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Study on agile service oriented shipping companies in container terminal

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STUDY ON AGILE SERVICE ORIENTED SHIPPING COMPANIES IN CONTAINER TERMINAL

By

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Research paper: **Study on Agile Service Oriented Shipping Companies in Container Terminal**

Degree: **MSc**

Agility is regarded as one of the core capabilities and the developing trend of supply chains and their enterprises. With the development of economical globalization, supply chain management, and containerization, the container ports, as a part of supply chain, take more roles like logistics center or distribution center. Under this background, the container terminal should have superior response and develop agility. The main goal of this paper is to emphasize and illustrate the importance and imminence of implement of agility in container terminals. To achieve this goal, an analysis of economies of scale in container terminal is presented to prove the necessity of the agility in container terminal. The concept and characters of agile services, especially the services oriented shipping companies in the container terminal, are to be illustrated in this paper. Then, flexible organizational structure of container terminal is introduced based on a quantitative analysis, and a fuzzy quality synthetic evaluation method is given to evaluate the performance level of agile service in container terminal oriented shipping companies. Finally, some advice for container terminal to achieve agility will be given. This paper provides a study on the agile service in container terminal and a suggestion that container terminals improve the agility of service to adapt the changeable market environment.

Key words: container terminal, agile service, organizational structure, flexibility, performance evaluation

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List of Abbreviations

AC	Average Cost
AI	Agility Index
AM	Agile Manufacturing
APS	Agile Production System
AS	Agile Services
CMM	Capability Maturity Model
ITT	Integrated Transportation Teamwork
JIT	Just in Time
MC	Marginal Cost
PTP	Port of Tanjung Pelepas
SCM	Supply Chain Management
VE	Virtual Enterprise

1. Introduction

1.1 Background and objectives

Agility is regarded as one of the core capabilities and the developing trend of supply chains and their enterprises. The study of agility first takes place in manufacturing industry. With economical globalization and the development of electronic commerce, supply chains and their enterprises are facing competition coming from global market, facing the challenge of shortening delivery time, improving productions' quality, improving service, satisfying the demand of individuation, reducing cost etc. To adjust to market environments and meet customer expectations, the enterprise should have the ability of quick response. With the appearance of the agile manufacturing, an advance management ideology and manufacturing philosophy, a lot of changes have happen not only in the manufacturing industry, but also the whole supply chain.

At the era of the economical globalization and supply chain management (SCM), ports have become one part of the supply chain but an isolated point in the transportation chain. Ports are confronted with the increasing pressure from the market. The competition is changing from between ports to between the supply chains in which the ports take part. Therefore, the requirements, which are met by the manufacturing industry in the supply chain, also lead to a range of changes in the port industry.

Due to the containerization, container port has been developing rapidly in the past several decades. From the view of developing trend of the logistics industry, container ports, as vital nodes of the international integrated transport network, are

today responsible for not only the traditional loading and discharging cargoes but a wide range of logistics activities also (Paixao and Marlow, 2003). Under the background of the global economy, the container ports take more roles like logistics center or distribution center. To take the event, U.S. West Coast Port Lockout in July 2000, for example, locked port resulted in hundreds of ships waiting outside of the ports and huge numbers of goods could not delivery to the destination. Moreover, the enterprises in the US faced a large amount of inventory, thus the modern SCM and Just-in-Time (JIT) inventory management meeting a big challenge.

For the liner shipping companies, however, high quality service from container terminals plays a very important role in their transport chain. It can help the shipping companies compress the turnaround time and save costs as well as improve their services to shippers, and then the competitive advantage. It is because of the special position of container ports in modern logistics that the largest liner shipping company, Maersk, decided to turn the pivot port in Southeast Asia from Singapore to PTP. The objective is to improve the quality of the transport service and to get some special service.

Under all above background of development, the container terminal is required to be more agile to adopt the changeable environment and the individual requirements from the shipping companies. Therefore, in this paper, the focus is on the agility of the container terminal, especially on the agile service oriented shipping companies in container terminal.

1.2 Main content and methodologies

The main goal of this paper is to emphasize and illustrate the importance and

imminence of implement of agility in container terminals. To achieve this goal, an analysis of economies of scale in container terminal is presented to prove the necessity of the agility in container terminal. The concept and characters of agile services, especially the services oriented shipping companies in the container terminal, are to be illustrated in this paper. Then, flexible organizational structure of container terminal is introduced based on a quantitative analysis through the information theory, and a fuzzy quality synthetic evaluation method is given to evaluate the performance level of agile service in container terminal oriented shipping companies. Finally, some advice for container terminal to achieve agility will be given.

The remainder of this paper is organized as follow: Section 2 discusses the economies of scale in container terminal and the necessity of agile service. Section 3 presents the concepts and characters of agile service oriented shipping companies in container terminals. Section 4 observes the agile organizational structure in container terminal. A performance measurement model is developed in Section 5. Section 6 is to give some suggestions.

1.3 Literature review

1.3.1 Review of agility

1.3.1.1 Understanding of agility

The concept of agile enterprise has existed since 1990's, based on a realization that the abilities of many established organizations could not keep up with the pace of change in the business environment (Dove, 1999). Accordingly, Dove defined as

"the ability of an organization to thrive in a continuously changing unpredictable business environment". Vokurka and Fliedner (1998) describe that agility is the ability to produce and market successfully a wide range of high quality, low cost products with short lead times, which provide added value to individual customers through customization. Zhang and Shrifi (2000) survey agility as the ability of enterprises to cope with unexpected changes, to survive unprecedented threats from the business environment.

One important view of agility is that it is an essential property of an alliance of collaborating systems. Huang et al (2000) presents agility as a measure that shows how well a system can adjust itself while also seeming to help from other enterprises in the system. Hooper et al (2001) observes that the term agility is the ability of an enterprise to develop and take advantage of its inter- and intra-organizational capabilities to compete successfully in an uncertain and volatile business environment.

Agility is a combination of speed and flexibility. Vastag et al (1994) observes that time-based competition and flexibility converge through agile manufacturing. McGaughey (1999) regarded agility as the ability of enterprise to respond to change quickly and successfully. Prater et al (2001) observes that an agile firm should design its organization, processes and products in order to quickly respond to changes in a useful time frame, and the two-edged nature of requisite capabilities are speed and flexibility.

1.3.1.2 Agility in logistics system

Global Logistics Research Team (GLRT) at Michigan State University (MSU) made

a World Class Logistics research in 1995, and established a logistics competency model. n this model, GLRT (1995) defined that logistical agility deals with how well performance relates to customer expectation. t draws on three important capabilities that directly impact customers. The first is relevancy, which is the ability to maintain focus on the changing needs of customers. The second attribute of agility is accommodation. To accommodate is to respond quickly to unique customer requests. The final attribute that creates agility is flexibility, which is the ability to exploit unexpected circumstances.

Xue Zhangyi (2004) observes that agile logistics should give the cost and efficiency optimization program in a right time frame. The main goal of agile logistics is to satisfy the customers within the specified time. Beyond the right time frame, the logistics service will have no value. There are many ways and meanings to achieve agile logistics, such as reduce order-processing time, JIT inventory management, Virtual Enterprise (VE), postponement, etc.

1.3.1.3 Agility in port operation

The agility of port is presented owing to the changes of economic functions of port. According to the version of United Nations Conference on Trade and Development (UNCTAD), ports have been going through three generations and the 4th generation will be developed. The changing function of port is explained in Table 2-1.

Table 1-1 Economics Functions of Port

	First Generation	**Second Generation**	**Third Generation**	**Fourth Generation**
Started Period	Before 1960	After 1960	After 1980	After 2000

Principle Cargo	Conventional Cargo	Conventional and Bulk Cargo	Bulk and Unit Cargo Containerization	Specialization in special type of cargo like container handling ports
The port development position and Development strategy	Conservative junction of sea and inland transportation	Expansion transportation and production center	Industrial principle international trade base chain connecting transportation system	Itself converting into the industry
Activity Scope	(1) Cargo handling, storage, navigation assistance	(1) + (2) Cargo Type change ship related industry-enlargement of port region	(1) + (2) (3) Cargo information, Cargo distribution, logistics activity Formation of terminal and distribution center	(1) + (2) + (3) (4) Developed as regional distribution and logistic center (5) Consultancy service on port project
Structure Formation and specifies	◆ Every Body act individually in the port, ◆ Port and its user maintain informal relation	◆ Relation between port and its user become more close, ◆ Emergence of slight correction among port activities, ◆ Negative cooperation	◆ Formation of port cooperation system, ◆ Trade and transportation chain concentration in the port ◆ Relation between port and self governing	◆ Port corperatization from port authority, ◆ Changes from Monopoly market to Oligopoly market structure internally and externally

		relation between Port and Self-governing community	community become more close ◆ Extension of the port structure	
Character of the productivity	◆ Invention of cargo distribution ◆ Individual supply of the simple services	◆ Processing ◆ Cargo complex services ◆ Increase of the vale added	◆ The flow of cargo and information ◆ Distribution of cargo and information ◆ Combination of diversified services and distribution ◆ Value added	◆ Trade off between economies of scale and economies of scope
Core factor	Labor/Capital	Capital	Technical-Know How	Information Sharing

Source: Prakash Gaur (2005). Port Planning as a strategic tool: a typology. Retrieved May 3, 2007 from the World Wide Web: http://www.worldbank.org

Paixao and Marlow (2003) observe that the third generation of port would be sufficient if the market is of certainty, but the environment is changeable, therefore, they suggest that ports adopt a new logistics approach, agility, to cope with the market uncertainty. They also present five phase in implementing an agile ports, including identification of the port current processes, JIT preparation phase, the running of JIT operations phase, the lean phase and from lean to agile phase.

1.3.2 Review of agility measurement

Dove (1994) was the first one to discuss agility measurement as the ability of a process to respond to unexpected change. Metes et al (1998) extend Dove's (1994) change proficiency domains to agile networking as an agility metric. The methodology is to use a scorecard to assess different agility domains.

Kumar and Motwani (1995) observe that it has become a focal competitive priority of enterprise to compressing the time from idea to market, namely the enterprise's time-based competitiveness. To assess the strategic value of a company in terms of its "time" performance, they have developed an agility matrix called the agility index (AI) whose cells represent intersection of agility-determinants and segments of time-to-market. The AI is computed after grading a company on each cell, a weighted sum, and it is an indicator of the firm's capability to compete on time.

Dove (2001) introduces a five level maturity model to measure the agility of a enterprise. The basis of the approach is to assess company practices or characteristics via a degree of low, medium, or high. Using the three-value scale, companies can be classified into one of the five levels of increasing maturity of agile practices. This model is similar to the capability maturity model (CMM) that is widely used in software industry to describe the maturity of the software development process.

2. Analysis of economies of scale in container terminal and agility

2.1 Impacts on terminal for economies of scale in container ship sizes

In the analysis of economies of scale in container transport, it seems that the shipping industry has little disagreement on the trend of economies of scale in container ship sizes. But for large to what extent -- the largest amount of boxes stowage, there are different views. Behind the trend of increasing scale of ship size, a fundamental reason for this is that in principle the bigger the ship the cheaper the unity cost of transport (Ma Shou, 2005, pp.98). However, the total efficiency that a ship completes a voyage is also closely related to the time of its total journey. This relevance is that the container ship handling efficiency does not directly increase with the increase scale of the ship sizes. On the surface, the development large and ultra-large container ship is an inevitable trend. Nevertheless, this kind of trend brings a lot of new requirements to the container terminal.

First, the bigger ship is, the longer time it will be in port, and the costs will increase. Thus, it is not economic during the time in the port. In a door-to-door container transport, the cost of transport by sea occupies only 23% of the total costs, and the cost in ports accounts for 21%. The rest 52% is the cost of the other (see Table 3-1). Under this background, economies of scale in container port have become a problem of enthusiastic discussion.

Table 2-1 the cost proportion of container transport

Inland	Shipping	Terminal	Container	Other
25%	23%	21%	18%	13%

（Source：http://www.easipass.com 04/30 Hu Shuwei）

Second, the larger container ship, due to the volume of containers more focused, there appears congestion, which is harmful to the environmental protection and transport order as well. Meanwhile, it requires higher levels of the port handling equipment, the scale of the yard and distributing infrastructure. To meet this need, the container terminal must add handling equipments, enlarge the scales of berths, yard and other infrastructure, and further escalation container port distributing system to maintain, even to enhance the speed of cargo through the port and to improve the efficiency of logistics.

Third, at the same time, people pay more attention to speed and flexibility. Now with the rapid progress of computer information technology and the development of modern logistics, people will increasingly focus on improving the container shipping speed and flexibility.

In past years, the scale of infrastructure has become a competitive objective of most port. Based on economies of scale and increased competition considerations, that the larger scale the better became the credo for decision makers to make infrastructure investment decisions. To enlarge the scale of the terminal became the most important strategy for most container terminal companies. However, practice has proved that the container port in specific locations is to provide specific regional services, to promote trade, increase employment and income. Port authorities should develop an appropriate scale of port, but not build a super port blindly. Sometimes, building super ports can be understood and accepted, but in most cases, a small port having suitable location often made good returns, and the costs are low. Therefore, the scale of infrastructure should not be a competitive objective of a container port. Competition between ports is to improve the operating efficiency of the port.

2.2 Demonstration of economies of scale in container terminal

Economies of scale, also known as Scale Merit, refers to the phenomenon that the company produces on a large scale, while the average cost declines. Economies of scale in container terminal can be defined as the phenomenon of declining average cost caused by expanding the scale of production and increasing container throughput, with container terminal enterprises to expand investment scale, to purchase terminal facilities and equipment and to increase the number of flights.

Due to the increasing transport requirements of small batches of various goods and the increasing volume and widening scope of goods, the port is requested new requirements. There is a growing awareness of the importance of the affluent capacity of goods through the port. It is regarded as a golden role to make the berths wait the ships in past years. In the era of transport containerization, container throughput is an important capacity for the container terminal.

As a result, container terminal are becoming larger to adapt the big size of the ships and improve the volume capacity of goods flow. The port enterprises in each state invest heavily in the infrastructure of the ports, such as extending the length of berth, improve the depth of water, increasing the length and height of cranes, expanding the yard area, etc.

However, there are some queries during the construction of terminal, whether the volume capacity of good flow is the larger the better, the more berths the better, and the large scale of port leads to waste or not.

Judging from the economic point of view, during the expanding process for

enterprises from small to large scale, there will appear economies and diseconomies of scale.

For container terminal, because the production cost shares of the fixed costs greatly, and in certain production scope, the marginal cost of increasing unit output (container throughput) is very low. As a result of increased throughput of the terminal, the average cost of production will continue to decline. Before its throughput capacity being fully utilized, the marginal cost of production is lower than the average cost. Therefore, the production of container terminal is of significant economies of scale.

(1) The larger ports generally are able to take advantage of natural or mining channels and pools to accommodate large container ships; furthermore, large ships during transport also present economies of scale. As a result, the large port can not only reduce the production costs itself, but also brought the decrease of average costs in the whole transportation system.

(2) Generally, there are more berths in a large terminal, and utilization of the berths is higher. For the small size of the port, because of its relatively small number of berths (and in some cases only one or two), and the randomness of ships coming to the port, the higher utilization of the berths in a small port usually results in the existence of the port congestion. If the port is on a larger scale and has more berths, the substitutability between the berths is larger. Thus, for the larger port, the higher utilization of berths will not necessarily lead to port congestion. This shows that the expansion of the scale of the port, the rate of actual increase of production output in port is larger than that of expanding scale. This will bring the average cost of the port decline.

(3) The economies of scale in container terminal are also from in the use of large-scale port machinery and equipment and increasing throughput capacity, then unit handling costs will decline.

It is because of the obvious economies of scale in port production, the marginal production costs in port are significantly lower than the average cost (AC). It means that if the container terminal uses the marginal cost (MC) as the price, the pricing strategy under pure competition, the company will suffer loss. There appears a contradiction between marginal costs pricing and the goal of profit-maximization in container terminal, as shown in Figure 3-1.

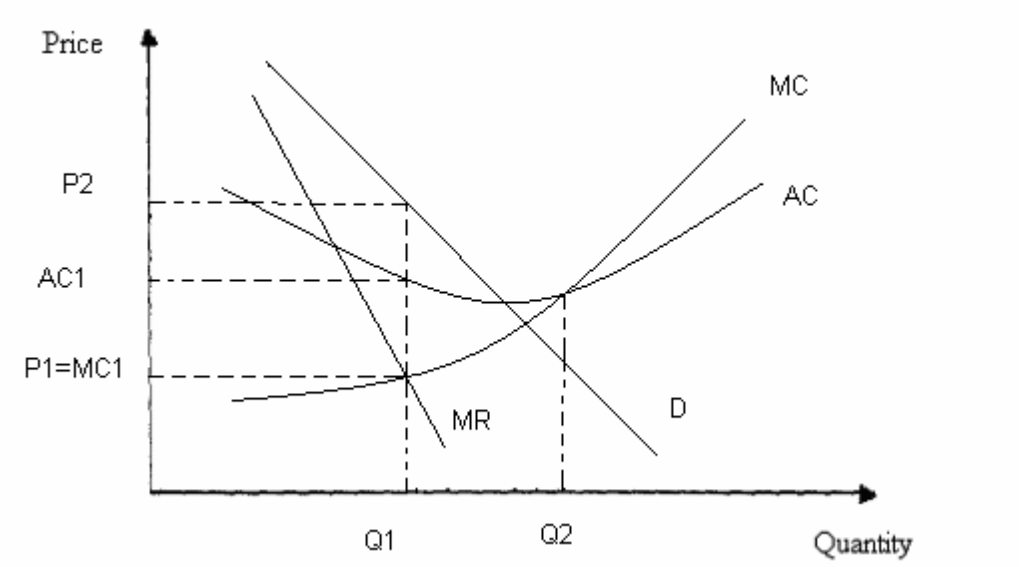

Figure2-1 Economies of scale in container terminal and pricing

From Figure 2-1, it can be see that because of the existence of economies of scale of production in the container terminal, the terminal should produce in the scale of left side of Q_2 (Q_2 corresponding to the lowest point of average cost). At the left side of Q_2, the average cost is at a downward trend, and the average cost is more than the

marginal cost. According to traditional economic theory, marginal cost pricing should be taken in order to make reasonable allocation of the resources, i.e. the price set at the point P_1=MC_1, this time the output of Q_1, and the average cost of AC_1. Because AC_1 is more than MC_1 (average cost more than the marginal cost), if using marginal cost pricing, the terminal will suffer profit loss. If choosing the price of P_2, according to monopoly pricing, it is difficult to make rational allocation of resources, and social resources are wasted greatly. If expanding the production scale blindly, the terminal produces at the right side of the Q_2, then the average cost will be to increase instead of to reduce, thus the diseconomies of scale in the container terminal. This is not what the container port operators are willing to see.

From above economic demonstration, it can be seen clearly that the scale of terminal cannot be enlarged without restraining. The unlimited expansion will cause the waste and diseconomy in the terminal. Therefore, the container port is not the larger scale the more economies, but a reasonable economy of scale. Container terminal needs an appropriate scale can be achieved better economic results.

2.3 The scale development role in China’s coastal container terminal

Here use the change of the throughput of China’s coastal container terminal to make a further analysis the scale development role in container terminal. Table 2-2 shows the basis figures of the analysis.

Table 2-2 Throughputs of ten main China's costal container ports

Unit: million TEU

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Shanghai	2.53	3.07	4.22	5.61	6.34	8.61	11.28	14.55	18.09
Shenzhen	1.15	1.95	2.99	3.99	5.08	7.62	10.65	13.66	16.20
Qingdao	1.03	1.21	1.54	2.12	2.64	3.41	4.24	5.14	6.31
Ningbo	0.26	0.35	0.60	0.90	1.21	1.86	2.77	4.01	5.21
Tianjin	0.94	1.02	1.30	1.71	2.01	2.41	3.02	3.82	4.80
Guangzhou	0.69	0.84	1.18	1.43	1.74	2.17	2.77	3.30	4.68
Xiamen	0.75	0.65	0.85	1.09	1.29	1.75	2.33	2.87	3.34
Dalian	0.45	0.53	0.74	1.01	1.22	1.35	1.67	2.21	2.69
Lianyungang	0.11		0.11	0.12	0.16	0.21	0.30	0.50	1.01
Zhongshan	0.32		0.43	0.51	0.56	0.64	0.76	0.93	1.00

Source: www.simic.net.cn

These ports are the first ten ports in China's coast, which are including three areas' ports, North China (Qingdao, Tianjin, Dalian), East China (Shanghai, Ningbo, Lianyungang) and South China (Shenzhen, Guangzhou, Xiamen, Zhongshan). As these ten ports account for large proportion of market sharing in China, it is enough to show the role by comparing the throughputs percentage of each port in different areas. Because the three ports in North China, Qingdao, Tianjin and Dalian, are all the ports round the Bohai Sea, they are at the same development level and have similar hinterland, and the trend is not clearly in this area. Therefore, the focus is on the analysis in East and South China. The figure 2-2 is to show the throughputs change trend of the different ports respectively in East China.

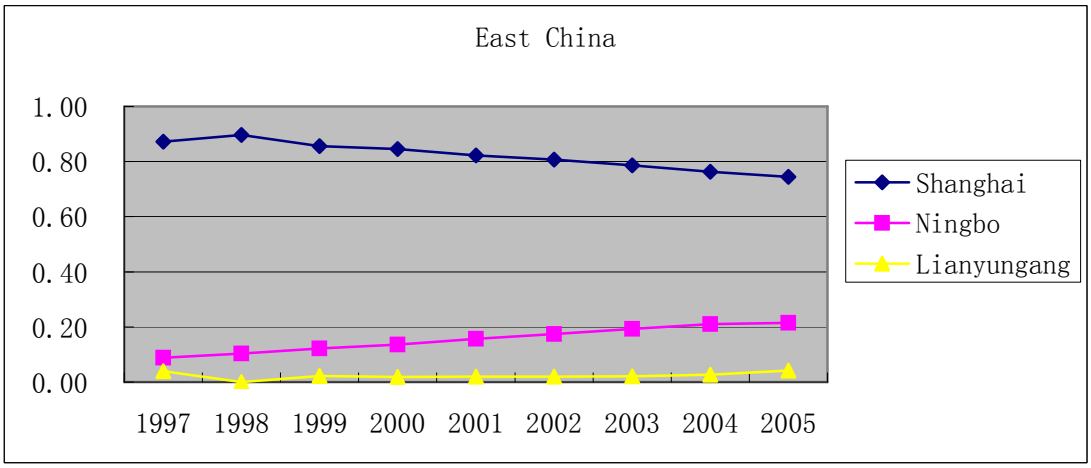

Figure 2-2 Throughput proportions of ports in East China

*The proportion=Throughput of each port / the total throughput of the area which port is in

It is clear that the throughput proportion of Shanghai port is decreasing every year and that of Nignbo port is growing quickly every year. These two lines are going toward the middle.

In the South China, as there are lots of cargo transported through Hong Kong, here Hong Kong should be considered in system when doing analysis. Table 2-3 shows the throughput volume of Hong Kong in recent years, and Figure 2-3 reflects the trend of change.

Table 2-3 Throughput volumes of Hong Kong port in recent years

Unit: million TEU

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Hong Kong	14.56	14.65	16.10	18.20	17.80	19.14	20.45	21.93	22.60

Source: www. Chinaports.com.cn

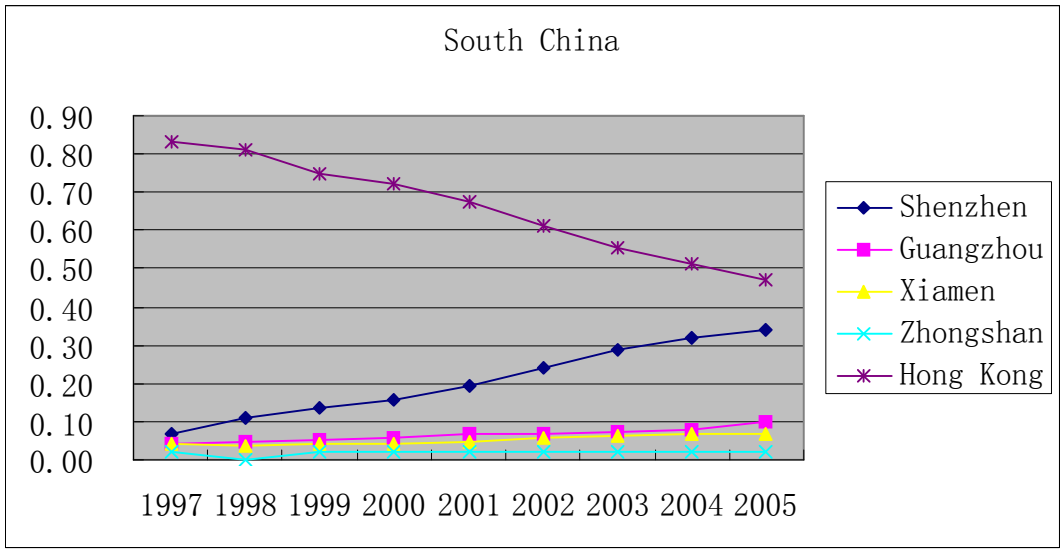

Figure 2-3 Throughput proportions of ports in South China

It is obvious that the throughput proportion of Hong Kong port decrease rapidly and the percentages of the other ports in South China are all increased, especially the Shenzhen port. The market sharing of Shenzhen port grows every year and has a trend to catch up with Hong Kong.

All above phenomenon indicate that the container would not converge to one port forever because of the economies of scale in container terminal. Hong Kong is a best example to show that when the port scale is developed to a high extent, the continuous development of scale will cause a series of problems, like lack of land, increase cost, and traffic congestion, etc. If there is a new port closed, the cargoes will go to the new place.

2.4 The necessity of the agility in container terminal

However, the decrease of the throughput proportion does not mean the reduce of the volume of throughput, on the contrary, due to the growing volume of world trade, the

volume of the throughput will increase, yet with a low growing rate. Table 2-2 and Table 2-3 reflect it. Then, a problem is coming, how to cope with the increase volume within the certain optimum terminal scale.

To solve this problem, terminals should make the cargo flow smoothly in the terminal and shorten the time for ships in terminal. To achieve this goal, it is necessary for the port enterprise to respond to the shipping companies quickly, and provide more flexible and agile service, especially under the trend of the enlarging sizes of vessels. Actually, many port enterprises have realized this problem, and they take a lot of activities, such as adopting more flexible production systems, upgrading Information Management System and optimizing the logistics network in the terminal, etc. All these activities are to shortening cycle time and improve service performance, and also reflect that container terminals want to have superior response and develop agility.

In addition, another reason to improve the agility of container terminal is that the requirements of manufacturing flexibility and agility from the market also affect the other links in the supply chain. The individual requirements from the customers and uncertainty from the market have great impact on the port operation. To cope with the uncertainty, port is not only to make sure a reasonable scale to achieve economies of scale, reduce logistics costs, but also to take into account the response capability to the market, but to pursue the development of port scale blindly.

3. Study on agile Service in Container Terminal

3.1 Agile Service in Ports

3.1.1 Meaning of agile service in ports

According to Agile Manufacturing (AM) thinking, Agile services (AS) of port logistics service firms can be defined as a logistics community service system with a dynamic characteristics of the organizational structure, the core of high-quality and well-coordinated staff, the network information technology over the port, shipping logistics service providers, thus the formation of quick response to market opportunities. The characters are as follow:

1) Quick response to customer demand for the service as a basic feature, a change from a simple market-oriented to customers participation market-oriented, to meet the owners, shipping companies and other clients individualized needs. In the other words, the firm should consider not only the arrival species, quality and price factors. What is more important is to consider customer satisfaction.

2) Internet technology at the core of Information technology, as the AS's technical support. The port firms should consider not only the internal logistics information, functional integration, but also to consider the logistics system between various service providers integrated.

3) Internal flexibility and external dynamic alliance of organizations, as the organization features. Within the enterprise, organizations develop from a vertical pyramid to a flat and network type, from rigidity to flexibility, to instantaneously

communicate between the various departments via internal information technology and network; outside the enterprise, all enterprises take advantage of their own core competitiveness through commercial tenders and network division to form a temporary logistics services dynamic alliance, in which the information superhighway is as a bridge. The enterprise reaches organizations, personnel and technology effectively integrated via a flexible way.

4) AS is very different with the traditional service patterns. When optimizing business strategy, the first is to use quick and convenient activities to improve service levels and achieve shorter delivery time. AS pays attention to further inputs of organization updates and the quality of people, such as reorganization, staff training, etc. Profit is not just a single enterprise economy of scale, but also strategic cooperation partners' economies of scale.

3.1.2 Element supports of port enterprise agile service

1) Agile techniques

The technology, based on AS Port Enterprises needing, can be divided from border into internal information technology systems and external information network system. Divided by the process of service items provided by the port logistics enterprises, it is including agile organizing of cargo resource and agile storage, packaging, processing, transportation and so on. Of course, agile technical means must combine with agile management to achieve a real sense of agility.

2) Agile organizations

Agile organization is including two aspects, that is, organic, flexible, flat organizational structure of internal enterprise, and virtual, dynamic, network

organizational structure between enterprises. The former is the basic of agile services; the latter is guarantee of agile service.

3) Agile port management

Agile technology and agile organizational structure are inseparable from the support of agile management. To effectively integrate human resource, technology and organization, to achieve the dynamic alliance and virtual organization among enterprises, and to complete the logistics items and quick respond to the market, port enterprises need agile management philosophy and management skills.

3.2 Contents of agility in container terminal

Agile container terminal is to flexibly integrate three aspects, advanced production equipment, advanced communications and information technology, the labor force with skills and knowledge, and the flexible management, to make quick and effective response to the volatile market. Agile container terminal emphasizes the organic integration of human resource, technology and management. By the three closely integrated to achieve the best overall efficiency. The content of agility in container port is summarized as follows:

(1) The core competitive advantage integration of container port enterprises and their partners is the basis to quickly respond to the market demand. To catch the fleeting market opportunities, the enterprises need not only integrate all its internal resources, but make full use of external resources also.

(2) To goal is to satisfy customers and add value to their products. For this reason, some ports are to provide customers not just products or services, moreover, to

provide solutions that achieve their value-added in the process. With the diversification of customer demand, solutions provided to customers should also be customization.

(3) Virtual Enterprise (VE) is a necessary new organizational form to integrate the core advantage of container port. It has the ability to flexibly allocate resources, reduce services cycle time and quickly respond to customers' needs.

(4) Since there exist physical barriers to hinder information flow between the members of VE, integration is the key factor to achieve agility.

(5) The container terminal need to improve competitive advantage through the capability of labors, thus necessary to train a large number of highly flexible, well-trained, capable and highly responsible staff, and giving full play to their role.

(6) The agile enterprise is a new organizational models and management approaches. Agile enterprise management structure should be appropriate to streamline, such as dynamic and flexible model of flat-decentralized cooperation, thus reorganization and readjustment.

3.3 Characters of AS oriented shipping companies in container terminal

3.3.1 JIT services

The increasing degree of production globalization results in more stringent requirement of logistics time in international trade. It is reflected clearly from the

rapid growth the volume of cargo transported by air in the last few years. Although transport by air can not replaced transport by sea, from the view of volume and costs, it can distribute goods to customers directly, save inventory costs; Container Liner has the advantages of large transportation capacity and low costs, but the time for delivery is much longer. However, logistics speed is not a pure speed of fast or not. Quick response is the main goal of a logistic system (Barad and Sapir, 2003). Agile logistic is not mean how fast it is but how close it catches the pace of the customer, and during this process, the logistic costs should always be considered (Xue, 2004, pp.320). Therefore, agile container terminal should consider the customer's individual requirements from the view of cost and time and meet the customers' JIT demand with a cost-effective manner in the useful time frame.

Shipping companies pay great attention to the total time for ships in the container terminal. If a ship spends a deal of time in the port, on one hand, the operating costs of shipping companies will increase, on the other hand, the delivery time of shipping companies will be extended, thus impact of the logistics service quality of shipping companies. This requires that the container port is to provide JIT customer service, in the other word, to satisfy the customers' different loading and unloading requirement within the right time frame. The JIT services are including four elements.

1) *Quick response* It does not mean the quick the better. Quick response means to make the correct response to the customer's requirements and be able to satisfy the requirements timely. Actually, the appropriate speed that customer needs is the objective of quick response. The speed being too slow, it will cause the customer's dissatisfaction, while it being too fast, it also brings problems. For example, when loading the containers, if the speed of response to the shipping company is slow, it

will affect the schedule of the work, thus the time for ship in the terminal. If the speed is too fast, the cost will increase and lead to waste.

2) *Flexibility* It is the ability to cope with the unexpected circumstances. Agile service is the service that container terminal uses to meet the uncertainty from the market, and the flexibility is one of the most important capabilities in the AS. To agile service oriented shipping companies, the flexibilities affect the speed for container terminal to respond the requirements from the shipping companies and the changes of terminal environment.

3) *Synchronization* Actually, the AS is a comprehensive problem based on time, speed and efficiency. AS must be to harmonize each link to achieve synchronizing operation. For example, if the time and speed are all right, but the efficiency of the rubber tired gantry crane cannot keep pace with the other equipments, the total efficiency will reduce.

4) *Low cost and high efficiency* The JIT service does not mean to improve the service level by sacrificing the cost. The agile service is a kind of service with low cost and high efficiency. When a container terminal provides agile service for the shipping companies, it should consider not only how to improve the efficiency and compress the time for ship in the terminal, but also how to control the cost.

3.3.2 Agile production system

Adopting agile production system is the character of production in agile container terminal. With the development of economies of scale in ship size, shipping companies set higher requirements to shorten the time for ships in port.

International hub port have improved handling technology, improve working efficiency, and actively develop new technologies to consolidate the position of hub port, with the use of electronic data interchange systems to enhance terminal and container yard utilization, reasonable adjustments set distributing system to strengthen the comprehensive port capacity and the use of quicker response production system.

Container terminal Agile Production System (APS) is formed by a unified terminal information control system and production equipment control system, which is a automation production system adapting to different objects.

Agility reflects the flexibility of the facilities and equipment allocation in the international container hub port. Regional hub port should adapt equipments allocation to both large container ships and small and medium-sized container ship. International large port should also require the high performance of quay cranes to adapt the large ships to shorten the time in ports. At the same time, the cranes should be able to handle different kinds and sizes of containers.

Container terminals should have advanced, automated and highly flexible operating equipments and loading and unloading programs, therefore, the terminal operators can provide handle different services in changing from one operation to another (Paixao and Marlow, 2003), and to satisfy the customers with different requirement.

3.3.3 Flexible organizational structure

Agile service need the support of process flexibility, which relates to the speed at which the port can make decisions, alter schedules or amend existing orders (Paixao

and Marlow, 2003). For container port, it is absolutely essential to change the traditional organizational structure in order to enhance the speed of market response and the ability to satisfy customers. A flexible organizational structure is a basis of the agile service. As above describe, a main character of agile service is quick response. To achieve this goal, within the enterprises, container terminal firms should adopt a flat-type and flexible organizational structure; on the other hand, they should use a dynamic organizational structure. For external of the container terminal, the container terminal enterprise should have a greater scope for integration and elect all superior forces from the company and other companies to integrate a single flexible operating entity, such as virtual enterprise (VE). (The structure will be discussed in Section 5 more completely) Therefore, it is necessary to integrate internal advantages of the enterprise and external advantages of different companies as fast as possible.

3.3.4 Effective management

Service is as a system (Lovelock, 2001, pp.53). It can be shown as Figure 3-1.

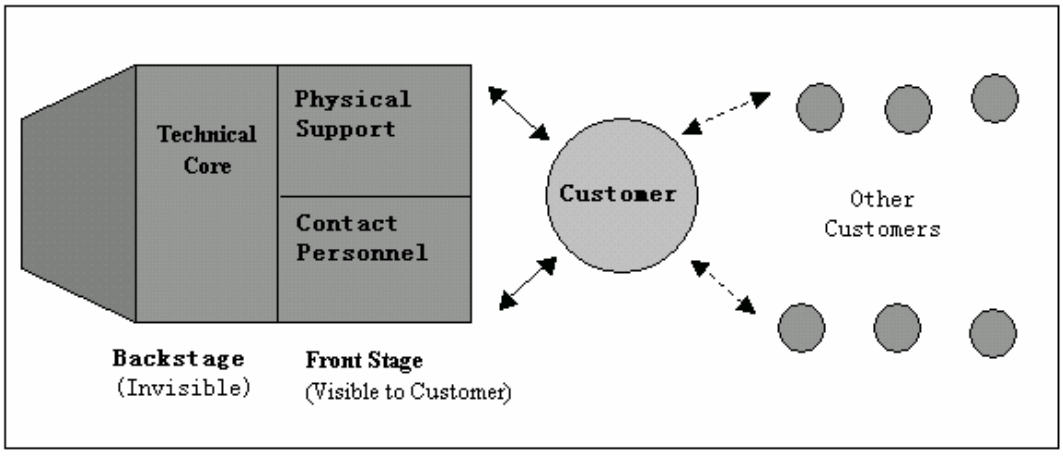

Figure 3-1 The Service Business as a system
Source: Langeard et al (1981) Adapted from Lovelock, 2001, pp.53.

As Figure 3-1 shows, front stage faces to the customer directly. It is obvious that

the great performance of front stage will increase the customer satisfaction. Agile service is to achieve high level of customer satisfaction, so it is necessary to adopt effective management to improve the performance. If a container terminal wants to achieve agile services, it should take effective management on these two parts, thus the comprehensive quality management and humanistic management.

3.3.4.1 Comprehensive quality management

Superior service performance is one of the main attributes for an agile port (Paixao and Marlow, 2003). Service quality is an important indicator to assess the performance of an agile container terminal. An agile container terminal enterprise should try it best to improve the quality level of service, such as shortening the wait time for ship in the port, increasing the correct rate of loading containers and so on. The high quality level of service is helpful to the customer's satisfaction as well as to improve the competitiveness of the terminal. To achieve the superior service performance, a serious of rigid and comprehensive quality management should be implemented during the services process.

3.3.4.2 Humanistic management

The words, "People are the most important asset", are popular in many organizations. It has been found that strong correlations between employees' attitudes and perceptions of service quality among customers of the same organization (Lovelock, 2001, pp.465-470). And the success cycle is shown as Figure 3-2.

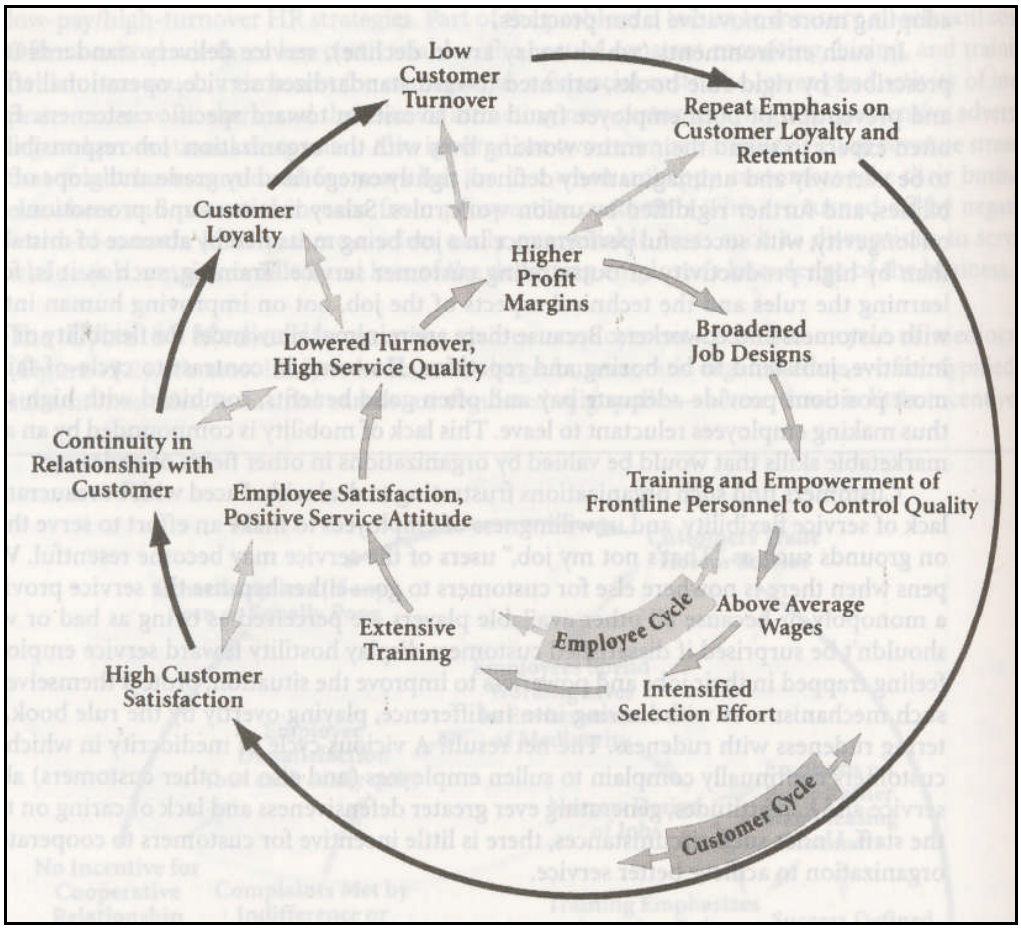

Figure 3-2 The Cycle of Success in services

Source: Schlesinger et al (1991). Scanned from: Lovelock, 2001, pp.470

For an agile container terminal, the most important factors of the competitiveness of are the skills and creativity of staff. The more staff creativity and responsiveness the staff has, the greater potential for success the enterprise obtains competitive advantages. Unrealized human potential is a kind of waste in container terminal management (Paixao and Marlow, 2003). Therefore, container terminal enterprises should have humanistic management to encourage the staff to take advantage of their activities and creativities, and to help the staff improve personal quality and master innovative skills, thus fully exploiting human potential and gaining a competitive advantage.

Self-management and indirect control are the means of management in organization of agile container terminal. Compared with the staff of traditional container terminal, the personnel who work on the first line in the modern container port are not only with good professional knowledge, rich experience and proficient skills, but also have their own capability of decision-making and self-management and their own views and ideas. Therefore, modern container port use indirect control as the main management means to take advantage of the staff's potential, thereby great service performance.

4. Study on the organizational structure in agile container terminal

4.1 Characters of organization in agile container terminal

4.1.1 Objectives and principles

The objective of an agile container terminal organization is to satisfy customers with the market demand orientation. With the development of global economy, the volume and the scope of cargo flow are steadily increasing and extending. Due to the increase of transport demand of small quantity and multiple types cargoes, the more flexible and agile modes of transport is requested, thus a new request to the port enterprises, which is to satisfy the demand of customers like shipping companies with all aspects of the ports, such as port function, service quality, price, etc. The competition of global logistics industry requests more benefits when the cargo flow through container terminal. To compress the time for ships in port can not only speed up the turnaround time of ships, thus directly increasing income of the owners, but also shorten the delivery time to the owner of cargo. Meanwhile, owe to the information and communications technology development and port services network establishment and perfection, port enterprise is able to know and grasp the market demand dynamics of the cargo owners and shipping companies timely and accurately. The satisfaction to cargo owners and shipping companies is not only an indispensable economic approach for the container terminal enterprises to establish their operation characteristics and position as well as corporate image, but also prompts enterprises to improve the overall service quality, and then getting competitive advantage in the market. For example, to meet the demand of shippers and shipping companies, the container terminal enterprise can establish a more adaptable and more flexible container logistics services system.

An agile virtual organization of container terminal takes full empowerment as the organizing principles. Based on the time competition, the vertical management approach in traditional port enterprises organizations cannot adapt to the customer-orientated objective in the volatile market environment. In container terminal, since the frontline staff is dealing with customers all the time, they can catch the market dynamics timely, and they can also master the entire process of tasks or projects and the goal of an enterprise through information communication system, therefore being given full decision-making power. To different projects and tasks, the work team or group should be authorized to manage and control the whole service process.

4.1.2 Structure unit

To the internal of an agile container terminal enterprise, the firm can organize Integrated Transportation Teamwork (ITT) as the basic organizational unit during the process of production and business activity, which is organized based on the business process or operation process of projects and tasks. ITT can be regarded as a virtual organization, which can be organized according to various clients and established with a collection of different experts according to the various requirements. This virtual organization replaces the traditional mode of meeting coordination and command, thereby the service being more timely, comprehensive and effective. This team has no redundancy of the same type of expert, and all the team members coordinate their work through the information network between different levels and different departments. Through changing high centralization of the traditional organization, ITT gives staff certain autonomy. Business process is divided into several parts, and everyone in the ITT is in charge of one part. The team is a

relatively stable organization, and it will be disbanded after the completion of a project or task.

4.1.3 Virtual Enterprise

To the external of the agile container terminal enterprise, competitions among enterprises result in greater scope for integration. To achieve the integration of the companies, it is necessary for the company to develop Virtual Enterprise (VE). The VE is a single operating entity that is integrated by the company to elect all superior forces from the internal and external. This virtual firm can be organized flexibly, quickly respond to the market, and complete tasks of the project independently. Once the task is finished, the virtual firm will be disintegrated immediately, and the member of this firm will be also diverted to other projects. Container terminal can use this kind of dynamic structure to achieve agile services and to adapt itself to the increasing competition in the market.

4.1.4 Organization alliance

Container terminal company can be a global extension joint organization that is cross- boundaries of enterprises, industry and region. The merger and union between port investments and the implementation of globalization strategy have become more and more popular. Mergers and union, multinational operations, the implementation of global strategy, expanding the size of enterprises, and expanding the control of the enterprise market are the strategies that the container terminal enterprise adopts to get the economies of scope.

During the development of the port and shipping industry, the unions and joint organizations appear everywhere there have cargo resource and market opportunities.

The pursuit of this kind of organizations cooperation based on AS is not simply economies of scale, nor economies of scope, but joint economic benefits. In the other words, through the form of union, the enterprise can effectively take advantage of the resources that do not belong to the enterprise but the union, and make full use of the sharing factors of production, thus effects in excess of just cost saving. For example, a port company and a liner shipping company invest a container terminal. To the port company, it has a loyal customer and provider service of high quality level and agility because of the sharing factors, such as the information. To the shipping company, because of the agile services from the terminal, it can not only save cost, but also satisfy his customer.

4.2 A quantification on agility of container terminal organization

To the modern container terminal, if it want to gain competitive advantages from the changeable, high level of quality required, high integrated logistics services market, it two basic features of agility: flexibility and quick response. A flexible organizational structure is helpful to the goal of quick response, thus achieving agility. Next the quantification of the agility of the organizational structure is studied based on the information theory. During the study, the relationship between the entropy of organizational structure and flexibility as well as the relationships among the entropy, division of labor, organizational hierarchy and flexibility are discussed.

Before the analysis, two different concepts of system diversity and complexity will be analyzed from the view of set. If regarding an economic system as a set of elements, the diversity of set increases with the number of elements. In information theory, set variability can be defined as the logarithm to base 2 of the number of

elements (Weaver, 1949), i.e. $V = \log_2 n$, in which, *V* is the variability, *n* is the different number of elements in the set. This definition, on the one hand, shows the variability of systems increases with different number of elements; on the other hand, it also shows the new element lead decrease to marginal effect of system variability.

4.2.1 Entropy of organizational structure and flexibility

To organizations, the entropy is a quantitative description of the state of the organizational structure, which reflects the state degree of the complexity of the organizational structure (Arteta and Giachetti, 2004). Different organizational structures have different entropies. Entropy can be used to characterize the specific organizational structure of the macro complexity and variability. Entropy measures he degree of the complexity and diversity of the organizational structure.

In order to understand the relationship between the entropy of organizational structure and flexibility, two dictionaries as example is used to illustrate. A normal sales dictionary (A) apparently has lower entropy than the dictionary (B) that is a random combination of the characters A contains. The storage capacity of dictionary information in a state of A is higher than in a state of B where is much disorder. However, from the state of B, it is more easily to recombine and generate many new states. The state of A is only one of them. From this point of view, the dictionary B of the disorder state with a low storage of information has higher potential information than the A of more order state, and has a larger restructuring flexibility. Putting forward to the organizational structure, it means that an organization with a lower entropy will be able to store much more specialized information and it will be able to adapt themselves to a more stable environment

better. Organization with higher entropy has higher adjustment to adapt changes of the storage type of information caused by environment.

Generally, the specific information stored by an organization is to be used again and again. If the environment is stable, well, this is an effective strategy. Therefore, a highly structured organization in a stable environment is usually very efficient. However, the environment is changing rapidly, and the highly structured organizations may encounter difficulties. Through observation (Mintzberg, 1983), it can also be noted that in a dynamic environment running organizations tend to adopt the “organic” structure, and in a more stable structure or the environment, organizational structures tend to “mechanistic” structure. For an organizational structure with low entropy, its higher information storage, to some extent, hampers the new information to enter, thus the less channels of adjustment. Therefore, in the changeable market environment, container terminal organizational structure to maintain a certain degree of entropy is able to adapt to the current environment better.

4.2.2 Division of labor, entropy and flexibility

The flexibility of two different organizational arrangements that complete the same business will be analyzed and compared. In the first case, it is the staff with mutual non-existent division of labor that completes the business process. The other is to maximize the use of the division of labor to complete it. Business process consists of a series of operations. To simplify the problem, it is the assumption in both cases, that the number of operations is the same number of staff, which would be equivalent to n.

1) No division of labor. Each employee independently completed *n* operations by the order, and finally gains output. Then, each employee who completes the whole process can be viewed as a unit of the system. But the system does not constitute an organization. As each of the employees is independent of each other, the total entropy of the system can be estimated by calculating all probability of each state of the system. One state of the system is equal to a combination of *n* employees who choose one operation independently and randomly. Two examples of the system state are as following.

$$\mathrm{a} = X_1O_1, X_2O_2, \cdots, X_nO_{\mathrm{n}}$$

$$\mathrm{b} = X_1O_3, X_2O_6, \cdots, X_nO_{\mathrm{m}}$$

In which, $\mathrm{X}_1, X_2, \cdots, X_n$ is the employee; $O_1, O_2, \cdots, O_{\mathrm{n}}$ is the operation. The probability of each state of the system can be defined as:

$$P_{\mathrm{a}} = P(X_1O_1, X_2O_2, \cdots, X_nO_{\mathrm{n}})$$

$$P_{\mathrm{b}} = (X_1O_3, X_2O_6, \cdots, X_nO_{\mathrm{m}})$$

As each of the employees is independent of each other, *Pa* can be denoted as probability product of the event of $X_1O_1, X_2O_2, \cdots, X_nO_{\mathrm{n}}$, i.e.

$$P_{\mathrm{a}} = P(X_1O_1)\ P(X_2O_2), \cdots, P(X_nO_{\mathrm{n}})$$

In addition, there is no division of labor in the system, so

$$P(X_1O_1) = P(X_1O_2) = \cdots = P(X_1O_n) = P(X_2O_1) = P(X_2O_2) = \cdots = P(X_2O_n) = P(X_nO_n)$$

In the other words, every state of the system, P_i, is of the same probability, then it can be get:

$$P_i = 1/n^n;\ \ S_{11} = -\sum P_i \lg P_i = n \lg n \qquad (4.1)$$

In which, S_{11} is the total entropy of the system without division of labor.

2) Maximize the division of labor. In such circumstances, the *n* operations that constitute the business process of the system remain unchanged. But it is a division of labor extreme example; that is to say, each employee completed only one of the *n* operations. Under this circumstance, the state of the system is different from that, the same probability, in the former case. It is clearly that there is only one state at this situation, which each employee deals with the operation that is arranged for him or her. Correspondingly, the total entropy of the system is

$$S_{12} = -1\lg 1 = 0 \qquad (4.2)$$

Through an comprehensive analysis of the above two cases, the general conclusion can be get that the total entropy will reduce from $n \lg n$ to 0 when a system without division of labor changes to a system with maximized division of labor. Therefore, the specialization of the organization and division of labor will decrease the flexibility of system adjustment.

4.2.3 Entropy, organizational level and flexibility

From the view of organizational levels to compare two different organizational structures, one of the cases is the organization without the boundaries between departments; the second case is an organization combined with a series of departments. According to the terms of Simon (1981), the former one is a flat organization structure and has a single level and control span. The control span equal to the number of staff in the organizations. In the latter case, due to added department, the levels of the organization will increase to at least two. It is because that if the other departments are at the same level, the department responsible for the

overall coordination and planning departments must occupy a higher-level situation. In such cases, the control span will be confined to the number of workers in each department. In addition, due to added department, the non-uniformity of the organization will increase. The workers of each department are generally only with the skills that the corresponding department needs, therefore the lower interchangeability. Likewise, we assume that organizational system has *n* workers and *n* operating form.

1) Flat structure. It does not exist departments in this organization. It means that the effect of a different operation done by different workers is similar. In other words, all staff is able to exchange. To simplify the problem, it is assumed the operation are the same and the employees are entirely interchangeable, it is that, the staff can be free to exchange between the all operations in organization, and in second cases, employees can only exchange between the operations belong to the same department. For the first case, because there are *n* employees who can completely interchange between *n* same operations, all the state of the system would be of the same probability. Similarly, in this case the total entropy of the organization, S_{21}, can be given as the logarithm of the number of the system states, i.e.

$$S_{12} = \lg n! \qquad (4.3)$$

2) Hierarchical structure. In such circumstances, due to the introduction of department, the employees are interchangeable only in their respective departments, so the number of the system state is fewer than that in the former case. To prove the entropy of hierarchical organization is lower than that of flat one, it is assumed that each department deals with the same operation in the second case. Thus, the

difference between the entropy under the first situation and under the second situation is $\Delta S(1 \to 2) = S_{22} - S_{21} = R\lg\{p(2)/p(1)\}$, in which, $p(1)$ and $p(2)$ are the number of the system state at the first situation and at the second situation, furthermore, $p(1) = n!$.

At the second situation, assume *k* is the number of the departments established, and $\mathrm{n}(1), n(2), \cdots, n(k)$ is the number of the employees in each department, then

$$p(2) = n(1)!n(2)!\cdots n(k)! \quad (4.4)$$

As $n(1) + n(2) + \cdots + n(k) = n$, and $n(1), n(2), \cdots n(k) \geq 1$ Open $n!$ to get:

$$p(1) = n! > n(1)!n(2)!\cdots n(k)! = p(2) \quad (4.5)$$

So $\{p(2)/p(1)\} < 1$, that is to say, $\Delta S(1 \to 2)$ is always smaller than 0.

Therefore, it can be concluded that, due to the limitation of department, the freedom of staff's movement and exchange gets restrictions and decreases in the organizational system, thus the corresponding system entropy becoming lower. From the evidence, it also shows that the system entropy reducing and the number of department is positively correlated relationship. Similarly, the hierarchy of the organizational structure will also reduce the degree of adjustment flexibility.

4.3 The organizational structure in container terminal

From the above quantitative study, we can know that flat type of the organizational structure is more flexible adjustment. The achievement of organizational flat can optimize the organizational structure of the port. Generally, meticulous division of production operations, too many links and the block of information flow make it

difficult to know the requirement of customer (carrier) to the service from container port timely and accurately.

Loading and unloading service is one of the services oriented shipping companies in container terminal. To explain the problem, the unloading process in the container terminal, which is simpler than loading process, is taken as an example. Figure 5-1 shows the import unloading process in container terminal.

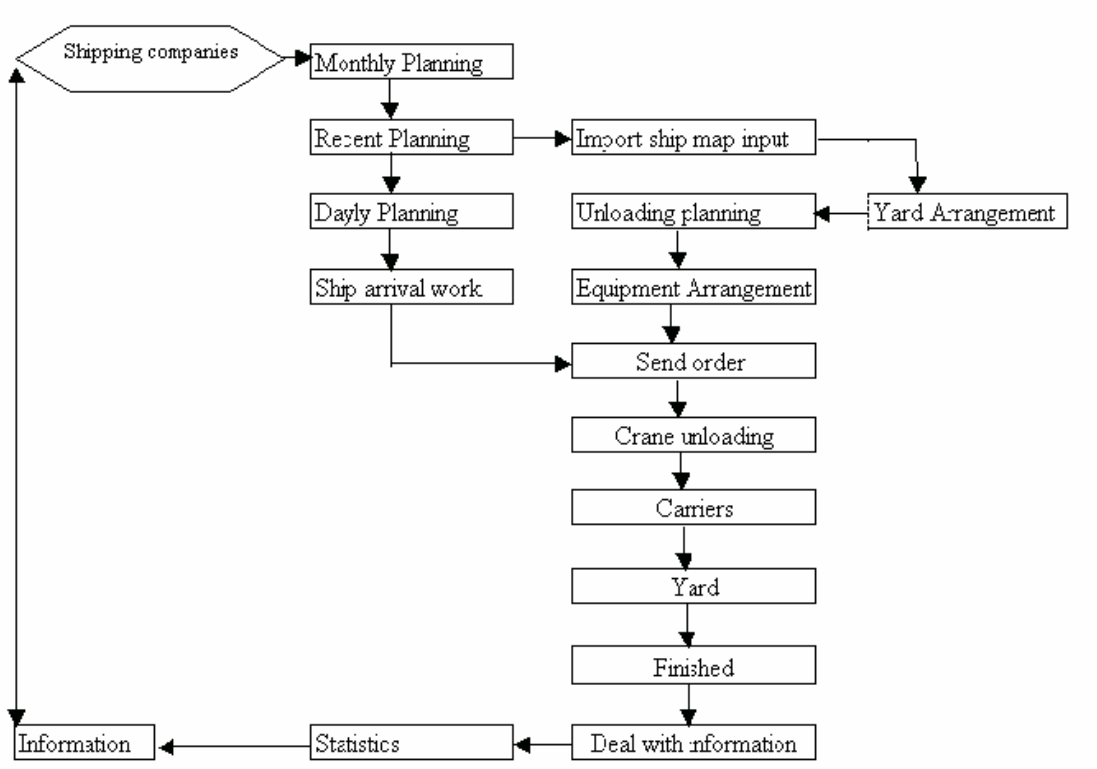

Figure 4-1 Import unloading process in container terminal

There are 15 operations in this process, and the process is split into two phases, planning and implement. If using the hierarchical structure and maximized division of labor, there is only one state in this situation, i.e. the entropy of the organizational structure $S_1 = -\lg 1 = 0$.

If using the method of ITT, the structure can be changed as follow Figure 5-2.

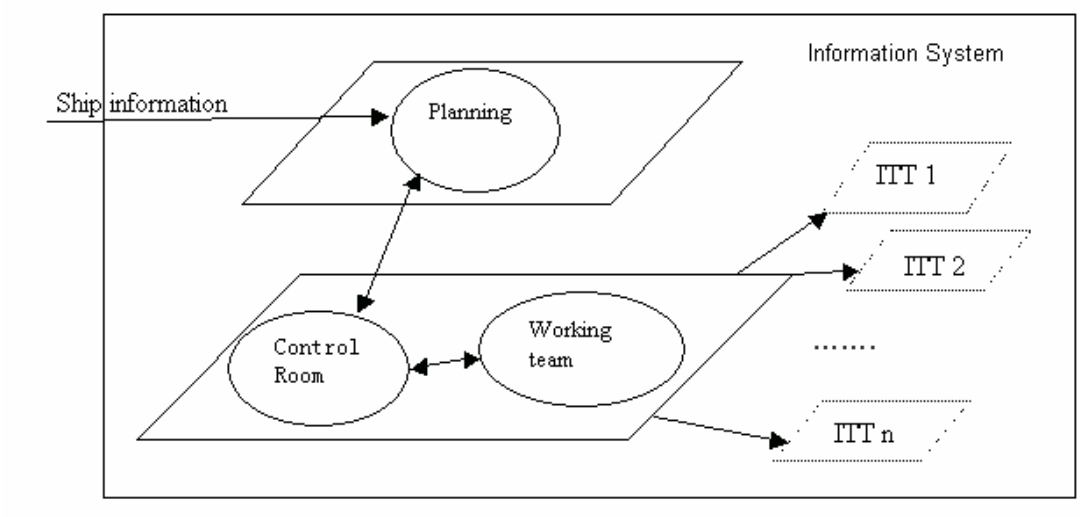

Figure 4-2 Service process in flat type organizational structure

In this structure, all the departments are working under the same information system. Through the planning department and the implement department are not at the same level, the same information system can help them communicate very quickly, just like at the same flat. The control room and the working team at the terminal locale are on the same level. The control room is including the operations of ship monitor, yard monitor and stowage planning, and the working team includes all the workers at the terminal locale. The operations are certain but the ITT is flexible. In Figure 5-2, if the n=5, the he entropy of the organizational structure $S_2 = \lg 5!$

The new framework is to be in accordance with customer driven, to arrange special projects production operations group and change the vertical process to parallel process, thus the flat type of the organizational structure.

5. Performance evaluation of AS in container terminal

It is important for container terminals to provide AS to shipping companies. It is also important to do a performance appraisal of AS, because it provides the basis for calibrating the effectiveness of AS. The objective of performance measurement of AS in container terminal is not only to know the performance condition of the AS, but also to get the aspect that should be improved. The performance measurement is a dynamic course of controlling and revising the work continuously.

5.1 Index system of AS in container terminal oriented shipping company

Performance measurement on the AS should reflect the whole dynamic run condition. Therefore, it is necessary to set up effective performance measurement index. Considering container terminal providing AS to the shipping companies, its performance evaluation can be including two respects inside and outside. Inside performance evaluation is mainly to compare the activity and course with the assignment and goal. Outside performance evaluation is more focus on the customer's satisfaction from the shipping companies. Thereby, the performance evaluation index system can be considered as following Table 5-1.

Table 5-1 Index system of performance evaluation on the AS oriented shipping companies in container terminal

Goal Layer		First Class Index	Second Class Index
Index system	The index system of inside performance evaluation	Cost (U1)	Handling cost (B11) Maintenance cost (B12) Information cost (B13) Management cost (B14) Other cost (B15)

of performance evaluation on the AS oriented shipping companies in container terminal		Service Level (U2)	Berth utilization (B21) Equipment utilization (B22) JIT (B23) Response time to requirements (B24) Response accuracy (B25) Customer feedbacks (B26)
		Productivity (U3)	Productivity index (B31)
		Quality (U4)	Damage Frequency (B41) Loading accuracy (B42) Document accuracy (B43) Information availability (B44) Number of credit claims (B45)
		Flexibility (U5)	Container handling (B51) Process (B52) Volume (B53)
		Manning Level (U6)	Cooperation ability (B61) Degree of skills (B62) Training (B63) Empowerment (B64)
	The index system of outside performance evaluation	Customer's satisfaction (U7)	Supply time (B71) Service level (B72) Information sharing (B73)

5.1.1 Inside performance evaluation

Cost expansion The AS cannot be to achieve without considering cost expansion. The costs of the AS oriented shipping companies in container terminal are mainly including handling costs (all equipments costs, inventory cost), maintenance cost, information cost, management cost and so on.

Customer Service Level As a service provider, the customer service is one of the most importance factors in the container terminal. Customer service is to investigate the company's ability to satisfy the customer's demands. For the container terminal enterprise, it is essential to fully use the recourses to rapidly and timely meet the individualized and diversified requirements of shipping companies as much as possible. The index are consist of berth utilization, equipment utilization, JIT service, cycle time, response time to requirements, response accuracy and customer feedbacks

Productivity The productivity is the relation between the equipment quantity used to produce and the output (throughout) in container terminal. It reflects the total efficiency of the container terminal.

Quality The quality index is the main one pointing the whole measuring course. The high quality of the service is the core business for the container terminal. This index includes damage frequency, loading accuracy, document accuracy, information availability, number of credit claims, etc.

Flexibility The flexibility can be seen as the ability that the port operators have in changing from one operation to another to handle different service (Paixao and Marlow, 2003). Because here is just the AS oriented the shipping companies discussed, the index is only with three aspects, container handling flexibility—the ability to handle different types of containers, process flexibility—decision making and organizational flexibility and volume flexibility.

Manning Level To fully develop human potential is one of the characters of AS. The level of manning affects the service quality and the customer satisfaction.

Therefore, the index system introduces the manning level as an index, including cooperation ability, the degree of skill, training situation and the employee empowerment.

5.1.2 Outside performance evaluation

The outside performance measurement mainly is the degree of customer satisfaction. As a service enterprise, the main goal is to make the customer satisfy. Furthermore, the purpose of the introduction of AS to the container terminal is also to meet the requirements of the customers rapidly and in time and to have a quick response to the changeable market. And this index will focus on the attitude of the customer (shipping companies) to the service from the container terminal. As the shipping companies pay more attention to the service supply time, service quality, the price and the information sharing, this index is combined with these four aspects.

5.2 The method of AS performance evaluation

Agile service performance measurement system is a multi-level system of standards and itself fuzzy and complex, to evaluate several situations of the service, so it is necessary to select and use the measuring method that can consider various factors comprehensively and integrated views of all sectors, multi-objective, multi-level, multiple factors. The fuzzy quality synthetic evaluation method is one of the popular methods today. The fuzzy quality synthetic evaluation method can be used to solve the fuzzy problem in the comprehensive measurement, thus, it is more suitable to measure the system with more factors and multi-level structure, and then it can provide the basis of comparison and discrimination to decision-making, therefore decision-making more scientific and correct. The steps of the method are

as follow.

5.2.1 Establish evaluation rank aggregation of measurement

First step is to establish evaluation rank aggregation of measurement $V = \{V_1, V_2, V_3, V_4, V_5\} = \{\text{Distinction}, \text{Excellent}, \text{Good}, \text{Medium}, \text{Poor}\}$, namely the rank aggregate.

5.2.2 Establish evaluation object factor aggregation of measurement

To establish evaluation object factor aggregation of measurement, there are 7 levels of evaluation target, i.e.

$$U_1 = \{B_{11}, B_{12}, B_{13}, B_{14}, B_{15}\}$$

$$U_2 = \{B_{21}, B_{22}, B_{23}, B_{24}, B_{25}, B_{26}\}$$

……

$$U_7 = \{B_{71}, B_{72}, B_{73}\}$$

5.2.3 Determine the weight Vector A of measuring factor

Because the factor U_i has different degree of importance, in fuzzy quality synthetic evaluation, w_i in the weights Vector $A = (w_1, w_2, \ldots, w_7)$ refers to the subordination degree of factor U_i to the fuzzy subset. It is normalized that $\sum_{i=1}^{7} w_i = 1$. Here uses the method with more feasibility in practice, the expert

judging method, to determine the various target weight. The first-class targets weight determination is shown as Table 5-3. The second-class weight determination is the same as first-class.

Table 5-2 First-class targets weight determination of AS in container terminal

Serial Number	Expert 1	Expert 2	…	Expert n	Average value	Normalization
1	a_{11}	a_{12}	…	a_{1n}	$a_1 = \frac{1}{n}\sum_{i=1}^{n} a_{1i}$	$w_1 = a_1 \Big/ \sum_{i=1}^{7} a_i$
2	a_{21}	a_{22}	…	a_{2n}	$a_2 = \frac{1}{n}\sum_{i=1}^{n} a_{2i}$	$w_2 = a_2 \Big/ \sum_{i=1}^{7} a_i$
…	…	…	…	…	…	…
7	a_{71}	a_{72}	…	a_{7n}	$a_7 = \frac{1}{n}\sum_{i=1}^{n} a_{7i}$	$w_7 = a_7 \Big/ \sum_{i=1}^{7} a_i$

5.2.4 Establish the subordination degree and fuzzy relationship Matrix R

The subordination degree r is the degree that some measuring factor belongs to the measuring rank; for example, the degree of customer service belongs to the rank aggregation is “excellent”.

1) For the larger the more superior (efficiency type), the measuring factor can use the function as follow to evaluation the subordination degree.

$$r=\begin{cases}1, f(x)\geq \sup(f)\\ \dfrac{f(x)-\inf(f)}{\sup(f)-\inf(f)}, \inf(f)< f(x)<\sup(f)\\ 0, f(x)\leq \inf(f)\end{cases} \tag{5.1}$$

2) For the smaller the more superior (cost type), the measuring factor can use the function as follow to evaluation the subordination degree.

$$r=\begin{cases}1, f(x)\leq \inf(f)\\ \dfrac{\sup(f)-f(x)}{\sup(f)-\inf(f)}, \inf(f)< f(x)<\sup(f)\\ 0, f(x)\geq \sup(f)\end{cases} \tag{5.2}$$

$f(x)$ is the real value, $\sup(f)$ and $\inf(f)$ is the maximum value and minimum value. To cope with the data used the above function, the subordination degree is in the zone of $[0,1]$.

3) For some neutrality index, the measuring factor can use the function as follow to evaluation the subordination degree

$$r=\begin{cases}\dfrac{f(x)-\inf(f)}{opt(f)-\inf(f)}, \inf(f)\leq f(x)\leq opt(f)\\ \dfrac{\sup(f)-f(x)}{\sup(f)-opt(f)}, opt(f)\leq f(x)\leq \sup(f)\\ 0, f(x)<\inf(f), f(x)>\sup(f)\end{cases} \tag{5.3}$$

In which, the $opt(f)$ is the optimum value, and we can use the under standard to score it.

Table 5-3 Standard to appraise the neutrality value

Level	Distinction	Excellent	Good	Medium	Poor
Score	1	0.8	0.5	0.3	0

Set up the rank aggregation and extracted the subordination degree $r1_{ij}, r2_{ij}, \ldots, r7_{ij}$ of second-class targets, quantification of the item is evaluated in each factor $U_i (i = 1,2,\ldots,7)$ one after another. And then, set up the fuzzy relationship Matrix $R_i (i = 1,2,\ldots,7)$. It means that the item is evaluated from the single factor to various ranks fuzzy subset. The fuzzy relationship Matrix R is as follow.

$$R_1 = \begin{bmatrix} r1_{11} & r1_{12} & r1_{13} & r1_{14} & r1_{15} \\ r1_{21} & r1_{22} & r1_{23} & r1_{24} & r1_{25} \\ r1_{31} & r1_{32} & r1_{33} & r1_{34} & r1_{35} \\ r1_{41} & r1_{42} & r1_{43} & r1_{44} & r1_{45} \\ r1_{51} & r1_{52} & r1_{53} & r1_{54} & r1_{55} \end{bmatrix}$$

$$\ldots\ldots\ldots\ldots\ldots..$$

$$R_7 = \begin{bmatrix} r7_{11} & r7_{12} & r7_{13} & r7_{14} & r7_{15} \\ r7_{21} & r7_{22} & r7_{23} & r7_{24} & r7_{25} \\ r7_{31} & r7_{32} & r7_{33} & r7_{34} & r7_{35} \\ r7_{41} & r7_{42} & r7_{43} & r7_{44} & r7_{45} \end{bmatrix} \qquad (5.4)$$

In this situation, we use the above method to get the second-class target weight $M_i (i = 1,2,\ldots,7)$, $M_1 = (m_{11}, m_{12}, m_{13}, m_{14}, m_{15}) \ldots M_7 = (m_{71}, m_{72}, m_{73}, m_{74})$, and then to get:

$$R = M_i \times R_i \Rightarrow \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_7 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & \cdots & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{71} & \cdots & \cdots & r_{75} \end{bmatrix} \quad (5.5)$$

In Matrix R, i line and j row element r_{ij} refers to subordination degree the item is evaluated to the rank V_j fuzzy subset looking from the factor U_i.

5.2.5 Produce fuzzy measurement result Vector B

Use the Vector A and Vector R to produce the fuzzy measurement result Vector B. In R, the different line reflects the subordination degree evaluated each rank fuzzy subset looking from the single factor. The different row with power vector A reflects the various ranks fuzzy subset looking from overall, namely the fuzzy quality synthetic evaluation result Vector B. Here, the element b_j refers to the rank fuzzy subset looking from the whole service system.

$$B = A \times R = (w_1, w_2, \ldots, w_8) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & \cdots & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{71} & \cdots & \cdots & r_{75} \end{bmatrix} = (b_1, b_2, \ldots, b_5) \quad (5.6)$$

5.2.6 Analysis of fuzzy quality synthetic evaluation result

Because the fuzzy quality synthetic evaluation result Vector B considers all factors as the effect, it is able to judge not only the whole situation of the AS system in container terminal, but also the single factor. According to the largest subordination degree principle, if V_3 is correspond to Max $b_j (j = 1,2,3,4,5)$, namely b3= Max b_j,

then V_3 means performance level of the AS is “good”. At the same time, the performance level of each aspect in first-class can also be seen. It is helpful for the container terminal to improve the service level and customer (shipping companies) satisfaction.

Future market being changeable and unpredictable, the container terminal should provide agile service to satisfy the customers’ requirement. An evaluation index system of AS is established in this section and to do quantification on the index. In practice, the service of container terminal is more complex and the customers is not just shipping companies, so the index can be added looking at the target and situation.

5.3 Simple numerical examples

First, let us to determine the weight of the first-class index. Assume that there are 10 experts who are invited to make this determine. Use the method of Table 5-3 to get the weight $A = \{0.1,0.1,0.15,0.1,0.15,0.15,0.05,0.2\}$, similarly the $M_i (i = 1,2,\ldots,7)$ shown in Table 5-4.

Next, cope with the information. Here use the monthly data to evaluate. For example, the information cost (B13) of one Shanghai terminal is 0.3 million yuan last year, and the maximized cost the terminal can afford is 0.5 million yuan, and the minimized cost can suggest as 0. It is the cost type, using (5.2), so

$$B_{13} = \frac{MaxB_{13} - B_{13}}{MaxB_{13} - MinB_{13}} = \frac{0.5 - 0.3}{0.5 - 0} = 0.4$$

The loading accuracy (B42) is 92%, and the MaxB52 is 100% and MinB52 is 90%, and it is the efficiency type, using (5.1), so the subordination degree:

$$B_{42} = \frac{B_{42} - MinB_{42}}{MaxB_{42} - MinB_{42}} = \frac{92 - 90}{100 - 90} = 0.2$$

Then we can get the Table 5-4, with the weight, real value and subordination degree of performance index.

Table 5-4 Weight, Real value and Subordination degree of performance index

First Class Index	Weight	Second Class Index	Weight	Real Value	Max	Min	Subordination
Cost (U1)	15%	Handling cost (B11)	30%	3 m	5 m	2 m	0.67
		Maintenance cost (B12)	20%	1.5	3	0.5	0.6
		Information cost (B13)	20%	0.3	0.5	0	0.4
		Management cost (B14)	15%	4	5	3	0.5
		Other cost (B15)	5%	0.1	0.2	0	0.5
Service Level (U2)	15%	Berth utilization (B21)	10%	80%	90%	50%	0.25
		Equipment utilization (B22)	10%	80%	90%	50%	0.25
		JIT (B23)	25%	90%	100%	85%	0.33
		Response time to requirements (B24)	20%	Good			0.5
		Response accuracy (B25)	20%	Good			0.5
		Customer feedbacks (B26)	15%	80%	100%	70%	0.33

Productivity (U3)	10%	Productivity index (B31)	100%	32 m	35 m	25 m	0.7
Quality (U4)	15%	Damage Frequency (B41)	25%	1%	2%	0%	0.5
		Loading accuracy (B42)	25%	92%	100%	90%	0.2
		Document accuracy (B43)	20%	98%	100%	97%	0.33
		Information availability (B44)	15%	Good			0.5
		Number of credit claims (B45)	15%	7%	10%	0	0.3
Flexibility (U5)	15%	Container handling (B51)	30%	Excellent			0.8
		Process (B52)	40%	Excellent			0.8
		Volume (B53)	30%	Good			0.5
Manning Level (U6)	10%	Cooperation ability (B61)	30%	Good			0.5
		Degree of skills (B62)	30%	Excellent			0.8
		Training (B63)	20%	Good			0.5
		Empowerment (B64)	20%	Good			0.5
Customer's satisfaction (U7)	20%	Supply time (B71)	40%	4	8	2.5	0.73
		Service level (B72)	40%	Excellent			0.8
		Information sharing (B73)	20%	Medium			0.3

According to the subordination, results can be got from the experts who were asked

for to choose in the rank aggregate V. For example, to the information cost performance, there are 10% people choose distinction, 40% excellent, 40% good, 10% medium, and no people choose poor, then $r_{13} = \{0.1,0.4,0.4,0.1,0\}$, similarly, the other factors in the Cost index can be evaluated. Then,

$$R_1 = \begin{Bmatrix} 0.2, & 0.6, & 0.1, & 0.1, & 0 \\ 0.2, & 0.5, & 0.2, & 0.1, & 0 \\ 0.1, & 0.4, & 0.4, & 0.1, & 0 \\ 0.1, & 0.5, & 0.2, & 0.2, & 0 \\ 0.1, & 0.4, & 0.2, & 0.2, & 0.1 \end{Bmatrix}$$

$$\Rightarrow$$

$$B_1 = M_1 \times R_1 = (0.14,0.455,0.19,0.11,0.005).$$

Similarly, the other second-class factors R_i can be get and then the total R.

$$R = \begin{Bmatrix} 0.14, & 0.455, & 0.19, & 0.11, & 0.005 \\ 0.04, & 0.27, & 0.37, & 0.25, & 0.09 \\ 0.2, & 0.5, & 0.3, & 0, & 0 \\ 0.02, & 0.16, & 0.34, & 0.35, & 0.14 \\ 0.17, & 0.47, & 0.26, & 0.1, & 0 \\ 0.11, & 0.29, & 0.44, & 0.14, & 0.02 \\ 0.12, & 0.4, & 0.3, & 0.16, & 0.02 \end{Bmatrix}$$

And then the Vector B can be got.

$$B = A \times R = (0.11,0.36,0.31,0.17,0.04)$$

It can be seen that b3= Max b_j, it means the agile service performance in this container terminal is excellent. However, the score is not very high, it means there are still things should be improved, especially the quality of the service. From the

Matrix R, it shows clearly that the quality performance is at the level of “medium”

In practice, however, the economic functions of the container terminal are more and more complex and the customers are not only the shipping companies. The agile service oriented the land logistic companies are also a big problem to study. If a container terminal is as a distribution or logistic center, the scope of the service will become larger, and the performance evaluation index system will become more complex.

6. Suggestions and Conclusions

With the progress of globalization economy and containerization transport, the container terminals face the more and more uncertain environment. And the economies of scale in ship sizes also result in challenge how to compress the time for ship in terminal. However, a terminal could not solve the problem via just expanding the scale of the terminal. A blind expansion of terminal scale would cause diseconomy. It obliges the terminal to adopt new management strategies to be more competitive. Agility is one of the strategies can help the terminal to adapt the new economic environment. Agile services are different from the traditional services in container terminal, which are able to respond the uncertainties in the market quickly.

To implement agile service, a container terminal enterprise should proceed first with internal integration and second with external integration (Paixao and Marlow, 2003). In the process of internal integration, the container terminal is to integrate the resources and redesign the process. When doing these activities, the measurement is the basis approach for the container terminal to decide the core business and the link need to improve. The application of fuzzy quality synthetic evaluation can help to know the whole situation of the agile service, and the single factor also. During the integration, it is also necessary to adjust the organizational structure. Via the analysis from the angle of information theory, the container terminal had better adopt a flat type of organizational structure that is more flexible to achieve the agile service.

The external integration consists of vertical integration and horizontal integration. Vertical integration is the integration along with the logistic chain. The objective of

vertical integration is to improve the communication and service level. Horizontal integration is to integrate with the other terminal operator in order to control the flow of cargo and reduce the total cost and increase the efficiency. During the external integration, it also needs the virtual integration. The virtual integration can both reduce the investment and develop the high efficiency and flexibility.

At the same time, the container terminal enterprise should improve the quality of labor. High quality labor will become core competitiveness in the flexible terminal operation and in the agile services.

Under the environment with more and more uncertainties, the agility of terminal is the inevitable. The terminal operators should take actions as soon as possible to put themselves in the supply chain, set up an agile container terminal and provide agile services to customers so that they can satisfy the requirements of customers.

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