed or limited their trade borders, causing disruptions in vehicle movements, labour shortages, and the preservation of physical distance in production facilities. Due to the pandemic event, several difficulties were found in multimodal transportation operations and are expected to impact worldwide international trade considerably.

Dwivedi, et al. [1] suggest that the COVID-19 epidemic has significantly and severely affected the existing methods of facilitating the flow of goods. It is worth noting that the pandemic revealed the vulnerability of business concerns and operations while also posing new obstacles. Due to transport limitations, some countries were forced to temporarily close their borders to remedy the outbreak. COVID-19 has created a challenge to force entrepreneurs to plan and adapt promptly to cope with these rapid changes. It is also worth noting that this event is a global event that has directly impacted the global economy. According to the survey [2,] managing the supply chain across borders and enabling commerce has become one of the most difficult jobs in keeping a firm alive. As a result, logistics service providers must adapt while retaining operating performance and cost [3,4].

In ASEAN and its neighbouring countries, the impact of COVID-19 on road freight transport includes short- and long-term impacts on costs and delays of cross-border transport operations, which ultimately affect the freight transport industry. A decrease in global economic activity leads to less freight transport demand, and in the case of COVID-19, a decrease in supply has been observed due to lockdowns, quarantine, the suspension of production, and border closures. The pandemic has reduced cross-border freight transport and according to the Economic and Social Commission for Asia and the Pacific (ESCAP) 2020, freight transport services providers in the ASEAN Member States have been severely affected by the COVID-19 pandemic at 50% of the total members. The epidemic crisis affects cross-border transport, especially regarding cost and time criteria. In line with the research [5], the information on cost and time criteria needs to be considered to obtain comprehensive analysis for decision-making in multimodal transport during COVID-19. Therefore, this research uses the Time-Cost Distance Method to create fundamental analogies for freight route decisions because the advantages of the time–cost and distance method are that it is a simple model, shows the current situation, and can track time changes of operation. Therefore, it can be used to compare different transportation routes and helps compare and evaluate transportation route decisions [6].

This study will concentrate on five routes: R3A, R3B, R9, R11, and R12, which convey agricultural goods from Thailand to Southern China. The researchers analyze the activities on five routes impacted by the COVID-19 epidemic using the Time-Cost Distance Method. This study illustrates an overview of the COVID-19 pandemic's influence on the phases of cross-border transportation. These findings could assist policymakers in establishing strategies to address multimodal transportation challenges during the epidemic

crisis. Furthermore, it can assist logistics service providers in planning the delivery of products to accommodate unforeseen challenges.

II. Literature review

A. Multimodal Ttransport

The delivery of goods to customers using two or more modes of transportation is referred to as multimodal transportation. This can be done in either public or private vehicles (for example, buses, taxis, metros, trains, and ships, car, motorbike, bicycle, and walking). Multimodal transportation has grown in importance in the modern world because it promotes high levels of cross-border movement at the regional level [7]. The conveyance of goods from point A to point B under the management of a single transport operator is referred to as international multimodal transport. Multimodal transportation is similar to intermodal transportation in that it employs many modes of transportation to move across international borders while using a single contract and single carrier. The contrast between intermodal and multimodal transportation is the cargo handling during the voyage. Cargo handling will be required during multimodal transport operations. Some people may also refer to multimodal transportation as integrated transportation. However, combined transport is no longer in use because of the 1975 ICC Rules were superseded by the 1992 UNCTAD/ICC Rules for multimodal transport. As a result, when the carrier is responsible for door-to-door transportation, the term "multimodal transport" should be used. As a fundamental foundation, multimodal transport operators may build and evaluate transportation systems, plan operations, and deliver realistic transportation at competitive rates and shorter times in specific routes. According to the law, multimodal transport is a contract for the carriage of goods that includes a carrier known as the multimodal transport operator that transports products via at least two distinct modes of transport from the point where the goods originate to the point of delivery.

As part of the contract, commodities are transported by two or more distinct means of transportation (such as road, rail, air, or inland canal, and short- or deep-sea ships). A multimodal transport operator (MTO) is frequently in charge of the full haulage contract, from shipping to destination [8]. Goods transportation might be intra-national or international, with extra procedures such as customs clearance.

B. The COVID-19 impact on Multimodal Transport

COVID-19 has created complications for the performance and profitability of most industrial sectors [9,10,11]. According to Loske [12], the spread of COVID-19 sickness has had a large effect on multimodal transportation since the government has adopted different restrictions that have hampered enterprises' capacity to execute logistical operations. The pandemic had been formally announced at the end of January 2020, resulting in the COVID-19 epidemic that has infected every country [13]. Many governments have imposed limits and policies to safeguard individuals and reduce disease spread [14]. However, according to Fernandes [15], these restrictions and policies have harmed the country's economy by preventing businesses from growing at their previous rates. Furthermore, the downturn in trade, industry, and other commercial sectors has harmed transportation and logistics. Consequently, it has negatively influenced the total GDP growth rate across nations globally [13]. Furthermore, Aloi, et al. [16] investigated the impact of COVID-19 on urban mobility and found that total mobility fell by 76%, with public transport users falling by up to 93%. Finally, trade barriers, demand restraints, and a scarcity of trained labor have a substantial influence on supply chains and freight volume [12].

The multimodal transport of goods for various items during the COVID-19 crisis has encountered challenges in the part of cross-border transport constraints [1]. As more strict public health policies result in additional limitations on cross-border transit, transportation costs and times climb [10]. COVID-19 has a direct influence on logistics providers as well. The pandemic had an impact on logistics companies, which are important components of value chains that help businesses deliver their products to clients by facilitating trade and commerce inside and across borders [17,18]. As a result, competitiveness, economic development, and job creation have all declined. The COVID-19 pandemic showed the fragility of provider-sector activities and created additional issues. Policymakers have struggled to help logistics service providers and exporters with the new federal COVID rules due to a lack of coordination and collaboration [19].

Firms have attempted to resolve the shift in customer and supplier paradigms while minimizing potential operational and economic challenges [9]. Moreover, suppliers have struggled to manage the logistics supply chain across borders while still supporting commerce and business [20]. Results of the concerns found in the freight and multimodal transportation during the COVID-19 outbreak were found in this study, notably in Thailand and the South China trade corridor, as well as crucial factors that would serve as a guideline for future epidemic management.

III. Research Methodology

A. The Delphi Method

The RAND Corporation created the Delphi approach in the 1950s to forecast the influence of technology on combat. This approach was used to find the most trustworthy consensus from iterated "group replies" to consecutive surveys to deal with a complicated situation. Therefore, this strategy is used in a wide range of disciplines to identify and prioritize challenges for management decision-making [21]. The Delphi method entails a group of experts with extensive expertise and knowledge on a particular issue responding to questions.

B. Time – Cost Distance Method

The assessment of two intermodal transport corridors was carried out through the evaluation of the physical condition of infrastructure and transport processes including non-physical bottlenecks along the corridors. Data related to the state of transport infrastructure, time, and cost involved in the whole transportation process along the corridors were collected. The overall condition, performances, operational effectiveness, and efficiency of corridors were evaluated and compared. The condition of the road surface, geometry, type of pavement, border crossing facilities, intermodal logistics infrastructure, and facilities was evaluated by visual survey during the site visits as, well as through the comparison of collected data. For this purpose, the Time–Cost–Distance approach was used [6]. By evaluating and comparing the cost and time required for transportation, processing, and

transshipment along a leg of a corridor and at intermodal transfer and border crossing points, any inefficiencies or bottlenecks of the transport process are identified.

This model uses curve steepness to reflect the cost changes in each mode, the slopes indicate transport cost per distance, and vertical surges show the cost steps of multimodal transfer [22]. The cost of the different combination of modes may vary depending on the chosen route. Therefore, the model provides an intuitive and accessible graphical comparison between routings and finds the best cost- and time-wise route using cost, transit time, and distance.

IV. The Research Process

The research process was separated into two phases. The first phase used the Delphi method to establish a sub-criterion of transport across borders, following the time-cost distance method. After that, a second phase collected data from 35 logistics service providers who transported goods from Thailand to Southern China. Finally, the researcher used the time-cost distance method to describe the impact of the COVID-19 outbreak on all five routes (R3A, R3B, R9, R11, and R12) of transportation of goods from Thailand to China.

A. Data Collection

TABLE I. The sub criteria of Time-Cost Distance

No	Time-Cost Distance criteria in cross border transport		
	Criteria	***Description***	***Ref.***
T1	Time of Customs Clearance	Time for border crossing; time for customs clearance; and exchange rate fluctuation during delivery time.	[23,24]
T2	Time of Transport	Time for transportation	[23,25]
C1	Transport Costs	Costs for transportation; costs for possible additional costs during transportation; additional insurance (insufficient safety).	[25,26]
C2	Border Crossing Cost	The cost of passing goods through customs so they can enter or leave the country to a shipper shows that the customs duty has been paid and the goods can be shipped.	[23,24]
C3	Budget Overrun	A cost increase which involves unexpected, incurred costs due to an underestimation of the actual cost during budgeting.	[23]
D1	Distance of Transport	The sum of the distances of all transportation stages.	[27]

This is the process of gathering data via questionnaires. The questionnaires were distributed to operators who had been registered with the Multimodal Transport Operator of Thailand (MTO of Thailand) and had been providing MTO services for at least five years. It contains 30 LSPs, according to the Marine Department of Thailand 2019. The data was gathered through face-to-face, phone, and email interviews with LSP decision-makers. The survey was carried out over a period of 60 days (from 1 May 2021 to 30 June 2021).

B. Compare The Route by the Time-Cost Distance Method

This procedure was performed to compare five routes in a normal period to the COVID-19 period using the time-cost distance technique. This study analysed multimodal transport parameters during regular times with COVID-19 to determine which elements led to this epidemic condition and to develop a guideline for logistics service providers and policymakers to improve and choose routes.

The primary transportation corridor between Thailand and Kunming [28] are R3A and R3B. Distances, timings, road types, and customs clearance procedures vary between these itineraries between Laos and Myanmar [29]. As a result, each route is appropriate for different types of commodities. However, owing to competition in transportation costs, efficiency, and the impact of the pandemic, this study looked into other routes, including R8, R9, and R12. All three routes have the capacity to convey commodities from Thailand to Kunming, China. Normally, all three routes will be utilized as an option to carrying agricultural commodities from Thailand to Kunming until agricultural items are supplied from Thailand to Nanning through Laos and Vietnam.

V. Result

A. Route Analysis – Pre Pendamic

The main transportation routes between Thailand and Kunming consist of multimodal routes [28]. There are two major routes from Thailand to Kunming, namely, R3A and R3B. These routes transport through Laos and Myanmar have different distances, times, road types, and customs clearance processes [29]. As a result, each route is suitable for different goods. However, due to competition in transportation cost, transportation efficiency, and the impact of the epidemic, this study further investigated other routes, namely, R8, R9, and R12. All three routes have the capacity to convey commodities from Thailand to Kunming, China. Normally, all three routes will be utilized as an option to carrying agricultural commodities from Thailand to Kunming until agricultural items are supplied from Thailand to Nanning through Laos and Vietnam.

1. R3A Route

R3A is an international highway linking Thailand–Laos–China, with approximately 1,240 kilometres from Chiang Rai to Kunming. It is an important route for both the export and import sectors. In particular, the agricultural products sector is connected through the key points of all three countries as shown in Table II.

TABLE II. Time–Cost–Distance of R3A

Route R3A	**Distance(Km)**	**Time(Hr)**	**Cost(USD)**
Bangkok-Chiang Rai	830	13	1,450
Chiang Rai-Chiang Khong	110	2	180
Border crossing	-	2	250
Chiang Khong- Boten border	228	4.5	1,200
Border crossing	-	3	1,400
Boten border - Kunming	690	14	2,000
Total	**1,858**	**38.5**	**6,480**

2. R3B route

R3B, like R3A, is part of the Kunming-Bangkok Expressway. The distinction is that as it reaches Chiang Rung, it separates into a road, R3B, that heads to the Burmese border at Daluo in Shan State, via Kengtung and Tachileik, and enters Thailand at Mae Sai District in Chiang Rai Province, passing through various ethnic enclaves in Myanmar. As a result, tolls must be paid along the way. Because transportation is expensive, it is not widely employed in route decisions (Table III).

TABLE III. Time–Cost–Distance of R3B

Route R3B	**Distance(Km)**	**Time(Hr)**	**Cost(USD)**
Bangkok-Chiang Rai	830	13	1,450
Chiang Rai- Mae Sai	60	1.5	100
Border crossing	-	3	700
Mae Sai- Kengtung	163	3.5	1,800
Border crossing	-	3	1,400
Kengtung - Kunming	760	14	2,300
Total	**1,813**	**38**	**7,750**

3. *R8 route*

R8 starts at Bueng Kan Province; enters Paksan District of Laos through Vinh Heading to Hanoi, Vietnam; and ends in Guangxi. R8 is a route that connects four countries, starting from Bueng Kan Province, Thailand; passing the Bueng Kan border; entering Laos PDR; cutting through Vietnam; and reaching China. Most of the paths cut through the mountains, with this route stretching a total distance of more than 879 kilometers. There are various products, such as chemicals, pharmaceuticals, automobiles, equipment, and components to consumer products fabrics and threads, fresh fruit, and agricultural products, which are connected through the key points of all four countries as shown in Table IV.

TABLE IV. Time–Cost–Distance of R8

Route R8	**Distance(Km)**	**Time(Hr)**	**Cost(USD)**
Bangkok - Bueng Kan	718	11.5	1,300
Border crossing	-	4	220
Paksan - Nam Phao	222	6	540
Border crossing	-	4	760
Cau Treo - Lang Son	657	13	1,510
Border crossing	-	2.5	1,400
Lang Son - You Yi Guan	200	3	520
You Yi Guan - Kunming	784	12	1,300
Total	**2,581**	**56**	**7,550**

4. *R9 route*

Route R9 in Vietnam runs from the Lao Bao customs border, opposite the Lao People's Democratic Republic border gate, to Dong Ha, where it connects to Vietnam's main route. The entire distance between Danang to Danang Pier is roughly 260 kilometres. The route is a two-lane road with no shoulders and decent pavement on both sides, largely through rural regions.

Logistic facilities along Route R9 do not include truck stopping points with modern amenities along the route from Lao PDR to Vietnam; there are only gas stations. There are three main points for the transfer of goods: 1) the point of transfer of goods in Thailand in Mukdahan Province; 2) the transportation point in Lao PDR, Thakhek Province Savannakhet; and 3) the Dansavan–Lao Bao border crossing as show in Table V.

TABLE V. Time–Cost–Distance of R9

Route R9	**Distance(Km)**	**Time(Hr)**	**Cost(USD)**
Bangkok-Mukdahan	609	10	1,100
Border crossing	-	2.5	220
Mukdahan- Savannakhet	300	5	580
Border crossing	-	3	750
Lao Bao - Lang Son	900	18	2,070
Border crossing	-	2.5	1,400
Lang Son - You Yi Guan	200	3	520
You Yi Guan - Kunming	784	12	1,300
Total	**2,793**	**56**	**7,940**

5. *R12 route*

R12 links north-eastern Thailand with Guangxi Province, beginning in Nakhon Phanom Province and passing via Vietnam's Ha Tinh Vinh and Hanoi provinces before concluding in Guangxi. Following the November 2011 completion of the third Thai-Laos Friendship Bridge (Nakhon Phanom-Khammouan), Route R12 became the fastest route for transporting products from Thailand to Guangxi, China.

As shown in Table VI, R12 is one of the shortest transit routes from Thailand to Vietnam and China, and it is regarded a route that connects Thailand's north-eastern area with neighbouring nations. Beef cattle, dairy cattle, dairy products, electrical appliance electronic components, consumer items, agricultural products, and petroleum are all routinely carried along this route.

TABLE VI. Time–Cost–Distance of R12

Route R12	**Distance(Km)**	**Time(Hr)**	**Cost(USD)**
Bangkok-Nakhon Phanom	724	11	1,300
Border crossing	-	3.5	220
Nakhon Phanom- Cha lo	150	3.5	350
Border crossing	-	4	820
Cha lo– Lang Son	620	12.5	1,430
Border crossing	-	2.5	1,400
Lang Son - You Yi Guan	200	3	520
You Yi Guan - Kunming	784	12	1,300
Total	**2,478**	**52**	**7,340**

B. *Route Comparisons*

The route with the lowest cost is via Route R3A (USD 6,480). The other routes are via R3B, R12, R8, and R9, which cost USD 7,150, USD 7,340, USD 7,550, and USD 7,940, respectively, as shown in Fig 1. The total transport cost of Routes R8, R9, and R12 is higher than for routes via Chiang Rai because three routes have to cross three borders with three separate cross border costs. As a result, the routes crossing more borders have high transport costs.

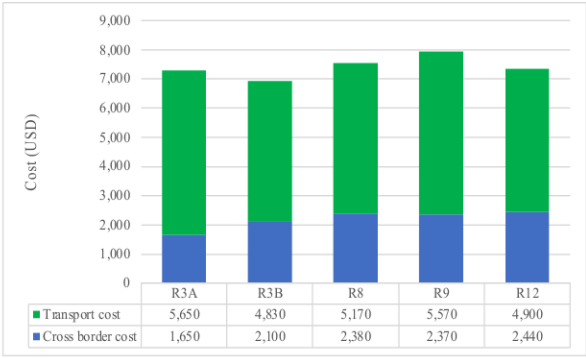

Fig 1. Total transport cost

The shortest route in terms of travel time is R3B, which takes 38 hours. The alternative routes, as illustrated in Fig 2, are R3A, R12, R8, and R9, which take 38.5, 56, 56, and 52 hours, respectively. Routes R8, R9, and R12 have a longer total travel time than routes through Chiang Rai because three routes must cross three borders with three different cross-border fees. As a result, routes that cross more borders have longer travel durations. According to the data, the average time to cross a border is 2.5 hours.

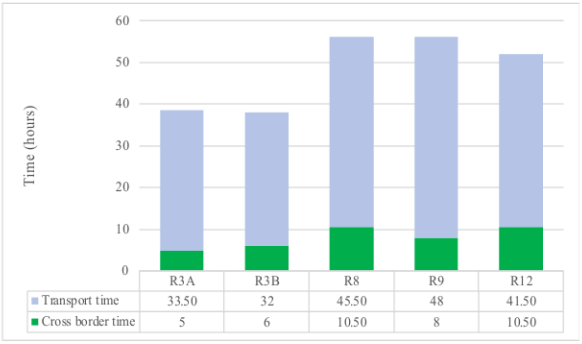

Fig 2. Total transport time

C. *Time – Cost Distance Analysis During Pandemic*

Table VII shows the criteria affected by the pandemic, of which the most affected criteria were the time of customs clearance and transport cost. However, the effect on each route was different because each route's context and underlying components differed. For example, the rules for opening and closing international border crossings during epidemic situations differed for each route, affecting transit time and excess delivery time.

TABLE VII. Details of Increase ratio change (%) criteria of each route during pandemic

Criteria	R3A	R3B	R8	R9	R12
T1	40%	66%	14%	25%	19%
T2	-	-	-	-	-
C1	49%	56%	32%	15%	3%
C2	10%	25%	10%	10%	12%
C3	20%	42%	20%	10%	15%
D1	-	-	-	-	-

From interviews with LSVs and related parties, both public and private, about the impact of the COVID-19 epidemic situation regarding international transport, it was found that some operators had changed their transport routes. From the case study of the transportation of goods from Thailand to the People's Republic of China in the past, the transport route used by operators was Route R3A after the outbreak of the COVID-19 virus. Lao PDR has strict protection standards for the transportation of goods through Lao PDR, and trucks must change cars and drivers at Huay Sai. As a result of such measures, the cost of transporting goods via Route R3A is higher, with an average increase of 5,000-7,000 USD per trip. Therefore, most operators have started to opt for Route R9 to transport goods to the People's Republic of China instead of Route R3A.

From the study of agricultural and food transport routes on the R12, it was found that, the R12 will have a dry port in Nakhon Phanom province to transport the cargos over the China–Vietnam border. Therefore, the transportation of goods on the R12 may increase. However, at present, the epidemic situation makes it necessary to have strict pandemic measures in place. Entrepreneurs need to apply for approval documents from the Nakhon Phanom Provincial Public Health Office before shipping. Moreover, the time limit for the cargo to be completed is 16 hours. As a result, some operators may opt for Route R9 can transport cargo more quickly than freight transport route via Route R12.

VI. Conclusion

In this research, cross border transport was clearly affected by the pandemic along with lacked information to manage international transport operations. The identified issues have a direct impact the transport industry from surveys conducted by the 30 Multimodal Transport Operators of Thailand (MTO of Thailand). Regarding to practical implications, this research highlighted the importance of the Time-Cost Distance model from the literature and the perspective of logistics service providers, which could provide a new perspective on conducting decisions related to multimodal transport operations, especially in the pandemic era.

The impact of the pandemic, Yunnan Province has increased the process of cross-border freight services, and border crossings are point-to-point transport systems. This means Chinese drivers are not allowed to cross to other country, and foreign drivers cannot transport goods across the border into China. Therefore, two Lao drivers and two Chinese drivers are required to bring empty cars to pick up goods at the Laos border post. Chinese and foreign drivers must deliver trucks and goods to adhere to the strict transportation rules at designated points of checkpoints and border crossings. In particular, at the Bo Ten-Bo Han checkpoint, strict testing for COVID-19 may apply to the driver and the goods.

As a result of the strict measures, transport costs and time have increased to a large extent. Previously, before the outbreak of the pandemic, Route R3A was the most popular among Thailand's logistics service providers for transporting goods to China. However, during the pandemic, the transport costs were noticeably higher compared to cross-border transport in Mukdahan (R9) and Nakhon Phanom (R12). As R3A has not been approved by the Cross-Border Transport Agreement (CBTA) for Thailand–China–Laos cargo, resulting in the spread of COVID-19, and the requirement of truck transfer, the cost of transport has increased by approximately 2,200–2,800 USD. These are significant problems and obstacles for entrepreneurs transporting goods from Thailand to China. This is because many problems are uncontrollable factors which could not resolved by shippers but required co-operation with the government. For example, freight costs fluctuated significantly during the COVID-19 pandemic, making the opening, and closing of borders unclear.

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