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AGILE SERVICE ORIENTED SHIPPING COMPANIES IN THE CONTAINER TERMINAL

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Abstract. Agility is regarded as one of the core capabilities and the developing trend of supply chains and their enterprises. Along with the development of economical globalization, supply chain management and containerization as well as container ports as a part of supply chain take more roles like logistics or distribution centers. 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 implementing agility in container terminals. To achieve this goal, the analysis of the economies of scale in the container terminal is presented. In this paper, however, more attention will be paid to agile service oriented shipping companies. The concept and characters of agile service in the container terminal is illustrated. The paper also focuses on the agile organizational structure of the container terminal. Finally, the fuzzy quality synthetic evaluation method is given to evaluate the performance level of agile service in container terminal oriented shipping companies.

Keywords: container terminal, agile service, organizational structure, performance evaluation.

1. Introduction

Agility is regarded as one of the core capabilities and the developing trend of supply chains. The study of agility first took place in manufacturing industry. With economic globalization and the development of electronic commerce, supply chains and their enterprises are facing competition from the global market and the challenge of shortening delivery time improving production quality, satisfying the demand of individuation, reducing cost etc. To adjust to market environments and meet customers' expectations, the enterprise should have the ability of quick response. Apart from agile service, an advanced management ideology and manufacturing philosophy, a lot of changes have happened not only in manufacturing industry but also in the whole supply chain. Under this circumstance, ports have become an isolated point in the transport chain and are confronted with increasing pressure from the market (Baublys 2009; Paulauskas 2009; Vasilis Vasiliauskas and Barysienė 2008a and 2008b; Kisler 2008; Paulauskas and Bentzen 2008; Burkovskis 2008; Afandizadeh and Moayedfar2008; Lingaitienė 2008; Miao and Xi 2008; Kabashkin 2007; Tolli and Laving 2007; Rohács and Simongáti 2007; Meirane 2007; Jaržemskis and Vasilis Vasiliauskas 2007 etc.).

Due to the process of containerization, container ports have rapidly developed. From the point of view of the developing trend in logistics industry, presently, container ports and the vital nodes of the international integrated transport network are responsible not only for traditional handling work but also for a wide range of logistics activities (Paixão and Marlow 2003; Vasilis Vasiliauskas and Barysienė, J. 2008a). They play more roles as a logistics or distribution center. For example, in July 2000, to take the event, U.S. West Coast Port Lockout locked the port and resulted in hundreds of ships waiting outside the ports having a huge number of goods being delayed. Moreover, the enterprises in the US faced a large amount of inventory so modern SCM and Just-in-Time (JIT) inventory management are meeting a big challenge. For liner shipping companies, however, high quality service from container terminals plays a very important role in their transport chain. It can help them with compressing turnaround time and saving costs as well as improving their services to customers and further competitive advantage. This is due to a 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 transport service. Therefore, the container terminal is required to be more agile to adopt a changeable environment and individual requirements.

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

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agility service in container terminals. The analysis of the economies of scale in the container terminal is presented and more force will be put on agile service oriented shipping companies. The concepts and characters of agile service and its organizational structure are also illustrated. Finally, a mathematical method is given to evaluate the performance level of agile service.

2. Literature Review

2.1. Understanding Agility

The concept of an agile enterprise has existed since 1990's, based on awareness that the abilities of organizations could not keep up with changes in business environment (Dove 1999). Accordingly, Dove defined it as 'the ability of an organization to thrive in a continuously changing environment'. Vokura and Fliedner (1998) point out that agility is the ability to produce and successfully market a wide range of high quality, low cost products within short time which provide added value to individual customers through customization. Zhang and Sharifi (2000) survey agility as the ability to cope with unexpected changes and to survive unprecedented threats from 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 and get help from other enterprises in the system. Agility is a combination of speed and flexibility. Vastag *et al.* (1994) finds it time-based competition and flexibility converge through agile manufacturing. McGaughey (1999) regarded agility as the ability of an enterprise to quickly and successfully respond to change. Prater *et al.* (2001) emphasizes that an agile firm should design its organization, processes and products in order to quickly respond to changes in a useful time frame.

2.2. Agility in a Logistics System

Global Logistics Research Team (GLRT) at Michigan State University (MSU) made World Class Logistics research in 1995 and established a model of logistics competency in which GLRT (1995) defined that logistical agility was dealing with how well performance related to customer expectation. Three important capabilities make a direct impact on customers. First goes relevancy maintaining focus on the changing needs of customers. Second is accommodation which means to quickly respond to the unique customer's request. The final attribute that creates agility is flexibility which is to exploit unexpected circumstances. Zhangyi (2004) observes that agile logistics should give the cost and efficiency optimized program in the right time frame. The main goal of agile logistics is to satisfy customers within the specified time. There are many ways of achieving agile logistics such as reducing order-processing time, JIT inventory management, Virtual Enterprise (VE), postponement etc.

Table 1. Economic functions of the 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	Specialized in a specific type of cargo like containers
The port development position and strategy	Conservative junction of sea and inland transportation	Expansion transportation and production center	Industrial principle and international trade chain connecting transportation	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	+ (2) (3) Cargo information, cargo distribution, logistics activity, formation of terminal and distribution center	(1) + (2) + (3) (4) Regional distribution and logistic center (5) Consultancy service on port project
Structure formation and specificities	– Everybody acts individually in the port, – Port and its user maintain informal relation	– Relation between port and its user become closer, – Emergence of slight correction among port activities, – Negative cooperation, relation between port and self- governing community	– Formation of port cooperation system, – Trade and transportation chain – Relation between port and self governing community becomes closer – Extension of the port structure	– Port corperatization from port authority, – Changes from Monopoly market to Oligopoly market structure internally and externally
Character of productivity	– Invention of cargo distribution – Individual supply of simple services	– Processing – Cargo complex services – Increase of the value added	– Cargo flow and information – Cargo distribution and information – Combination of 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

2.3. Agility in Port Operation

Agility in port is presented owing to changes in the economic functions of the port. According to the version of the 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 the port is explained in Table 1 (Gaur 2005).

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

3. The Analysis of the Economies of Scale in the Container Terminal and Agility

3.1. The Impact of the Container Terminal on the Economies of Scale in Ship Sizes

Analyzing the economies of scale in container transport, the shipping industry agrees on the trend of the economies of scale in container ship sizes. However, there are different views on how large it will be appropriate. A fundamental reason for this trend is that, in principle, the bigger the ship is, the cheaper the unity cost of transport will be (Ma 2006). However, the total efficiency of a ship completing a voyage is also closely related to the time of its total journey, i.e. container ship handling efficiency does not directly increase with the increase scale of the ship sizes.

First, the bigger the ship is, the longer time it will spend in the port and the costs will increase. In door-to-door container transport and 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 others (see Table 2 from *http://www.easipass.com*).

Table 2. The cost proportion of container transport

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

Second, a larger container ship seems to be more harmful to environmental protection and transport order. Meanwhile, it requires the higher levels of port handling equipment and a larger scale of the terminal. Therefore, the container terminal must add handling equipments, enlarge the scales of berths, yard and other infrastructure, further escalate a container port distributing system to enhance the speed of cargo handling in the port and improve the efficiency of logistics.

Above all, Port authorities should develop an appropriate scale of the port, not a super port blindly. Therefore, the scale of infrastructure should not be a competitive objective of a container port.

3.2. Demonstration of the Economies of Scale in the Container Terminal

The economies of scale, also known as Scale Merit, refer to the phenomenon that the company produces on a large scale while the average cost declines. Accordingly, the economies of scale in the container terminal can be defined as the phenomenon of declining average cost by increasing container throughput which demands container terminal enterprises to expand investment scale, to purchase terminal facilities and equipment and to increase the number of flights. Judging from the economic point of view, during the expansion process, the economies and diseconomies of scale will appear.

For the container terminal, the fixed cost has a great proportion of the production cost, and thus in certain production scope, the marginal cost of increasing unit output (container throughput) is very low. As a result of the 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 economies of scale in the process of producing the container terminal seem to be evident.

Larger ports generally are able to take advantages of natural or mining channels and pools to accommodate large container ships. As a result, a large port can not only reduce the production costs itself but also bring a decrease in average costs in the whole transportation system. Generally, there are more berths in a large terminal and the utilization of the berths is higher. For a small size of the port, the higher utilization of the berths usually results in port congestion. If the port is on a larger scale and has more berths, the substitutability among the berths is higher. This will decline the average cost of the port. Using large-scale port machinery and equipment can also help with achieving the goal of the economies of scale in the container terminal.

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

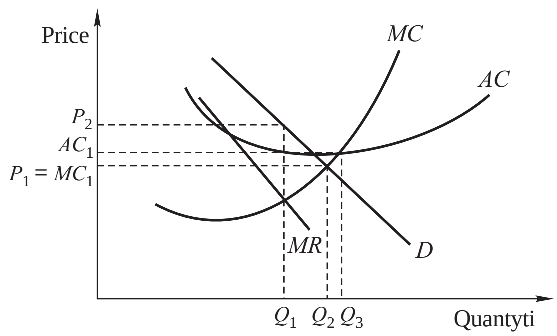

Fig. 1. The economies of scale in the container terminal and pricing

Figure 1 indicates that because of the existing economies of scale of production in the container terminal, the terminal should produce in the scale of the left side of Q_3 (Q_3 corresponding to the lowest point of the average cost) where the average cost is at a downward trend and the average cost is more than the marginal cost. According to the traditional economic theory, marginal cost price should be taken in order to make reasonable the allocation of resources, i.e. the price is set at the point $P_1 = MC_1$ and this time, the output is Q_1 and the average cost is AC_1. Because AC_1 is more than MC_1 (the average cost is more than the marginal cost), if using marginal cost pricing, the terminal will suffer from profit loss. If choosing the price of P_2, according to monopoly price, it is difficult to make a rational allocation of resources and social resources are wasted greatly. If blindly expanding the production scale in the terminal producing at the right side of Q_3, the average cost will increase instead of reducing which leads to the diseconomies of scale in the container terminal. Therefore, a reasonable economy of scale is required. Only in this way, container terminals can achieve better economic results.

3.3. The Necessity of Agility in the Container Terminal

There is a growing awareness of the importance of the affluent capacity of goods through the port. In the era of transport containerization, container throughput is important capacity for the container terminal. As a result, container terminals are becoming larger to adapt to 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 ports in ways such as extending the length of berth, improving the depth of water, increasing the length and height of cranes, expanding the yard area etc. However, it is clear that the scale of the terminal cannot be enlarged without restraining. Unlimited expansion will cause waste and diseconomy in the terminal. Furthermore, the requirements for manufacturing flexibility and agility from the market also affect other links in the supply chain. The individual requirements from the customers and uncertainty from the market have a great impact on port operation. To cope with these requirements, ports not only need to make a reasonable scale to be economic and reduce logistics costs, but also to take into account response capability to the market. To achieve the goal of compressing time for ship in the port and quick response to shipping companies, it is necessary for the port enterprises to provide more flexible and agile service, especially under the trend of the enlarging sizes of vessels.

4. Agile Service in the Container Terminal

4.1. Agile Service in Ports

According to the idea of Agile Manufacturing (AM), Agile Services (AS) of port logistics service firms can be defined as a logistics community service system with dynamic characteristics including:

1. the basic feature is that to have response, firms should not only consider the factors of species, quality and price but also meet customers' satisfaction;
2. with the Internet technology as AS technical support, the port firms should consider not only internal logistics information and functional integration but also the logistics system among various service providers;
3. internal flexibility and an external dynamic alliance of organizations is the organizational feature;
4. differently from traditional service patterns, AS pays attention to the further inputs of organization updates and the quality of people such as reorganization, staff training etc.

The element support of agile service in port enterprises are as follows:

1. *Agile techniques.* The technology of AS can be divided into internal information technology systems and external information network systems. Divided by the process of service, it includes an agile organization of cargo resource and agile storage, packaging, processing, transporting etc. What is more, agile techniques must be combined with agile management to achieve a real sense of agility.
2. *Agile organizations.* The agile organization includes two aspects, i.e. an organic, flexible, flat organizational structure of the internal enterprise and virtual, dynamic, network organizational structure among enterprises. The former is the basic of agile services; the latter is the guarantee of agile service.
3. *Agile port management.* Agile technology and organizational structure are inseparable from the support of agile management. To effectively integrate human resources, technology and organization and to quickly respond to the market, port enterprises need agile management philosophy and skills.

4.2. The Content of Agility in the Container Terminal

The content of agility in the container port is summarized as follows:

1. a core competitive advantage of agility is to quickly respond to the market demand; accordingly, enterprises need not only integrate all its internal resources but also make a full use of external resources;
2. the goal of agility is to satisfy customers and add value to their products; with the diversification of customer demand, solutions provided to customers should also be customized;
3. Virtual Enterprise (VE) is a new organizational form to integrate the core advantages of the container port as it has the ability to flexibly allocate resources, reduce service cycle time and quickly respond to customers' needs;
4. physical barriers to hinder information flow among the members of VE exist and integration is the key factor to overcome these barriers;
5. the container terminal needs to improve competitive advantage through enhancing the capability of labors;
6. the agile enterprise is a new organizational model and the agile enterprise management structure should be appropriate to streamline.

4.3. The Characters of AS Oriented Shipping Companies in the Container Terminal

1. *JIT Services.*
   The increasing degree of production globalization results in more stringent requirements of logistics time in international trade and quick response is the main goal of a logistic system (Barad and Sapir 2003) and the logistic costs should always be considered (Zhangyi 2004). Therefore, the agile container terminal should meet the customers' JIT demands 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 will increase. On the other hand, delivery time will be extended, thus impacting on the quality of logistics service. Therefore, the container port should provide JIT customer with service to satisfy customers' different loading and unloading requirements within the right time frame. JIT services include four elements:
   – *quick response* to make a correct response to the customer's requirements and be able to timely satisfy the requirements;
   – *flexibility* to cope with the unexpected circumstances;
   – *synchronization* to harmonize each link to achieve a synchronizing operation.

2. *An agile production system.*
   Container terminal Agile Production System (APS) is formed of a unified terminal information control system and a production equipment control system. Agility reflects the flexibility of the facilities and equipment allocated in the international container hub port. Equipment in regional hub ports should adapt to every kind of container ship. International large ports should have a high performance of quay cranes to make large ships shorten time in ports. They should also have advanced, automated and highly flexible operating equipment and loading and unloading programs so that the terminal operators can handle different services in changing from one operation to another (Paixão and Marlow 2003) and then meet different requirements.

3. *A Flexible Organizational Structure.*
   For container ports, it is absolutely essential to change the traditional structure of the organization to enhance the responding speed and ability to satisfy customers. To be quick at response, within the enterprises, container terminal firms should adopt a flat-type and flexible organizational structure. As for the outside of the container terminal, it should have a greater scope for integration and elect superior forces from the company and other companies to integrate a single flexible operating entity such as a virtual enterprise (VE).

4. *Effective Management.*
   Superior service performance is the main attribute for an agile port (Paixão and Marlow 2003) and service quality is an important indicator to assess performance. An agile container terminal enterprise should try it best to improve the quality of service which is helpful to satisfy the customers as well as to improve the competitiveness of the terminal. Therefore, a series of comprehensive quality management should be implemented during the service processes.
   It is found that there are strong correlations between employees' attitudes and the perceptions of service quality in the same organization (Lovelock 2001). The success cycle is shown as Fig. 2 (Schlesinger and Heskett 1991).

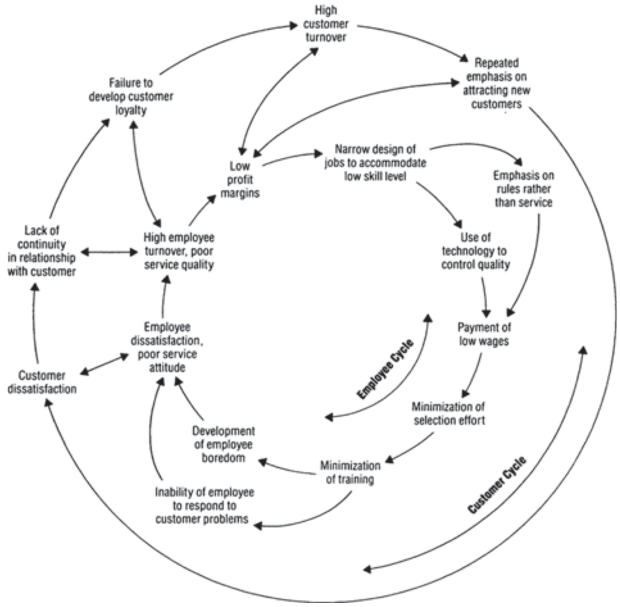

Fig. 2. The cycle of success in services

Not realizing human potential is a kind of waste in container terminal management (Paixão and Marlow 2003). Therefore, container terminal enterprises should use humanistic management to encourage the staff to take advantage of their skills and creativities and help the staff with improving 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 the agile container terminal. For those on the first line in modern container ports with rich experience, proficient skills and ability to make decisions, this kind of means could be used to take advantage of the staff's potential and then provide great service performance.

5. The Organization in the Agile Container Terminal

5.1. The Characters of the Organization in the Agile Container Terminal

1. *Objectives and Principles.*
   The objective of an agile container terminal organization is to satisfy customers' demands. Due to an increase in transport demand for small quantity and the multiple types of cargoes, more flexible and agile modes of transport are requested. To compress time for

ships in the port can not only shorten the turnaround time of ships directly increasing the income of the owners but also decrease the delivery time of cargo. Meanwhile, owing to the development of information technology and port services network, container terminal enterprises are able to timely and accurately grasp the market demand. Therefore, they can not only establish their operating characteristics and corporate images but also improve the overall service quality, thus getting competitive advantages in the market.

An agile virtual organization of the container terminal takes full empowerment as the organizing principle. Based on time competition, the vertical management approach in traditional port enterprises cannot adapt to the customer-orientated objectives in the volatile market environment. Since the frontline staff is directly dealing with customers, they can timely catch market dynamics and master the entire process of tasks as well as the goal of the enterprise through an information communicating system. Therefore, they should be given full decision-making power and even be authorized to manage and control the whole service process.

2. *The Structure Unit.*
   Within the agile container terminal enterprise, Integrated Transportation Teamwork (ITT) can be organized as the basic organizational unit during the process of production and business activity. ITT can be regarded as a virtual organization and organized according to various clients and requirements. It replaces the traditional mode of coordination through meetings, thereby service being more timely, comprehensive and effective. All team members coordinate their work through the information network among different levels and departments. Different from the high centralization of the traditional organization, ITT gives staff certain autonomy. The business process is divided into several parts and everyone in ITT is in charge of one part. The team is a relatively stable organization and will be disbanded after completing a project or task.

3. *Virtual Enterprise.*
   Competitions among enterprises outside the agile container terminal enterprise result in greater scope for integration. Therefore, it is necessary for companies to develop Virtual Enterprise (VE) which can be flexibly and quickly organized to respond to the market and can complete tasks independently. Once the task is finished, the virtual firm will be immediately disintegrated and the members will then be diverted to other projects. The 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. *Organization Alliance.*
   Along with the development of the port and shipping industry, unions and joint organizations appear everywhere with cargo resources and market opportunities. The pursuit of this kind of cooperation based on AS is not simply the economies of scale or scope but joint economic benefits. In other words, through these unions, the enterprise can effectively take an advantage of resources that do not belong to the enterprise but to the union making a full use of the sharing factors of production, thus reducing costs.

5.2. The Quantification on the Agility of Container Terminal Organization

The quantification of the agility of the organizational structure is studied based on the information theory. In this study, the relationship between the entropy of the organizational structure and flexibility as well as the relationships among entropy, labor division and organizational hierarchy are discussed. Before analysis, two different concepts of the system, diversity and complexity will be analyzed from the view of a set. If we regard an economic system as a set of elements, the diversity of the set will increase with the number of elements. In the information theory, set variability can be defined as the logarithm to base 2 of the number of elements (Shannon and Weaver 1949), i.e. $V = \log_2 n$, in which V is variability and n is the number of elements in the set. This definition, on the one hand, shows the variability of systems increasing with the number of elements, whereas on the other hand, shows new elements lead decrease the marginal effect of system variability.

1. *The Entropy of the Organizational Structure and Flexibility.*
   Entropy is a quantitative description of the state of the organizational structure reflecting the state degree of the complexity of the organizational structure (Arteta and Giachetti 2004). Two dictionaries are used to illustrate the relationship between the entropy of the organizational structure and flexibility. Dictionary (*A*) apparently has lower entropy than dictionary (*B*) that is a random combination of the characters *A* contains. The storage capacity of dictionary information in the state of *A* is higher than that of *B* which is much disordered. However, from the state of *B*, it is easier to recombine and generate many new states. Accordingly, the dictionary *B* of the disorder state with a low storage of information has higher potential than *A* with more order state and has larger restructuring flexibility. Therefore, an organization with lower entropy will be able to store much more specialized information and to adapt itself to a stable environment better while organizations with higher entropy are able to adapt to changes in the storage type of information more easily caused by the environment.
   Generally, if the environment is stable, it is an effective strategy for an organization to use specific information again and again. However, the environment is rapidly changing. Therefore, the organizational structure of the container terminal with a certain degree of entropy is able to become better adapted to the current environment.

2. *The Division of Labor, Entropy and Flexibility.*
   The flexibility of two different organizational arrangements that complete the same business are analyzed and compared. One of those deals with completing the task through staff without labor division. The other maximizes the use of labor division to complete it.

To simplify the problem, in both cases, there is an assumption that the number of operations is the same with that of the stuff that would be equivalent to n:

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

$$a = X_1O_1, X_2O_2, ..., X_nO_n,$$

$$b = X_1O_3, X_2O_6, ..., X_nO_m.$$

In which, $X_1, X_2, ..., X_n$ is an employee; $O_1, O_2, ..., O_n$ is an operation. The probability of each state of the system can be defined as:

$$P_a = P(X_1O_1, X_2O_2, ..., X_nO_n),$$

$$P_b = P(X_1O_3, X_2O_6, ..., X_nO_m).$$

As employees are independent to each other, Pa can be denoted as a probability product of the event of $X_1 O_1, X_2 O_2, ..., X_n O_n$, i.e.

$$P_a = P(X_1O_1)\ P(X_2O_2)\ , ...,\ P\ (X_nO_n).$$

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

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

It means that in every state of the system, P_i is of the same probability and then we can get:

$$P_i = 1/n^n;\ S_{11} = -\sum P_i \lg P_i = -n \lg n.$$

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

2) *Maximize labor division.* Under this circumstance, the n operations remain unchanged. However, labor division to extreme extent exists in which each employee completes only one of n operations. It is clear there is a single state in this situation, in which each employee deals with the operation arranged for him/her. Correspondingly, the total entropy of the system is $S_{12} = -\lg 1 = 0$.
Through a comprehensive analysis of the two above introduced cases, we can conclude that total entropy will be reduced from $n \lg n$ to *0* when a system maximizes labor division. Therefore, the specialization of the organization and labor division will decrease the flexibility of system adjustment.

3. *Entropy, Organizational Level and Flexibility.*
There are two different organizational structures. One of those is an organization without boundaries among departments and the other 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 equal to the number of staff in the organizations. In the latter case, due to the added department, the levels of the organization will increase to two at least. It is because that if the other departments are at the same level, the department responsible for the overall coordination and planning must occupy a higher-level situation. In such cases, the control span will be confined to the number of emploees in each department.
Likewise, we assume that the organizational system has n workers and n operating form:
   1) *Flat structure*. No departments exist in this organization which means that the effect of a different operation done by different workers is similar. In other words, all staff is able to exchange. We assume the operation is the same and the employees are entirely interchangeable, that is, the staff can be free to exchange among all operations in the organization. In the first case, because there are n employees able to completely interchange among n similar 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 like $S_{21} = -\lg n!$.
   2) *Hierarchical structure*. In such situation, due to limitations on 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 the hierarchical organization is lower than that of the flat one as it is assumed that each department deals with the same operation in the second case. Thus, the difference between entropy under the first and 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 numbers of the system state in the first and the second situation and $p(1) = n!$.
In the second situation, we assume that k is the number of the established departments and $n(1), n(2), \cdots, n(k)$ is the number of the employees in each department, then

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

As $n(1) + n(2) + \cdots + n(k) = n$,

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

$$p(1) = n! > n(1)!\,n(2)!\cdots n(k)! = p(2).$$

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 limitations on the department, the freedom of staff's movement and exchange gets restricted and decreased in the organizational system, and thus the entropy of the corresponding system becomes lower. It also shows that the reduction of system entropy positively correlates with the number of a department. Similarly, the hierarchy of the organizational structure will also reduce the degree of adjustment flexibility.

4. *The Organizational Structure in the Container Terminal.* From the above quantitative study, we know that the flat type of the organizational structure is more flexible to achieve which can optimize the organizational structure of the port. Generally, a meticulous division of product operations, too many links and the block of information flow will make difficult to timely and accurately know the requirements of customers (carriers) to service from the container port. The new framework is to be customer driven to arrange special projects and to change the vertical process to the parallel one, thus forming the flat type of the organizational structure.

6. Performance Evaluation of the Container Terminal

It is very important to make a performance appraisal of AS because it provides the basis for assessing the effectiveness of AS. The objective of performance measurement on AS in the container terminal is not only to know the performance condition of AS but also to get the aspect that should be improved. Performance measurement is a dynamic course to continuously control and revise work.

6.1. The Index System of AS in the Container Terminal Oriented Shipping Company

Performance measurement on AS should reflect the whole dynamic condition. Therefore, it is necessary to set up an effective performance measurement index. Considering a container terminal providing AS to shipping companies, its performance evaluation can include inside and outside aspects. Inside performance evaluation is a comparison of activity and course with an assignment or goal. Outside performance evaluation focuses on the customer's satisfaction. Thereby, the performance evaluation index system can be considered as presented in Table 3.

Table 3. The index system of performance evaluation on AS oriented shipping companies in the container terminal

Goal Layer		First Class Index	Second Class Index
The index system of performance evaluation on AS oriented shipping companies in the container terminal	The index system of inside performance evaluation	Cost (U1)	Handling cost (B11) Maintenance cost (B12) Information cost (B13) Management cost (B14) Other cost (B15)
		Profitability (U2)	Rate of return of total assets (B21) Turnover rate of total assets (B22) Rate of an increase in profit (B23) Capital value preserving and appreciation rate (B24)
		Service Level (U3)	Berth utilization (B31) Equipment utilization (B32) JIT (B33) Cycle time (B34) Response time to requirements (B35) Response accuracy (B36) Customer feedbacks (B37)
		Productivity (U4)	Productivity index (B41)
		Quality (U5)	Damage Frequency (B51) Loading accuracy (B52) Document accuracy (B53) Information availability (B54) Number of credit claims (B55)
		Flexibility (U6)	Container handling (B61) Process (B62) Volume (B63)
		Manning Level (U7)	Cooperation ability (B71) Degree of skills (B72) Training (B73) Empowerment (B74)
	The index system of outside performance evaluation	Customer's satisfaction (U8)	Supply time (B81) Service level (B82) Price (B83) Information sharing (B84)

1. *Internal Performance Evaluation.*
   The system includes the following index:
   1) *Cost expansion* mainly includes handling costs (equipments costs, inventory costs), maintenance costs, information costs, management costs etc.
   2) *Profitability* of AS in container terminals considers profits that is simultaneously short and long run term profit including the rate of the return of total assets, the turnover rate of total assets, the rate of an increase in profit and the rate of preserving capital value and appreciation.
   3) *Customer Service Level* investigates the company's ability to satisfy customers' demands. The index consists of berth and equipment utilization, JIT service, cycle time, response time to requirements, response accuracy and customer feedbacks.
   4) *Productivity* connects equipment quantity used to produce with the output (throughout) reflecting the total efficiency of the container terminal.
   5) *Quality* of service is the core business for the container terminal. This index includes damage frequency, loading accuracy, document accuracy, information availability, the number of credit claims etc.
   6) *Flexibility* index includes container handling flexibility to handle different types of containers and process flexibility embraces making decisions and maintaining organizational and volume flexibility.
   7) *Manning Level* affects service quality including cooperation ability, the degree of skill, training situation and the employee empowerment.
2. *External Performance Evaluation.*
   The outside performance measurement is the degree of customer satisfaction. As a service enterprise, the main goal is to make the customer satisfied. Accordingly, the purpose of AS in the container terminal is also to rapidly and timely meet the requirements of the customers and to make a quick response to the changeable market. As shipping companies pay more attention to service time, service quality, price and information sharing, this index is combined with these four aspects.

6.2. The Method of AS Performance Evaluation

The agile service performance measurement system is a multi-level system of standards. As it is fuzzy and complex to evaluate several situations in servicing, it is necessary to select a measuring method that can comprehensively consider various factors. The fuzzy quality synthetic evaluation method is one of the most popular recent methods that can be used to solve a fuzzy problem of comprehensive measurement, thus being suitable to measure the system with more factors and a multi-level structure. The steps of the method are as follows:

1. *Establish the Aggregation of the Evaluation Rank.*
   First step is to establish the aggregation of the evaluation rank.

$$V = \{V_1, V_2, V_3, V_4, V_5\} =$$

{*Distinction*, *Excellent*, *Good*, *Middle*, *Poor*} and the number from 0 to 1 can stand for the rank as shown in Table 4.

Table 4. The quantitative type of the evaluation rank

Rank	Distinction	Excellent	Good	Middle	Poor
Number	1	0.8	0.6	0.3	0

2. *Establish the Aggregation of the Evaluation Factor.*
   The second step is establishing the aggregation of the evaluation factor. There are 8 levels of the evaluation target, i.e.

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

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

………………

$$U_8 = \{B_{81}, B_{82}, B_{83}, B_{84}\}.$$

3. *Establish the Subordination Degree and Fuzzy Relationship Matrix R.*
   Subordination degree r is the degree that belongs to the measuring rank. For example, the degree of customer service belongs to rank aggregation 'excellent' and makes 0.8:
   1) In case efficiency type is larger and more superior, we can use the function for evaluating the subordination degree of the measuring factor as follows:

$$r = \begin{cases} 1, f(x) \geq \sup f(f) \\ \left[\dfrac{f(x) - \inf(f)}{\sup(f) - \inf(f)} \right]^n, \inf(f) < f(x) < \sup(f). \\ 0, f(x) \leq \inf(f) \end{cases} \quad (1)$$

   2) In case cost type is smaller and more superior, we can use the function for evaluating the subordination degree of the measuring factor as follows:

$$r = \begin{cases} 1, f(x) \leq \inf(f) \\ \left[\dfrac{\sup(f) - f(x)}{\sup(f) - \inf(f)} \right]^n, \inf(f) < f(x) < \sup(f), \\ 0, f(x) \geq \sup(f) \end{cases} \quad (2)$$

   $f(x)$ is real value, $\sup(f)$ and $\inf(f)$ is maximum and minimum value. To cope with the data used in the above function, the subordination degree is in the zone of [0,1].
   Set up rank aggregation and extract the subordination degree $r1_{ij}, r2_{ij}, \ldots, r8_{ij}$ of the second-class targets. Factors $U_i (i = 1, 2, \ldots, 8)$ are evaluated quantitatively one after another. Next, set up fuzzy relationship Matrix $R_i (i = 1, 2, \ldots, 8)$ which means that the item is evaluated from the single factor to the

fuzzy subset of various ranks. The fuzzy relationship Matrix R is as follows:

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

$$R_8 = \begin{bmatrix} r8_{11} & r8_{12} & r8_{13} & r8_{14} & r8_{15} \\ r8_{21} & r8_{22} & r8_{23} & r8_{24} & r8_{25} \\ r8_{31} & r8_{32} & r8_{33} & r8_{34} & r8_{35} \\ r8_{41} & r8_{42} & r8_{43} & r8_{44} & r8_{45} \\ r8_{51} & r8_{52} & r8_{53} & r8_{54} & r8_{55} \end{bmatrix}. \quad (3)$$

4. *Determine the Weight Vector A of the Measuring Factor.* As factor U_i has a different degree of importance in fuzzy quality synthetic evaluation, w_i in the weights Vector $A = (w_1, w_2, \ldots, w_8)$ refers to the subordination degree of factor U_i to the fuzzy subset. It is normalized that $\sum_{i=1}^{7} w_i = 1$. In this case, to determine different target weight, we use a method with more feasibility in practice which is the expert judging method. The first-class targets weight determination is shown in Table 5. The second-class weight determination is the same as that of the first-class.

5. *Produce Fuzzy Measurement Result Vector B.* First, use the above method to get the second-class target weight, $M_i (i = 1, 2, \ldots, 8)$

   $M_1 = (m_{11}, m_{12}, m_{13}, m_{14}, m_{15}) \ldots M_8 =$ $(m_{81}, m_{82}, m_{83}, m_{84}),$

   an then next step to get:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_8 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & \cdots & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{81} & \cdots & \cdots & r_{85} \end{bmatrix}. \quad (4)$$

In Matrix R, i line and j row element r_{ij} refer to the subordination degree and the item is evaluated to the rank V_j fuzzy subset looking from factor U_i. Vector A and Vector R can produce the fuzzy measurement result which is Vector B. In R, a different line reflects the subordination degree evaluating each rank fuzzy subset looking from the single factor. We can get vector B which is the result of fuzzy synthetic evaluation by multiplying weight Vector A with Matrix R. Here, the element b_j refers to the rank fuzzy subset looking from the whole service system.

$$B = A \times R = (w_1, w_2, \ldots, w_8) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & \cdots & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{81} & \cdots & \cdots & r_{85} \end{bmatrix} = (b_1, b_2, \ldots, b_5). \quad (5)$$

6. *The Analysis of Fuzzy Quality Synthetic Evaluation Result.* Because Vector B considers all factors as the effect, it is able to judge the whole situation in the AS system in the container terminal as well as a single factor. According to the largest subordination degree principle, if V_3 corresponds to $\mathrm{Max}^{b_j (j=1,2,3,4,5)}$, namely $b_3 = \mathrm{Max}^{b_j}$, then V_3 means a performance level of AS which is 'good'. Meanwhile, the performance level of each aspect in the first-class can also be noticed. The future market is expected to be changeable and unpredictable, and thus the container terminal should provide agile service to satisfy customers' requirements. An evaluation index system of AS is established in this section to do quantification on the index. In practice, the service of the container terminal is complex and customers are not shipping companies only, so the index can be added in accordance with the target and situation.

7. Conclusions

1. Along with the progress of economic globalization and transport containerization, container terminals face an increasingly uncertain environment. The economies of scale in ship sizes also result in the challenge of shortening time for ships in terminals. However, a terminal could not solve problems via expanding the scale as blind expansion would cause diseconomy which oblig-

Table 5. The first-class targets weight determination of AS

Serial Number	Weight target	Expert 1	Expert 2	…	Expert n	Average value	Normalization
1	B_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	B_2	a_{21}	a_{22}	…	a_{2n}	$a_2 = \frac{1}{n}\sum_{i=1}^{n} a_{2i}$	$w_2 = a_2 \Big/ \sum_{i=1}^{7} a_i$
…	…	…	…	…	…	…	…
8	B_8	a_{81}	a_{82}	…	a_{8n}	$a_8 = \frac{1}{n}\sum_{i=1}^{n} a_{8i}$	$w_8 = a_8 \Big/ \sum_{i=1}^{7} a_i$

es the terminal to adopt new management strategies to be more competitive. Agility is one of the strategies that can help the terminal with surviving in a new economic environment.

2. This research presents the concept and characters of agile service in the container terminal mainly oriented to shipping companies. It is suggested that from the theoretical point of view, the container terminal should adopt a flat type of organizational structure to be more flexible to achieve agile service. Performance measurement is necessary in order to control and improve the required level of agile service. The application of fuzzy quality synthetic evaluation can help in knowing the whole situation of agile service as well as of a single factor.
3. However, the economic functions of the container terminal are more complex and customers are not only shipping companies. Agile service oriented land logistics companies are also a serious problem of studying. If a container terminal is as a distribution or logistic center, the scope of service will become larger and the performance evaluation index system will become more complex. Therefore, the problem of agile service provided by the container terminal needs further studies.

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