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Research on Coordination Strategy of Port Supply Chain with Logistic Service Symbiotic Networks Involved

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ABSTRACT: This paper studies coordination of logistics service symbiotic network in port supply chain of the member enterprise of supply chain and pricing strategy of the core enterprise on the premise of the centralized decision-making. Then it analyses the influence of loading ratio of logistics cost to the benefit of the whole port supply chain. The conclusions are extended to the general case of n order of port supply chain. Conclusions show that multilateral collaboration of logistics service symbiotic network and port supply chain can bring the whole supply chain more efficient. Meanwhile, this paper proposes a third-order port supply chain coordination model based on the service capacities. Based on this, this paper thinks that LSI and its service network need to be included the supply chain and promote actively the port logistics service innovation. Simultaneously, LSI build interactive logistics services symbiotic network. It promotes all companies to cooperate to achieve the joint optimization of the whole port supply chain system.

KEYWORDS: Port supply chain; Logistics service symbiotic network; Coordination; Service capacities.

INTRODUCTION

With the refinement of social division of labor, trend of outsourcing of Non core business in the enterprises is becoming increasingly apparent. The enterprises in the supply chain will be more focus on their core businesses. Meanwhile, logistics companies also from the previous passive, subordinate business forms towards the direction of development, take the initiative to cooperate with enterprises in the supply chain. Even as the core enterprise leading supply chain, Logistics Service Integrator (LSI) integrates Functional Logistics Service Provider (FLSP) and forms logistics service symbiotic network for the purpose of meeting the logistics demands of product supply chain. The logistics service symbiotic network undertake passive logistics business, the demand of logistics service which embodies in the product supply chain is the final performance in the supply chain of all enterprises logistics demand preference aggregation. But it only shows the individual preference of core enterprises. Personalized demands of the final presentation of the logistics demand are bound to ignore the logistics demand of non-core businesses. When logistics service symbiotic network acts as the core of the LSI and LSI embeds structural holes between the enterprises in product supply chain and FLSP (Burt, 1992) [1]. It can meet the product supply chain enterprises of logistics service demand of personalized preferences through the information aggregation advantage and product supply chain multilateral linkage. Finally, product supply chain revenue increase.

Port supply chain refers to the port enterprises as the core platform of the supply chain, by a suitable mechanism and structure, the upstream and downstream suppliers, manufacturers, service providers, retailers and customers all node and segment combined with to form an organic whole. And Port supply chain put the right amount of goods to the right place at the right time to realize the function network of the lowest costs in the entire supply chain (Chen, 2009) [2]. Port supply chain as a service value chain are significant differences among members, from the scale morphology and nature, all enterprises in the middle and lower reaches. The interest of each member is in conflict with each other. This leads to the conflict between the supply ports of any enterprises in the chain as the core enterprise to coordinate the whole supply chain is not appropriate. Port logistics services through symbiotic between network and supply chain upstream and downstream enterprises establish partnership with the complementary voluntary expansion and advantage. It forms the rapid response capability of the response to changes in market demand. So the members of the supply chain maximize the benefits and efficiency is the highest (Jiang, 2012) [3]. So each enterprise benefit in port supply chain must be built with the LSI as the core of the logistics service symbiotic networks to coordinate and reflect each enterprise in port supply chain in the required logistics service preference. Based on this, the research on coordination strategy of logistics services symbiotic networks in port supply chain is very necessary.

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LITERATURE REVIEW

As independent individuals, Supply chain enterprises have their own profit aspirations and alone decision. It tends to maximize their own profit. "Double marginalization" phenomenon reduces the overall supply chain benefits. But centralized decision-making with coordination can make the Total revenue of supply chain achieve maximum. Most of the existing literature compare the benefits of centralized and decentralized decision-making and seek a reasonable allocation scheme by design contract. Xu (2006) concerned that a one-supplier-one-retailer supply chain in which the additional service can be offered to its customers by the supplier or the retailer or both of them. It shows that under the Stackelberg game framework, the best strategy is that both the supplier and the retailer provide service [4]. Zhang and Liu (2006) considered a two-stage supply chain consisting of a supplier and a retailer and establishes Stackelberg games of profit division. Revenue sharing contracts are employed in the games as a profit division approach. In addition, many scholars consider the introduction of third-party logistics providers to supply chain coordination [5]. Xie and Li (2008) used game theory pricing models for third-party logistics services are constructed, where the objective is maximizing profits of a manufacturer and a service provider. And the analysis of this Paper shows that the equilibrium in cooperation decision mode is a good mechanism, which fits the characteristics of the third-party logistics as a long-time, mutually beneficial, strategically co-operational partnership [6]. Gong and Li (2008, 2012) thought that the system of supply chain includes a manufacturer, a retailer and a third-party logistics provider. The third-party logistics provider was introduced to supply chain quantitatively. the price of logistics service is shared by manufacturer and retailer. pricing, products and profits are analyzed by game theory. And further analysis of pricing and profits under two types of non-cooperation decision-making supply chain model obtained that supply chain efficiency of TPLSP-leading is superior to that of manufacturer-leading supply chain system [7-8]. Liu (2011) based on the supply structure of one supplier, one logistic service provider and one retailer. Coordination strategy is studied when market demand of a product is influenced by retail price and logistic service level, and when a logistic service provider with a quadratic service cost is involved. The total profit of supply chain will be increased through the cooperation of three participants [9].

The concept of Symbiosis was first proposed by Anton DeBary. Symbiosis is the relationship among of living organisms to live together and convolution according to a certain pattern formation because of the need to survive, and they form a symbiotic system of interdependent, mutual adjustment and co-evolution. Later, it is to be explained a development state of integration, interactive and coordination among of the inter-industry or business module, which is constituted by a mechanism and divided difference symbiosis and homogeneity symbiosis (Hu, 2008) [10]. Port logistics service network is a multi-level complex networks, which is a symbiosis network that can assemble common interests of all enterprises. And its role in coordinating port supply chain has attracted the attention of many scholars. Liu and Yu (2015) introduced the background of port supply chain and summaries the port supply chain definitions and structure [11]. Also it proposed the future research of port supply chain. Zang and Zhang (2012) analyzed four key factors influencing the benefits distribution of companies member from Stakeholder, object and intermediary in port supply chain.Then established a benefit distribution model that considered comprehensively of investment, risk, contributions and status factors [12]. Theoretical methods and tools such as game theory, contract theory, system modeling and simulation and ANP were employed to research coordination mechanism of port service supply chain (Shao, 2013). Furthermore, he constructured coordination mechanisms of two-level and three-level port service supply chains. Then he researched on the pattern of distribution of profits, influencing factors, gaming of the distribution of profits and the distribution method [13]. Peggy.D.Lee (2006) explained the application of the social network theory in coordination degree of the port supply chain. He used three port supply chain to illustrate the fact that port supply chain is a social network. Their success is largely affected by a network coordination and cohesion level. Although he did not explain the causal relationship, but this paper on supply chain relationships and port supply chain integration established the foundation of using social network theory for future [14]. Based on fractal theory Yang (2012), Port service supply chain is decomposed into a lot of fractal supply chain cells. The calculation model on the similarily between fractal supply chain cells is constructed and service supply chain network organization structure can be accurately studied [15].

From the context of the existing literature, the role of logistics service symbiotic network in the entire port supply chain has become increasingly prominent. Currently some scholars have noted a significant impact of logistics service symbiotic network generated on the coordination of port supply chain, but they did not do in-depth analysis on it. Along this important idea, coordination strategy issues of logistics services symbiotic network in port supply chain will be further researched in this paper.

RESEARCH MODEL

As a modern logistics center, port should joint actively enterprise each floor in supply chain to build an integrated and seamless logistics service symbiotic network in addition to continuing to play a traditional functions such as loading

and unloading, transport etc, which is joint development, mutual benefit and win-win, and continue to extend the port logistics function, enhance the overall level of service in port supply chain while achieving its own development.

To further explore the role of logistics service symbiotic network in port supply chain, research model provided in this paper is shown in Figure 1, which includes a third-order port supply chain consists of a supplier, a manufacturer and a retailer's and a logistics service symbiotic network with LSI core in the core of LSI.

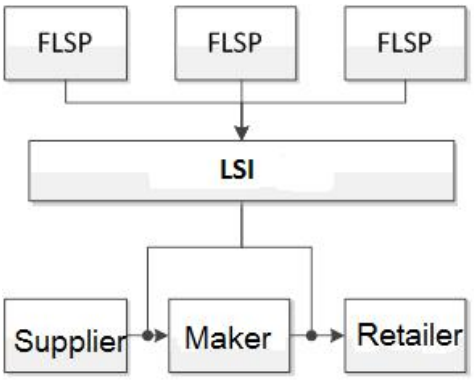

Figure 1. Research model.

MODEL PARAMETERS AND DECISION VARIABLES

L, Logistics service providers.

Q, Quantity of market demand.

PS, PM, PR, represent respectively supplier pricing, ex-factory price and retail price.

CS, CM, CR, represent respectively supplier costs, manufacturing costs and retail costs.

∏S, ∏M, ∏R, represent respectively supplier profits, manufacturing profits and retail profits.

PLSM, Logistics service price from supplier to manufacturer.

PLMR, Logistics service price from manufacturer to retailer.

CLSM, Logistics service costs from supplier to manufacturer.

CLMR, Logistics service costs from manufacturer to retailer.

∏LSM, Logistics service profit from supplier to manufacturer.

∏LMR, Logistics service profit from manufacturer to retailer.

ks, kr, represent respectively suppliers and retailer undertake logistics costs ratio.

ksm, manufacturers undertake logistics costs ratio from suppliers to manufacturers.

kmr, manufacturers undertake logistics costs ratio from manufacturers to retailer.

MODEL ANALYSIS

In this model, logistics service symbiotic network formed by the integration provides logistics service for port supply chain, and logistics costs shared by the supplier, manufacturers and retailers. Retailers purchase products from the manufacturers and all products sold to consumers or customers. According to the law of market demand, they satisfy the relationship between P and Q: $P_R = a - bQ, a > 0, b > 0$. Suppose all companies in port supply chain have complete information, and the cost information is transparent, then parties profit:

$\prod_S = (P_S - C_S - k_s P_{LSM}) * Q$ (1)

$\prod_M = (P_M - P_S - C_M - k_{sm} P_{LSM} - k_{mr} P_{LMR}) * Q$ (2)

$\prod_R = (P_R - P_M - C_R - k_r P_{LMR}) * Q$ (3)

$\prod_{LSM} = (P_{LSM} - C_{LSM}) * Q$ (4)

$\prod_{LMR} = (P_{LMR} - C_{LMR}) * Q$ (5)

Then total profit:

$\prod_{total} = \prod_S + \prod_M + \prod_R + \prod_{LSM} + \prod_{LMR}$

$= (P_S - C_S - k_s P_{LSM} + P_M - P_S - C_M - k_{sm} P_{LSM} - k_{mr} P_{LMR} + P_R - P_M - C_R - k_r P_{LMR} + P_{LSM} - C_{LSM} + P_{LMR} - C_{LMR}) * Q \quad = (P_R - \sum C) * Q$,

$(k_s + k_{sm} = 1, k_{mr} + k_r = 1)$ (6)

$$\prod_{total} = (a - bQ - \sum C) * Q$$

Then, $Q^* = \frac{a - \sum C}{2b}$

Maximum total in Port supply chain profits: $\prod^*_{total} = \frac{(a - \sum C)^2}{4b}$.

Suppose core enterprises in port supply chain obtain all profits and develop appropriate contract to distribute the profits to coordinate companies each order in port supply chain, then Pricing decisions and logistics cost-sharing situation as shown in Table 1:

Table 1. Pricing decisions and logistics cost-sharing situation.

core company	company pricing	logistics cost-sharing situation
supplier	$P_s^* = \frac{a + C_s - C_M - C_{LSM} - C_{LMR} - C_R}{2}$	$k_S=0, k_{SM}=1. k_{MR}+k_R=1$
manufacturer	$P_M^* = \frac{a + C_S + C_M + C_{LSM} - C_{LMR} - C_R}{2}$	$k_{MR}=0, k_R=1. k_S+k_{SM}=1$
retailer	$P_R^* = \frac{a + \sum C}{2}$	$k_R=0, k_{MR}=1. k_{SM}+k_S=1$
Logistics service providers	$P_L^* = \frac{a + C_L - C_S - C_M - C_R}{2}$	

It can be seen, when the company in port supply chain is the core company, the core company does not assessment logistics costs of downstream company, and the downstream company undertakes logistics costs. That is, by reducing logistics costs prepaid amount and increasing incentives for logistics service providers, logistics cost-sharing ratio of core Company and upstream enterprise is unconstrained. If logistics service costs are a quadratic function about the service level ($C_L = \frac{\partial l^2}{2}$, ∂ ,cost-sensitive factor. l ,logistics services. C_L ,logistics costs) [4], the enterprise that is insensitive to costs undertakes a greater proportion of logistics costs, then service levels improve while Logistics costs remain constant. But when the core company is logistics service providers, P_L^* is independent of each order companies in port supply chain on logistics costs ratio. LSI embeds structural holes of port supply chain and gathers information of enterprise and logistics services symbiotic network. Due to LSI integrates port supply chain and provide logistics integrated services from the port supply chain perspective. The coordination of logistics personalized service needs in port supply chain company is made between logistics service symbiotic networks. logistics

companies can maximize individual needs. Logistics services symbiotic network interacts multilaterally with port supply chain, and the benefits distribution and quality supervised of logistics services symbiotic network are completed by LSI. Core companies in port supply chain integrate simply LSI. It can reduce effectively transaction costs of the enterprises in port supply chain and logistics service providers. Figure 2 is Forming path of logistics services symbiotic network based on interaction with the port supply chain.

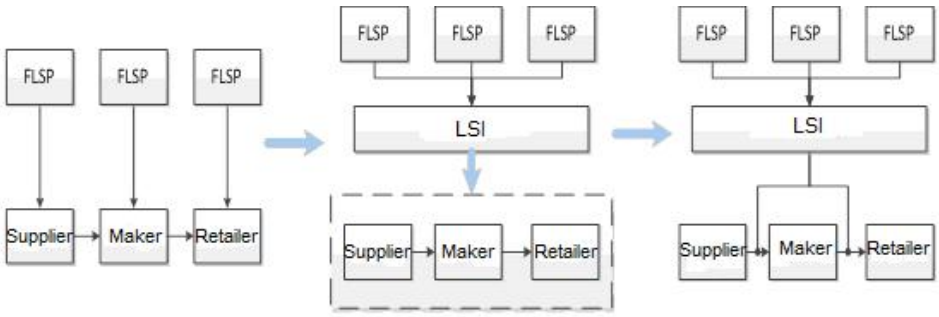

Figure 2. Forming path of logistics services symbiotic network based on interaction with the port supply chain.

MODEL EXTENSION

Above conclusions it can also be extended to the n-th order port supply chain (including service providers, customers, etc.). When the company in port supply chain is the core company: $P^*_{core} = \frac{a + \sum_{upstream} C - \sum_{downstream} C}{2}$.When the core company is Logistics service providers: $P^*_L = \frac{a + C_L - \sum_{port\,sup\,plychain} C}{2}$. It can be seen, in the n-th order port supply chain, when the logistics service providers involve in the coordination of the entire port supply chain, the transaction cost has reduced and the efficiency of the entire market has been optimized.

COORDINATION MODEL OF THIRD-ORDER PORT SUPPLY CHAIN BASED ON THE SERVICE CAPABILITIES

Port supply chain is a service supply chain based on service capabilities and cooperation. The service becomes a major link in the independent enterprises in port service supply chain. Port supply chain also needs the capabilities and cooperation to configure the service capabilities of port services supply chain. In the port supply chain, logistics service providers allocates logistics services tasks to the port supply chain based on the ability to provide the service (such as handling, storage,shipping, freight forwarding, transport, customs, etc.), it belongs to the Capacity allocation. Therefore, this part studies further the coordination of port supply chain based on the service capabilities.

To facilitate research, the model is third-order port supply chain composed of port enterprises, logistics service providers and logistics subcontractors. Port enterprises purchase to logistics service providers according to customer demand (n). Then logistics service providers will outsource to subcontractors according to the actual situation of the logistics service capability order quantity. Each symbol meaning in Model as given in Table 2:

Table 2. Each model symbol meaning.

Symbol	P	R	Q	W	G
Meaning	Price of port provide logistics services to customers	Price of logistics service providers provide services to port enterprises	Quantities of port enterprises purchase to logistics service providers	Price of subcontractors provide services to logistics service providers	Unit capacity of opportunity loss cost(Q<n)

Symbol	C_F	$\prod_{SC}$	$\prod_R$	$\prod_F$	$\prod_S$
Meaning	Cost function of logistics service providers ($C_F=e_FQ^2$,e_F 〉 0) (Demirkan,2008) [16]	Expected profit function of port supply chain	Port expected profit function	Expected profit function of logistics service providers	Expected profit function of logistics subcontractors
Symbol	C_S				
Meaning	cost function of logistics subcontractors ($Cs=c_sQ+e_sQ^2$,c_S, e_S, cost coefficients, c_s 〉 0,e_s 〉 0)(Demirkan,2008) [16]				

MODEL ASSUMPTIONS:

(1) Suppose that port enterprises, logistics service providers and logistics subcontractor are entirely rational, risk-neutral and symmetric information, and they make decisions based on the principle of maximizing their expected profit.

(2) Suppose that market demand of port enterprises is uncertain. f (n) is demand function. f (n) is subject to the probability distribution and price-sensitive. The service capabilities of logistics service providers are inadequate when port Enterprises ordering is excessive. Then they need to outsource logistics services(Q_F), logistics service price(W) is determined by logistics subcontractors according to Q_F and operating costs, P〉 R〉 W〉 0,G〉 0.

(3) Suppose that logistics service providers will outsource all logistics capability port ordered to subcontractors logistics, $Q_R=Q_F=Q$.

(4) Suppose that market demand function n=D—kp,D,Market Scale.k,Price-sensitive factor,k〉 0.

(5) Suppose that Shortage of service capabilities of logistics service providers and logistics subcontractor does not exist.

MODEL FORMULATION

Based on the above assumptions, we can see under the centralized decision-making the port expected profit function:

$$\prod_R=\int_{n-\theta}^{Q}(P-R)nf(n)dn+\int_{Q}^{n+\theta}(P-R)Qf(n)dn-\int_{n-\theta}^{Q}(Q-n)Rf(n)dn-\int_{Q}^{n+\theta}(n-Q)Gf(n)dn \tag{7}$$

Among them, Item 1 of profit function represent the profit in $n<Q$,Item 2 of profit function represent the profit in $n>Q$,Item 3 of profit function represent the loss in $n<Q$,Item 4 of profit function represent the loss in $n>Q$.

Then:

$$\prod_F=(R-W)Q-e_FQ^2 \tag{8}$$

$$\prod_S=WQ-c_SQ-e_SQ^2 \tag{9}$$

MODEL SOLVING

In the centralized coordination of port supply chain, port enterprises, logistics service providers and logistics subcontractors can share information. They can be a unified decision- making and achieve profit maximization in port services supply chain system. In this case, the overall profit of the port supply chain:

$$\prod_{SC}=\prod_R+\prod_F+\prod_S \tag{10}$$

Then:

$$\prod_{SC}=\frac{G+P+4\theta e_F+4\theta e_S}{4\theta}Q^2+\frac{(G+P)(D-kP+\theta)-2\theta c_S}{2\theta}Q-\frac{P(D-kP-\theta)^2+G(D-kP+\theta)^2}{4\theta} \tag{11}$$

It can be seen, in the case of centralized coordination and W have no effect on $\prod_{SC}$ and mainly regulate the distribution of profits of the supply chain node enterprises.

Under the premise $\prod_{SC}$ has maximum, when the optimal policy (P *, Q *) of the entire port supply chain satisfies the following two conditions, the overall profits of port supply chain will maximize.

$$\frac{\partial\prod_{SC}}{\partial P}=-\frac{Q^2}{4\theta}+\frac{(D-2kP-kG+b)Q}{2\theta}+\frac{(D-kP-\theta)kP+(D-kP+\theta)kG}{2\theta}-\frac{(D-kP-\theta)^2}{4\theta}=0 \tag{12}$$

$$\frac{\partial\prod_{SC}}{\partial Q}=-\frac{(P+G+4\theta e_F+4\theta e_S)Q}{2\theta}+\frac{(P+G)(D-kP+\theta)}{2\theta}-c_S=0 \tag{13}$$

The system optimal policy (P*, Q*) will be obtained according to the equation (12) and (13),then optimal expected profits under centrally coordination will be available according to (P *, Q *).

From the above analysis, in the third-order port supply chain, price sensitive coefficient (k) affects the service capabilities (Q). When k increases, the members in port services supply chain will choose to reduce service order quantity. As demand increases, the members of the supply chain will increase the service order quantity to get more expected revenue. With the costs increase of logistics service providers and logistics subcontractor, their respective expected profit increase, but the entire performance of port services supply chain will be reduced. The coordination in centralized decision-making mode can avoid idle resources caused by excess logistics investment capacity. It can also avoid the loss caused by losing some sales opportunities due to lack of logistics capabilities invest. Thereby it will increase their profit levels, its coordination better than master-slave coordination mode that each order company in port supply chain act as the core company.

CONCLUSIONS AND RECOMMENDATIONS

How to coordinate each enterprise in product supply chain and achieve a win-win situation has always been an important topic in the study on supply chain management. In the 21st Century, competition between ports has been transformed into the competition of port supply chain. The operation and management efficiency of port supply chain directly affects the survival and development of the enterprises in the supply chain. Therefore, the cooperation participated in the enterprises of port supply chain should change the management idea, instead of competition with cooperation and reduce the strategic behavior of enterprises in the cooperation. Based on this, this paper proposes the following recommendations on how to manage the port supply chain more efficiently.

1. The FLSP or LSI and its service symbiotic networks should be brought into the port supply chain. All enterprises cooperate and promote the coordination each other. As mentioned, when the logistics service symbiotic networks undertake passive logistics business, the core enterprises in port supply chain only consider maximizing benefit themselves. On the other side, the interests of non core enterprises have been seriously squeezed, resulting in damage to the overall interests of the entire supply chain. The logistics service symbiotic network should be brought into the whole port supply chain as a member of the cooperative chain. Partners on the downstream of the core enterprise will be actively considered. In order to protect the enthusiasm of the member enterprises, it should be give full play to the effect of scale economy and the scope economy effect. LSI improves the operation efficiency of the whole supply chain through the collaborative operation of port supply chain logistics business.

2. The traditional operation mode should be changed and LSI manage the logistics operation in port supply chain. In the LSI management mode, logistics service personalized demands of each company in port supply chain be fully considered. And all demands balance in order to achieve the joint optimization of individual and whole. LSI can even be further developed into supply chain coordinator and director for the entire supply chain management.

3. Logistics service symbiotic network system will be built based on the interaction between the core enterprise in port supply chain and LSI. In the port supply chain, the coordination of inter enterprise needs to be strengthened, which leads to inefficiency and cost increase. Investigates its reason, mainly because of the angle of the inter dynamic LSI logistics service symbiotic network system is not perfect. The interaction and coordination among the member enterprises is needed to further considered from the operation of the port supply chain standards. Therefore, that constructing an interactive logistics service symbiotic networks system among enterprises is an imminent problem.

4. The innovation of port logistics service and network diffusion should be actively promoted. The interaction of LSI and the core enterprise in port supply chain can promote the logistics service innovation, on the one hand, innovative services can enhance the operational capacity and the competitiveness of enterprises .On the other hand, innovative logistics service can provide differentiated services for the core enterprise in port supply chain, and enhance the market competitiveness of products or services to support business transformation and upgrading to provide strong. The service innovation of logistics enterprises in logistics service symbiotic network had been spread. The role of innovation will chieve maximum. Logistics service innovation symbiotic network and interaction of LSI and the core enterprise of in port supply chain produce positive feedback. It forms a virtuous circle of the interaction promote innovation and innovation driven interaction.

This paper discusses the importance in port supply chain of the logistics service symbiotic networks that LSI acts as the core member. In their participation and coordination, the transaction costs of member enterprises in port supply chain reduce and improve the operation efficiency compared to other companies in port supply chain as the core enterprise's pricing decision and the logistics cost proportion and the transaction cost of the member enterprises in the port supply chain. Of course, the coordination problems of logistics service symbiotic network in port supply chain are also needed to be further studied. For example, that the influence of logistics service quality in all decision-making of port supply chain is needed to be studied in the future. In addition, the constraint information complete in real terms are too harsh. In the case of asymmetric information, coordination of each order enterprises in port supply chain will be further studied in the future.

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