

The Impact of Epidemic on the Trans-Pacific Container Liner Shipping Market: A Game of the Supply and Demand

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Abstract

Since January 2020, the global novel coronavirus epidemic (referred to as the epidemic) has raged. Countries around the world have "suspended" most economic activities in order to prevent the spread of the epidemic. As a result, the global supply chain is severely disrupted, causing global inflation to rise. Freight rates on the trans-Pacific route from North America to the Asia-Pacific region continued to skyrocket, surcharge items increased, and delivery events were extended. Based on the analysis of the current situation of the impact on the trans-Pacific supply chain, the paper uses the data of the growth rate of Sino-US trade volume as a "pay off" sample to establish a supply-demand game model for container liners on the trans-Pacific route under the background of the epidemic. Under the dynamic assumption of incomplete information, a Bayesian refined Nash equilibrium is obtained. Finally, the paper uses the Bayesian refined Nash equilibrium model to analyze the trend of container liner shipping rates on trans-Pacific routes under the background of the epidemic.

Keywords: epidemic, trans-Pacific shipping routes, container liner shipping, Bayesian refined Nash equilibrium

1. Introduction

Since January 2020, the epidemic has depressed the global economy, leading to a gradual increase in global inflation (Yanxuan & Xianshui, 2020). The trans-Pacific route between East Asia and North America is an important international trade bridge between East Asia and North America (Fei, 2019). The early days of the epidemic coincided with the traditional Chinese Spring Festival. Due to the double impact of the epidemic and the Spring Festival (Jingwen, 2019), the container liner transportation on the trans-Pacific route has been severely affected. As a result, the container freight rate of the trans-Pacific route dropped sharply in the early stage; then container liner shipping companies were forced to cut transportation supply, and the trans-Pacific container liner shipping market fell into turmoil (Hongjia & Jian, 2020). In April 2020, the epidemic in China was gradually brought under control, and container liner shipping on the trans-Pacific route gradually recovered (Runyuan, 2020). However, the outbreak of the epidemic in the United States soon broke out, the US economy suffered a sharp setback, and inflation gradually rose. In January 2022, U.S. inflation hit 7.5%. Due to the repeated impact on container liner transportation on the trans-Pacific route, the freight rate continued to skyrocket. In May 2020, states in the United States gradually unblocked, and economic activities from East Asia to North America gradually resumed. Due to the increased demand for China's anti-epidemic materials and basic daily necessities in the United States (Zhonghua, 2009), the demand for container liner transportation on the trans-Pacific route has continued to increase. In August 2020, the container liner shipping market on the trans-Pacific route experienced a situation of "space shortage", "explosion of cabins" and "rejection of containers". Freight rates on the trans-Pacific route from East Asia to North America have risen sharply, various surcharges have been numerous, and delivery events have been extended.

2. The Current Situation of Container Liner Transportation in the Pacific Route Affected by the Epidemic

2.1 Rising Container Liner Shipping Costs

The epidemic has caused an increase in the freight rate of container liner shipping, starting with the impact of transportation costs. The epidemic has improved the daily epidemic prevention level of crew members, resulting

in an increase in the demand for epidemic prevention materials such as masks, disinfection items, disposable protective clothing and ship quarantine. In addition, once a ship has a crew member infected with the epidemic, the ship may be forced to "detour". "Detours" will inevitably increase the "voyage cost" of ship navigation; finally, if dock workers at the port are infected with the epidemic, according to the epidemic prevention requirements of many countries and regions, port facilities and ships need to be disinfected, especially the crew and dock loading and unloading staff perform nucleic acid testing. These prevention and control measures increase the complexity of ships calling at ports and loading and unloading operations, and also reduce the loading and unloading efficiency of ports (Zhonghua, 2009). The reduction of port loading and unloading efficiency directly leads to "ships jamming the port" and "heavy containers pressing the port". Moreover, a large number of container ships are constrained by the shipping schedule, and "empty ships return to the port" without "returning to the market" for empty containers, which also greatly increases the "ship cost" of container liner transportation.

2.2 Freight Rates Paid by Shippers (or Cargo-owners) Continue to Rise

The increase in shipping costs will inevitably be passed on to shipping rates. From 2008 to 2019, the trans-Pacific container liner shipping was affected by the global economic crisis in 2008 and the freight rate of the route dropped sharply for 10 years. In the months before the outbreak in 2019, the shipping rate per TEU was close to \$1,000/TEU. Liner companies have been struggling for 10 years. Of course, this was also the "golden" period when shippers (or cargo owners) enjoyed 10 years of low freight rates. However, since the epidemic spread globally in December 2019 to March 2022, container liner freight rates on trans-Pacific routes have continued to skyrocket. Between June 12, 2020 and December 31, 2020, the composite index of Shanghai export container freight rate soared from \$1015.33/TEU to \$2783/TEU, an increase of 274%.

2.3 The Surcharge Items for Container Liner Transportation Have Increased

In addition to the above-mentioned increase in the benchmark freight rate, in order to make up for the loss caused by the cost, container liner companies add various additional charges on the basis of the increased benchmark freight rate. For example, the surcharge for priority delivery of goods means that the shipper will add a surcharge ranging from USD 1000 to USD 3000 per FEU on the basis of the base freight rate to ensure that the shipper's goods arrive at the destination on time, otherwise the goods may take two weeks or even more than a month to reach the destination; in addition, CMA CGM and Yixing also introduced surcharges for "operating expedited routes". In order to ensure the "space" and "box space" of the shipper's goods, the ship owner can ensure that the shipper's container goods can be "fast" and "accurate" to the receiving port of the major destination, and set up surcharges with priority for loading and unloading. Liner companies such as Hapag-Lloyd in Germany, Hyundai Merchant Marine in South Korea, Ocean Netlink in Japan, and Yangming Shipping in Taiwan also levy "guarantee" service surcharges from shippers, and shippers pay the "guarantee" surcharges to make sure that the shipper's "booking" arrangements are in place.

2.4 The Delivery Date of the Goods Is Extended

In addition to the increase in base rates and surcharges, shippers are also facing issues such as extended delivery dates for their consignments. During the epidemic, many countries took measures such as "closing the city", which affected the work of stevedores. The normal order of loading and unloading operations at the port cannot be guaranteed, and the cargo of the cargo owner (or shipper) may not be called at the time and berth announced in the shipping schedule, in addition to being "dropped" and "dropped" by the shipowner. In order to get the goods to the yard, the shipper can only pay a large premium surcharge to the liner company, so that the goods can be delivered on time. Even if the premium surcharge is paid according to the liner company's requirements, the entire transportation process is still full of risks and uncertainties. When the transportation resources are extremely tight and the market environment is extremely complicated, the container liner still cannot deliver the goods to the destination on time, causing the shipper to the delivery date of the goods is extended.

3. The Game of Supply and Demand Trends in the Context of the Epidemic

The epidemic has led to a sharp increase in the rates and surcharges of the above-mentioned routes. How long will it last? This paper will take the supply and demand sides of the container liner shipping market in the trans-Pacific route as participants, establish a dynamic game model of incomplete information between the supply and demand sides, and analyze the trend of trans-Pacific route rates under the background of the epidemic.

3.1 Participants' assumptions

3.1.1 On the basis of the supply and demand sides of the trans-Pacific route as participants, the trans-Pacific

route market is introduced as a "natural" participant. "Natural" chooses the type T of the participant, neither supply nor demand know their type, but demand can observe the choice of supply.

3.1.2 "Natural" participants choose the future trend of the epidemic to "rise" or "not to rise". Based on the elaboration in the first part, we assume that the trend of the epidemic situation is rising, then the freight rate of trans-Pacific container liner will "increase"; if the trend of epidemic situation is "not rising", the freight rate of container liner of the trans-Pacific route will "not increase". The two participants in supply and demand do not know whether the epidemic is "rising" or "not rising"; but the demand can observe that the supply on the trans-Pacific route is "increased capacity input" or "no increase in capacity input".

3.1.3 It is assumed that the supply capacity of the supply comes from other routes around the world or new ships are ordered.

3.2 Data Sources

In the context of the epidemic, the probability of "natural" participants in the trans-Pacific container shipping market in the future "increase" in the epidemic trend is "P"; on the contrary, the probability of the epidemic trend "not increasing" is "1-P". The "pay off" data of the model guides the "Shanghai Export Container Comprehensive Freight Index Growth Rate" and "China-US Import and Export Trade Volume Growth Rate" in 2020. When the index is higher, it indicates that the supply and demand status of the trans-Pacific route is in "in short supply", and shipowners benefit; on the contrary, the lower the index is, it indicates that the supply and demand status is in "oversupply", and the demand, that is, the cargo owner (or shipper), benefits. See Table 1 for the growth rate of the container comprehensive freight index and Table 2 the growth rate of China-US import and export trade volume.

Table 1. the growth rate of the container comprehensive freight index of shanghai in 2020 unit:%

MONTH	The growth rate of freight in the West Coast	The growth rate of freight in the East Coast	The comprehensive growth rate
1	1.9	2.6	10.3
2	2.4	5.8	0.3
3	-0.9	-2.8	-3.3
4	2.8	1.3	-1.9
5	10.4	-2.4	0.6
6	3.1	-1.4	0.4
7	13.7	6.2	2.4
8	5.0	1.1	2.1
9	13.6	12.8	9.9
10	5.2	8.4	8.9
11	4.2	4.4	7.0
12	8.8	5.4	28.5

Source: China Shipping Database. <http://www.mofcom.gov.cn/>

Table 2. Growth rate of China-US import and export trade volume in the past two years, Unit: %

	2018		2019		January-June 2020	
	China	US	China	US	China	US
total import growth rate	13.05	8.25	-1.92	-1.67	-3.3	-1.49
total export growth rate	9.31	7.73	0.26	-1.25	-3	-1.35
total import and export growth rate	17.82	8.59	-0.73	-1.5	-3.2	-1.58

Source: According to the data released by the Ministry of Commerce of the People's Republic of China <http://www.mofcom.gov.cn/>

3.3 A Set of "Strategies" for Participants on Both the Supply and Demand Sides

3.3.1 Participant's Strategy When "the Epidemic Trend Continues", That Is, "the Freight Rate Rises"

If the supply strategy is "increase in capacity investment", that is, when the shipowner adjusts the capacity from

other routes to the trans-Pacific route or orders new ships, referred to as “increasing capacity investment”, the demand decision is “expanding the demand”, that is, the cargo owner (or shipper) decided to expand trade with the United States. At this case the supply and demand sides "payoff" are positive.

If the supply decision is "no increase in capacity investment", that is, the shipowner believes that the future trend of the trans-Pacific route is uncertain, and the past operation mode is still adopted for the route. According to the stabilization of the epidemic or even the end of the epidemic, it is decided to "expand demand" for the trade on the trans-Pacific route. At this time, the market of the trans-Pacific route will have a market situation of "short supply", and the demand is that the owner (or shipper) will pay High shipping costs. In this case, the pay-off for supply is "positive" and the pay-off for demand is "negative".

If the decision of supply is "increase in transport capacity" and the strategy of demand is "do not expand demand", the market is more favorable to demand than to supply. However, at this time, the pay off received by both the supply and demand sides is smaller than the pay-off obtained by the combination of "increasing transport capacity investment and expanding demand".

If the supply strategy is "do not increase capacity investment" and the demand strategy is "do not expand demand", the market is in a low level of equilibrium, the market activity is not enough, both the supply and demand sides are slightly at a loss, and the pay-off received is "negative" (such as Table 3: pay off Matrix when Market Type T is "Freight Rate Increase").

Table 3. Participant's strategy when "the epidemic trend continues", that is, "the freight rate rises"

		Supply Side			
		CI		CN	
Demand Side	DE	9.31	9.9	-3.3	8.9
	DN	7.73	0.3	-1.35	-3.3

Note: Expanding Demand, abbreviated as: DE; Non-Expanding Demand, abbreviated as: DN

increase in capacity input, abbreviated as: CI; No increase in capacity input. (abbreviated as: CN

Source: Based on the data in Table 1

3.3.2 Participant's Strategy When "the Epidemic Trend Ends" That Is, "the Freight Rate Does Not Rise"

If the strategy of supply is "increase in transport capacity" and the strategy of demand is "expand demand", then the pay off on both sides of the supply and demand is "positive". At this time, the supply and demand of the container liner shipping market on the trans-Pacific route are in equilibrium, and both supply and demand can make profits.

If the supply strategy is "no increase in capacity input" and the demand strategy is "expand demand", then the market is in a state of "in short supply" at this time, and the market is unfavorable to demand. Then the payoff for supply is a "positive" value; the payoff for demand is a "negative" value.

If the supply strategy is "increase in transport capacity" and the demand strategy is "do not expand demand": the market is in a state of "oversupply". The demand pay off is larger than the supply pay off, but it is "smaller" than the "expanding demand" strategy under the condition of supplying the "increase capacity input" strategy.

If the supply strategy is "no increase in capacity investment" and the demand strategy is "no demand expansion". At this time, the container liner shipping market on the trans-Pacific route is in a low-level "temporary" equilibrium state, with "small" or even slight losses on both sides of the supply and demand (when the type T of the route market is "freight rate does not rise", the pay off matrix is shown in Table 4).

Table 4. Participant's strategy when "the epidemic trend ends" that is, "the freight rate does not rise"

		Supply Side			
		CI		CN	
Demand Side	DE	13.05	10.03	-3	28.5
	DN	8.25	-1.9	-1.49	0.6

Source: Based on the data in Tables 1 and 2.

3.4 Harsanyi Conversion

According to the contents of Table 3 and Table 4, the payoff Matrix(see Table 5) and the game tree in Figure 1 are obtained by sorting out and performing the Harsanyi transformation. In the game tree, N is a "natural person", which represents the container liner shipping market on the trans-Pacific route.

Table 5. Harsanyi Conversion payoff Matrix

		FR(P)				FN(1-P)			
		Supply Side				Supply Side			
		CI		CN		CI		CN	
Demand Side	DE	9.31	9.9	-3.3	8.9	13.05	10.3	-3	28.5
	DN	7.73	0.3	-1.35	-3.3	8.25	-1.9	-1.49	0.6

Note: As the epidemic continues, freight rates rise, abbreviated as FR

After the epidemic is over, the freight rate will not increase, abbreviated as FN

Source: Based on the data in Table 3 and Table 4.

The freight rate trend of the container liner shipping market on the trans-Pacific route is affected by the epidemic: if the epidemic trend continues, according to the above description, the freight rate of the container liner shipping market on the trans-Pacific route "increases", and its increase probability is P; otherwise, it "does not increase" and the probability is 1-P. As the epidemic continues, freight rates rise, abbreviated as FR; After the epidemic is over, the freight rate will not increase, abbreviated as FN. The supply and demand of the participants do not understand the future trend of the epidemic, that is, the supply and demand of the participants only know that the probability that the market freight rate will increase is P, and the probability that it will not increase is 1-P. Then the supply response strategies are "increase in capacity investment", referred to as "CI"; otherwise, "CN". The strategy of participants' demand is to respond to the strategy of "DE" and "DN" in the market freight rate, and to expand import and export trade. If it is to expand exports Strategy, referred to as "DE"; otherwise referred to as "DN".

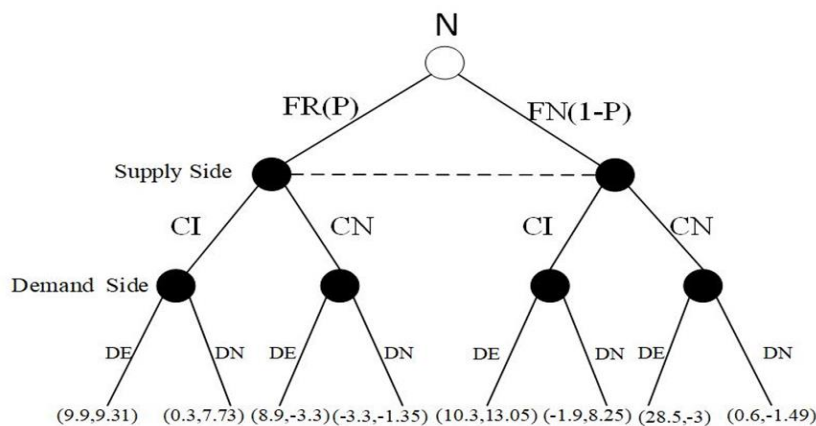


Figure 1. Harsanyi transformation diagram

3.5 Bayesian Refinement Nash Equilibrium Solution

For the payoff matrix in Table 5, use the dash method to solve the pure-strategy Nash equilibrium strategy (see Figure 2). The Nash equilibrium obtained by the dash method is: when the type of the supplier is T "freight rate increases", the supply "transport capacity input does not increase"; when the supplier type T is "freight rate does not rise", then the supplier "transport capacity does not increase". increased investment."

For the demand, whether to expand shipping demand, according to the Bayesian refined Nash equilibrium theory, only the probability P needs to satisfy the following equation: The first stage: "Participant demand side expands demand", that is the demand side expands import and export trade. Demand-side expansion of trade demand expectations:

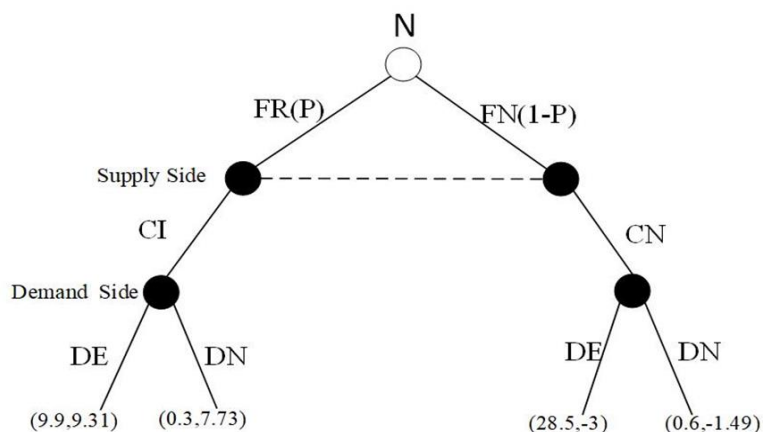


Figure 2. "branch" of non-Nash equilibrium tree diagram

$E_1 = 9.31P - 3(1 - P)$; The expected value of the demand side not expanding trade demand: $E_2 = 7.73P - 1.49(1 - P)$;

When $E_1 > E_2$, $P > 0.49$: Participant demand will expand import and export trade

The second stage: When the participant's supply side understands that the probability of the demand side's epidemic trend rising is greater than 0.49, the participant's demand side will expand import and export trade, and the participant's supply side will increase investment in transport capacity. The specific measures taken by the participants and suppliers to increase the investment of transport capacity mainly include transferring transport capacity from other routes to the trans-Pacific route, or ordering new ships to be used on the trans-Pacific route. Player demand and supply Bayesian refined Nash equilibrium: $(\{DE, CI\}, P_1 = (0.49, 1), P_2 = 1)$.

4. Conclusion

Due to the impact of the epidemic, Container liner transportation costs on trans-Pacific routes have risen, freight rates have skyrocketed, surcharges have been numerous, and delivery events have been prolonged. Based on the economic significance of the Bayesian refined Nash equilibrium ($\{\text{expanding demand, increasing investment}\}$, $P_1 = (0.49, 1)$, $P_2 = 1$), The paper believes that if the epidemic trend continues, the container liner freight rate on the trans-Pacific route will still continue rise. Because when the supply side chooses "increase transport capacity investment", if the demand side chooses "expand demand", the supply side will receive a pay off 9.9, which is obviously greater than 8.9; even if the demand side chooses "not expanding demand", the supply side can also receive a pay off 0.3, obviously greater than -3.3. Therefore, the supply-side "increasing capacity investment" is a "dominant" strategy. Therefore, under the trend of the epidemic, the capacity of the route will continue to increase. Therefore, for a long period of time under the trend of the epidemic, the supply of capacity in trans-Pacific routes will continue to rise. And demand, after observing the increase in the freight rate of the route, will ensure that the probability of expanding import and export trade increases is 49%. Therefore, under the trend of the epidemic, the supply-controlled market will continue, and the freight rate of trans-Pacific routes will continue to rise.

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