

How to measure the logistics capability in supply chain: calculation model of circulation quantity and response time

Xiaoqun Liu, Shihua Ma^{*}

School of Management, Huazhong University of Science and Technology
1037# Luoyu Street, Wuhan 430074, P.R.China
<http://www.logistics-chain.com>

Abstract: - A model is established to quantify and measure the capacity performance in the process of the supply chain. For most logistics capability based on quantity and time, the supply chains is regarded as complete distribution balance network to analysis and deduct the maximum circulation quantity, integrate circulation quantity and response time, through which the quantization formula for index measuring is determined. Via analysis of the formula, the ways to improve circulation and shorten the response time of the supply chain is studied on the circulation capacity and processing time of the nodes, the quantity of circulation between different nodes, route length between nodes as well as the transportation speed and the time cost on the route.

Key-Words: - supply chain management, logistics capability, circulation quantity, response time

1 Introduction

Most companies have been in an environment of fierce global competition, short product cycle, highly decentralized operation and management driven by demand. Facing the ever-changing and unforeseeable buyer's market, enterprises gradually focus their attention in LOGISTICS, the Third Source of Profit after lower material consumption and higher working efficiency, expecting to lower operation cost with improved customer service.

However, competition between modern enterprises is not restricted in enterprises themselves, but in supply chains as well. Any single node enterprise, even with best operation, can not ensure the supply chain is optimized in a whole, especially in logistics operations. For example, small batches and multiple orders in the lower stream usually result in disequilibrium deficiency in scale economy in upper stream enterprises, thus it is necessary to re-integrate the physical distribution of the supply chain in geographical distribution and channel management [1].

Therefore, logistics, as one of the most important parts of supply chain, is extensively and closed focused because the logistics capability is believed to have definitive influence on the competitiveness of the whole supply chain. On the basis of globalization and lean production, David Pollitt took a comprehensive retrospect, conclusion and prospect on performance improvement, info-tech application, strategy integration and demand response of supply chain in the new century [2]. Investing 111 excellent enterprises in 17 different countries in Northern

American and Europe, the Global Logistics Research Team of Michigan State University identified 32 capabilities which have influence on supply chain performance, in which 17 are determined as general capabilities, classified in four categories: positioning, integration, agility and measurement [3].

In various logistics capability, Quantity and Time are most usually used for analysis, from which derived some relative capabilities, such as delivery punctuality, delivery credibility, turnaround time consistency, duration of response time, flexibility of time compression. In a study on the influence of logistics capability on competitive advantage and enterprise cost, Morash *et.al* draw out the first three capabilities of the four most influential factors to business performance: delivery reliability, responsiveness to target market(s) and delivery speed [4]. In a interview made by Daugherty in 1998 to the customers enjoying delivery service in the consumption industry, what most usually mentioned by the interviewee are accuracy of goods, order processing rate, turnaround time consistency, duration of turnaround time, delivery punctuality, delivery frequency and so on [5], all of which are closely related with Quantity and Time. It is conformed with an investigation to delivering and distribution experts carried out by US Quest for Quality.

Daugherty and Pittman studies logistics on Time, and holds that Delivery Flexibility is one of the most significant distribution capabilities [6]. Studying US businessmen's plants in Mexico, Fawcett (*et.al*) analyzed the logistics capability that improves international operation performance of the business,

^{*} Corresponding author

and one of the most important factor is Time-based logistics capability, including delivery capability, quality capability, flexibility capability and so on [7]. In an investigation and study on member firms of National Council of Logistics Management in 2001, Zhao and other scholars pointed out that an important factor influential to business performance is customer attention featured with Time-based Responsiveness and Flexibility [8].

However, the study on the above mentioned logistics capability focuses generally on individual firms, and mostly just the case study with description and conclusion. Therefore, it is very necessary to quantify logistics capability to further the study on the basis of supply chain and the analysis model so as to establish foundation of study on influence of logistics capability to the competitiveness of the supply chain. Via an analysis to logistics features, Professor Wang Zhongxi found that it is possible to depict logistic feature via vector analysis method and he established the concepts of logistics momentum and logistics circulation quantity. Via quantization and calculation on logistics momentum and logistics flux, he studied logistics momentum—the basic law of supply chain logistics under the ideal condition of “even delivery and uniform velocity” [9]. Nevertheless, the structure of supply chain defined in the paper is relatively simply, and no special study is carried on the Time factor in logistics. In reference of Equilibrium model of network economics, Nagurney regard the supply chain as special network structure, and in the hypothesis of “homogeneity”, he analyzed node behavior in separate decision-making condition and deduced the balance condition of the whole supply chain [10]. The network balance model of supply chain, quite rational, consists of one of the basic methods for supply chain balance [11], but it is mainly applies for decision of each node in supply chain, not in quantization of logistics capability.

As most logistics capability is based on Quantity and Time, via the basic quantifying calculation of logistics momentum and logistics flux via vector analysis, this paper takes supply chain as a whole of circulation balance network, and quantifies logistics capability from logistics flux (including max. logistics flux and whole circulation quantity in supply chain) and response time, through index of which instructions are made for improvement in logistics capability.

2 Model description, assumptions and notation

In a supply chain, logistics system consists of multiple logistic nodes and jobs of supply, production

and distribution subsystems. Thus, logistics capability in supply chain should be an integration of capabilities of these subsystems, nodes and jobs, but meanwhile, it is not simply sum of these capabilities of the subsystems.

Take an example of logistics in ordinary supply chain in Figure 1. Hypothesize that m supplier S_i supply material to the Supply Hub H , the production system consists of n serial production and processing nodes P_j , which process materials from the upper node or the Supply Hub, the finished products, via warehouse W , are delivered to distribution center D , and finally they are shipped to distributors R_k (retail trader or users) from D . In the whole chain, the logistics capability includes capabilities of supply logistics (or inbound logistics), production logistics and distribution logistics (or outbound logistics), in which the logistics capabilities of subsystems consists of node capabilities and connection capabilities between nodes.

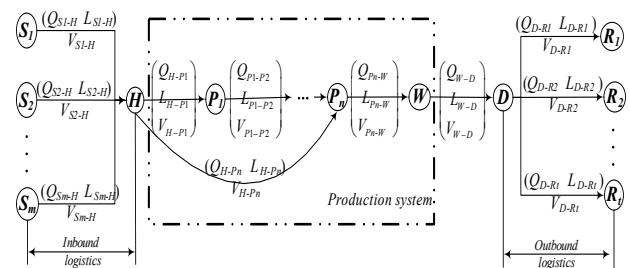


Fig.1. Model of product circulation in supply chain

Where:

S_i : The i^{th} supplier, $0 \leq i \leq m$;

H : Supply Hub [12];

P_j : The j^{th} production (processing or assembly) node, $0 \leq j \leq n$;

W : Finished product warehouse;

D : Distribution center;

R_k : The k^{th} distributor (retail trader or user), $0 \leq k \leq t$;

$(Q_{Si-H}, L_{Si-H}, V_{Si-H})$: The material circulation quantity in unit time, from supplier S_i to distributor H is Q_{Si-H} , transportation distance is L_{Si-H} , and the flow velocity is V_{Si-H} ;

$(Q_{H-Pj}, L_{H-Pj}, V_{H-Pj})$: The material circulation quantity in unit time, from Supply Hub H to production node P_j is Q_{Si-H} , transportation distance is L_{H-Pj} , and the flow velocity is V_{H-Pj} ;

$(Q_{Pn-W}, L_{Pn-W}, V_{Pn-W})$: The material circulation quantity in unit time, from the last production node

P_n to the finished product warehouse W is Q_{P_n-W} , transportation distance is L_{P_n-W} , and the flow velocity is V_{P_n-W} ;

$(Q_{W-D}, L_{W-D}, V_{W-D})$:The material circulation quantity in unit time, from finished product warehouse W to distribution center D is Q_{W-D} , transportation distance is L_{W-D} , and the flow velocity is V_{P_n-W} ;

$(Q_{D-R_k}, L_{D-R_k}, V_{D-R_k})$:The material circulation quantity in unit time, from the distribution center D to distributor R_k is Q_{D-R_k} , transportation distance is L_{D-R_k} , and the flow velocity is V_{D-R_k} .

3 Logistics capability Index calculation

3.1 Supply chain max logistics flux Q_{max}

For the whole logistics chain, the max logistics flux Q_{max} in unit time is a essential index indicating material-transporting capacity, and it is the max output in unit time in the supply chain according to general theoretic of circulation network. Calculation of Q_{max} is as follows.

(1) Determine the max circulation quantity processed by S_i, H, P_j, W, D, R_t in unit time are respectively $Q_{S_i}, Q_H, Q_{P_j}, Q_W, Q_D, Q_{R_k}$;

(2) Determine the max circulation quantity between different nodes($S_i \rightarrow H, H \rightarrow P_j, P_j \rightarrow P_{j+1} (j=1,2,\dots,n-1), P_n \rightarrow W, W \rightarrow D, D \rightarrow R_k$) of each route in unit time are respectively $Q_{S_i \rightarrow H}, Q_{H \rightarrow P_j}, Q_{P_j \rightarrow P_{j+1}}, Q_{P_n \rightarrow W}, Q_{W \rightarrow D}, Q_{D \rightarrow R_k}$. Thereafter:

① Circulation quantity capacity of the supply route in unit time is $Q_{S \rightarrow H} = \sum_{i=1}^n Q_{S_i \rightarrow H}$;

② Circulation quantity capacity of the production route in unit time is: $Q_{H \rightarrow D} = \min(Q_{H \rightarrow P_j}, Q_{H \rightarrow P_{j+1}} + Q_{P_j \rightarrow P_{j+1}}, Q_{P_n \rightarrow W})$;

③ Circulation quantity capacity of the distribution route in unit time is: $Q_{D \rightarrow R} = \sum_{k=1}^t Q_{D \rightarrow R_k}$;

(3) The max circulation quantity capacity, in unit time, of logistics subsystem consisting connection routes between different nodes is determined with three factors: max circulation quantity capacity of source point on the route (starting point), max circulation quantity of the route itself and the max

circulation quantity capacity of the end point on the route. Therefore:

① The circulation quantity capacity of the single delivering passage in the supply system is: $Q_{S_i-H} = \min(Q_{S_i}, Q_{S_i \rightarrow H}, Q_H)$, the circulation quantity capacity of the whole supply system is:

$$Q_{S-H} = \min(\sum_{i=1}^n (\min(Q_{S_i}, Q_{S_i \rightarrow H}), Q_H));$$

② The circulation quantity capacity of the single delivering passage in the production system is $Q_{H-P_i} = \min(Q_H, Q_{H \rightarrow P_i}, Q_{P_i})$, $Q_{P_j-P_{j+1}} = \min(Q_{P_j}, Q_{H \rightarrow P_{j+1}} + Q_{P_j \rightarrow P_{j+1}}, Q_{P_{j+1}})$ ($j=1,2,\dots,n-1$), $Q_{P_n-W} = \min(Q_{P_n}, Q_{P_n \rightarrow W}, Q_W)$, $Q_{W-D} = \min(Q_W, Q_{W \rightarrow D}, Q_D)$.

So the circulation quantity capacity of the whole production system is: $Q_{H-D} = \min(Q_{H-P_i}, Q_{P_j-P_{j+1}}, Q_{P_n-W}, Q_{W-D})$;

③ The circulation quantity capacity of the single delivering passage in the distribution system is: $Q_{D-R_t} = \min(Q_D, Q_{D \rightarrow R_t}, Q_{R_t})$, the circulation quantity capacity of the whole distribution system is:

$$Q_{D-R} = \min(\sum_{k=1}^t (\min(Q_D, Q_{D \rightarrow R_k}), Q_{R_k}));$$

(4) In the whole supply chain network, the max logistics flux Q_{max} is the minimum of circulation quantity of subsystems.

$$Q_{max} = \min(Q_{S-H}, Q_{H-D}, Q_{D-R}) = \min(\min(\sum_{i=1}^n (\min(Q_{S_i}, Q_{S_i \rightarrow H}), Q_H)), \min(Q_{H-P_i}, Q_{P_j-P_{j+1}}, Q_{P_n-W}, Q_{W-D}), \min(\sum_{k=1}^t (\min(Q_D, Q_{D \rightarrow R_k}), Q_{R_k}))) \dots(1)$$

3.2 Supply chain circulation quantity C_{Chain}

In view of material circulation, nodes capacity can be valued with circulation quantity through the node in unit time, and the connection capacity between nodes can be valued with quantity of good turnover, therefore, the logistics capacity of the circulation quantity of the whole supply chain C_{Chain} is:

$$C_{Chain} = C_{S-H} + C_{H-P} + C_{P-W} + C_{W-D} + C_{D-R} \\ = \sum_{i=1}^m (\int_0^{L_{S_i-H}} Q_{S_i-H} dt) + \sum_{j=1}^n (\int_0^{L_{H-P_j}} Q_{H-P_j} dt) + \\ \sum_{j=1}^{n-1} (\int_0^{L_{P_j-P_{j+1}}} Q_{P_j-P_{j+1}} dt) + \int_0^{L_{P_n-W}} Q_{P_n-W} dt) + \\ \int_0^{L_{W-D}} Q_{W-D} dt + \sum_{k=1}^t (\int_0^{L_{D-R_k}} Q_{D-R_k} dt) \dots (2)$$

Where, Circulation quantity of the supply logistics system $C_{S-H} = \sum_{i=1}^m \left(\int_0^{L_{S_i-H}} \frac{Q_{S_i-H}}{V_{S_i-H}} dt \right)$; Circulation quantity of the production system $C_{H-P} + C_{P-W} = \sum_{j=1}^n \left(\int_0^{L_{H-P_j}} \frac{Q_{H-P_j}}{V_{H-P_j}} dt \right) + \sum_{j=1}^{n-1} \left(\int_0^{L_{P_j-P_{j+1}}} \frac{Q_{P_j-P_{j+1}}}{V_{P_j-P_{j+1}}} dt \right) + \int_0^{L_{P_n-W}} \frac{Q_{P_n-W}}{V_{P_n-W}} dt$; Circulation quantity of the distribution system $C_{W-D} + C_{D-R} = \int_0^{L_{W-D}} \frac{Q_{W-D}}{V_{W-D}} dt + \sum_{k=1}^l \left(\int_0^{L_{D-R_k}} \frac{Q_{D-R_k}}{V_{D-R_k}} dt \right)$.

In view of circulation, circulation quantity of the supply chain C_{Chain} represents the covering capacity of the whole logistics chain, which is a comprehensive indication of circulation quantity, delivering distance and delivering speed of each logistics node. In view of warehouse, the circulation quantity of the supply chain C_{Chain} represents in-delivering warehouse capacity of the whole logistics chain. Generally speaking, the more capacity the in-delivering warehouse holds, it is more safe to ensure supply, production and distribution of the supply chain, however, with more capital.

3.3 Supply chain response time T_{Chain}

Figure 2 shows the logistic chain with time limits.

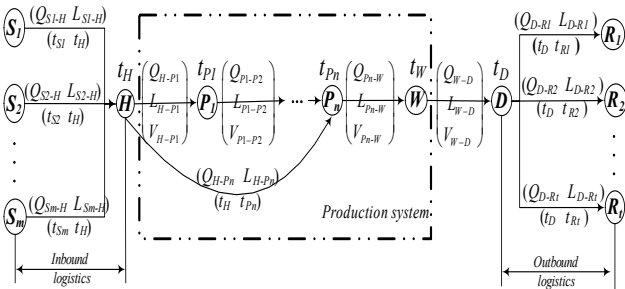


Fig.2. Logistic chain model with time limits

Where,

$t_e(S_i \rightarrow H)$: Starting time from supplier S_i to supply hub H , $0 \leq i \leq m$;

$t_l(S_i \rightarrow H)$: Terminal time from supplier S_i to supply hub H , $0 \leq i \leq m$;

$t_e(H \rightarrow P_j)$: Starting time from supply hub H to production sector P_j , $0 \leq j \leq n$;

$t_l(H \rightarrow P_j)$: Terminal time from supply hub H to production sector P_j , $0 \leq j \leq n$;

$t_e(P_j \rightarrow P_{j+1})$: Starting time from production sector P_j to production sector P_{j+1} , $1 \leq j \leq n-1$;

$t_l(P_j \rightarrow P_{j+1})$: Terminal time from production sector P_j to production sector P_{j+1} , $1 \leq j \leq n-1$;

$t_e(P_n \rightarrow W)$: Starting time from production sector P_n to warehouse W ;

$t_l(P_n \rightarrow W)$: Terminal time from production sector P_n to warehouse W ;

$t_e(W \rightarrow D)$: Starting time from warehouse W to distribution center D ;

$t_l(W \rightarrow D)$: Terminal time from warehouse W to distribution center D ;

$t_e(D \rightarrow R_k)$: Starting time from distribution center D to distributor R_k ;

$t_l(D \rightarrow R_k)$: Terminal time from distribution center D to distributor R_k ;

t_H, t_{P_j}, t_W, t_D : processing time within nodes of supply hub H , production sector P_j , warehouse W and distribution center D .

Other marks are the same with the foregoing paragraphs.

Hereafter:

$$t_l(S_i \rightarrow H) = t_e(S_i \rightarrow H) + \frac{L_{S_i-H}}{V_{S_i-H}} ;$$

$$t_e(H \rightarrow P_j) = \max \{t_l(S_i \rightarrow H)\} + t_H ,$$

$$t_l(H \rightarrow P_j) = t_e(H \rightarrow P_j) + \frac{L_{H \rightarrow P_j}}{V_{H \rightarrow P_j}}$$

$$t_e(P_j \rightarrow P_{j+1}) = \max \{t_l(H \rightarrow P_j), t_l(P_{j-1} \rightarrow P_j)\} + t_{P_j}$$

$$t_l(P_j \rightarrow P_{j+1}) = t_e(P_j \rightarrow P_{j+1}) + \frac{L_{P_j \rightarrow P_{j+1}}}{V_{P_j \rightarrow P_{j+1}}} ;$$

$$t_e(P_n \rightarrow W) = \max \{t_l(H \rightarrow P_n), t_l(P_{n-1} \rightarrow P_n)\} + t_{P_n} ,$$

$$t_l(P_n \rightarrow W) = t_e(P_n \rightarrow W) + \frac{L_{P_n \rightarrow W}}{V_{P_n \rightarrow W}} ;$$

$$t_e(W \rightarrow D) = t_l(P_n \rightarrow W) + t_W ,$$

$$t_l(W \rightarrow D) = t_e(W \rightarrow D) + \frac{L_{W \rightarrow D}}{V_{W \rightarrow D}} ;$$

$$t_e(D \rightarrow R_k) = t_l(W \rightarrow D) + t_D ,$$

$$t_l(D \rightarrow R_k) = t_e(D \rightarrow R_k) + \frac{L_{D \rightarrow R_k}}{V_{D \rightarrow R_k}} .$$

The calculation of time in each route is based on the starting time from the supplier to the Supply Hub, so for distributor R_k , the response time of the whole demand supply chain is

$$T_{Chain}(R_k) = t_e(D \rightarrow R_k) + \frac{L_{D \rightarrow R_k}}{V_{D \rightarrow R_k}} .$$

In deduction of $T_{Chain}(R_k)$, starting time of the processing section $P_j(j=2,3,\dots,n-1)$ of production system to P_{j+1} is the bigger one of (1) the terminal time from above section P_{j-1} to this section and (2) the terminal time from the Supply Hub H . To time $t_l(H \rightarrow P_j)$, i.e., $t_e(P_j \rightarrow P_{j+1}) = \max\{t_l(H \rightarrow P_j), t_l(P_{j-1} \rightarrow P_j)\} + t_{P_j}$ ($j=2,3,\dots,n-1$).

For P_1 , $t_l(H \rightarrow P_1) = \max\{t_l(S_i \rightarrow H)\} + t_H + \frac{L_{H \rightarrow P1}}{V_{H \rightarrow P1}}$.

For a processing section P_j ($3 \leq J \leq n-1$), $t_e(P_j \rightarrow P_{j+1})(j=J)$, $t_e(P_j \rightarrow P_{j+1}) = \max\{t_l(S_i \rightarrow H)\} + t_H + \max\{\frac{L_{H \rightarrow P1}}{V_{H \rightarrow P1}} + \sum_{j=2}^J(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \frac{L_{H \rightarrow P2}}{V_{H \rightarrow P2}} + \sum_{j=3}^J(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \dots, \frac{L_{H \rightarrow Pj}}{V_{H \rightarrow Pj}}\} + t_{P_j}$.

The response time of the whole supply chain is $T_{Chain}(R_k)$.

$$T_{Chain}(R_k) = \max\{t_l(S_i \rightarrow H)\} + t_H + \max\{\frac{L_{H \rightarrow P1}}{V_{H \rightarrow P1}} + \sum_{j=2}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \frac{L_{H \rightarrow P2}}{V_{H \rightarrow P2}} + \sum_{j=3}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \dots, \frac{L_{H \rightarrow Pn}}{V_{H \rightarrow Pn}}\} + t_{P_n} + \frac{L_{P_n \rightarrow W}}{V_{P_n \rightarrow W}} + t_W + \frac{L_{W \rightarrow D}}{V_{W \rightarrow D}} + t_D + \frac{L_{D \rightarrow Rk}}{V_{D \rightarrow Rk}} \dots (3)$$

In T_{Chain} , according to different stage, time of supply logistics is $T_{Chain}(S_i - H) = \max\{t_l(S_i \rightarrow H)\} + t_H$, time of production logistics is

$$T_{Chain}(H - D) = \max\{\frac{L_{H \rightarrow P1}}{V_{H \rightarrow P1}} + \sum_{j=2}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \frac{L_{H \rightarrow P2}}{V_{H \rightarrow P2}} + \sum_{j=3}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}} + t_{P_{j-1}}), \dots, \frac{L_{H \rightarrow Pn}}{V_{H \rightarrow Pn}}\} + t_{P_n} + \frac{L_{P_n \rightarrow W}}{V_{P_n \rightarrow W}} + t_W + \frac{L_{W \rightarrow D}}{V_{W \rightarrow D}}$$

, time of distribution logistics is $T_{Chain}(D - R_k) = t_D + \frac{L_{W \rightarrow D}}{V_{W \rightarrow D}}$. Accordingly, in T_{Chain} , time ratio used in supply logistics is $R(S_i - H) = \frac{T_{Chain}(S_i - H)}{T_{Chain}}$, in production logistics is $R(H - D) = \frac{T_{Chain}(H - D)}{T_{Chain}}$, in distribution logistics

is $R(D - R_k) = \frac{T_{Chain}(D - R_k)}{T_{Chain}}$. Time ration of subsystems represents distributing status of the response time of the whole supply chain T_{Chain} in different stage.

In T_{Chain} , according to different time features, the delivery time is

$$T_{Chain}(T) = \max\{t_l(S_i \rightarrow H)\} + \max\{\frac{L_{H \rightarrow P1}}{V_{H \rightarrow P1}} + \sum_{j=2}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}}), \frac{L_{H \rightarrow P2}}{V_{H \rightarrow P2}} + \sum_{j=3}^n(\frac{L_{P_{j-1} \rightarrow P_j}}{V_{P_{j-1} \rightarrow P_j}}), \dots, \frac{L_{H \rightarrow Pn}}{V_{H \rightarrow Pn}}\} + \frac{L_{P_n \rightarrow W}}{V_{P_n \rightarrow W}} + \frac{L_{W \rightarrow D}}{V_{W \rightarrow D}} + \frac{L_{D \rightarrow Rk}}{V_{D \rightarrow Rk}}$$

, while the node processing time is $T_{Chain}(P) = t_H + \sum_{j=2}^n(t_{P_{j-1}}) + t_{P_n} + t_W + t_D$. In T_{Chain} ,

time ration used in delivery is $R(T) = \frac{T_{Chain}(T)}{T_{Chain}}$, and

time ration used in node processing is $R(P) = \frac{T_{Chain}(P)}{T_{Chain}}$. The time and ration taken by

delivery and node represents distributing status via function in the response time of the whole supply chain.

4 Discussion

According to formula (1), (2) and (3), measures to improve circulation quantity and response time of the supply can be taken from the following five aspects.

4.1 Processing capability of nodes

Logistics nodes refer to the source points and end in a logistics system, including suppliers, supply hub, manufacturers, wholesalers, distributors, warehouse, and distribution center and so on. Nodes are one of the two most fundamental factors of logistic network, the processing capability of which includes:

One is the node circulation capability. In formula (1), max circulation quantity of route nodes (source points and end points) is one of the two influential factors of the max logistics flux Q_{max} . Therefore, improvement in circulation quantity of the nodes is helpful for the max logistics flux of the supply chain.

Another is the node processing time. According to formula (3), the node processing time is one of the components of response time of the whole supply chain T_{Chain} , and its ratio in it represents time ratio taken by storing or processing in the supply chain.

4.2 Circulation quantity in routes between nodes

Circulations quantity refers to the presented quantity of the connection route with a certain time. Circulation quantity of a connection route is determined with the carrier of the goods on it, mainly including carry capacity, delivering frequency and efficiency and so on, and it is under effect of processing capacity of the nodes of the two sections.

4.3 Length of route between nodes

A route is the connection between a source point to the end, which is another fundamental factor of logistics network. The length of a route is flow, which means the quantity of good paths in a certain time on the route. According to formula (2), the longer route usually indicates the more circulation quantity holding on the route, and the C_{Chain} is bigger.

4.4 Flow velocity of goods on route between nodes

Flow velocity refers to the speed of goods on a certain path (flow) of the route, which is also an influential factor of the response time of the whole supply chain T_{Chain} .

4.5 Time cost in route between nodes

Time cost in route between nodes equals to the ration of length of route to moving velocity of logistics. According to formula (3), in a given length of route, a higher velocity means shorter logistic time, quicker response time to demand. At a given flow velocity, the longer the distance between nodes is, the more time it is taken in the route and the longer the time responses in the whole supply chain.

5 Conclusion

In view of the important impact of logistics to supply chain performance, it is extremely significant to study the whole flow of logistics in supply chain according to its capability. However, the present studies logistic capability are mainly case study without quantization and calculation for specific indexes. As most logistics capability are based on Quantity and Time, this paper, taking supply chain network as complete goods circulation balance network, deduces the three indexes of supply chain: the max circulation quantity, the whole circulation quantity and the response time, on which the formula for index calculation is determined. With the formula, a brief analysis is made on how to improve circulation quantity and response time in supply chain from circulation quantity and processing time of nodes, goods flow of router between nodes, length of route between nodes, moving velocity on the route and time cost in the route.

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