Research on Diagnostic Index System of Port Supply Chain Based on SCOR

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Abstract

With continuous deepening of economic globalization and increasing frequency of the international trade, it is the only way for the port to survive and develop by building port supply chain in which the port is the core and relies on the joint efforts of various nodes of the chain to meet the challenges of the times. The formation and development of the port supply chain needs to evaluate the overall operation level of the port supply chain in real time, diagnose the supply chain operation status and discover the process problems. Therefore, it is very important to establish the port supply chain diagnostic indicators and the diagnosis model. Based on the SCOR model and the operation of the port supply chain, this paper constructs a port supply chain diagnostic index system with supply chain reliability, supply chain responsiveness, supply chain agility and supply chain cost as the primary indexes.

Keywords: Port supply chain, Supply chain diagnosis, SCOR model, Diagnostic indicators.

1. INTRODUCTION

Due to low cost, large transport capacity and other advantages, water transport, especially marine transport becomes the main mode of international transport. As the junctions of sea shipping and land transport, ports have become the assembly points of integrated logistics services in the global transport network (Du and Yan, 2016; Wang, 2015). With the improvement of international logistics network and logistics service level, the cost of logistics service in society is gradually reduced and the competition between ports becomes more and more intense. In this environment, it is difficult for a port itself to gain an advantage in the industry competition, therefore, the port and its upstream and downstream nodes have to work together to meet the challenges of the times from the supply chain perspective. It is an important way to improve the port's own competitiveness and enhance the overall operation performance of the port supply chain through strengthening the port's basic functions of loading and unloading, storage and transportation in the international logistics, improving the interaction between port and hinterland as well as deepening the cooperation between the upstream and downstream industries of the port (Zhen et al., 2015).

The structure of port supply chain is complex. Its scientific construction and healthy development depends on the evaluation of the overall operation level of the port supply chain in real time and the diagnosis of the operation problems. Therefore, it is very important to study the construction of the diagnostic index system and the diagnosis model of port supply chain (Robinson, 2002; Carbone and Martino, 2003) (Bichou and Gray, 2004). There are many differences between port supply chain and traditional manufacturing supply chain, and the previous study has not yet established a unified and effective port supply chain diagnostic system. So analyzing the structure and operation mode of the port supply chain, constructing the diagnostic index system and model, finding out the problems and its courses in the port supply chain through the diagnosis, is of great significance to promote the management mode of each node in the port supply chain, and improve the overall operation status of the existing port supply chains so as to improve the competitiveness of the entire port supply chain.

Based on the SCOR model, this paper analyzes the characteristics and performance factors of the port supply chain in details, and puts forward the port supply chain diagnostic index system which includes four primary indexes such as reliability, responsiveness, agility and cost of port supply chain.
2. SUPPLY CHAIN DIAGNOSTICS

The goal of supply chain management is to provide the products or services that meet certain requirements of the customer, that is, to coordinate the enterprises in the supply chain to pass products and services meeting the quantity and quality requirements to the customer through appropriate ways at the right time and place under the cost constraints. The most important indicator of the overall operation level of the supply chain is the degree of customer satisfaction which includes service efficiency, customer response, order completion rate and so on.

In order to analyze the operation performance of the supply chain and ensure the overall quality of the supply chain, it is necessary to carry out supply chain diagnosis. It is very important to take the factors which have significant impact on the supply chain as diagnostic indicators to analyze the overall operation, problems and courses of the supply chain. Finding ways to improve supply chain operations is of great significance to keep the supply chain competitive (Lambert et al., 2005; Presutti and Mawhinney, 2007; Slone, 2007). The meaning of supply chain diagnostics was first proposed by Douglas and Trevor in the Supply Chain Management Handbook: as same as doctors’ diagnosing patients, organizations can also diagnose their supply chains to improve operations and stabilities of supply chain.

The research on supply chain diagnosis methods is still relatively few and there hasn’t a perfect supply chain diagnostic system to be formed (Dong, 2015; Liu, 2006). Master Class Session method, proposed by the Industry Forum Action Group, is mainly related to the organizing of industrial experts in the manufacturing technology, detailed study and analysis on production processes from which typical sections can be improved; in simple terms, it is a process of recognizing problems and conducting improvements. Quick Scan diagnostic method focuses on specific business processes from customer to supplier, analyzing and evaluating each process in the supply chain after establishing corresponding assessment indicators, finding bottlenecks that constrain the entire supply chain operations, and then taking appropriate measures to achieve improvement and optimization. In this way, the overall operation of the supply chain can return to normal.

Profit Pool Mapping method is implemented by identifying the marginal value of the value chain, increasing profit obtained by various measures and reducing unnecessary cost by analyzing the cost structure of the procurement plan, and thus increasing actual benefits of the overall supply chain. Values Stream Mapping method mainly uses industrial design tools to identify and classify the impact of the process, the product structure and the channel on the overall operation of the supply chain, and therefore strengthens the favorable process and product structure in the supply chain operation, analyzes and improves the operation process of supply chain. Other scholars have put forward some diagnosis methods that only deal with one aspect of the supply chain operation (reliability, trust, risk, etc.), such as GO method, fault tree method and series mutation method (Chen et al., 2012; Liu et al., 2013; Han and Zhang, 2013).

3. SUPPLY-CHAIN OPERATIONS REFERENCE-MODEL

The SCOR (Supply-Chain Operations Reference-model) was developed in 1996 by the Supply-Chain Council which led by the PRTM and AMR consulting firms in Boston. The model can help companies to manage the supply chains better and change the function-based management model to the process-based management model, which is an operation reference model suitable for supply chains in different areas. The SCOR model consists of four parts: general definitions of the supply chain management process, benchmarks for the performance of the process, descriptions of the best practices in the supply chain, and information on the selection of supply chain software products.

3.1 SCOR Scope and Its Five Processes

The SCOR-model has been developed to describe the business activities associated with customer’s demand. The Model itself contains several sections and is organized around five primary management processes, namely, Plan, Source, Make, Deliver, and Return (shown in Figure 1). By using these process building blocks, the Model can be used to describe supply chains that are very simple or very complex with a common set of definitions. It spans: all customer interactions (order entry through paid invoice), all physical material transactions (supplier’s supplier to customer’s customer, including equipment, supplies, spare parts, bulk product, software, etc.) and all market interactions (from the understanding of aggregate demand to the fulfillment of each order). It does not attempt to describe every business process or activity. Specifically, the Model does not address sales and marketing (demand generation), product development, research and development, and some elements of...
post-delivery customer support.

![Figure 1](image)

**Figure 1.** SCOR is organized around five major management processes

### 3.2 Performance Attributes and Metrics of SCOR

The performance section of SCOR consists of two types of elements: performance attributes and metrics. A performance attribute is a grouping of metrics used to express a strategy. An attribute itself cannot be measured or used to set strategic direction. Metrics measure the ability of a supply chain to achieve these strategic attributes. Reliability, responsiveness and agility are considered as customer-focused; cost and asset management efficiency are considered as internal-focused. Associated with the Performance Attributes are the Level 1 Strategic Metrics, as shown in Table 1. The SCOR metrics are organized in a hierarchical structure. SCOR describes level 1, level 2 and level 3 metrics. The relationship between these levels is diagnostic. Level 2 metrics serve as diagnostics for level 1 metrics.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Level 1 Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Perfect Order Fulfillment</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Order Fulfillment Cycle Time</td>
</tr>
<tr>
<td>Agility</td>
<td>Upside Supply Chain Flexibility, Upside Supply Chain Adaptability, Downside Supply</td>
</tr>
<tr>
<td>Cost</td>
<td>Total Supply Chain Management Cost, Cost of Goods Sold</td>
</tr>
<tr>
<td>Asset</td>
<td>Cash-to-Cash Cycle Time, Return on Supply Chain Fixed Assets, Return on Working Capital</td>
</tr>
</tbody>
</table>

Table 1 Performance Attributes and Associated Level 1 Metrics

### 3.3 Application of SCOR

SCOR integrates the concepts of business process reengineering, benchmarking and process evaluation into a cross-functional framework that provides help for effective communication between supply chain partners with a standard language that helps managers focus on management issues. SCOR is also a supply chain diagnostic tool that covers all industries enabling supply chain nodes to accurately explore supply chain issues, which can evaluate the performance of supply chain objectively and describe the goal of performance improvement in standard language.

![Figure 2](image)

**Figure 2.** Application Progress of the SCOR Model

SCOR model does not simply describe and define the supply chain operations, but rather provides an operational guide that guides the supply chain nodes to design and manage unique processes on their supply chains so that to gain lasting competitiveness. Each organization that uses the SCOR model to define and improve the supply chain operations should extend the application scope of the model with its own distinctive supply chain business process and measures. Figure 2 shows the general application progress of the SCOR model.
4. CONCEPT AND STRUCTURE OF PORT SUPPLY CHAIN

4.1 Definition of Port Supply Chain

Based on the terminal consumer demand, from supplying raw materials to producing semi-finished products or goods user needs, and then to sending them to the final consumer through different sales methods and sales channels, supply chain is a complex network formed by related business and organizations (suppliers, manufacturers, transporters, customers, etc.), which also includes the flow of business, logistics, capital and information between the nodes in the chain (Lu, 2009).

Focusing on services providing, the port supply chain is mainly composed of various industries and enterprises closely related to the port, including service providers (loading and unloading services, processing services, warehousing, distribution, customs and others) and service requestors (shippers and shipping companies). It is the net-chain structure effectively integrating various port companies (including service providers and customers) around the port, which delivery goods of correct quantity and quality at the right time to the specific location through co-operation; its purpose is to reduce the total cost of the supply chain and to maximize the benefits of customers (Zhao et al., 2016).

According to the definition, it is not difficult to find that there are many differences between the port supply chain and the traditional manufacturing supply chain. The port supply chain has no production process and the core of the net-chain structure is the port which integrates various service providers (Zhao, 2016).

4.2 Structure of Port Supply Chain

The main nodes of the port supply chain include suppliers, shipping companies, shipping agents, freight forwarders, customs agents, trucking companies, rail operators and barge companies, loading and unloading service providers, yard and consignee, etc. Usually the supplier and the receiver are service requester while others are service provider (here service providers are all treated as port enterprises to simplify the port supply chain structure). The structure of port supply chain is shown in Figure 3.

![Figure 3. Structure of Port Supply Chain](image)

Figure 3 shows that the operation process of the entire port supply chain. When there is the demand, the consignee sends requirements to the supplier, the supplier supplies the goods and the port enterprises in the port supply chain provide variety of services including transportation, loading and unloading, storage, water transport and etc, to complete the logistics activities between supplier-port, port-port, port-the consignee. Unlike the traditional supply chain, the port is not just a simple node in the supply chain. As a convergence point for various trade and various modes of transport, the flow of goods may be sent from port hinterland to other areas or vice versa, so the logistics in port supply chain is bi-directional which are essentially different from the recycling or waste logistics in traditional supply chain. The two-way logistics of the port supply chain is determined by the special status of the port. The intersection of logistics, information and capital at the port makes the port the core of the whole port supply chain.

The two-way information flow of the port supply chain mainly includes the demand information from the customers, the supply information of the suppliers, the two-way information of logistics, operations, funding in the chain. As an intersection of information, the port can obtain valuable information resources from variety of channels. It can monitor the flow of goods in real-time and timely plan and adjust related activities of port enterprises. Business flow will lead to the capital flow in the port supply chain. According to market conditions, the supplier decides the price of goods, and then the demander pays the relevant costs; simultaneously, related service demanders pay fees for port using, site occupying, loading & unloading, handling and other operations to the service provider, all which make up the capital flow.
Because of the particularity of port resources, the port usually plays an important role in the port supply chain. How to play the leading role of the port to make the various nodes of the port supply chain in close collaboration is a very important issue for improving the overall competition level and the operational efficiency of the port supply chain.

5. BUSINESS PROCESS ANALYSIS OF PORT SUPPLY CHAIN

Comparing with the traditional manufacturing supply chain business process, based on the SCOR model, this section analyzes the business process structure of the port supply chain, identifies the key factors impacting the port supply chain performance from aspects of reliability, responsiveness, agility, cost and assets management and other level 1 indicators, and builds the port supply chain diagnostic index system structure. In view of the complexity of the supply chain asset management, the paper does not do further research in the part of port supply chain asset management.

5.1 Business Process Analysis of Traditional Manufacturing Supply Chain

The traditional manufacturing supply chain mainly consists of three parts: suppliers, manufacturers and customers. The operation of the entire supply chain is triggered by the customer's needs. The manufacturer analyzes the customer's needs and then makes the purchase plan. The production plan and the delivery plan are made according to the inventory. The supplier performs activities of planning, production and distribution in accordance with the manufacturer's purchasing plan. Finally, the customer receives and assesses the goods, and then return plans and future purchase plans are developed accordingly. The process of the traditional manufacturing supply chain can be translated into the standard language with symbols from the SCOR model, such as plan, resource, make, deliver and return, as shown in Figure 4.

![Figure 4. Process Model of Traditional Manufacturing Supply Chain Based On SCOR](image)

5.2 Business Process Analysis of Port Supply Chain

The port supply chain is a huge complex network integrated various service demanders, service providers, relevant government regulators (such as port management, customs, maritime, inspection and quarantine, border) and other variety of industries and departments. There are a lot of business activities involved in the whole port supply chain, mainly including dry bulk business, container business, grocery business and oil, etc. For different business activities, the port supply chain should provide services including land transportation, water transportation, loading and unloading, warehousing, custody, circulation processing, logistics finance and so on.

The important difference between the port supply chain and the traditional manufacturing supply chain is that the port supply chain does not involve the manufacturing process. Port supply chain’s most fundamental function is to be responsible for the transportation, loading and unloading, storage and transshipment of the goods, that is, making goods flow. In addition, the goods in the port supply chain are mostly bulk cargoes, such as coal, ore, bulk groceries and oil, which generally are not involved in the return process. In summary, the business process of port supply chain is defined as follows.

(1) Customer Demand Confirmation: the customer sends the order to the supplier; the supplier arranges the
distribution plan according to the order demand or the corresponding replenishment plan if the stock is insufficient. The suppliers in the port supply chain are mostly the energy industry which hardly involves manufacturing activities, and their production activities generally refer to the exploitation of resources and so on.

(2) Port Collection: goods are transporting from supplier to port by vehicles or trains, which is the gathering of goods to the port. (3) Port Service: port service integrators develop plans of loading & unloading, storage and transporting according to the needs of the owner after the arrival of goods, arrange various activities until the departure of goods. (4) Water Transport: the cargoes are shipped to the downstream port after loading and then are unloaded to storage or transshipments; (5) Terminal Delivery: the goods are delivered from the destination port to the final owner through transporting.

As shown in Figure 5, the operating procedure model of port supply chain can be obtained by describing the above processes with standard SCOR model processes. In the figure, P represents loading & unloading plan and stocking plan of the port enterprise while M represents loading & unloading and storage operations, which are different from the meanings of symbol P and M in the traditional manufacturing supply chain.

6. ANALYSIS AND SELECTION OF DIAGNOSTIC INDICATORS FOR PORT SUPPLY CHAIN

This section analyzes the operational processes and key influencing factors of the port supply chain and selects the diagnostic indicators of the port supply chain based on four basic indicators of supply chain including reliability, responsiveness, agility and cost.

6.1 Reliability of Port Supply Chain

Supply chain reliability is defined as the ability to operate without malfunction within a specified period and to respond to customer needs in a given period of time through working together of the whole member in the supply chain. The reliability of the single node in supply chain (even the core enterprise) can not fully show the reliability of the whole supply chain, so the reliability diagnosis of supply chain should be studied from the system point of view. SCOR uses the “perfect order fulfillment” to measure the reliability of the supply chain. However, the port supply chain is complex with lots of members, and there are many factors that can influence the order fulfillment. Therefore, the reliability of port supply chain is often influenced by a number of uncertainties. Uncertain factors include the uncertainty of the business process in each supply chain nodes and the uncertainty of the business convergence between the nodes. Based on the selection method in SCOR model for supply chain reliability indicators, we analyze the reliability diagnosis indexes of port supply chain from two aspects: the reliability of supply chain satisfies user’s demand and supply chain operation reliability of its own.

The main target of the port supply chain is to send the needed goods to customers in time, so the delivery reliability can be chosen as a reliability indicator of port supply chain, which can measure if the port supply chain can reliably meet the needs of end customers. The delivery reliability can be expressed by three indicators including delivery quality qualified rate, on-time delivery rate, and product order fulfillment rate. The completion of the supply chain overall plan is also an important indicator to measure the degree that the supply chain meets users’ needs and should be included in the index system.

The reliability of the supply chain's operation describes whether or not the whole operation of the supply chain...
is stable and orderly, which is closely related to the good run of the nodes in the port supply chain and the perfect connection between the nodes. The stability of the supply chain depends on the timely and correct transmission of information between nodes, that is, the reliability of information transmission determines the reliability of the port supply chain; therefore, the reliability of information transmission can be assessed by information sharing extent and accuracy of information transmission.

**Table 2 Reliability Indicators of Port Supply Chain**

<table>
<thead>
<tr>
<th>Attribute of Port Supply Chain</th>
<th>Metrics</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Delivery Reliability</td>
<td>Ability to deliver goods with right quality and quantity at predetermined time</td>
</tr>
<tr>
<td>Plan Completion</td>
<td></td>
<td>The ratio of plan completion amount to total plan amount in supply chain</td>
</tr>
<tr>
<td>Degree of Information Sharing</td>
<td></td>
<td>The ratio of the amount information shared by nodes to the total amount in supply chain</td>
</tr>
<tr>
<td>Reliability of Non-shared Information Transferring</td>
<td></td>
<td>The degree of timely and correctly transmission of information between nodes</td>
</tr>
</tbody>
</table>

### 6.2 Responsiveness of Port Supply Chain

Supply chain responsiveness is expressed in terms of the supply chain response cycle, which is the time that, starting from the end customer's demand, the node enterprises of the entire supply chain collaborate to organize resources, provide products or services and finally deliver the products or services to the customer. The cycle is the accumulation of time that spent in all processes of the entire supply chain to meet the needs of the final customer rather than the time of related activities in a node or subsystem.

Different from the traditional manufacturing supply chain which takes manufacturing enterprises and manufacturing process as the core, the port supply chain does not include the production processes (except for occasional unpacking, packaging, labeling and other simple processing), and mainly involves activities such as transshipment, loading & unloading, and storage. The response time in the port supply chain to meet customer needs is shown in Figure 6.

![Figure 6: Structure of Port Supply Chain Response Time](image-url)

SCOR has four indicators to express the responsiveness of supply chain: the order fulfillment cycle, production cycle, distribution cycle, retail distribution cycle. But since there isn’t manufacturing process in the port supply chain, the production cycle is not applicable. In addition, although port has the same function as the transit node of the traditional supply chain does, it become the core node in the whole port supply chain because of the monopoly of resources. It is the intersection of information, logistics and capital, and plays an important role in coordinating and controlling the port supply chain system.

Therefore, the response cycle of the port supply chain ought to focus on port collection (the supplier shipping the goods to the port), port operations (port enterprises completing loading & unloading, storage, shipping and other operations) and other logistics activities. Seven diagnostic indicators of port supply chain responsiveness are shown in table 3. Order processing time and replenishment time are part of the order processing cycle; port collection transporting time belongs to the supply cycle; the time vehicles or ships waiting in port, the time cargo stocking in port and the time loading and unloading for vehicles or ships are all typical port operations time which belongs to the storage & transit cycle; the delivery time of goods belongs to the product distribution cycle.
Table 3 Responsiveness Indicators of Port Supply Chain

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Metrics</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsiveness of Port</td>
<td>Order Processing Time</td>
<td>Time from the order is issued by consignee to the time supplier begins to execute the order.</td>
</tr>
<tr>
<td>Supply Chain</td>
<td>Replenishment Time</td>
<td>Time for replenishment due to insufficient supply.</td>
</tr>
<tr>
<td></td>
<td>Port Collection Transporting Time</td>
<td>Time required for the goods to be shipped from the supplier to the port.</td>
</tr>
<tr>
<td></td>
<td>Time of Vehicles or Ships Waiting in Port</td>
<td>Time of vehicles/ships waiting in port caused by the lack of handling capacity, yard or berth.</td>
</tr>
<tr>
<td></td>
<td>Time of Cargo Stocking in Port</td>
<td>Time of the goods stocking in port due to insufficient shipping capacity, loading and unloading ability or incorrect cargo shipment plan.</td>
</tr>
<tr>
<td></td>
<td>Time of Loading and Unloading for Vehicles or Ships</td>
<td>Time from beginning to the end of loading &amp; unloading the vehicles or ships.</td>
</tr>
<tr>
<td></td>
<td>Delivery Time of Goods</td>
<td>Time required for the goods to be delivered from the port to the receiver.</td>
</tr>
</tbody>
</table>

6.3 Agility of Port Supply Chain

The agility refers to the ability of the supply chain as a whole to respond to the uncertain customer's needs in a constantly changing market environment. The factors that influence the supply chain agility include: unexpected demand, uncertainty of supply shortage caused by suppliers’ lack of supplying ability; the manufacturing uncertainty due to management level and production malfunction; demand uncertainty because of forecast bias, customer psychology and changes in purchasing power; and other external uncertainties in the supply chain related to policy changes or natural disasters, emergencies.

With respect to agility diagnosis, three aspects of supply chain are involved in SCOR, namely, flexibility, supply chain adaptability and supply chain overall risk. Detailed indicators of the specific processes are given such as planning, procurement, production, distribution and return. Port supply chain does not involve manufacturing and production, so agility diagnostic indicators of port supply chain should be analyzed mainly from aspects of planning process, port operating process and distribution process.

In port supply chain, the suppliers mainly refer to those supply coal, iron ore, oil, bulk cargo and etc. These companies usually use simple mode of continuous production and there are no product flexibility issues in them. But occasional “out of stock” of these suppliers will make the port supply chain impossible to meet demand, so the percentage of supplier being out of stock can be selected to measure the agility of the port supply chain.

In the process of goods flowing in the port supply chain, the cooperation of each link and the influence of uncertainty factors have a great impact on how port supply chain adapt to changes in demand, the port operation processes such as unloading, stockpiling and shipment are also important factors of port supply chain agility. Comparing with the production process in the manufacturing industry, we can select the indicators that can express how the port supply chain meets the changing needs when unexpected changes occur in demand. As shown in table 4, the seven indicators are the diagnostic indexes for the agility of the port supply chain, in which, percentage of plan changed being executed describes the level of the port supply chain meeting the demand when the demand changes; percentage of job relaxation time reflects the recovery situation after the malfunction; percentage of operations completed ahead of schedule and percentage of operation delayed express the completion of the operation.

Percentage of plan changed being executed reflects the flexibility of production process which includes adapting to changes of users’ mutative needs, such as delivery time, delivery quantity and even product categories; The less the increase in production cycles due to changes in demand and the cost increase, the higher the percentage of plan changed being executed and the greater the flexibility of the port supply chain is as a whole. The percentage of job relaxation time is invalid waiting time due to shortage or machine equipment malfunction, and is generally expressed by the ratio of difference between average operating time and shortest operating time to the average operating time.
### Table 4 Agility Indicators of Port Supply Chain

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Metrics</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agility of Port Supply Chain</td>
<td>Percentage of Supplier being out of stock</td>
<td>Probability of the suppliers can’t organize the relevant resources for supplying due to out of stock when customers issue orders.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Delivery in Advance</td>
<td>The proportion of times delivering to customer ahead of scheduled time to the total times of deliveries.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Plan Changed being Executed</td>
<td>The proportion of amount changed plans being executed to the total amount plans.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Job Relaxation Time</td>
<td>Invalid waiting time during operation due to shortage or machine equipment malfunction.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Effective Turnaround Time</td>
<td>The ratio of value-added time to turnaround time.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Operations Completed Ahead of Schedule</td>
<td>The probability of finishing the planned operation ahead of expected completion time.</td>
</tr>
<tr>
<td></td>
<td>Percentage of Operation Delayed</td>
<td>The probability of finishing planned activities lagging behind the expected completion time.</td>
</tr>
</tbody>
</table>

The percentage of effective turnaround time indicates effectiveness of the timeconsuming in the supply chain production process. The turnaround time is the entire time composed of the independent process units, in which the time consumed by working units generate values is called value-added turnaround time and the time consumed by working units that don’t generate values is called non-value-added turnaround time such as the non-operation waiting time. The ratio of the value-added turnaround time to the entire processing time can reflect the overall operational capacity and ability to adapt to the change of the port supply chain.

### 6.4 Cost of Port Supply Chain

SCOR divides the operation of the supply chain into five aspects: plan, resource, make, delivery and return. ‘Plan’ of port supply chain includes collection of data and development of operational processes plan, which mainly related to management costs. ‘Resource’ mainly based on the procurement plan to contact the supplier to obtain resources to meet customer demand and the relevant costs include ordering costs, transaction costs and information costs. The production(‘make’) cost of port supply chain mainly contains the transportation costs of the logistics activities, the costs of the port operating and related management costs. The delivery process mainly involves the transportation costs of the distribution channel and the operating and management expenses. The purpose of the support activities is to make the operation of port supply chain system healthy and efficient. The main costs involve expense of partner selection and maintenance as well as the resulting personnel and management cost.

Costs of order processing, process management, fund transferring and information processing are integrated into port supply chain management costs, coupled with logistics-related costs, transportation costs, storage costs and vehicle/ship loading & unloading operation costs which are more prominent in the port supply chain than in the traditional manufacturing supply chain. The cost indicators of port supply chain are shown in table 5.

### Table 5 Cost Indicators of Port Supply Chain

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Metrics</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Port Supply Chain</td>
<td>Transportation Costs</td>
<td>Costs mainly refer to goods transporting from suppliers to port or from port to demanders.</td>
</tr>
<tr>
<td></td>
<td>Vehicle/Ship Loading &amp; Unloading Operation Costs</td>
<td>Cost of loading / unloading cargoes in the port.</td>
</tr>
<tr>
<td></td>
<td>Storage Costs</td>
<td>Cost of goods stockpiling in port.</td>
</tr>
<tr>
<td></td>
<td>Supply Chain Management Costs</td>
<td>Cost to manage and coordinate the entire supply chain.</td>
</tr>
</tbody>
</table>

7. CONCLUSION
Based on the SCOR, this paper analyzes the business process in the port supply chain, and constructs the port supply chain diagnostic index system from four aspects: supply chain reliability, supply chain responsiveness, supply chain agility and supply chain cost. But the paper does not deal with the port supply chain asset management issues, so the diagnostic index system also has some defects. Therefore, exploring the port supply chain diagnostic model according to the diagnostic index system is an important research topic worth of further study in the future.

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REFERENCES


