ESSAYS ON PORT SYSTEM DEVELOPMENT IN THE NEW ENVIRONMENT

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CERTIFICATE OF ORIGINALITY

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Abstract

Due to the witnessed inland duplication of port functions, the port therefore becomes an intermodal logistics system centered on seaport rather than the traditional maritime logistics node. The undergoing transition in port industry brings new questions on port planning, investment, competition and operations under the increasing environmental concerns among global supply chain and the unsolved worldwide economic crisis. Previous researches on port operation are composed mainly based on the belief that maximizing cargo throughput is the critical and only objective of port operation. However, other dimensions of port evaluation, such as the service quality and Marginal Output, need to be considered under dramatically changing operating environment. This dissertation, which contains six separate essays, studies the operation and development of port-oriented system under the carbon reduction through the integrated logistics network and the recent economic recession.

The first essay seeks to understand influences of logistics decarbonization on port operation and ports' optimal strategic responds applying qualitative analysis. The analysis highlights the content and strategic scope of attaining the competitive advantage of port in the structural change of the competitive environment due to the new atmospheric requirements on logistics network based with broad literature review.

The second and third evaluate port sections efficiency with modified DEA models by considering *Marginal Output* and *Service Quality* as output indicators in port operations. *Marginal Output* measures the operational performance of port operators while erasing the influence of hinterland economy on port throughput; while

Service Quality measures how well a delivered intermodal logistics service matches the customers' expectation. The second essay assesses the productivity of the Chinese major container terminals during the time period from 2004 to 2007 and the result explores the significance of dealing with economic heterogeneity for container port efficiency evaluation. The third essay focuses on analyzing the efficiency of 26 dry ports located in Jawaharlal Nehru Port Trust region in Year 2008 and 2009. Subsequently this essay attempts to find out which of the efficiency estimates so derived are more relevant from the stakeholder's perspective.

The forth essay applies the SERVQUAL model to measure the service quality of dry ports from India and analyze the gaps in its quality of service. The research recalls service quality as one important indicator for performance evaluation of logistics industry. This study ascertains the reasons behind the differences in perspective of service quality and the groups of participators, as well as the policy effects on the service quality of dry port industry. The third and forth essays are two of the scare studies that the service quality of dry ports is taken into the evaluation consideration in terms of SERVQUAL score.

The fifth essay suggests a new framework, which contains determinants for location and practical group decision-making model, to explore an appropriate route for dry port planning. The suggested model modifies a geometric least square method that overcomes the inconsistence of judgment matrix. Numerical example is given based on data collected from the experiments and industrial organization.

The sixth essay examines the port choice behavior of port investors by utilizing a random choice model based on data of major container port of China. A random risk-minimization model is established to analyze the investors' behavior under the global economic recession. The findings indicate that the location of the port, the economic development level of the hinterland, the logistic network combined with government support play significant roles in attracting private investment.

The overall conclusion is summarized as follows. (1) port operators and authorities should emphasize more on improving operational performance and inland port networking, besides reducing inner carbon emission technically, to better compete in the new environment; (2) evaluation of port performance should involve more indicators that presented different perspectives of operational objective to reduce the deviations to the actual characteristics; (3) design and planning of the port-oriented system need to be conducted based on practical framework and updated analysis to catch the changing demand of stakeholders.

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Chapter 1

Overview

1. Research Objective

With the further integration in the intermodal transport network, the concept of port has been amplified to the port-oriented system including inland transportation routes and hubs. Decarbonization in supply chain and the global economic recession bring new challenges to port operations and development. The actors in port industry need to reconsider the role of port in the intermodal transport system, and to better understand the changing environment as well as the possible reacting strategy. It also raises problems to scholars in relative fields to catch the formation of port system. This system under the new system desires cautious planning and effectiveness evaluation for the irreversible huge capital investment, the long return period and the significant position in logistics network.

The broad objective of this research is to study the operations and development of the port-based system under the changing competitive environment. Specifically, this research proposes to:

- Identify the changing competitive environment of port industry and its motivations, and classify the strategic reaction of port in the changing logistics network;
- Improve the understanding of port performance, with introducing new indicators and to port efficiency evaluation with classical models;

- Analyze the development of port infrastructure by suggesting practical modeling framework for port system planning; and exploring the recently preference of port investors.

1.2 Research Background

The significance of port industry is obvious due to the increasing growth of global trade and supply chain. According to the forecast by UN in 2005, around 570 new container berths will be required just in the Asia-pacific region by 2015. The common forecast believes that over $60 billion worldwide investment requirement includes only the cost of developing the terminals is expected for the building of the new berths. Substantial additional investment will be required to secure adequate access to the terminals by road, rail and inland waterways, for the effective distribution of containers to the expanded hinterlands. The additional costs of dredging, the provision of breakwaters and the establishment of land transport links and intermodal interchanges, as well as the environmental protection system could easily double this total. The sensible investment decision and efficient operation will be necessary for ports in the happening new era for port industry.

The traditional manner of port operation is challenging by the new environments of global logistics network and global supply chain, which raises demands due to atmosphere protection and logistics integration. Combining with the environmental pressures on port operation, the further integration of the logistics network recalls the importance of port efficiency and the inland intermodal hubs. Port efficiency measures the operational performance of port/terminal operators. To exactly assess the potential competitiveness brought by the operator to the port/terminal, the homogeneity issue in efficiency evaluation should be clarified. Dry port has been concerned as an element of port system rather than separate mechanism, but studies on performance, competitiveness, regulation and planning of dry port is still inadequate in the maritime research. The massive investment on port causes intensive competition and pressures of cost-recovering. Port planning and operation determines individual port's competitive advantage and profit possibility.

Performance evaluation allows the decision makers and scholars to understand the status of port industry and to find the proper manner for improving the operational and financial performance of the ports. It also has been applied to monitor the effectiveness of the port investment as a major useful tool. Different indexes have been utilized by scholars and managers to evaluate the performance, such as the total handled cargo, the efficiency and the service quality for different purposes. There are several methods for performance evaluation based on different theoretical backgrounds and business objectives. Utilization of different methods and new indicators of port performance evaluation will bring new thoughts and insights to operations of port-related logistics sections. The effect of the choice of the indexes, as well as the research method, needs to be identified to conduct unbiased research.

Moreover, the port studies need to consider the seaport and the inland logistics chain as a whole. A successful dry port network is also critical for port competition in the extremely market. The dry ports are important nodes in global logistical networks and the quality of their services influences the effectiveness of the entire logistical network. The dry ports are also became extension of seaport and have been involved in seaport master planning and operation. Location is the initial step for develop or construct the individual dry port, or seaport. The theoretical location modeling is necessary for the actors in the port system. The classical location models as the optimization models cannot be duplicated to the location selection problem for dry port. The industrial process of deciding a location for dry port construction and development can be mostly described as a group decision-making process rather than an engineering optimization mechanism. It exits a new requirement in the comprehensive framework on location selection of intermodal transport hubs.

Drawing interests of the investors on the port construction and implementation is problematic under the present global economic circumstances. Even location initially determine the possible success of particular port/dry port, it cannot guarantee that the planners could achieve adequate capital investment and ideal ownership structure. The economic crisis has not only reduced the public expenditures of authorities on transportation infrastructures; but also caused a cutback on the investment intentions of the traditional port investors. To compete with other port project for scarce venture capital, port planners and authorities have to understand the preference of the investors, especially the private investors. Therefore, it is significant to investigate the choice behavior of private port investor by modeling their current investment orientation.

1.3 Research Scope

Research on port industry, which is a traditional industry with hundreds years of history, is a complicate field. Hence the qualitative analysis and quantitative studies are equally significant. This dissertation contains six concerns regarding to the changing business environment of port industry: Influences of logistics decarbonization on port operation and ports' optimal strategic responds; Port efficiency evaluation considering the hinterland economic development; Dry port productivity evaluation considering the service quality; Implication of service quality in dry port operation and the impacts of regulation; Framework for dry port location selection modeling; Preference of private investors on port project choice.

The first essay seeks to understand port operations in light of decarbonization in logistics network and discusses the impact of carbon reduction on strategic and operational issues of port management. As an elementary obligation, the proposed analysis highlights the content and strategic scope of attaining the competitive advantage of port in the structural change of the competitive environment due to the new atmospheric requirements on logistics network. The operational strategies which determine the port market share are supposed to suggest to port operators for their competitive advantage in the new era.

The second essay applies classical DEA models to evaluate the productivity of the Chinese major container terminals during the time period from 2004 to 2007. The study supposes to highlight the effect of economic environment on the port operations and the significance of choosing different index for performance evaluation with different purpose. The efficiency of a decision making unit (DMU) measures the DMU's capacity of producing outputs using given inputs. The DEA model is widely applied in seaport efficiency study due to its advantages on benchmarking and dealing with multiple outputs. Among the previous researches, the container throughput is always selected as the main output factor. However, it cannot properly reveal the real production of the container port as the container throughput is highly influenced by the macroeconomic environment, which is beyond the control of the port management. This chapter introduces the *Marginal Output* as new output factor adjust the effects of macroeconomic factors on the evaluation of port efficiency and capture the systematic variance.

The third and forth essays introduce service quality to the measurement of dry port efficiency and performance. The efficiency study without specification according to the features of research units is harmful and dangerous to the managers and policy makers on policy issues. These essays are two of the scare studies that the service quality of dry ports is taken into consideration in terms of SERVQUAL score. Despites that the transport industry is a service industry, efficiency studies in this field with the consideration on customer satisfaction are almost negligible.

The dry ports not only play an important role in increasing the throughput of transport industry but also in the region's economic development. The third essay attempts to measure the efficiency of 26 dry ports located in the Jawaharlal Nehru Port Trust (JNPT) region of India using the Data Envelopment Analysis (DEA) approach with *Service Quality* as a new output. Efficiency measures of transport service providers vary across different models. The efficiency study without specification according to the features of research units is harmful and dangerous to the managers and policy makers on policy issues. Subsequently the paper attempts to find out which of the efficiency estimates so derived are more relevant from the stakeholder's perspective.

The forth essay proposes to use the SERVQUAL model to evaluate the service quality of the Ahmadabad dry port from India and analyze the gaps in its quality of service. The research proposes to raise service quality as one important index for performance evaluation of logistics industry. Hence it becomes necessary to ascertain the service quality of the dry ports. However, service quality differs in perspective from the point of view of the different stake holders involved in dry port operations. It also alters over a time period. The SERVQUAL model is extensively used to measure the quality of service provided by different types of service providers. This study also attempts to ascertain the reasons behind the differences in perspective of service quality and the groups of participators, as well as the policy effects on the service quality of dry port industry.

The fifth essay suggests a new framework, which contains qualitative and quantitative variables and practical model, to explore an appropriate route for dry port planning. Starting with the location problem, the planning of dry port mostly involves consultative evaluation and proposal from group of experts and institutions. The suggested model modifies a geometric least square method that overcomes the inconsistence of judgment matrix. Numerical example is given based on data collected from the experiments and industrial organization.

The sixth essay models the port choice behavior of port investors by utilizing a random choice model. Under the trends of privatization, deregulation and decentralization, the public port authorities are eager to attract private capital into both port infrastructure and operations, aiming to high efficiency and competitive advantages. Investment decisions of private investors are crucial to policy formulation in port authorities and operators. A random risk-minimization model is established to analysis the investors' behavior under the global economic crisis. The random risk-minimization model allows each port investor faces a choice of several alternatives and makes their decision on the basis of various port and terminal characteristics.

Chapter 2

Analysis on Port Operations Strategy in the Green Logistics Network

2.1 Introduction

Adhering to the concept of "green", low carbon becomes the newest environmental requirement on the global supply chain and logistics network. The CO_2 emissions, which have been quantified by carbon footprint, are agreed to be necessarily globally reduced from 48 billion tons in 2007 to 24-28 billion tons in 2050 to avoid the serious environmental problems caused by an uncontrollable temperature rise. Carbon footprint is the overall amount of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions (e.g. methane, laughing gas, etc.) associated with a product. Due to the life cycle assessment (LCA) of carbon footprint, the business circle is extremely encouraged by market forces and public authorities to shoulder its share of the reduction responsibility (Stern, 2007). The end-to-end supply chain, encompassing all aspects of the product life cycle from raw material to disposal, is now being evidenced with the more strategic view. The carbon emissions in the supply chain arise from various processes, ranging from the processing of raw materials to the dispatching of finished goods. Every process is presently required to be reviewed for the overall carbon reduction in the supply chain which will lead to the restructuration of the chain as a whole.

The levels and types of carbon emissions at logistics stage depend on the mode of transportation, choice of fuel used, and distance travelled (Hui *et al.*, 2007). The participants of logistics network are suffering imminent pressures to re-access their decisions on the transportation routes, modes and fuel types to progressively decrease the carbon emissions due to the logistics activities. As the main drivers of emissions growth of GHG, the transport and logistics activities engenders around 2,500 of totally 50,000 mega-tons annual humanities CO_2 emissions[1]. Meanwhile, the maritime transport takes around 3% of the humanity's carbon emission. Considering that 90% of the total cargo is undertaken by maritime transport in the international trade, the maritime transport sections bear significant responsibility of reducing the carbon emission respective to their share of the global logistics network.

As a player in maritime transport, the gateway port is also suffering the challenges brought b the adjustment of carrier's preference, besides the political and social force of reducing carbon emission. The carrier is turning to choose particular ports linking the lower carbon logistics route concerning the total carbon emission yield from the logistics sections for the goods they transport. The emergence of reorganizing the global logistics network has been processed by the gradual decarbonization. It should be further noticed that although the carbon emission has been raised to the top layer of the stakeholder's concern on supply chain, the customers still pursue the traditional expectation on cost, quality and time. The port,

[1] The Role of Logistics and Transport in Reducing Supply Chain Carbon Emissions, WEF

as the other logistics section, should improve their operations to balance the productivity and environmental efficiency.

As a parasitical industry of the supply chain and the nodes of the global logistics network that connect different transport modes, the gateway ports need to understand their role in decarbonization across the supply chain and logistics network. To maximize the carbon abatement potential from their investments, port firms are seeking to engage with both policy makers and shippers to make cohesive changes across the entire industry. Under the demand of manufactures, the choice of shipping lines on gateway port nowadays is depending on the network design with lower GHG emission. The dynamic market environment requires the analysis on efficient change that taken by port operators to retain the competitive advantage and accomplish the carbon reduction assignment. The following parts of this paper will discuss the implications of decarbonization in logistics network, the significance of re-evaluate the port operation and the possible move port can take to gain competitive edge in the new era.

2.2 Decarbonization and Its Implication in the Logistics Network

Politicians have declared various requirements on logistics carbon emission toward to the Kyoto Summit target. For example, the European Union stated its wiliness of legislation draft aiming that tackling the shipping industry’s rapidly growing contribution to climate change, by including the sector in Europe carbon dioxide cap-and-trade system. The threat of unilateral action from the EU, which controls 41% of the world's fleet, could stimulate the debate. Meanwhile following the rule of LCA, the requirement to incorporate the GHG emissions related to the transportation of goods leads the demand for lower carbon emission from final customer to be transitive to logistics stakeholders. Effects of the changing consumer demands, combined with a supporting response from the large global retailers, could therefore have a profound effect on supply chain and logistics network. The logistics sections are responsible for the carbon emission related to their operational activities under the carbon emission cap and carbon tax initiatives.

2.2.1 Structural Change in Supply Chain

Decarbonization in logistics is rewarded by the environmental requirement on supply chain. The potential fundamental revamp of the supply chain affect every link to the chain, including raw material sourcing, production, distribution and use in responding to climate change. Several processes will take place during this transition and change the global supply chain structurally (Soylu & Dumville, 2011). The risk assessment for competitiveness needs to rely more on environment-related factors in support of the structure changes. The business and policy uncertainty could be created by the inconsistent methods of carbon accounting for supply chain management. Respectively, financial and risk modeling need to be expanded to considering the environmental impacts of alternatives; and the public policy and managerial thoughts that reduce risk and inconsistency will be concerned to increasingly influence the supply chain.

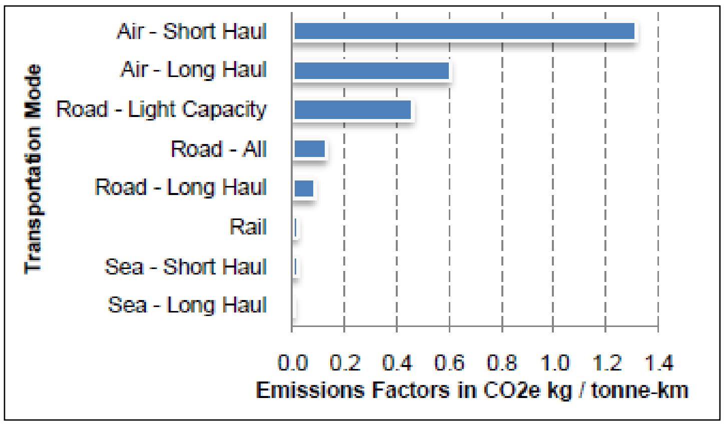
The decarbonizating business environment could lead sourcing goods from more efficient production locations and near-shoring be likely resurgent if the carbon reduction is continually carried out as a rule. The ear of lower environmental cost, cheap transport and wage arbitrage potential will result in a large movement to low cost region sourcing. With rising volatility in fuel prices and the possible carbon tax, plus the growing need for flexibility in supply chains, near-shoring could be both a cost-efficient and environment-efficient choice in manufacturing location decisions. There have been literary discussions focused on switches to Mexico for the US and Canadian market, and to Eastern Europe for high technology manufacturing for the Europe market (Bock, 2008; Goel, 2008). Energy efficiency, as well as the stability and effectiveness of public policy of natural resource management, will also become the distinguishing factors in selecting suppliers of raw material, finished products and logistics. The structural change in supply chain will involve more competitors in the port service for the regional concentration of the supply chain. The geographic location could turn into an important GHG emission related competitive advantages ultimately.

2.2.2 The optimized integration along the logistics network

Although the existed carbon-trading mechanism can be applied to spread the elasticity of individual shipper's carbon emission allowance, the shippers' transportation costs could be added 4% due to the mechanism at the same time (Tasiaux, 2009). The carriers still prioritize cutting carbon emissions accordingly rather than purchasing carbon credit with additional cost for their goods. Carbon emission from the transport sector can be expressed through the following identity (IEA, 2000): Emissions=Travel Activity*Mode Share*Mode Fuel Intensity*Fuel Carbon Intensity. The carriers can minimize the carbon emission through optimizing the combination of the transport modes and networks. The total mobility emissions of logistics and transport sector have an estimated carbon footprint of around 2,500 mega-tons (WEF, 2009). Road freight is the greatest part, at around 64% of the total, with ocean freight some way behind at 25%, following by 8% of rail freight. Assessed in terms of emissions intensity per ton-km, air freight is considerably more carbon intensive than road, as shown in Figure 2.1. It can be clearly pointed out that the most carbon efficient modes are rail and ocean freight.

Figure 2.1 – Emission Efficiency per Transport Mode

(*From* WEF Report)



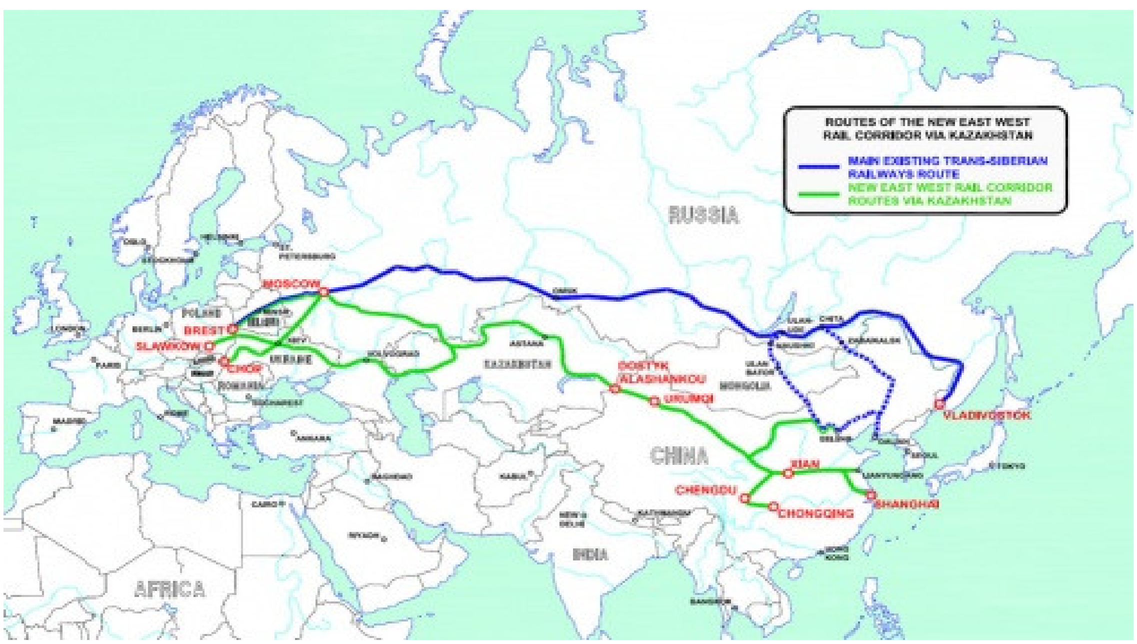
Optimizing the intermodal and intermodal integration of the logistics network's can consequently brings significant reductions in all cost, time and carbon emission. The large "closed networks" need to be deployed to ensure efficient hierarchies and nodal structure. The integrated optimization efforts across multiple networks are even more necessary under the supply chain decarbonization. The improved intermodal and intermodal coordination respectively means less GHG emitted during goods transfer and less expensive for selecting the lower carbon intensive modes. The research conducted by WEF (2009) has shown that many networks remain at least partially inefficient as a result of both inertia to change and lack of durability in supply chain strategy decisions, and restructuring the network give both an 11% cost reduction and a 10% CO2e emission abatement. The optimum solution of the decarbonization predicament of logistics network can be optimizing the network with as frequent as much utilizing marine, waterway and rail transportation. The optimized network can reduce the carbon emission caused by inefficient intermodal and intermodal connection, less eco-efficient modes of transport.

Carriers have started to utilize more railway transport instead of highway transport and even long-distance ocean transport for the cargo forwarding. The railway connecting Southwest China and Europe has been started recently and the transit time of the freight train from Chengdu, China to the major European ports is about 13-15 days, which can save 20 days comparing to the transit time of ocean shipping connecting the same both ends. Moreover, the construction of Euro-Asian high speed railway as shown in Figure 2 has been planning by various rail companies from different countries. With the development of high-speed rail using new energy, it can be expected that the rail transportation will take more mode share for its advantage on transport time and environmental friendship.

The network optimization will stimulate the vertical and horizontal integration in logistics industry which have been widely discussed by scholars (Panayides & Song, 2008; Song and Panayides, 2008). The shipping line's leadership along the logistics chain consequently is enhanced through providing the value-added services pursuing the lower carbon footprint of the goods from the manufactures. Most of the shipping lines, such as OOCL and Maersk have released the carbon footprint calculator for their service to distinguish their service from the competitors. To maximize their market share, the shipping lines have to investments more on the port ownership and inland transport capacity from the shipping lines. The concentration in liner shipping can be boosted under the globally logistics decarbonization as the share of the top 20 lines in total global cellular capacity is over 80% now, which will intense the port competition further. The carbon-oriented optimized logistic network could be either opportunity or challenge and both to the port operators. Adams and Quinonez (2009) point out that the GHG reduction will bring competitive advantages to individual port in composing the “green route”. The competitive nature of port industry will also trigger new round of capacity extension, technology update, network building and even legislation among the competitors of port service market which yields enormous financial and social cost.

Figure 2.2-Planning in the Eurasian High-speed Rail Line Plans

(Source: http://www.70794.com)



2.2.3 Significance of the Efficient Operations

The popular suggestions to reduce the carbon emissions in logistics sectors are burning lower carbon fuel; despeeding the logistics network, including slowing the ocean freight vessels in transit; and enlarging the ship size to move the same volume of goods while decreasing the number of trips. A linear decrease in ship speed can bring a quadratic decrease in carbon emissions in ocean freight. However, the overall requirements of individual final consumers and/or logistics customers should not be ignored. The quick response required by the logistics market means that the consumer demand can be met effectively but at the trade-off of increased carbon emissions. The awareness on carbon reduction of the consumers' supply chain and the low carbon requirement of customers cannot afford the significant loss of delivery speed, as well as quality and cost. Many factors drive speed in the logistics industry, such as load times, and deadlines. The increased ship speed, utilization of less efficient transport mode and the increased number of expedited order and so on can all lead to the additional emissions. It is thought that only reduce the port time, congestion and the accidental mistake with an effective planning and operation can make up the speed loss due to the ocean transport despeeding while leading to the balance of quick delivery and emissions abatement. Transport congestion across modes and nodes has grown in most economies as a result of international trade growth outstripping the supply of new infrastructure and technology.

Improvements in the nodes of junction are necessary to make sure that the carbon footprint savings at trip from despeeding are not to be lost on transshipment or inland operations. The operational efficiency cannot only lower the cost burden but also eliminate the excrescent GHG emissions for logistics stakeholders, i.e., enhancing the port efficiency has the same impact on accommodating larger and environment efficient ship. The efficiency is recognized by researchers as significantly influencing gateway port competitiveness (Sanchez *et al*., 2003; Comtois and Black, 2005; and Winebrake *et al.*, 2008). The advanced transport intermodal combination and fuel require government spending on expanding transportation capacity and improving cargo handling technology, as well as the inventory of new type fuel, to faster the loading, unloading and berthing time. The huge amounts of investment from government require better operational performance which can definitely alleviate delay of the logistics service and maintain the carbon reduction of the logistics operations.

2.3 The Evaluation of Port Operations for New Challenges

In the light of the optimization of the logistics network and the increased customer's expectations resulting from the decarbonizing supply chain, ports have had to rethink their business operations. The port operation is facing various challenges which are social, financial and market under the carbon reduction trends of logistics industry. To remain being efficient and resilient, ports must anticipate the impacts of carbon reduction by assess their operation strategy for advanced improvement.

2.3.1 Requirements on Carbon Reduction within Port

Ports currently start to work on reducing GHG emissions either as in response to regulatory or policy drivers external to their organizations and the potential GHG reduction policies or to their users' expectation. At present, it suggested that the port industry has began to see carbon management as a mechanism to support their social license, i.e. demonstrating their role as good corporate citizens; and as well as a reply to the current demand from other industrial players such as shippers or freight forwarding companies (Adams & Quinonez, 2009). Seaports have been also putted a strong pressure on reducing the GHG emission in their construction and operation drove by policy regimes and regulatory the government's total carbon emission reduction target.

The main categories of users of the port are shipping companies, agents, forwarders, importers, exporters. Therefore the activities taken by the port authorities and the terminal operators always consist of port administration and regulation within the port district; provision of basic infrastructure for shipping; imports and exports. In relation to shipping, the services consist of keeping the sea-lane open and providing adequate berths for ships. The services also consist of planning, developing and maintaining terminals for container traffic, bulk transport and cargo traffic, both foreign and coastal. The GHG is produced accompany with the entire operational activities and service combination. The most important environment focus areas of the port industry have been: Implementation of an environmental management system; Waste and ship-waste; Dredging of contaminated sediments and cleaning sea bed; Noise reduction; Emissions to sea; Emissions to air; Energy consumption; Landscape pollution; and Communication with stakeholders. Among the above concerns, the greenhouse gas (includes CO_2) emissions are the key environmental concerns of the port operations in the environmental perspective, and have addressed various policy elements, such as the ISO 140001. The early adopters of reducing carbon emission can have an advantage over laggards as regulators are less likely to impose restrictions or interfere with operations of those ahead of the trend. Various scheme of “green” port operation have been designed and is undergoing by port operators and authorities, such as the San Pedro Bay Ports Clean Air Action Plan released by Port of Los Angle and Port of Long Beach; the Clean Air Initiatives and Harbor Air Management Plan introduced by Port of New York and New Jersey; the Rijnmond Regional Air Quality Action Program adopted by Port of Rotterdam; and the Green Port Guidelines of Sydney Ports.

Despite the initial purpose of chasing political responsibility and social fame, the above environmental management schemes in addition influence the port competitiveness incidentally. The GHG emissions can be linked to low operational efficiency, such as the pollution and increasing emissions are essentially the results of inefficient operations. Therefore, the “green” performance could ideally be used to evaluate the port efficiency by maximizing the units transported per unit resource input. This “eco-efficiency” will be the competitive advantage from cost and finance perspective of ports. It is possible to market the link between carbon reductions and increased overall efficiency of their internal operations. GHG reduction internally could suggest optimized logistical systems that minimize cargo handling time (reductions in GHG from reduced equipment idling for example).

Carbon management also can be a route to lower costs and greater visibility of the cost base. The ports achieve competitive edge normally by either provide low-cost service or/and specific port service differ from the competitors offering greater value to the customer. In the sustainable decarbonization fashion cost leadership cannot provide all necessary tools to face port competition. Seaports that will succeed in the

21st century will be those that are "customer led", who really understand customer needs and who can offer "best-in class" performance (Notteboom & Winkelmans, 2001). The essential factors of surviving in the increasingly competitive market are flexibility to adapt quickly to carbon reduction as well as the capacity of integrated logistics service in transport chains. Port operators and authorities have to respond the changing competitive conditions with financial investment and operational improvement. The investment and improvement should focus on all elements of transport chain, maritime access, port capacity and efficiency, hinterland transport and application of new technology and energy.

2.3.2 The Changing Competitive Environment of Port

The witnessed integration of suppliers, manufacturers, distributors and retailers, which is known as the supply chain has been self-updated in order to deliver products to consumers in a timely, efficient and especially green manner. Port competition in supply chain has been discussed by researchers (Veldman & Buckmann, 2003; Garcia-Alonso & Sanchez-Soriano, 2009; Lam & Yap, 2011) The logistics network has always been part of the supply chain and its further integration for the purpose of carbon reduction has been recently undergoing. The optimized environmentally friendly logistics network changes the competitive environments as well as the competitive determinants of ports from different dimensions. The economics of the optimized decarbonization transport system changes the shipping industry's routing patterns and port selection preference, which leads to the increased port competition, yet results in disequilibrium of the port demand and supply side by concentrating the client's power.

The integration of supply chain has been taken place in the past decade and the logistics network has been mainly viewed as significant value creating and/or cost reducing elements of the supply chain. The selection of the shippers on transport route including the inland transport, shipping lines and gateway ports has been majorly considered as an entire decision which to be delivered to end customers. Port choice has become more a function of the overall network performance based on competing for profit. It has been academically discussed that ports have been increasingly competing not as individual firms but rather as firms with within supply chains (Heaver, 2006; Notteboom, 2007), however the port competition in real business does not changed as much as the scholars claimed it would until the logistics network turns to “green” optimized with the supply chain decarbonization. The contribution of a port to a supply chain depends on its infrastructure, connectivity, and ability to add value for delivering material and products from their source location to their ultimate customers. The green optimization of the logistics network intensifies the further change of port competitive determinants and remodels the port competitive environment. It is apparent that shippers are being offered for the most part logistics packages of varying composition which include ports services, and varying economic and environmental cost. The shipper need to make decisions on a logistics pathway, which signifies a serial set of logistics operations, warehousing and transport service including cargo forwarding and port operation, to consign freight to an end-market.

A particular pathway normally provides well accessible, connected and aligned shipping lines and inland transport to ensure the availability and suitability for the shippers to select with their needs and strategies. Accordingly, the shippers presently and will continuously have to consider not only the possible combinations of ports of origin and destination, but also the shipping lines, routes, and inland transport as well as other logistics factors for their carbon reduction pathway (De Martino & Morvillo, 2008). The choice of port can be argued as by-product of a choice of logistics pathway in which the environmental cost as carbon emission is one of the most considerations in "green" optimized supply chain. Port traditionally gains competitive advantage by providing proper port service and maintaining distinctive physical characteristics including the natural location (Murphy et al., 1992; Lirn et al., 2004; Tiwari et al., 2003; Nir et al., 2003; Bruno and Guy, 2006). Under the new competitive circumstance, the ports have to compete in a macro surface and the competitive advantages consequentially rely on better compatibility with other sections of the logistics chain.

Competition among port has changed from competition for hinterlands and internal operation to competition among alternate logistics systems, among which ports form an important component. Shippers and their customers seek the best combination of logistics provider, including steam ship carrier, third party logistics providers, customs house brokers, inland carriers and port operators for the overall operational performance of delivery system. To the extent that a spectacular port can be a part of the most efficient, effective and environmentally friendly logistics chain, then it will be able to out-compete other ports for a shipper's business. For instance, Tianjin Port, Dalian Port and Qingdao Port are the main competitors of the China's Bohai Rim gateway port market. Either Dalian Port or Qingdao Port has much better natural conditions and handled much more cargo than Tianjin Port in the past decades.

But due to the research done by Chinese scholars, the better inland transport connection and assorted economic environment of Tianjin Port, and the politically appreciation from China's central government on it lead the recently dramatic increase of the throughput handled by Tianjin Port, while about a shift of estimated 20% of the total range traffic from Qingdao Port and Dalian Port to Tianjin Port.

2.3.3 The Intensified Port Competition

2.3.3.1 Competitive Market of Gateway Port

Under the optimized logistics network for decarbonization, the major port customers select a port as a sub-system in logistics chain not merely depends on the gateway interface but on the reliability, quality and environmental performance of the complete transport process. Routings are organized to avoid congested among the intermodal and movement of freight through the efficient ports to ensure the timely delivery of products to the end-market with the possible lowest carbon emissions. Port competition is traditionally regional and among the ports who share a similar hinterland. With the integration of the logistics network, the port hinterland has been exceeding the geographical boundary. The intermodal movement of freight through ports has increased the reach of markets served from a given port. As the hinterland continuously becoming an economic concept for port, ports have to suffer the challenge from other ports located beyond the vicinal region.

The new competitive environment intensified the port competition by introducing new competitors to the individual geographical niche-market and offering new opportunities to the existed competitors who have less market share. The ability of providing a joint free connection through the entire transport chain will be necessary for port to gain competitive advantage, thus the operations management and infrastructure investment concerning the fluency of the transport environment-friendly sub-network will bring a better competitive position to both the new competitors and the loosing competitors of a particular port market. Ports must compete with others for business by being efficient or by providing value-added services. Operational efficiencies increases are attributed to a combination of improved capacity management and gains in operational efficiency, with using proper inputs economically for the proposed outputs.

Moreover, the centralized ports for the transshipment of containers also will go on applied by the shipping lines to containerized fright from smaller feeder ports. The inherent advantage of the shipping lines owned ports/terminals will cause a loss of potential cargo growth of the other competitors in addition. Some new ports will in addition draw definite freight call for their advantaged natural location due to the near-shoring under the supply chain carbon reduction.

2.3.3.2 Increased Power of Port Clients

Due to the horizontal and vertical alliance with other stakeholders of logistics business, the shipping lines is playing more significant role in the global logistics network as providing logistics services (Wiegmans *et al.*, 2008). The shipping lines have the natural advantages to provide an overall logistics service combination for carbon reduction. For a real example, Maersk Logistics has launched a consulting service, which is been titled Supply Chain Carbon Check, to help companies reduce the carbon emissions from their supply chain. This service simulates carbon emissions for alternative supply chain scenarios and compares the results with the current footprint based on calculation. By revealing the potentials for reducing carbon emissions, Maersk Logistics can evaluate in terms of ease of implementation and cost savings and help the company put the recommendations to the practice.

Owe to the relative consulting or 3PL service, the shipping lines gains greater control power over the logistics chain by designing and deciding the route of cargo flow. Hence it is clear that a concentration of client power will be resulted in the port market in the enhanced network optimization for overall decarbonization, won't even mention that the slot capacity of the top 20 shipping lines takes 83%, increased from 79% in 2009, of the global total container slot capacity of 2010. The inspection triggered by European Commission months ago explored the possible anticompetitive behavior that breaches the European Union's monopoly abuse rules of some of the largest container shipping companies, including A.P. Moeller-Maersk of Denmark, CMA CGM of France and Hapag-Lloyd of Germany. Moreover, the shipping lines, such as Maersk, OOCL and Hanjin, have invested in operating terminals to ensure their control power through the logistics chain. With spreading their terminal investment along the logistics chain, few shipping lines will carry off the barging power of the pure port/terminal operators and control the ocean shipping market as monopolists.

With the enlarged competitive market and concentrated demand, ports cannot simply rely on the loyalty of client but have to face the operational risk due to the constant market imbalance. Ports have to increasingly deal with large port clients who possess a strong bargaining power facing the operations of terminal and inland facilities. Port operators have to predict and understand the preference change of the clients and marketing their service accordingly. In the optimized logistics network, the most distinguish value-adding service relies very much on the inland connectivity of the sub-system surrounds the particular port. Any conservative management strategy solely concerns on equipping terminal infrastructures and the one fold endogenous operation and planning will lead to the seriously loss of port's cargo traffic.

2.3.4 Uncertainty of Port Investment

Either the port investment is practiced by public port authority or private investor and operators, or both of them (Wiegmans, 2002); the port investment is always substantive and has a normally long-drawn return period. Container ports usually invest significant without any insurance of the potential freight and cargo growth. To compete with their competitor, ports have to take the certain risk of investment with the uncertain financial return due to believing that lack of investment will not increase business. After the preceding financial crisis, the investment funds from port authorities is witnessed declining and the patience of local community and national government on the whopping long-term capital investment is losing as well. It can be predicted that the withdrawal of governmental investment on port infrastructure will encounter financial pressures on port operations to remain the competitive edge.

The changing competitive environment and financial pressures immerses ports to a paradoxical dilemma which is dealing with the inconsistence of the funders' demand of recovery the investment with dispatch that based on attaining competitive advantage and belief that the best workable strategy to defeat competitors is building advanced facility and infrastructure. In the changing competitive environment, ports have to invest more on port infrastructure, green technology and the interface among the transport chain, ascribed the succeed requirements under the logistics network decarbonization. The inconsistency between the political and social force of carbon reduction and the financial force of profit raise the uncertainty of port investment. A sustainable port operation strategy is necessary to reduce the uncertainty and lower the risk of port investment while remaining on the competitive edge to survive in the intensified market competition.

2.4 Achieve Port Competitiveness Under Logistics Decarbonization

The port competitiveness can be understood as the endurable ability to acquire clients to select the port service of the particular port over competing substitute. To attain the competitive advantage under the carbon reduction of logistics chain, the ports have to pursue certain operational strategies which are enablers that determine their market share:

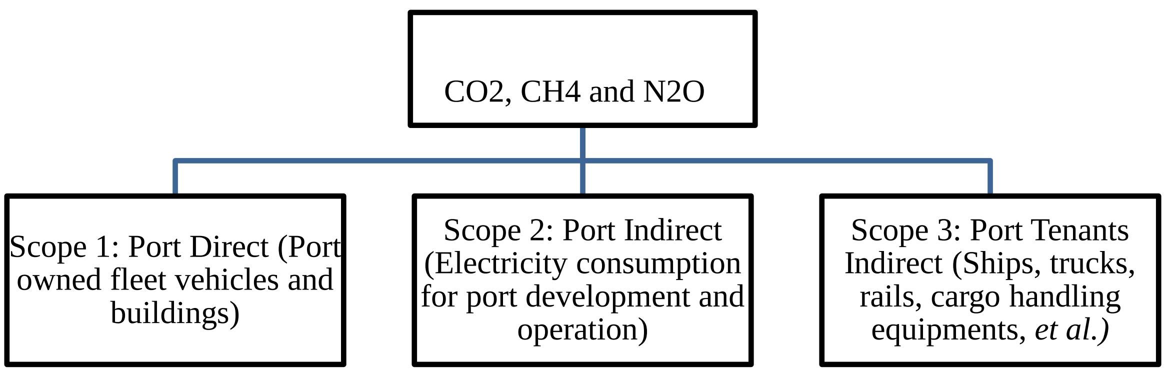
2.4.1 GHG Emissions Control of Port Operation

The environmental issue has become a factor of change in terms of obligations, responsibilities and competitiveness. Container ports have the similar major sources with other logistics sectors as airports, warehouses, trains and vehicles.

The major resources for carbon emissions in logistics sectors are energy and electricity consumptions (Canadell, *et. al*, 2007; Raupach *et al.*, 2007; Sundarakan et.al, 2010; Davis *et.al*, 2011; Mitchell, 2012;). However, the method for carbon footprint calculation of container ports is different from the other sectors. The ports are responsibility for not only the carbon emission yielded from their own energy and electricity consumptions, but also for the emission produced from the energy consumptions of container ships, trains, trucks during the port time. Such differences require operators of container ports to work on shortening average port time and releasing customer instruction on carbon emission, as well as improving their own energy utilization efficiency.

The port/terminal operators have to respond the competitive requirements by developing carbon management systems and programs. To reduce the carbon emissions within the port boundary, the source of carbon emissions is obligated to be analyzed. GHG emissions for an organization like a port are often categorized in terms of "scopes" that indicate how directly (or indirectly) the emissions are generated. Such categorization is a common element of emissions models and different protocols may define the boundaries of the scopes in a variety of ways. Scope determination is a central consideration and will further define how port sources are categorized. Based on the "scope" method, there are two main manners of scope definition with different consideration. The traditional one believes that only a fraction of those emissions are associated with port operations. The emission sources that are directly controlled by a port authority are an even smaller fraction of overall port-related emissions, which also include emission sources under control of port tenants (i.e., ships, harbor craft, trucks, rail, and cargo handling equipment). In order to address the climate change impacts associated with all port-related operations, this framework considers both direct port authority-related sources as well as the port tenants' sources. This framework covers topics and measures that affect emissions falling under all three traditional emission scopes. The traditional definition of scopes is illustrated below as it may apply to emissions associated with a port.

Figure 2.3 - An Illustration of Scopes as They Pertain to Port Operations



Another relative new manner as shown in Figure 3 divedes the emission sources in the following scopes:

- Direct emissions (scope 1) are those emissions that were emitted from sources of which the port has operational control. These emissions are mostly originating from the combustion of fossil fuels. Preferable emissions are always calculated by multiplying the fuel consumption per fuel (or unit mechanical power used) with the relevant national carbon emission factor;
- Energy indirect emissions (scope 2) are related to the import of power, heat and steam on sites controlled by the port. The origin of imported power is not

known for all sources. These emissions are usually calculated using international emission factors from the IEA statistics;

- Other indirect emissions (scope 3) are non-direct or energy indirect emissions that can be attributed to operations of the port.

These categories are more reasonable and available to the ports to adopt, as they only consider the factors which can be controlled by ports and could avoid the possible confusions caused by heterogeneity of different ports. The activities resulting in the three scopes for the port can be categorized in the following way:

Direct emissions (scope 1)

- Fuel usage for heating of port buildings;
- Fuel usage by company owned cars of port;
- Fuel usage by operational vessels owned by port;
- Fuel usage by operational machines and cranes owned by port;
- Capture and storage of GHG on the port;
- Combustion of biomass in operations controlled by the port;
- Export of energy from sites that are under the control of port.

Energy indirect emissions (scope 2)

- Electricity usage by cranes owned by port;
- Electricity usage for the purpose of harbor lightning port;
- Electricity usage for buildings owned by port;

- Electricity usage by lighthouses owned by port;
- Electricity usage from other sources in port;
- Heat or steam imported by the port;

Other indirect emissions (scope 3)

- Kilometers driven (by car) by commuting employees;
- Kilometers driven (by train) by commuting employees;
- Kilometers driven (by bus) by commuting employees;
- Kilometers driven (by motorcycle) by commuting employees;
- Kilometers driven (by boat) by commuting employees;

There are still some emission sources which have a negligible impact on the total carbon footprint could be taken into account further based on the stakeholder expectations, feasibility and reduction, such as the technical gases that are produced as a by-product during combustion processes and F-gases as a result of cooling processes.

Ports are obligated to deal with each source of GHG emissions with investment and management reform chasing for update technology and advanced operational thoughts to remain a certain environmental performance. The drivers for ports investment and operational reform in environmental performance, environmental performance indicators, and environmental programs are already in place or undergoing, and their impact to port’s operations, marketing and finance. The concerns on the reducing carbon emissions involve carbon control of assets and infrastructure, the use of energy-efficient vehicles, waste reduction through process optimization. Increasingly one can expect that the existence of GHG monitoring will simply be part of the regulatory regime. Starting with the GHG monitoring, the port GHG emission from the scopes can be effectively reduced potentially through engine replacement, clean energy, emission control technologies, operational improvements and training.

The port is suggested to repower the harbor craft main and auxiliary engine; replace the older cargo handling equipment, locomotive and construction equipment; the frequent used heavy and light duty vehicles (Giuliano & O'Brien, 2007), with the new items that meet cleaner engine standards and building longer trains for overall fuel efficiency. The ports should also implement the use of cleaner fuels, such as the emulsified diesel fuels, with low sulfur content for the equipment including vehicles. For instance, a wide survey within shows that many ports have introduced new vehicles to replace the old types of higher fuel consumption, and the carbon emission can be relatively reduced for 10-15% averagely. By using electricity instead of oil for the RTG container cranes since last year, Qingdao Port of China has save total 80 million RMB of energy cost and reduced 47,000 tones of CO_2 emission while the average TEU handling cost dropped 60%. With applying the similar scheme, Shekou Port of Shenzhen in China achieved annual energy saves is around 11,000 tones of coal and CO_2 emission reduction for 20,000 tones.

Besides the technical improvement of equipment and infrastructure, the port need to enhance the efficiency of gates and terminals, relieve congestion by moving more cargo to rail and water where feasible in off-peak terminal hours; encourage more efficient use of duty vehicles; increase the efficiency how trains are stacked and queued and building trains to reduce drag to maximize the emission reduction. Increasing attention on the fuel savings achievable and the proficiency through equipment operator training programs and offering relative courses of GHG emission could also be helpful to emissions manage from the behavioral aspects of port operation.

2.4.2 Improve the Operational Efficiency

Port plays an important role in global industrial and logistics network as a logistics and industrial center and subsystem of supply chain and provides hinterland access and indispensable link to the logistics chain. The creation of port competitive advantage depends on the reliability and fluency of the interface service port provided rather than lower cost in the optimized transport network integration. The efficient port operation can ensure the speed and reliability of port services. The port operational efficiency deal with capital and labor productivity as well as asset utilization rates (Tongzon and Ganesalingam, 1994). Port productivity can be applied to evaluate the financial and operational performance as an efficient port can produce more outputs with certain inputs by a more effective way. Ports traditionally provided only berthing service, temporary storage and infrastructure for cargo handling and movement within port. The development of global supply chains changes ports' towards environmentally efficient distribution of products across supply chains as opposed to performance in loading, unloading of ships and berth availability.

In moderate port industry, the cargos must be moved to the markets on time and under fixed carbon emission limitation, while the terminal operators as vital nodes in the logistic chain must guarantee shipping lines very reliable service levels. These include on-time berthing of vessels, guaranteed turnaround time for vessels and guaranteed connection of containers which all can assist in the carbon reduction of logistics chain. Only an efficient port, which expend its capital and labor investment in the precise way, can fulfill the new role and need of the customer in the new environment oriented supply chain. The efficient transportation of cargo promoted by port can lower the cost of maritime transportation and improve the service quality. Operational efficiency can smooth the port connectivity to lower the maritime transportation cost and time.

Port efficiency can be conventionally viewed to reflect the freight rates charged by shipping companies, turnaround time of ships, cargo dwelling time and GHG emissions of the shipping scheme. The longer a ship stays at berth, the higher is the cost that a ship will have to pay which can be passed on to shippers in terms of higher freight charges and longer cargo dwelling time, and thus debase the priority of a port to the shippers and shipping lines. As mentioned, the cargo dwelling time at port is significant for compensation of the time loss due to the despeeding for carbon emission reduction. The ports also have to deal with the unexpected increase of the carbon emission and evolution yield by the unwanted delay of ships departure.

Due to the benefits brought the users, higher efficiency attracts more clients with more choices offered. With better port infrastructure management and higher operational efficiency, individual port can perform better in frequency of ship visits, shipping capacity, range of services and maximum ship sized. Based on the efficient operations, the value added service in low carbon route can also benefit port directly or indirectly. Service customizing and providing value-added service even at higher prices have been suggested to be port competitive advantages in the present era. Substantial market share and financial returns can be attain from technology investment with the insurance that the efficiency gains can obviously bring cost and time savings to port operators (Low, 2010) and users , as well as the environmental benefits to port operation and port users' shipping route.

Port efficiency has a significant influence on gateway port competitiveness by reducing transport costs and time; and improving service in the form of effective and reliable transport service provided to the customers. In the decarbonizating logistics network, port efficiency will increase the attractiveness of a particular port to the shipping lines and improve the business environment of a port socially and politically. With the consistent performance benchmarking among major gateway port world widely will show the industry the efficiency frontier (Tally, 1988). Studies on port efficiency can improve the understanding of the port efficiency and find the source of inefficiency. Port is obligated to implement efficient operations for maintaining more flexibility and responsiveness to the preferences of shipping lines in the optimized integration of the logistics chain.

2.4.3 Inland Connectivity and Port Networking

Cooperation with the collaborates from the upstream and downstream within the supply chain, such as the shipping lines and the inland transport system, port can upgrade the service ability to preserve the competitive edge effected by updated route selection rules of shipping lines. The shipping route and the transportation modes will be changed and the low-carbon route could be a marketable feature considering that the carbon management policies are continuously implemented. The port choice will be influenced by the decarbonization as the shippers could select the ports that have great connectivity to lower carbon transportation modes and shorter distance to the final destination as the last "jump node". The ports operator and governmental authority need to respond the changing demand of port service with large investments to improve the market share of their port in the competitive market. The forecasting approach is required for port operators and government to support the further decision. Thus it is necessary to model port competition with the updated potential determinants of shippers' choice. Zondag *et al.* (2010) models the port competition considering the maritime, port and hinterland characteristics.

Under the optimized network, port competition is considered as among sub-logistics-chains which consists marine and inland connectivity's that connecting the original nodes, ports and destination nodes. Gaining competitive edge in the port industry more and more is a matter of extending the strategic scope beyond the geographical boundaries area of the ports. The port competition will be started with the ship loading, through ship unloading, storage transport, storage loading transport and be ending at hinterland loading. The shipping firms has been viewed as being in the logistics business and even acting as the leaders in the developing integrated system. The shipping lines rather than shippers, have more power on the route selection for the development of logistics integration and 3PL contracting. The shipping lines will prefer to select sub-systems to organize an atmospheric friendly route for cargo flows. Although the routes will not be pure carbon emission minimization route, the shipping line will adjust its preference by adding carbon reduction in to concerns to satisfy the decarbonization requirement of the upstream participants due to its responsibility for part of the goods according to the Life Cycle Assessment (LCA) framework.

The most important strategy for port/terminal operators in the decarbonization millennium is definitely the cooperation with inland transport nodes, especially with the “green” manners such as railway connections and inland water transport. The port has managed to operate inland terminals such as rail terminal, barge terminal and dry port to broaden the geographical scale of its activities continuously. The optimized transport chain forces port/terminal operators to be engage in port networking with the inland ports and transport franchise. Gaining competitive advantage in the port industry more and more is a matter of extending the strategic scope beyond the geographical boundaries of the port area. By extending the strategic scope, port will enlarge the sub-systems surround itself then gain more power through the logistics route and will earn competitive edge by forming the environmentally friendly connection to the next node of the logistics chain. The port networking strategies can vary from informal coordination schemes to regular partnerships through strategic alliances, joint-ventures or even mergers and acquisitions. For instance, the port authority and operators of Tianjin Port have already operates its own inland terminals including dry ports and railway terminals at Hebei and Tianjin. Besides the direct investment, Tianjin port has also established strategic alliance with some inland terminals through the cooperation agreements of the local governments. It is conceivable that the optimal form for shaping the coordination and cooperation within a port network is depending upon the institutional and legal status of the stakeholders.

The port operator must develop new resources and capabilities to ensure the well balance of port networking instead of a loss of port throughput. Of primary importance is the development of location policy in the port networking. Scare resources need be allocated precisely for the expected specific function of the proposed inland partner of scope of the port. Methodology and model for solving partner selection problem is required to possess better resources to meet the demand linked to particular activities. Port is also suggested to cooperate and coordinate with oversea ports and neighboring ports on traffic management, site issuing, hinterland connections and environmental protection. Cooperation with oversea ports can ensure the barging power of all partners involved and provide port clients value added service with possible lower cost. The co-opetition among the neighboring ports will leads to reducing the investment uncertainty by information and capacity sharing.

A port networking strategy focused on environmentally friendly inland transportations enables port operators to tackle the problem of diseconomies of scale, which also could redound to the reduction of the average cargo carbon emission during the supply chain. It has been suggested that load and distribution centers can generated positive environmental influence to the logistics chain. Kia *et al*. (2010) investigated the amount of atmospheric pollution produced by: port to destination by truck and port to destination via Distribution Center (DC), which is an intermediate point between port and destination. The authors declare that the concept of DC also increases the number of containers destined to country areas carried by train resulting in less atmospheric pollution, eliminates dwell time and double-handling of containers at port terminals, and reduces the cost of transport and inventory costs on cargo. Inland terminals or dry port can make it easier to preserve their attractiveness and to fully exploit their potential economies of scale. The corridors towards the inland terminal network in fact create the necessary margin for further growth of the sea-borne container traffic. These inland terminals acquire an important satellite function with respect to the seaports, as they help to relieve the seaport area of potential congestion.

2.5 Conclusion

Currently, the transportation network and its associated players are viewed as major contributors to GHG emission and as such, must play its role. Simply put, shippers, and gateways can wait to do what they are inevitable told, or they can take the lead in the addressing the issue. It is not just about keeping regulators and neighbor's happy, it could mean getting a jump on the competition. The gateway adopting improved efforts to streamline internal operations and increase the efficiency of inter-nodal connections this can aid in the reduction of congestion and pollution associated with gateway terminals, improved social license and the potential of capitalizing on a trend that will inevitably again momentum in an increasingly carbon constrained world.

This study focuses on the carbon emissions of yield from the activities which can be controlled by the operators. Therefore, emissions that generated from port activities and ships are discussed rather than the emissions that generated from the industrial activities happened in port area. This research suggests that a successful port operator must constantly prepare to adopt new strategies in order to cope with the changing market environment. Key notions for port industry in the logistics network decarbonization are pressures on carbon emissions reduction technologically, optimized transport integration and the increased port competition added to it. It has been suggested that the traditional approach does not provide all necessary tools to cope with the highly competitive market environment and to secure their position in the global transport network. The traditional approach for attaining port competitiveness cares only improving the port capacity and inner infrastructure development has to be complemented based on greater flexibility and a focus on the logistics performance in the whole transport chain. This will allow a port operator to build core competitive advantages under the in the change the environment.

The network decarbonization is both challenge and opportunity to the ports. Port operators should apply the strategic scope that beyond that of a traditional facilitator. Port operator need to develop update technology and invest in cleaning infrastructure building that works on the carbon emission reduction within port area; improve the operational efficiency to reduce the congestions of port operation; and alliance with the inland transport to enhance the attractiveness of the subsystem in the supply chain to the shippers and shipping lines. Moreover, the port operators also need to prepare a carbon trading mechanism with the port industry stakeholders such as oversea ports, neighboring ports and shipping lines. The above topic would be a future research direction for port competition analysis in the decarbonizing global logistics network.

Chapter 3

Container Port Performance Evaluation Considering the Economic Environment

3.1 Introduction

The efficiency of decision making unit (DMU) measures the DMU's production capacity of producing outputs with given inputs. Port efficiency study is consequently significant to port operators and authorities. To provide valuable support to the policy makers, the efficiency evaluation should explore the ports' independent production capacity without the influence of external factors beyond the ports' control. However, intuitively, the container port industry is highly influenced by global economy for its role and functions. It is obvious that container throughput is significantly related by the economic development, the port location and hinterlands economic activity as well as situation of international trading. These relative factors are beyond the control of a container port but decide the starting point of the port's output. They are normally known as the heterogeneity of a particular container port. The results attained from traditional models ignoring the heterogeneity problem therefore cannot measure the port efficiency objectively and cannot provide supportive evidence for related policy makers.

As being operated under different economic heterogeneity, a container port with strong economic hinterland easily attains higher output than a port without strong economic hinterland. Moreover, the container throughput cannot be generated by container ports without the economic activities, especially the international trade. Under an economic crisis, the container ports normally yield downward output no matter how much effort it pays in the reduction of global trade value. This research introduces a new model of Data Envelopment Analysis (DEA) framework for seaport efficiency evaluation by adopting *Marginal Output* as output and considering the impact of economic environment on the container port. The model is then applied to evaluate the efficiency of the Chinese major container terminals.

The Marginal Output is introduced to reveal the output produced through the effort and resource which can be controlled by the port operators. The gap among the extremely high ranks in throughput and relatively lower ranks in operations performance are normally observed in ports of China. By reducing the impact of hinterland trade value, the operators' ability on marketing and operations, as well as the productivity with certain inputs can be explored. To testify the findings, other model for efficiency evaluation considering the heterogeneity problem will be employed in the future research.

The total container throughput of the Chinese ports recorded 145 million TEU in 2010 at an annual increasing rate of 18% comparing to year 2009. In year 2010, 9 container ports are ranked in Top 20 of global container ports, highlighting the Port of Shanghai and Hong Kong possessed 1st and 3rd respectively. The container throughput in China constituted around 25% of global container throughput. The major Chinese container seaports lie in the East coast, covering Bohai Rim Region (Dalian, Tianjin and Qingdao), Yangtze River Delta Area (Shanghai and Ningbo), Pearl River Delta Area (Shenzhen and Guangzhou) and Southeastern Area (Xiamen).

The total container throughputs of Bohai Rim Region (30 million TEU), Yangtze River Delta Area (45 million TEU) and Pearl River Delta Area (43 million TEU) accounted for 78% of the total container throughput of Chinese Seaport in 2010.

In the same year, the total GDP of the hinterlands of the above container port clusters reached more than CNY 1900 billion, and accordingly the total value of exports and imports performed excellent by achieving USD 200 billion, accounting for 66% and 79% respectively of the Chinese mainland. Since 2004, the Chinese governments and port authorities have enhanced the capital investment and supportive policies on container port industry to gain the competitive advantages and economic benefits in the global supply chain. To analyze the effect of the relative policies and the abundant amount of investment, it's necessary and significant to evaluate the performance of the major Chinese container ports.

3.2 Literature Review

Various academic studies focus on understanding and evaluating the operational efficiency of container ports, by applying different methods, mainly including Stochastic Frontier Analysis (SFA) and DEA. Some studies choose SFA to undertake the technical efficiency analysis (Roll & Hayuth, 1993; Coto-Millan *et al.*, 2000; Cullinane & Song, 2003; Margono & Sharma, 2006) for their research objectives. The majority of efficiency studies are about the DEA application to the seaports transportation. Roll and Hayuth (1993) presents a theoretical exposition and utilizes the cross-sectional data from financial reports to make the DEA solution operational and efficient. They find that the port re-development could take larger container vessels and then augment the throughputs. Tongzon (2001) applies DEA-CCR model to exhibit an efficiency measurement for 4 Australian and 12 other container ports around the world, using cross-sectional data from 1996. The total number of containers loaded and unloaded, and ship working rate are chosen to be output factors. He introduces a variety of input factors such as labor, land and capital which detailed in the container port equipments. Hidekazu (2002) applies DEA on efficiency of 8 major international container ports incorporating the data from 1990 to 1999, and then shows the significance of increasing import cargo and aggrandizing the capacity of receiving the large-size container ship of a container port to remain efficient during the re-development. Barros (2003) selects the Portuguese seaports to evaluate their technical and allocative efficiency; and analyzes the productivity change of the seaports in Portuguese using the Malmquist indicator. Wang *et al.* (2003) compares the CCR, BCC and FDH models of DEA framework to research the container port terminal efficiency. Top 30 container ports around the world in 2001 are chosen into the model respectively. The TEU throughput is defined as output and quay length, terminal area, quay crane, yard crane and straddle carrier are defined as inputs in this study. Cullinane *et al.* (2005) employs DEA to emerge the main objective of privatizing the ports to improve the efficiency.

Table 3.1 shows some other major DEA applications on evaluating the port or terminal efficiency for the review of input and output factors choice. As far as the previous studies of DEA applied to the container port or terminal is concerned, container throughput is a widely-used factor as output and various factors are used as input factors. However, the container throughput is influenced by some factors beyond the controlled of container ports/terminals' operations, which can be understood as the DMUs' decisions. The direct utilization of container throughput as output may lead a biased evaluation of the ports' operational efficiency. Therefore DEA application on the port efficiency evaluation should consider the economic heterogeneity of DMUs involved. Otherwise, a well operated container terminal with less developed economic hinterland would report a lower efficiency than a container terminal with hot economic hinterland due to ignoring the economic effects.

This study attempts to capture the macroeconomic influence by introducing a new model to the port efficiency study with a new output factor, *Marginal Output*. *Marginal Output* is defined as the ratio between the terminal's container throughput and the total trade value of the terminal's hinterlands. This output measures the terminal operator's capacity of producing the container throughput with given inputs under the hinterland's 1 million dollars trade value. This factor describes the operational output of the terminal operators under the similar macroeconomic influence. Given this output, the effect of macroeconomic heterogeneity on the port efficiency evaluation can be reduced and the real operational efficiency level of port operators is explored. In other words, this model can picture the true consequence of the decisions made by each DMU of the system without the main macroeconomic effects. To some extents, the non-homogeneity - inherent characteristic of DEA can be reduced by applying this ratio output, leading to an impartial comparison in the model. We then compare the efficiencies obtained by using different output measurements, the *Marginal Output* and *TEU Throughput*. This is the first time of concerning the economic heterogeneity with DEA based port performance analysis.

The rest of the paper is organized as follows. Section 3.2 reviews the theoretical basis of DEA framework and introduces the selected DEA models. Section 3.3 illustrates the definition of input and output factors and the data set. Section 3.4 shows computational result and its empirical interpretations. Section 3.5 concludes the research with proposing future study.

Table 3.1 - Factors selected by previous relative research

Author	DEA Model	Inputs	Outputs
Roll and Hayuth (1993)	CCR	Manpower; Capital; Cargo uniformity	Cargo throughput; Level of service; Users' satisfaction Ship calls
Martinez-Budria *et al*. (1999)	BCC	Labour expenditures; Depreciation charges Other expenditures	Total cargo moved through the docks; Revenue obtained from the rent of port facilities
Tongzon (2001)	CCR Additive	Number of cranes; Number of container berths; Number of tugs; Terminal area; Delay time; Labour	Cargo throughput; Ship working rate
Valentine & Gray (2001)	CCR	Total length of berth Container berth length	Number of containers Total tons throughput
Lee, Kuo & Chou (2005)	CCR	Number of cranes; Number of container berths; Number of tugs; Delay time; Labour	Cargo throughput Ship working rate
Cullinane, Wang, Song & Ji (2006)	CCR BCC	Terminal length; Terminal area; Quayside gantry; Yard gantry; Straddle carrier	Container throughput

3.2 DEA framework

DEA, as a common technical tool for evaluation of organization's performance, is a linear programming technique for measuring the relative efficiencies of DMUs. The selected DMUs should use similar inputs to produce similar outputs where the multiple inputs and outputs are incommensurate in nature. Furthermore, the DEA model provides estimates of the potential improvement comparing to the efficient DMUs, which can be made by an inefficient DMU. Thus, the efficiency scores assessed by DEA should be clearly understood and carefully explained. Meanwhile, as the DEA method yields relative efficiency of each DMU in the system, it requires high homogeneity of the DMUs. The DMUs should have control over the production process they employ to convert their resources into outcomes. For the fairness of comparing, the DEA models should be utilized with proper research scope and factors selection therefore. The efficiencies assessed in the context by DEA are intended to reflect the scope for output augmentation without additional resources (Thanassoulis, 2001). The efficiency of a DMU is defined as the ratio of output and input, which cannot be greater than 1. The efficient frontier is then determined by defining the output from the input so as to make DMUs achieve their highest efficiency scores. DEA evaluates the efficiency of each DMU by choosing a combination of weights upon input and output factors. The relative efficiency scores provide a direct view on the benchmarking of operational performance of the selected ports within the competitive port service market. Results of the DEA model can suggest the DMU of container port on what operating practices, mix of resources and scale of size a DMU of container port/terminal can adopt to improve their performance.

This study employs DEA-CCR model, introduced by Charnes *et al.* (1978), and DEA-BCC model, introduced by Banker *et al.* (1984) to evaluate the relative efficiency of container terminals of the Chinese major container ports, with respect to the output orientation for capturing the characteristics of the Chinese container port industry. The container ports are commonly supposed to maximize the outputs usually measured in TEU, with the given inputs. The TEU throughput is closely to the need for cargo-handling facilities and services especially terminal facilities. Meanwhile, it is also a primary standard to assess the relative size of a container port or terminal, investment power and even the port active level. Furthermore, it directly connected to the revenue and benefit of container ports or terminals. It is an important index to rank the ports normally not matter what other factors are adopted to evaluate the ports efficiency.

Assuming that there are *n* DMU_j (*j=1,…,n*), use *k* inputs x_{ij} (*i=1,…,k*) to produce *s* outputs y_{rj} (*r=1,…,s*), the relative efficiency score of DMU_o is acquired by computing the model submitted by Charnes et al. [16] below:

$$\text{Max } \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{k} v_i x_{io}}$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{k} v_i x_{ij}} \le 1 \qquad j = 1, \ldots, n,$$

$$u_r \ge 0 \qquad r = 1, \ldots, s,$$

$$v_i \ge 0 \qquad i = 1, \ldots, k,$$

where input weights v_i and output weights u_r are the unknown variables, and the x_{io} and y_{ro} are the observed input and output values of DMU_o, the DMU to be evaluated.

The target is to obtain weight u_r and v_i to maximize the ratio of DMU_j. The computation of the above equations can be converted to a linear programming formed in equation (3) – (5) as follows:

$$\text{Max } \sum_{r=1}^{s} u_r y_{ro} = \theta_o$$

Subject to

$$\sum_{i=1}^{k} v_i x_{io} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{k} v_i x_{ij} \le 0 \quad j = 1,\ldots,n,$$

$$u_r \ge 0 \qquad r = 1,\ldots,s,$$

$$v_i \ge 0 \qquad i = 1,\ldots,k,$$

The values of θ_o are the scores of DMU_o relative to all DMU_j between 0 and 1. A DMU is efficient if $\theta_o = 1$ for $x > 0$, otherwise it is inefficient. Consider the dual problem of above model, let φ and λ_j ($j=1,\ldots,n$) be dual variables. The above DEA-CCR model can be reformed as following,

$$\text{Min } \varphi$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \varphi \;\; x_{io} \quad i=1,\ldots,k$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r=1,\ldots, s$$

$$\lambda_j \geq 0 \quad j=1,\ldots, n$$

the following equations further restricted λ_j ($j=1,\ldots,n$) is known as DEA-BCC model,

$$\text{Min } \varphi$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \varphi \;\; x_{io} \quad i=1,\ldots, k$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r=1,\ldots, s$$

$$\lambda_j \geq 0 \quad j=1,\ldots, n$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

Moreover, the output-oriented measure of technical efficiency of DMU_o thus is derived as,

$$TE = \frac{1}{\varphi}$$

The DEA-BCC model differs from the DEA-CCR model only in that it includes the so-called convexity constraint $\sum_{j=1}^{n} \lambda_j$ =1. Then the CCR model can be modified to assess efficiency under variable returns to scale rather than constant return to scale. In port operation, returns to scale refers to changes in output subsequent to a proportional change in all inputs. If output increases by that same proportional change then there are constant returns to scale (CRTS). If output increases by less than that proportional change, there are decreasing returns to scale (DRS). If output increases by more than that proportion, there are increasing returns to scale (IRS). The economy of scale refers to the marginal cost of producing the port service decrease as production increases. Therefore, it is significant to the port operators to identify the return of scale for future decisions on cost control and efficiency improvement. The technical efficiency is concluded from CCR and BCC models as follows to measure the efficiency score of DMU_o:

$$SE = \frac{TE_{\_CCR}}{TE_{\_BCC}}$$

If SE =1 then the score is efficient otherwise the score is inefficient if SE <1.

DEA models have been successfully applied to efficiency evaluation of several areas, as financial services, police services and medical services for its advantages. But they should not be simply adopted to evaluate the efficiencies of DMUs in container port industry due to the macroeconomic heterogeneity issue. The improper utilization of DEA models in port efficiency study may cause significant biased findings of the researches; and should be avoided with further considerations about the features of container port industry. One way to improve the accuracy of relative studies is to select the appropriate research objectives and input and output factors.

3.3 Indicators and Data Sample

It is critical to select the appropriate input and output to DEA applications. Input and output factors should reflect the container port's actual production objectives and process as accurately as possible. The biased or inappropriate factor selection will probably mislead the findings. Most of the previous relative studies on container port efficiency utilizing DEA method ignore the impact of economic environment as focusing on the container throughput as an output to directly assess the efficiency of container ports or terminals with normal DEA models. This misplay against to the nature of the DEA method and container port industry may consequently causes the results of their researches biased and less reasonable. Given the errors of DEA utilization, a high-level TEU throughput easily determines a port or terminal efficient, or not, no matter what the operational performance of the DMU is. The results of this kind of researches cannot exactly explore the performance of the container port/terminal controlled by the DMU, and the findings based on these results are less supportable therefore.

To decrease the affects of the macroeconomic on the operational performance evaluation, a straight way is to find the real output yields from the operational decisions of the port/terminal operators. A new output, *Marginal Output* – ratio between TEU throughputs and total trade value, is introduced in this study to construct an advanced concept of port efficiency evaluation. This new output factor is a critical belt within the international trade chain, and the economic development level of hinterlands. The economic development level can be represented by total value of exports and imports (in million dollars) of main hinterland when concerning its effect on port development. This output factor measures the container terminals' productive capacity under the similar economic influence. The output of various terminals thus can be compared fairly. It is worthwhile to note that the rapid Chinese economy development and conditions of exports and imports contribute positively to the production of container throughput. In this sense, regards to the selected container ports in this paper, the impact of transshipped container over the total TEU throughput is ignored, in result of the tiny percentage they constitute. Besides, the boxes transshipped in the hinterlands are not considered in this paper either.

The other important ways to solve the problem is to advisably select the research scope and research objectives or, DMUs for evaluation. This research therefore focuses on the operational efficiency evaluation of the Chinese main container terminals, with the consideration of the empirical significance. The container terminals from one country are more homogenous than the terminals from different countries as sharing the same national level factors. The container terminal is designed as the estimating unit as it is the basic DMUs in the operation of the Chinese container ports. It's necessary to collect data from the container terminals from the major Chinese ports located in different region, such as Bohai Rim Region (Dalian, Tianjin and Qingdao), Yangtze River Delta Area (Shanghai and Ningbo), Pearl River Delta

Area (Shenzhen and Guangzhou) and Southeastern Area (Xiamen). The selected terminals are reported in Table 3.2.

The efficient operation of a container terminal is affected by the quality and quantity of supportive port infrastructure provided. According to orthodox economics, inputs to any form of production process can normally be classified as capital, labor and/or land. Container terminals' production depends on the efficient utilization of capital, labor and land. This study focuses on the capital inputs (in terms of equipment in container terminals). The information of labor input cannot be precisely attained as the total employee of ports or terminals is normally an appropriate one in the application in China due to the low cost and redundancy.

Other input factors that may possibly impact the terminal efficiency evaluation are derived from the analysis such as berth utility, berth accessibility, crane operating hours, capital invested in a terminal, total employees of the terminals and the average rate of container handling, due to the data confidential as well as the practically insignificance. The input factors of this study are number of berths, container storage capacity, capacity of terminal facilities, refer points, length of berths and terminal area. It needs to note that, the input "Capacity of Terminal Facilities" implies the sum of quay cranes, ship-shore container gantries, gantry cranes, yard cranes, yard gantries, reach stackers, yard tractors, forklifts, straddle carriers, etc.

Data of single output and 6 inputs are collected to evaluate the performance of container terminals in mainland China from 2004 to 2007. Additionally, the updated data is more worthy for research and a meaningful instruction for port efficiency evaluation in China consistent with its rapid development. The main data sources are the statistical yearbooks of the National Bureau of Statistics of China, and the Containerization International Yearbook, which provide comparatively accurate data and intelligence on the container industry. The websites of port authorities and container terminals also offer statistics to complement or verify some of the information about the terminals. A summary of the statistics information is presented in Table 3.3. As the extreme difficulty of getting confidential data from port operators, some respective data could not be applied into the model. However, the results of this study are still objective and reliable for the utilization of other alternative factors for measuring the terminals' operational performance.

Table 3.2 – Container Terminal List

Port	Terminal	Code
SH	Shanghai Container Terminal	SCT
	Shanghai East Container Terminal	ECT
	Pudong International Container Terminal	PICT
	Waigaoqiao Terminal	WGQT
SZ	Chiwan Terminal	CWT
	Shekou Terminal	SKT
	Yantian Terminal	YTT
QD	Qingdao Container Terminal	QCT
NB	Beilun International Container Terminal	BICT
GZ	Nansha Terminal	NST
	Xingang Terminal	XGT
	Xinsha Terminal	XST
TJ	Tianjin Container Terminal	TCT
	Tianjin Port Alliance International Container Terminal	PAICT
	Orient Container Terminal	OCT
XM	XICT Terminal	XICT
	Xiamen Songyu Container Terminal	XSCT
	Xianmen Haitian Container Terminal	XHCT
DL	Dalian Container Terminal	DCT
	Dalian Port Container Terminal	DPCT

Table 3.3 - Data Summary

	Output	Input					
	Marginal Output	Number of Berths	Container Storage Capacity	Capacity of Terminal Facilities	Reefer Points	Terminal Area	Length of Berths
Max	7197	15	97473	6926	3672	1820000	3058
Min	97	1	4300	29	174	270000	640
Mean	1283	5	41275	253	950	801486	1491
Standard Deviation	1472	2	26587	797	737	452456	694

3.4 Computation Results and Interpretation

The results are obtained by using DEAP to solve the models with dataset. The efficiency gains of DEA-CCR model and DEA-BCC model using *Marginal Output* as the output factor, as well as scale efficiency and return to scale of the selected Chinese container terminals in 2004-2007 are reported in Table 3.4 and Table 3.5. Four terminals (NST, PAICT, XSCT and XHCT) are excluded from the efficiencies evaluation of 2004 as they are not officially formed until 2005. Container ports form a vital link in the overall trading chain and, consequently, port efficiency is an important contributor to a nation's international competitiveness (Tongzon, 1989; Chin & Tongzon, 1998). Meanwhile, marine industry has switched into a capital-intensive industry instead of a labor-intensive one in the past. The efficiency of container port becomes a critical factor affecting the port development in the fierce competition and is highlighted by the port operators to evaluate their investment and operational performance.

According to the efficiency scores, some of the Chinese main container terminals are being well operated during 2004-2007 considering the economic impact on port throughput. Among the selected terminals, the Qingdao Container Terminal and Dalian Container Terminal are operated with the best operational performance as they are on the efficient frontier during the whole time period. The efficiency values of these two terminals equal to 1 under every DEA model and in each year. Only 3 out of 20 container terminals are identified as efficient in the CCR model, and BCC model identifies 9 efficient terminals in 2005, which is the bottom of the container terminal productivity in the selected years. As expected, the BCC model yields higher average efficiency scores than the CCR model in the time period. Besides, the BCC model identifies more efficient terminals than the CCR model, because the CCR model with an assumption of constant returns to scale provides information on technical and scale efficiency together, while the BCC model with the variable returns to scale assumption identifies technical efficiency alone [20]. All efficient terminals identified in the CCR model are evaluated as efficient in the BBC model, signifying that the dominant source of efficiency is scale. 2 and 10 efficient terminals out of 16 samples are identified by the CCR and BCC model respectively in 2004. The number changes into 4 and 9 of 20 respectively in 2006 and then increases to 6 and 11 of 20 in 2007.

Empirical results reveal that there exists substantial waste in the production of the container terminals in the sample. For instance, the average efficiency of these terminals under evaluation equals to 0.437 (CCR) and 0.755 (BCC) in 2004, 0.359 (CCR) and 0.662(BCC) in 2005, 0.393 (CCR) and 0.647 (BCC) in 2004, this value increases to 0.479 (CCR) and 0.687 (BCC) in 2007. Most of the Chinese major container terminals show increasing returns to scale in the estimation period explores that the Chinese container terminals still have space to improve their productivity. Cullinane and Wang (2006) notes that the care must be taken to illustrate these results on economics of scale. Capital investment of container ports is significant and infrequent for future growth in demand. The huge capital investment is used to expand the capacity to the level in excess of what may probably be required in the current situation. These are real cases which are likely to happen to the larger ports or terminals which are expanding and operating successfully, compared to the smaller ones.

It has also found that the average efficiency of container terminals located in different regions differs from each other. During the selected period, it concludes that the average efficiency of container terminals in the Bohai Rim Region prevails amongst three major container port clusters of mainland China, not matter what model (CCR or BCC) is utilized. Oppositely, container terminals in Yangtze River Delta Area show the low average efficient among these regions. It may possibly reveal that the local economy development level, as well as conditions of exports and imports, would have impact to the terminals efficiency of ports or terminals; on the other hands, however, when the *Marginal Output* is introduced into the model to weaken the economy development’s influence over the container throughput, the terminal efficiency does not exhibit an inclination consistent with the opinion that large ports have a high efficiency.

This research calculates the efficiency of the same models while using *TEU Throughput* as the output to explore the difference of the results and the potential risk of the previous studies. For analyzing the difference of the results of choosing different output factors, the results of DEA-BBC model with different two output factors are reported in Table 3.6. It can be obviously found that the results of different models are quite different. Almost every container terminal’s efficiency within the most the famous Chinese ports as Shenzhen, Shanghai and Guangzhou drops sharply when using *Marginal Output* as the output comparing to using *TEU Throughput*. Contrarily, some terminals with in Tianjin, Ningbo and Dalian report lower efficiency using *TEU Throughput* as the output comparing to using *Marginal Output* for adjusting the influence of uncontrollable macroeconomic factors of hinterland. Although the average efficiencies of models with different output factors are similar with each other, the efficiency ranks of the selected terminals are almost totally different.

Table 3.4 - Results of DEA models in 2004 and 2005

Port	Terminal	CCR		BCC		Scale Efficiency		Returns to Scale	
		2004	2005	2004	2005	2004	2005	2004	2005
SH	SCT	0.379	0.207	0.399	0.214	0.951	0.967	Increasing	Decreasing
	ECT	0.205	0.377	0.212	0.607	0.967	0.622	Decreasing	Increasing
	PICT	0.23	0.342	0.265	1	0.868	0.342	Increasing	Increasing
	WGQT	0.399	1	0.401	1	0.995	1	Increasing	-
SZ	CWT	0.601	0.216	1	0.224	0.601	0.964	Increasing	Increasing
	SKT	0.573	0.155	1	0.167	0.573	0.928	Increasing	Increasing
	YTT	0.262	0.521	0.345	0.65	0.761	0.803	Decreasing	Increasing
QD	QCT	1	1	1	1	1	1	-	-
NB	BICT	0.873	0.245	1	0.848	0.873	0.289	Increasing	Increasing
GZ	NST	-	0.092	-	0.146	-	0.63	-	Increasing
	XGT	0.188	0.164	1	1	0.188	0.164	Increasing	Increasing
	XST	0.217	0.19	1	1	0.217	0.19	Increasing	Increasing
TJ	TCT	0.393	0.348	0.465	0.614	0.843	0.566	Increasing	Increasing
	PAICT	-	0.364	-	1	-	0.364	-	Increasing
	OCT	0.184	0.247	1	0.485	0.184	0.509	Increasing	Increasing
XM	XICT	0.167	0.174	1	1	0.167	0.174	Increasing	Increasing
	XSCT	-	0.056	-	0.098	-	0.574	-	Increasing
	XHCT	-	0.099	-	0.189	-	0.525	-	Increasing
DL	DCT	1	1	1	1	1	1	-	-
	DPCT	0.327	0.385	1	1	0.327	0.385	Increasing	Increasing
Mean		0.437	0.359	0.755	0.662	0.657	0.6	-	-

Table 3.5 - Results of DEA models in 2006 and 2007

Port	Terminal	CCR		BCC		Scale Efficiency		Returns to Scale	
		2006	2007	2006	2007	2006	2007	2006	2007
SH	SCT	0.172	0.176	0.177	0.241	0.967	0.214	Decreasing	Increasing
	ECT	0.289	0.171	0.48	0.201	0.603	0.607	Increasing	Increasing
	PICT	0.301	0.193	1	1	0.301	1	Increasing	Increasing
	WGQT	1	0.824	1	0.851	1	1	-	Increasing
SZ	CWT	0.222	1	0.228	1	0.971	0.224	Increasing	-
	SKT	0.126	0.541	0.134	0.586	0.94	0.167	Increasing	Increasing
	YTT	0.506	0.224	0.641	0.226	0.79	0.65	Increasing	Increasing
QD	QCT	1	1	1	1	1	1	-	-
NB	BICT	0.214	0.174	0.756	1	0.283	0.848	Increasing	Increasing
GZ	NST	0.172	0.091	0.284	0.097	0.606	0.146	Increasing	Increasing
	XGT	0.148	0.088	1	1	0.148	1	Increasing	Increasing
	XST	0.17	0.407	1	1	0.17	1	Increasing	Increasing
TJ	TCT	0.342	0.267	0.584	0.341	0.585	0.614	Increasing	Increasing
	PAICT	0.477	1	1	1	0.477	1	Increasing	-
	OCT	0.205	1	0.396	1	0.518	0.485	Increasing	-
XM	XICT	0.36	0.28	1	1	0.36	1	Increasing	Increasing
	XSCT	0.051	0.043	0.086	0.063	0.591	0.098	Increasing	Increasing
	XHCT	0.105	0.109	0.174	0.139	0.603	0.189	Increasing	Increasing
DL	DCT	1	1	1	1	1	1	-	-
	DPCT	1	1	1	1	1	1	-	-
Mean		0.393	0.479	0.647	0.687	0.646	0.739		

Figure 3.1 – The results of DEA-CCR model

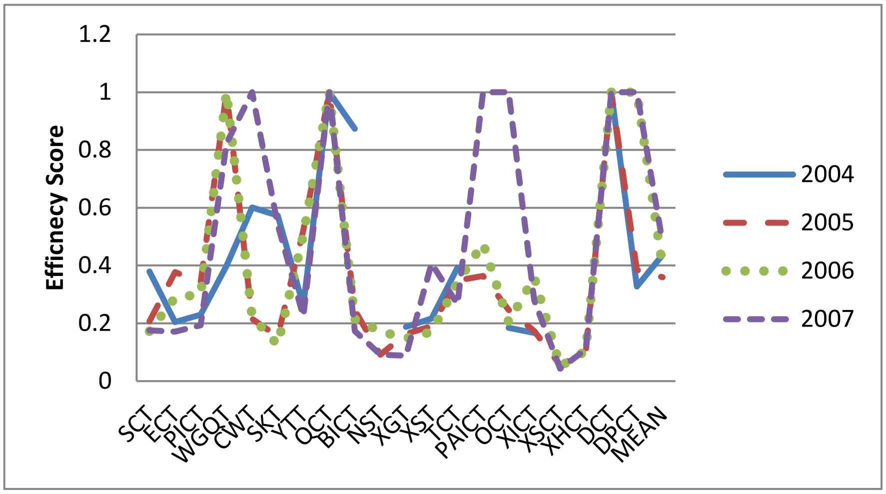


Figure 3.2 – The results of DEA-BCC model

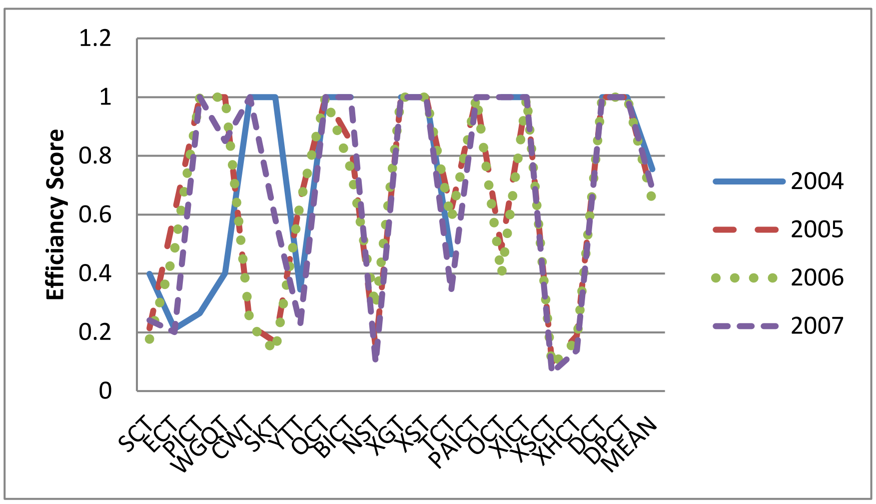
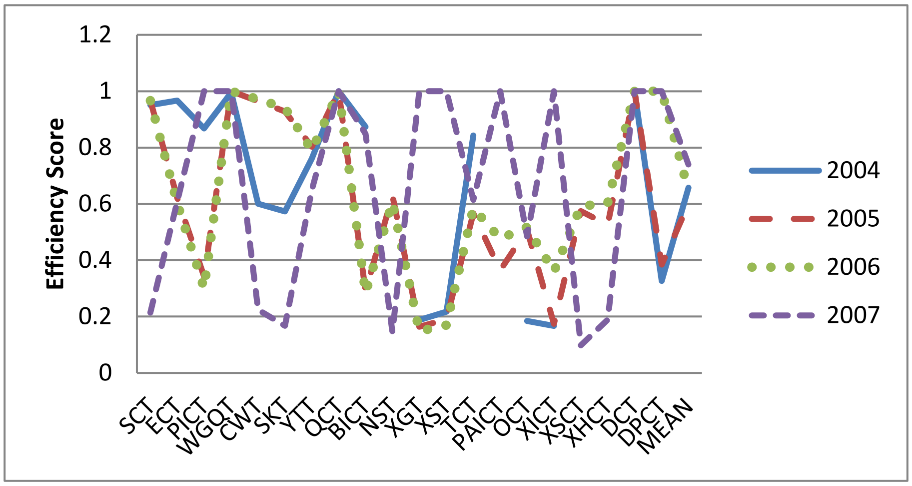


Figure 3.3 – The Scale Efficiency Values



This finding explores that some major Chinese container terminal are being operated not as well as it seems like. The high efficiencies of the Chinese famous ports as Shanghai and Shenzhen are mainly due to the large economic scale and well development of their economic hinterland, but not their operation. When the economic influence on each port is adjusted to a similar level, the productive capacities of those ports are actually lower than the mid-size Chinese ports. The great amount of container throughputs produced by those large Chinese container terminals is more possible because of the economic achievement of China, but not their efficient operation. Moreover, the previous relative studies ignored to consider the economic heterogeneities of container ports probably provides less reasonable findings accordingly.

It is important to note that, the results derived from DEA models with new output factor which reduced the influence of the economic heterogeneity and furnish the most possible optimum efficiency estimations in theory are useful and meaningful to take a close watch of port production, providing a pondering foundation on understanding of the operational efficiency of container port/terminal. In this regards, this efficiency estimation can merely offer the extension study area for the liner companies, port authorities and other relating parties for their review and consideration.

Table 3.6 – Results of DEA-BCC model with different output factor

Port	Terminal	2004		2005		2006		2007	
		MO	TEU	MO	TEU	MO	TEU	MO	TEU
SH	SCT	0.399	0.529	0.214	0.765	0.177	0.632	0.241	0.328
	ECT	0.212	0.51	0.607	0.976	0.48	0.715	0.201	0.233
	PICT	0.265	0.721	1	0.843	1	0.968	1	1
	WGQT	0.401	1	1	1	1	1	0.851	1
SZ	CWT	1	1	0.224	1	0.228	1	1	1
	SKT	1	1	0.167	0.738	0.134	0.564	0.586	0.643
	YTT	0.345	0.787	0.65	1	0.641	1	0.226	0.253
QD	QCT	1	1	1	1	1	1	1	0.639
NB	BICT	1	1	0.848	0.604	0.756	0.688	1	1
GZ	NST			0.146	0.253	0.284	0.452	0.097	0.11
	XGT	1	0.596	1	0.502	1	1	1	1
	XST	1	0.398	1	0.667	1	1	1	1
TJ	TCT	0.465	0.421	0.614	0.505	0.584	0.463	0.341	0.258
	PAICT			1	0.767	1	1	1	1
	OCT	1	0.204	0.485	0.484	0.396	0.399	1	1
XM	XICT	1	0.663	1	0.703	1	1	1	1
	XSCT			0.098	0.246	0.086	0.211	0.063	0.132
	XHCT			0.189	0.54	0.174	0.521	0.139	0.324
DL	DCT	1	1	1	0.674	1	0.599	1	0.206
	DPCT	1	0.082	1	0.193	1	1	1	1
Mean		0.755	0.479	0.662	0.673	0.647	0.761	0.687	0.656

3.5 Conclusion

This research is the one of first attempting to analyze the container terminal efficiency using DEA methods capturing the macroeconomic effects on each container terminal in China, and its developing logistics system. This study adopts the new output factor – the *Marginal Output* to commonly consider container throughput as the main output. The influence of hinterland's economy development over the container throughput of two different terminals have similar operational performance level can be consequently reduced. In other words, such model can probably measure the objective efficiency level of ports or terminals. The heterogeneous effects of efficiency evaluation applying DEA can be reduced by applying this ratio output in order to carry out a comparatively impartial evaluation through the model. Second, the paper collects the data of the Chinese major container terminal originated from the year of 2004 to 2007; such update information and the latest dataset is more valuable for the research especially there is no many existing articles which focus on DEA application to the port/terminal efficiency evaluation in mainland China with an updated data. The results obtained via the computation with the update dataset are more practical and worthwhile to be considered for the policy makers. Last but most importantly, by comparing the efficiency scores gained with Marginal Output, the results exhibited in this study reveal that the average efficiency of the Chinese container terminals could be not as high as it seems like; and the risk of misunderstanding and misevaluation might be hidden in the previous relative DEA application research.

Besides the economic heterogeneity concerned in this study, there are still some other issues as locations, economic and natural environments, politic and transportation systems should be further considered. However, the influence of heterogeneity on port efficiency evaluation is too complicate to be totally eliminated, and can be only reduced. The significance of dealing with the heterogeneity issues of DEA applications on container port study has been still exposure in this study. This research obtains more precise results by carefully adjusting the most important heterogeneity of container terminals, which is the economic heterogeneity. The findings can provide suggestions and more accurate insight of port performance to the container port/terminal operators and the relative policy makers. The extension of DEA framework also should be concerned with an extensive data collection survey by scholars to capture the heterogeneity problem in port efficiency studies Moreover, the competition among ports or terminals are no longer only influenced by the operational performance of the container ports/terminals, but also influenced by the operational performance of the logistics system the port/terminal involved. The idea and concept of this research can be developed to evaluate the performance of different logistics systems and other industries.

Chapter 4

An Efficiency Analysis of Dry Ports in the JNPT region of India

4.1 Introduction

At present, the logistics efficiency has been suffering from the consequences of massive over capacity resulting in unsustainable pressure on prices and profitability. In this environment the only possible way to survive for logistics firms is to cut costs and increase efficiency. The efficiency measures vary across different definitions of efficiency and identity of the factors involved. Therefore, the concept of efficiency should be studied cautiously by considering the different features and operational purpose of the research units. The efficiency measurement of logistics industry should take into consideration the changing business environment from both tangible as well as intangible perspective. In this vein the data envelopment analysis (DEA) is utilized to evaluate efficiency of the dry ports located in the JNPT region of India with two outputs viz; container throughput and service quality.

In the past decade, scholars have conducted various studies regarding the efficiency aspect of the transport industry from different perspectives. Tongzon (1995) specified and empirically tested the various factors which influence the efficiency and performance of a container port using empirical data from 23 international ports. Tongzon (2001) and Hidekazu (2002) applied DEA models to ascertain the factors influencing the efficiency of container ports. Farsi *et al*. (2006) computed the impact of cost and scale efficiencies on container ports operating within regional networks. The main focus of such studies was to ascertain the ability of DEA models to distinguish inefficiency from the unobserved firm-specific heterogeneity in a network industry. Roy and Yvrande-Billon (2007) investigated the impact of ownership structure and contractual choices on performance efficiency in the French port sector using stochastic frontier analysis (SFA). The econometric results corroborated the author's proposition that the performance efficiency of port operators depends on the ownership regime, in addition to the nature of contracts governing their transactions. A stochastic frontier analysis with cost function is also applied by Lan and Lin (2006) to measure the performance of hinterland rail services complementing the gateway ports. Growitsch and Wetzel (2009) conducted a pan-European efficiency analysis to investigate the performance of European railways with a particular focus on economies of vertical integration, and found beneficial efficiency advantages for such vertically integrated port companies.

Most of the productivity studies relating to logistics section research mainly adopted the container throughput as one of the outputs. If we accept this perspective, higher levels of throughput would indicate greater levels of efficiency with the unchanged levels of inputs. This argument is not only anomalous, but also untenable in industrial practice. The efficiency scores attained under this perspective cannot analyses precisely the real reasons behind operational performance of the individual ports as the container throughput is highly influenced by the factors beyond control of the decision making unit (DMU). Furthermore, this perspective also ignores the increased share of revenue brought by value-added service and the facts that maximize the throughput has not been the unique and unified operational objective of the business participators. In order to improve the focus of the dry port service providers, the output combination in this paper includes *Service Quality*, quantified with the help of the SERVQUAL model. We thus aim to develop a new perspective of efficiency evaluation. The selected DEA models utilized for efficiency evaluation in earlier studies have displayed beneficial advantages while dealing with multiple outputs and without selective usage of the empirical data. Unlike other relative regression techniques which assume a priory existence of functional relationship between inputs and outputs the DEA model is not constrained by such assumptions. A review of previous literatures using DEA method on efficiency evaluation in different fields can be found in several previous studies.

We propose to improve the understanding of performance analysis in hinterland transportation research by analyzing the productivity of the said 26 dry ports which act as significant nodes of the global supply chain and transport network. Usually located near/along gateway seaports, industrial regions and/or transportation axes, dry ports perform several important functions. (Nozick & Turnquist, 2000; Woxenius *et al.*, 2004). These functions include: (i) cargo aggregation and unitization; (ii) in-transit storage; (iii) custom clearance; (iv) issuance of bill of lading; (v) relieving congestion in gateway seaports; (vi) assistance in inventory management; and (vii) deference of duty payment for imports stored in bonded warehouse (Paul, 2005; Ng & Gujar, 2008).

The dry ports also play a key role in the logistics supply chain of a country's international trade and inland cargo transportation acting as a nodal point of cargo consolidation and distribution while providing connectivity to the gateway seaports. The concept of dry port should bring numerous benefits to the actors of the transport system (Roso, 2008); hence the operational efficiency of the dry ports has a bearing on the entire logistical supply chain. But before determining the efficiency of a dry port it becomes imperative to define the constituent inputs as well as outputs. It is also critical as well as necessary to understand and explore in the proper perspective, the fluctuations in the efficiency estimates with the variation in the constituent inputs and output factors. This paper in addition also endeavors to ascertain the relevance of efficiency itself from the dry port operator's perspective.

In order to determine the service quality of the dry ports we have made use of the SERVQUAL model. It takes into consideration five dimensions viz; Tangibles, Reliability, Assurance, Empathy, and Responsiveness. The overall effectiveness of a global supply chain to a large extent depends upon the speed and reliability of transport. Delays result in higher generalized and inventory costs. Hence the SERVQUAL model takes into consideration speed as well as the reliability of the hinterland transport service provided by the dry port operator. Furthermore it should also be noted that speed is not always critical for the dry port users as the value of the cargoes consolidated at a dry port may not be large enough to justify higher service charges necessary for transporting it to the gateway ports within shortest possible time.

The ensuing section of this chapter provides a research background to this paper with a review of major previous relative literatures. It is followed by Section 4.3, which is a conceptual buildup and explanation of service quality and validation of the SERVQUAL model for the quantification of the dry port service quality. Section 4.4

is an exposition of DEA methodology employed within this paper for analysis of a tangible as well as intangible data set of index collected from Indian dry port industry. Section 4.5 specifies input and output indexes which are utilized within the model developed specifically for the achievement of this paper's stated objective. This section also expounds upon the nature, for, substance and source of the data collection exercise. The results of the data analysis are presented in Section 4.6. The results of the analytical exercise along with conclusions and implications are presented in Section 4.7.

4.2 Literature Review

With the development of global multimodal supply chains, dry ports have assumed increasing importance to suit the need for market development, seamless integration and closer collaboration between the different participants of the supply chain and transport network. Thus, it is a natural corollary for the ports to extend the services to locations situated further hinterland by either patronizing, forming strategic alliances or buying out existing dry ports so as to optimize the supply chain. The establishment of dry ports allowed the shippers to undertake consolidation and distribution activities at inland locations relatively closer to their production facilities, resulting in the reduction of transaction costs and accompanying risks leading to their products becoming competitive in the global markets for example, textiles and automotive components. Due to the differentiation and customization of client demand, the profit model of port and dry port has been developed to a new stage. As the marginal profit of basic cargo dealing service continuous decreases, profit scale yields from satisfying customers' customized demand and improving the service quality is increasing in port and dry port. Even more the value-adding service has been separately provided by the dry port operators from the basic cargo transshipment services. Thus service quality should be take account into the efficiency analysis as output index with cargo throughput to catch upgrading industry and avoid research bias.

The concept of service quality is difficult both in defining it and measuring it (Wisniewski, 2001). There are several definitions and one that is commonly accepted is "the extent to which a service meets the customers' needs or expectations". The existence of customer-perceived logistics performance gaps would imply possibilities for improving logistics quality and customer satisfaction (Forslund, 2006). In other words, it could also indicate the difference between customer expectations of service and perceived service. Hence if expectations are greater than performance, then perceived quality is less than satisfactory and results in customer dissatisfaction (Asubonteng *et al.*, 1996). One of the most important ideas behind service quality is the statement by Gronroos (1984) that the perceived quality of a given service is an outcome of the comparison between the customer's expectations about the service and the perception about the actual service received by him. Taking this fundamental concept into consideration, Parasuraman *et al.* (1985) developed the gap model which has been extensively used in several service industries such as banking, hospitality, transportation, and retail etc. but is used for the first time to measure the quality of service offered by the dry ports in India.

Customer satisfaction is a critical component of service quality. In the current global economic environment, change is a norm and adaptability is significant to survival. As such the parameters of customer satisfaction are in a state of flux and the dry port operator is forced to alter his services accordingly to meet the demands of the customer. In this endeavor of aligning the expectations and perceptions of service quality of the dry port, the operator needs to be constantly aware of the expectations and perceptions about the services offered, not only of the customer but also of his employees and vendors.

Towards the end of 2008, about 200 dry ports have been established throughout India. Apart from the conventional functions as described above, dry ports in India are being perceived as the catalyst in promoting regional economic development (Dayal, 2006). As a consequence, the number of dry ports in India has accelerated recently, especially in view of the proposed implementation of establishing Special Economic Zones throughout the country and the simplification of customs procedures, notably digital documentation which would enhance transparency and simplify documentary processing. Contemporary global economy is characterized by increasing universality and consumption, of which simultaneous technological progress allows services to be provided at distant locations. This has opened up the global consumer markets to new economies such as India, with various special economic zones being established in notably Delhi, Punjab and Uttar Pradesh which promotes trade and exports for various agricultural, manufactured products and automotive components. To ensure that manufactured products can sustain competitiveness in the global market, cargo's shipment process must be smooth and efficient (Hariharan, 2001) which is likely to exert substantial pressure to India's supply chain (Sahay & Mohan, 2006). Being the inland logistics nodes of supply chains, the efficiency of dry ports becomes pivotal in complementing the changing role of ocean carriers and other stakeholders along the supply chain (Heaver, 2002; Sánchez *et al.*, 2003; Notteboom & Rodrigue, 2005).

It is this intense competition that characterizes the Indian dry port industry today which has stimulated interest in ascertaining the efficiency with which resources are utilized. Thus the analysis of performance of individual dry ports assumes significance for survival of the supply chain as a whole and competitiveness of the dry ports service providers in particular. Thus such an analysis will provide a powerful management tool for the dry port stake holders. In addition it will also constitute an important input for informing regional and national logistic planning and operations. It is imperative to note that the analysis contained within this paper is aimed at deriving comparing various estimates of the efficiency of the Indian dry port industry. Under the vigorous development of dry port industry, the study on the operational efficiency of Indian dry port would contribute on the operation management of the dry port located in the developing economy and the related policy issues of the local authorities.

4.3 Service Quality Conceptualization

The SERVQUAL model identifies any actual or perceived gaps between expectations of the customer on one hand and his perceptions of service offered on the other hand. This is one of the popular models used for service quality measurement developed by Parasuraman *et al.* (1985; 1991; 1993). As increased customer satisfaction levels is an important objective of the dry port service provider, the SERVQUAL model assists him in achieving this objective. As a result, the dry port operator can become more competitive in terms of cost, quality, delivery and flexibility.

Dry port operators like other organizations are realizing the significance of customer-centered philosophies (Bebko & Garg, 1985). The SERVQUAL model ascertains service quality and identifies service quality gaps. The model acts as an effective approach in analyzing the difference between customer expectations and perceptions. The model can assist in closing service quality gaps associated with customer services. As being applied in dry port research, the service quality model essential operates by comparing the customers' expectations before receiving service from the Dry Port Operator and his perceptions of the actual service obtained received by him. It has five dimensions / factors as: **Tangibles (**Physical facilities, equipment, personnel, etc), **Reliability** (Ability to perform the promised service dependably and accurately), and **Responsiveness** (Willingness to help customers and provide prompt service), **Assurance** (the Dry Port Operators ability to inspire trust and confidence), and **Empathy** (the access ability, communication and understanding which the customer receives from the operator). For instance the objective is to obtain on the possible factors which influence the dry port service quality where a number of semi structured questions are asked in a face to face setting. These interviews allow us to understand the factors that affect the dry port customers to patronize the dry ports and the advantage/benefits derived by them. The pilot study provides inputs to develop the survey questionnaire which is subsequently administered to the sample respondents in JNPT region.

The designed survey questionnaire consisted of 21 items which are used to measure the factors affecting the dry port customers as well as operators in patronizing and operating the dry port. All the measurement items are anchored on a 7-point Likert type scale (that is 7= strongly agree and 1= strongly disagree). The stages of patronizing the dry port are related with the extent to which the dry port is used which ranges for simple transportation to and from the gateway port under custom bond to consolidation, storage, stuffing, custom inspection and delivery to destination. The respondents are requested the extent to which their firms were patronizing the dry ports in terms of TEU per month for the last three years. The survey questionnaire is administered to two hundred respondents who patronized the dry port, including Shipping lines, Freight forwarders/NVOCC and Consignees/Clearing Agents, to different extents as stated in equal number. A total of 157 usable responses are received, in which 49 are from shipping lines, 59 are from freight forwarders and 49 are from consignees. For the purpose of elimination of bias and consistency the interview was repeated after an interval of 90 days.

The survey instrument is divided into two main sections. The first section is **Expectations (E)** that measures what is anticipated in an ideal service; and the second is **Perceptions (P)** which measures those aspects of service actually delivered or experienced. Then the **Satisfaction (S)** can be defined as the gap between Expectations and Perceptions: **S = E – P.** The average dimension scores of expectations and perceptions scores are tabulated and the difference between the two scores reveal the gaps. Listed hereunder are five features pertaining to dry ports and the services they offer. Each of the customer/ user is requested to allocate 100 points amongst the five features according to how important the features were to him:

a) External Appearance of Facilities, Equipment, Personnel, etc;
b) Competence of Operator to perform promised service;
c) Willingness to assist and provide prompt service;
d) Knowledge and Ability of operator to inspire trust of confidence;
e) Provision of Individual and Personnel Attention.

The total of the products of weights allotted and average dimension scores divided by five will give weighted SERVQUAL score. The higher SERVQUAL scores mean the better service quality of the individual service provider. The SERVQUAL scores should intuitively be negative as the service provider will never 100 percent satisfy the customer in long time period. The mean SERVQUAL scores of all the 26 dry ports taking into consideration all the 157 respondent surveys is reported in Table 4.1.

Table 4.1 - Mean SERVQUAL Scores of all the Dry Port Stakeholders

Dimensions	Expectations (E)	Perceptions (P)	Gap Scores G = (P-E)	Weightings (W)	Weighted average (G×W)
Tangibles	4.56	4.67	+0.11	18.7	+0.02
Reliability	6.55	5.29	-1.26	28.6	-0.36
Responsiveness	5.41	5.47	+0.06	22.2	+0.01
Assurance	6.23	5.67	-0.56	15.7	-0.08
Empathy	5.57	4.05	-1.52	14.8	-0.22
Overall average weighted SERVQUAL Score = -0.63					

4.4. Data Envelopment Analysis

DEA can generally be defined as a non parametric linear programming-based method for assessing the efficiency of a facility for a profit center which is euphemistically called a decision making unit (DMU). From a given set of DMU, the DEA technique constructs an empirical production frontier defined by relatively efficient DMU. The performance of an individual DMU is evaluated by comparing its performance with the best performing units within the system to the concept of operational efficiency. The performance measurement is expressed in the form of an efficiency score. The benchmarking of the DMUS' performance can be revealed from the necessary changes in inputs and outputs so that the performance of the unit becomes efficient, which can be indicated by DEA.

The model selected for the current paper is output oriented which attempts to maximize the output of production process while retaining the constant nature of inputs such as number of equipment and manpower deployed. Assuming that there are $n\,DMU_j$ ($j=1,\ldots,n$), use k inputs x_{ij} ($i=1,\ldots,k$) to produce s outputs y_{rj} ($r=1,\ldots,s$) and let φ and λ_j ($j=1,\ldots,n$) be dual variables, the dual output-oriented DEA-CCR model can be converted in equations below:

$$\text{Min } \varphi$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \varphi \;\; x_{im} \quad i=1,\ldots,k$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rm} \quad r=1,\ldots, s$$

$$\lambda_j \ge 0 \quad j=1,\ldots, n$$

the following equations further restricted λ_j ($j=1,\ldots,n$) is known as DEA-BCC model,

$$\text{Min } \varphi$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \varphi \;\; x_{im} \quad i=1,\ldots, k$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rm} \quad r=1,\ldots, s$$

$$\lambda_j \ge 0 \quad j=1,\ldots, n$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

Moreover, the output-oriented measure of technical efficiency of DMU_m thus is derived as,

$$TE = \frac{1}{\varphi}$$

The DEA-BCC model differs from the DEA-CCR model only in that it includes the so-called convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$. Then the CCR model can be modified to assess efficiency under variable return to scale rather than constant return to scale. In port operation, returns to scale refers to changes in output subsequent to a proportional change in all inputs. If output increases by that same proportional change then there are constant returns to scale (CRTS). If output increases by less than that proportional change, there are decreasing returns to scale (DRS). If output increases by more than that proportion, there are increasing returns to scale (IRS). The economy of scale refers to the marginal cost of producing the port service decrease as production increases. Therefore, it is significant to the port operators to identify the return of scale for future decisions on cost control and productivity improvement.

4.5 Dataset and Indicators

Despite the fact that over 80% of its international containerized trade moves only through the three ports of JNPT, Chennai and Mundra among the 12 major Indian seaports, the Jawaharlal Nehru Port Trust (JNPT) located on the west coast of India is by far the most frequented port by main line deep sea services commanding approximately 40 calls per week across the three main trade routes. Currently the port handles about 3 million TEUs annually which constitute about 55% of the country's container traffic (Ministry of Shipping, Government of India). The port is divided into three terminals (JNPTC, NSICT and GTI) with a fourth container terminal undergoing construction. Once built the new terminal is expected to handle an additional 2 Million TEUs. The port is linked by road and rail with a wide network of dry ports located all over the country. Therefore it is important to analyze the operational efficiency of the dry ports around the JNPT seaport for their significant connective role in the Indian inland transport network. The data should be collected with respect to the operational objective and strategy. In this paper the main objective of the dry port is assumed to be imparting of competitive advantage to the user by ways of maximization of service quality and eventually TEU throughput. Due to the author's personal and extensive experience of dry port operations in the JNPT region it was possible to obtain the necessary data, some of which was confidential in nature. The assumed objective of the dry port is entirely consistent with that of profit maximization and adequate returns on capital through raising the handled cargo throughput and relative service capability.

The precise definition of input and output index is critical for the application of DEA models. This is because ambiguous definition of variables would result in erroneous inferences emerging from the model. According to Norman & Stokker (1991) and Cullinane & Wang (2006) the variables should reflect the actual objectives and process of dry port services as accurately as possible. As to regarding the output index of the dry ports, container throughput is a widely accepted index of a dry port and all previous studies have treated it as such. However this paper has taken into consideration service quality as it relates closely to the need for appropriate cargo related facilities and services offered. Service Quality apart from throughput is the primary basis upon which the dry ports are compared. Most importantly to understand over here that service quality of a dry port is the fulcrum on which the competitive advantage derived by the user.

A dry port depends to a great extent upon the efficient use of labor, equipment and land as the major expenditures of dry port operation. The total terminal area, the number of handling equipment, the number of employers is deemed to be incorporated into the model as input variables. Other input factors which also influences the efficiency of the dry ports such as warehouse and yard occupancy, dry port access ability, proximity to major trade centers and gateway ports, age of equipment, levels of maintenance, usage of information technology, prompt response to customer complaints and commitment to customer service. However with the vast number or potential input variables which influence the dry port efficiency, the aspect of multi-colinearity amongst the different indexes becomes quintessential and glaring. It has been argued by different scholars such as De Neufville & Tsunokawa (1981) and Notteboom *et al.* (2000) that there exists a predetermined relationship between the size of terminals and number of employers deployed. However it has been noticed that this predetermined relationship is not applicable to all types of dry ports especially with different modes of connectivity. It is also erroneous to derive such relationships with different production scales.

The final sample included in the analysis compared 26 dry ports located in the JNPT region with a minimum annual throughput of 10000 TEU. The data was obtained by conducting personal interviews over a time period. The important statistics deployed in the sample is presented in Table 4.3 as under. As the SERVQUAL scores of the selected dry ports are negative as shown in Table 5. For the computation, the new value equals to (-1/SERVQUAL) is generate to transfer them to be positive under the requirement of DEA models with keeping the concept “the larger the better” of service quality scores. The data of equipment we organized is the sum of major mobile cargo handling equipment widely used in dry port operations.

Table 4.3 - Summary Statistics of Sample

	Equipment	Employees	Terminal Area (Sqm)	TEU Throughput	Service Quality
Mean	2.961538	20.73077	77801.96	54356.98	-0.87662
St.Dev	1.825329	7.973277	70759.38	46871.02	0.368201
Median	2.5	21.5	50000	37447.5	-0.81
Minimum	1	9	20000	10426	-1.63
Maximum	7	39	364000	184561	-0.023

4.6 Empirical Analysis and Discussion

According to the formulas stated above the relationships between the inputs and outputs are analyzed in three different ways for two different periods. In both the cases the inputs were kept unchanged. In the first case the throughput measured in terms of TEU is considered as output. In the second case service quality measured in terms of absolute SERVQUAL scores is considered as output and in the last case both the outputs are considered together. The results are shown in Table 4.4 & 4.5.

We also tested the correlations of the three different efficiency scores using SERVQUAL, TEU and both of them as the output index of the DEA-BCC model in 2008 and 2009 to check the degree of relationship among them. The correlation matrix of the scores is shown in Table 4.6. In addition, the Spearman's rank order correlation coefficient among them is also reported in Table 4.6. The correlation analyses reveal that there's a high positive correlation between the efficiency scores of using SERVQUAL and both of them. Nevertheless, the correlation between the efficiency scores of using TEU and SERVQUAL and using TEU and both of them are positive but not significant high. Such weak correlation implies that the individual companies might receive completely different evaluations depending on the adopted model. Without clearly specification, the managers and policy makers will be leaded to make biased decision beyond the true operation performance consequently.

Table 4.4 - Results of Year 2007-2008

Dry Port	**CCR**			**BCC**			**Scale Efficiency**			**Return to Scale**		
	ServQ	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*
1	0.023	0.141	0.15	0.026	0.145	0.153	0.853	0.969	0.986	Irs	Drs	Drs
2	0.02	0.508	0.549	0.021	1	1	0.938	0.508	0.549	Irs	Irs	Irs
3	1	0.282	1	1	0.394	1	1	0.716	1	-	Drs	-
4	0.035	0.073	0.101	0.039	0.078	0.101	0.899	0.929	0.997	Irs	Drs	-
5	0.026	0.358	0.362	0.028	0.426	0.429	0.919	0.84	0.844	Irs	Drs	Drs
6	0.023	0.346	0.35	0.023	0.397	0.4	0.971	0.872	0.876	Irs	Drs	Drs
7	0.056	0.233	0.248	0.243	0.256	0.325	0.233	0.912	0.762	Irs	Irs	Irs
8	0.382	0.268	0.614	1	0.268	1	0.382	1	0.614	Irs	-	Irs
9	0.058	1	1	0.206	1	1	0.282	1	1	Irs	-	-
10	0.037	0.839	0.84	0.044	1	1	0.833	0.839	0.84	Drs	Drs	Drs
11	0.081	0.383	0.444	0.14	0.563	0.588	0.579	0.681	0.755	Irs	Irs	Irs
12	0.033	0.393	0.413	0.034	0.466	0.482	0.959	0.843	0.857	Irs	Drs	Drs
13	0.071	1	1	0.1	1	1	0.708	1	1	Irs	-	-
14	0.065	0.488	0.514	0.943	1	1	0.069	0.488	0.514	Irs	Irs	Irs
15	0.041	0.147	0.166	0.077	0.197	0.222	0.539	0.747	0.75	Irs	Irs	Irs
16	0.287	0.333	0.539	1	1	1	0.287	0.333	0.539	Irs	Irs	Irs
17	0.114	0.201	0.298	0.402	0.201	0.438	0.282	1	0.679	Irs	-	Irs
18	0.023	0.806	0.806	0.03	1	1	0.769	0.806	0.806	Drs	Drs	Drs
19	0.081	0.383	0.444	0.14	0.563	0.588	0.579	0.681	0.755	Irs	Irs	Irs
20	0.033	0.393	0.413	0.034	0.466	0.482	0.959	0.843	0.857	Irs	Drs	Drs
21	0.076	0.68	0.732	0.138	0.999	0.999	0.549	0.681	0.733	Irs	Irs	Irs
22	0.078	0.326	0.376	1	0.478	0.497	0.078	0.681	0.756	Irs	Irs	Irs
23	0.02	0.454	0.463	0.026	0.466	0.473	0.781	0.973	0.978	Irs	Irs	Irs
24	0.052	0.277	0.316	0.093	0.375	0.396	0.562	0.74	0.798	Irs	Irs	Irs
25	0.069	0.22	0.255	1	0.497	0.497	0.069	0.442	0.514	Irs	Irs	Irs
26	0.06	0.149	0.188	1	0.769	0.769	0.06	0.194	0.244	Irs	Irs	Irs
Mean	0.109	0.411	0.484	0.338	0.577	0.648	0.582	0.758	0.769			

Table 4.5 - Results of Year 2008-2009

Dry Port	CCR			BCC			Scale Efficiency			Return to Scale		
	ServQ	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*	*ServQ*	*TEU*	*S&T*
1	0.464	0.136	0.578	0.672	0.136	0.672	0.691	1	0.86	Drs	-	Drs
2	0.48	0.171	0.546	0.789	0.171	0.793	0.608	1	0.69	Drs	-	Drs
3	0.558	0.183	0.557	0.918	0.183	0.918	0.608	1	0.607	Drs	-	Drs
4	0.419	0.159	0.485	0.662	0.159	0.669	0.633	1	0.726	Drs	-	Drs
5	0.271	0.199	0.436	0.446	0.199	0.562	0.608	1	0.775	Drs	-	Drs
6	0.285	0.204	0.323	0.469	0.204	0.502	0.608	1	0.644	Drs	-	Drs
7	1	0.231	1	1	0.253	1	1	0.912	1	-	Irs	-
8	0.776	0.312	0.881	0.776	0.312	0.881	1	1	1	-	-	-
9	0.363	1	1	0.363	1	1	1	1	1	-	-	-
10	0.224	0.568	0.733	0.529	0.811	0.826	0.422	0.701	0.888	Drs	Drs	Drs
11	0.788	0.477	0.978	0.854	0.562	0.98	0.922	0.848	0.998	Drs	Irs	Irs
12	0.193	0.428	0.716	0.344	0.509	0.722	0.563	0.841	0.991	Drs	Drs	Irs
13	0.497	0.614	0.921	0.591	0.667	0.941	0.84	0.922	0.979	Drs	Irs	Drs
14	1	0.223	1	1	0.696	1	1	0.32	1	-	Irs	-
15	0.525	0.133	0.65	0.57	0.183	0.673	0.922	0.724	0.965	Drs	Irs	Irs
16	0.576	0.196	0.611	0.833	0.999	1	0.691	0.196	0.611	Irs	Irs	Irs
17	0.804	0.235	0.852	0.804	0.235	0.852	1	1	1	-	-	-
18	0.262	0.664	1	0.672	1	1	0.39	0.664	1	Drs	Drs	-
19	0.549	0.392	1	0.595	0.462	1	0.922	0.848	1	Drs	Irs	-
20	0.487	0.424	0.758	0.865	0.504	0.974	0.563	0.841	0.778	Drs	Drs	Drs
21	0.679	0.848	1	0.736	1	1	0.922	0.848	1	Drs	Irs	-
22	0.991	0.569	0.827	1	1	0.842	0.991	0.569	0.982	Irs	Irs	Drs
23	0.28	0.626	0.659	0.401	0.675	0.67	0.698	0.928	0.984	Drs	Irs	Drs
24	0.524	0.362	0.657	0.588	0.507	0.679	0.891	0.714	0.968	Drs	Irs	Drs
25	0.707	0.32	1	1	1	1	0.707	0.32	1	Irs	Irs	-
26	0.691	0.196	0.717	1	1	1	0.691	0.196	0.717	Irs	Irs	Irs
Mean	0.554	0.38	0.765	0.711	0.555	0.852	0.765	0.784	0.891			

Figure 4.1 – Results of BCC model in 2008

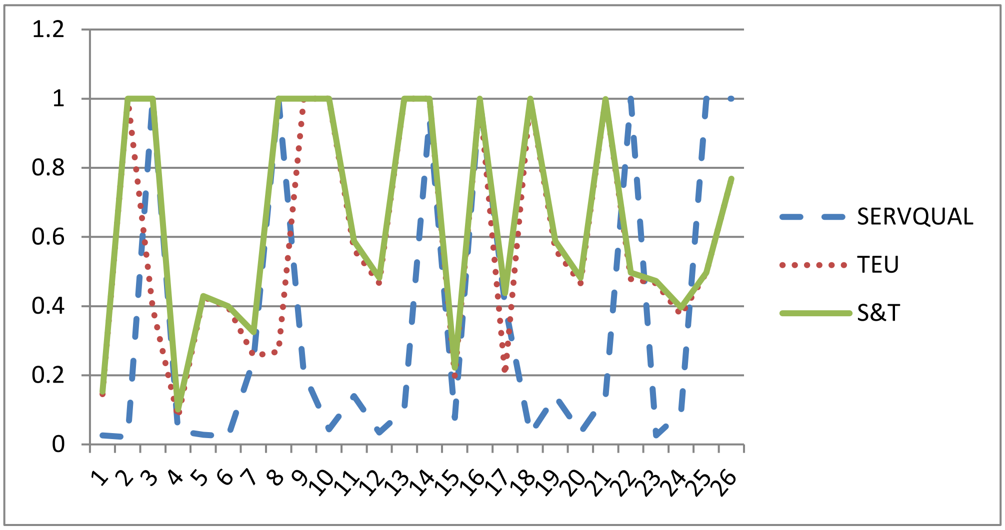


Figure 4.2 – Results of BCC model in 2009

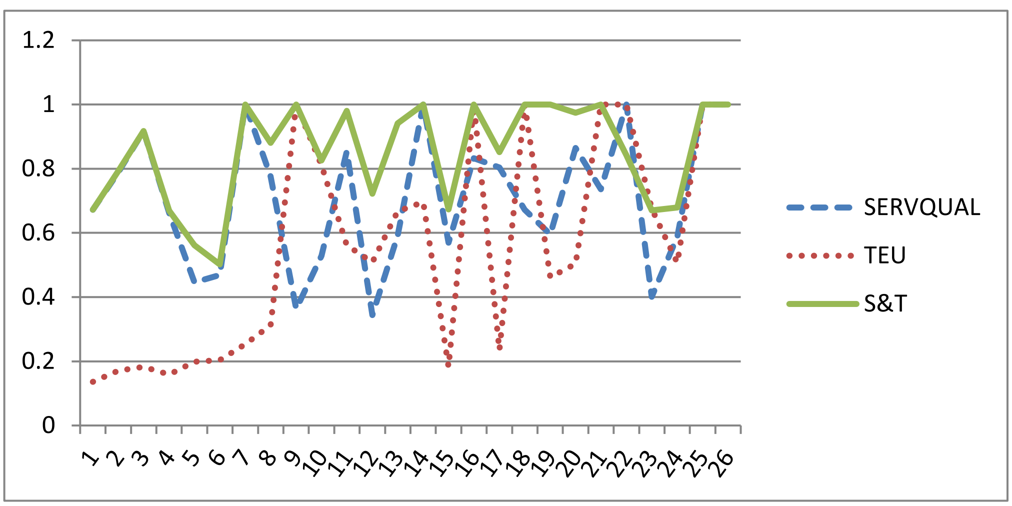


Table 4.6 – Correlation Test of Efficiency Scores

	2007-2008			2008-2009		
Correlation Test	TEU	SERVQUAL	BOTH	TEU	SERVQUAL	BOTH
TEU	1	-	-	1	-	-
SERVQUAL	0.0722	1	-	0.157	1	-
BOTH	0.3412	0.8329	1	0.5779	0.5863	1
Spearman Test	TEU	SERVQUAL	BOTH	TEU	SERVQUAL	BOTH
TEU	1	-	-	1	-	-
SERVQUAL	0.1075	1	-	0.1744	1	-
BOTH	0.3593	0.8110	1	0.5511	0.6212	1

One of the reasons for the different efficiency estimates for different time periods is the drastic changes in the value of the two outputs, videlicet throughputs and perceived service quality, albeit at different rates. The empirical results also suggest that there exists a fair level of wastage in production of the dry port services which signifies that the dry ports can improve their outputs significantly, especially those with increasing rates of returns. The returns to scale properties of the dry port yielded by DEA when considering both the outputs together and shown in the last column indicates that of the 26 dry ports 9 dry ports exhibit constant returns to scale while 5 exhibit increasing returns. The balance 12 displays decreasing returns. However when we consider the service quality as the only output the results undergo a drastic change. They exhibit that 17 dry ports have decreasing returns while 4 dry ports have increasing returns and 5 dry ports display constant returns. But when we consider the throughput as an out put the results vary again with 4 dry ports showing decreasing returns, 13 showing increasing returns and the balance 9 showing constant returns.

So the question which yields proper results are correct and should be relied upon by the dry port operator/manager to take suitable decisions is arisen. According to our investigations and field interviews conducted it appears that the customer profile patronizing different dry ports vary dramatically over the time period taken into consideration due to various reasons such as size, service quality, tariff, type of cargo handled, availability of credit facility and so on and so forth. In short the customer loyalty is in short supply.

From the Table 4 & 5, it can also be noticed that the scale returns also fluctuate with the different outputs. This would definitely cause confusion for the dry port operator and he would be unable to fathom as to what measures should be undertaken to enhance the efficiency of the dry ports. He would also not be able to decide as to whether his expansion plans would be profitable or not. However the efficiency analysis for the two different years in consideration does exhibit a consistent trend. It should also not be ignored that efficiency comes with a cost and for some customers costs would be more important than efficiency. Even the definition of efficiency as such is not constant. It not only varies with inputs and outputs taken into consideration but also with changes in time periods as the permutations and combinations, ratios and proportions constituting inputs and outputs undergo change. The needs and demands of the dry port customer also vary with changing market conditions and economy as a whole. As such the dry port operator is left with no alternative but to alter his operational plans to meet the customer’s expectations.

Every dry port has its own strengths and weaknesses, based on which they develop their own strategic business plan. The objective of every strategy is to establish its own niche market position. This is particularly the case of privately owned and managed dry ports which are completely focused on maximizing profits and financial returns. On the other hand the public sector owned/operated dry ports have an altogether different focus which is rather broad. The focus of the public sector dry ports is more aligned with the government's macroeconomic policies where the financial returns have a comparatively lower priority as compared to provision of service to the trade as a whole.

In such circumstances the perspective and outlook of the dry port owner/operator is bound to differ when viewing the efficiency estimates. The operator would naturally strive to align the results with his own strategic plan. For example, the public sector dry port operator would focus on increasing his market share and would prefer to improve the efficiency estimates which consider the throughput output alone. Whereas the privately managed operator will be more concerned about the service quality output as he wishes to develop a niche market position. To summarize it can be said that the response of the dry port owner/operator is not standardized but is customized to achieve his strategic plan objectives.

4.7 Conclusions

In tempting to interpret the results and findings of this study, especially while ensuring to draw some general inferences, caution needs to be exercised. This is because cross extrapolation is neither correct nor possible in most of the cases as it is practically impossible to replicate all the circumstantial inputs. Furthermore certain outputs are a result of several intangible inputs combined together in different ratios of permutations and combinations.

Some broad inferences still can curtain still be drawn from this paper. The first inference is that the quantum of minimum capital investments should be of a critical mass before economies of scale can be achieved. There is an unintended consequence of such capital investments which is creation of excess capacity to cater to future demand and growth which in turn adversely affects the dry port efficiency. Khadaroo & Seetanah (2008) states that the transport capital investment enhances productivity and output through: (1) reorganization and rationalization of production, distribution and land use; (2) better productivity and higher level of private investment; (3) wider markers, increased specialization and economies of scale. However the DEA model reveals that large throughput is likely to be associated with higher efficiency score. This inference is not very surprising as bigger dry ports usually utilize better and modern equipment and also possess the sustainability to survive the initial period of weak demand.

The average efficiency of the dry ports is found to differ to certain extent. It has been noticed that the privately organized dry ports have managed to fare better than those operated by the government. This finding is interesting because such a difference indicates that more complicated factors apart from those considered in this paper come into play which may exert a significance influence over the efficiency of dry port service providers. In addition comparative competence of management and organization structure is also an important factor which also has a bearing on the dry port efficiency (Cullinane et al., 2004). As such further investigation into the reasons behind the relative inefficiency of the dry ports as well as other components of global transport network not only becomes imperative but also relevant though it further complicates the issue. However to find the reasons behind inefficiency is a pre requisite for achieving further improvement. On the other hand the possible reasons behind the inefficiency such as level of regional economic growth and management structure becomes wide ranging and difficult to quantify. From this perspective the derivation of efficiency estimates analyzed in this paper merely constitutes the proverbial tip of the iceberg.

Chapter 5

Analysis on Dry Port Service Quality: Impact of Operational Objective, Market Competition and Regulations

5.1 Introduction

A dry port is normally defined as a common user facility with public authority status, equipped with fixed installations and offering services for handling and temporary storage of any kind of goods (including containers) carried under customs transit by any applicable mode of transport, placed under customs control and with customs and other agencies competent to clear goods for home use (UNCTAD, 1991). Nowadays, the dry port is popularly considered as the important links of the port orientated logistics chain. The service provided by the dry port includes warehousing, temporary admissions, re-export, temporary storage for onward transit and outright export. By constructing or cooperating with the dry ports, the seaports (including container ports) can effectively explore their hinterland to achieve the expansive market. For a customer to derive benefit in a service industry, the quality of service offered assumes critical importance. Therefore, the service quality is chosen by several scholars as one main index of performance measurement of the logistics industry.

The concept of service quality is difficult, both in defining and measuring it (Wisniewski, 2001). There are several definitions and one that is commonly accepted is “the extent to which a service meets the customers’ needs or expectations”. In other words, it could also indicate the difference between customer expectations of service and perceived service. If expectations are greater than performance, then perceived quality is less than satisfactory and results in customer dissatisfaction (Asubonteng *et al.*, 1996).

Identifying and closing the gap between customer’s expectations and their perceptions is imperative for improving service quality (Parsuraman *et al.* 1991). Hence, the SERVQUAL gap model was developed by (Parsuraman *et al.*, 1993) for those objectives. This widely applied model analyses the concept of service quality in totality rather than in a piecemeal manner as that the service quality gaps naturally exist between the customers and service providers in the service industry as a whole. However, the quantity of the applications of SERVQUAL gap model in the inland transports industry, especially in dry port industry is still limited. This paper evaluates the service quality of the Ahmadabad dry port of India from 2000 to 2009 as a case study by deploying a modified and extended version of the SERVQUAL gap model. The Ahmadabad dry port which locates in the state of Gujarat of India on the west coast of India is constructed in 1995 and is connected by rail and road to the three gateway ports of JNPT, Mundra and Pipavav. It has experienced consistent growth in throughput for the past 9 years.

As a result of containerization, most gateway port related activities such as consolidation and distribution of cargo could be physically conducted at inland locations distant from the gateway seaport. This consideration resulted in the development of dry ports also termed as logistics centers, distribution centers, freight stations or Inland Container Depots. In order to address this issue, many governments decide to set up dry ports at inland locations. Such facilities were considered to be capable of extending the reach of the gateway seaports. In recent past logistics management and transport connectivity has become closely linked with economic development of a region. This is mainly due to the reduction in generalized costs, improved delivery performance, increased customer satisfaction and competitive advantage. However, this industry is characterized by high costs of operations, low profit margins, shortage of talent, infrastructural bottlenecks, increasing demands from clients for latest technology and provision of one stop solutions to all their needs.

Taking into consideration the facts that setting up of dry ports and providing relating rail/road infrastructure connectivity to the gateway ports is a capital intensive business and the payback period can be quite long with very low rate of returns, government has no alternative but to take the initiative to construct the dry ports at different locations of the country. In addition it is also the responsibility to operate the dry port until they become financially viable (RITES, 2007). For this purpose the government ensures that the public sector dry ports enjoy a monopoly until it has been able to recover its investments and can also dominate the market by being a price maker which prevents exploitation by new private entrants (Dayal, 2008). As such even after entry to private sector dry port operators were permitted, it was practically impossible to compete with the well established public sector. It was also unsustainable for the operator to lower his tariffs while simultaneously continuing to provide high service quality. On the other hand raising tariffs would have guaranteed loss of market share.

As the dry ports in other countries, the dry ports in India act as critical nodes in multimodal logistics as they act as focal points which attract cargoes for consolidation or distribution. Thus assessing their service quality and identifying the shortcomings/gaps in the services offered by them becomes necessary and imperative. Since the early 1990s an unstoppable wave of globalization has been flowing across India which has unevenly impacted the regional economic growth of the country (Dayal, R; 2007). In order to address this phenomenon several policy measures were undertaken by the government.

The psychometric properties of the SERVQUAL model have been analyzed in several industrial researches with mixed results (Brady et al., 2002). The need for further investigations for the validity of the model has been called for by researchers (Durvasula et al., 1999). This research reveals that the service quality of a dry port measured by the SERVQUAL model is quite ephemeral and not an absolute truth. It alters with passage of time, changes in business environment, increasing competition or changes in government policies. Furthermore the expectations and perceptions of the different groups of stake holders, the customers, management, employees and vendors also vary sharply. It should also be noted that different dry ports even though located in the same region could have different objectives, purpose and vision. There is also considerable difference in the profile of their individual customers. At such times it would be pragmatic for the dry port operator to focus on those aspects of service quality which are in alignment with his own vision/objectives/strategy. However it goes without saying that an understanding of different perspectives regarding service quality of the different stakeholders by itself is immensely beneficial even if it has no immediate useful value.

The quest to improve service quality will be successful only if the emphasis is on the ability of the dry port to adapt to the changing demands of the customer. This is possible only if the dry port is agile in nature. Agility is all about creating responsiveness and anticipating market uncertainties with a fair degree of accuracy. This study concludes with a discussion on the reasons behind the differences in perspectives of service quality of the different stake holders. However in the altered environment the expectations and perceptions of the different stakeholders will undergo a further change, especially with regards to service quality. The dry port operator will have to understand and analyze these expectations and perceptions correctly in order to improve his service quality.

The remainder of the chapter is organized as follows. The ensuing section comprises of an extensive literature review followed by expounding of the research methodology, the research design, the case study of the Ahmadabad dry port, gap analysis, discussions and implications of our investigations and lastly the conclusion and inferences.

5.2 Literature Review

One of the most important ideas behind service quality is the statement by Gronroos (1984) that the perceived quality of a given service is an outcome of the comparison between the customer’s expectations about the service and the perception about the actual service received by him. As such the quality of the service is dependent on two variables, the expected and perceived service and when both these aspects are compared, they give birth to the concept of service quality. Taking this fundamental concept into consideration Parsuraman (1991) develops the gap model which has been extensively used in several service industries such as Banking, Hospitality, Transportation, Retail etc. but is used for the first time to measure the quality of service offered by the dry ports in India.

Gronroos (1984) has also stated that a service provider must have an understanding of the concept of service quality and the way the quality is influenced. In order to manage service quality the service provider has to align both the aspects of expected and perceived service with each other to achieve the desired results. This is only possible if the gaps between the expected and perceived qualities are identified, analyzed and covered by the dry port operator. With regards to dry ports, service quality indicates several aspects such as on time delivery, accuracy of order fulfillment, frequency of service, compensation for loss or damage, promptness in attending to customer complaints, commitment to continuous improvement etc (Millen & Maggard 1997).

As such the literature about service quality is extensive in terms of definitions, dimensions, models and measurement issues related to service quality (Asubongteng *et al.*, 1996; Dabholkar *et al*., 2000). It is also well supported by a large number of empirical studies from a variety of service related application areas (Badri *et al.*, 2005; Seth *et al.*, 2006; Yeh & Kuo, 2003). In the original model developed by Parsuraman et al. (1985) 10 components of service quality from 97 service items were identified. Subsequently after conducting exploratory research analysis the ten components were collapsed into five dimensions. As such the five dimensions along with 22 service items yielded the scale SERVQUAL model which has been revised, refined and reformed over the years. A detailed survey of the literature on the applications of the SERVQUAL model has been conducted by Badri et al., (2005). The model has been extensively used for assessment of service quality in different service industries such as retail banking, appliance repair firms, securities & brokerage etc. perhaps this is the first time that a modified version of the model is used to assess the service quality of dry port industry in India.

Several researches on service quality have been developed around this model (Davis & Mentzer; 2006, Piero et al; 2005, Chen & et al., 2009). However the conceptualization and measurement of service quality by using this model has not been bereft of its share of controversy and criticism. The psychometric properties of the model have been questioned in several research works (Asubonteng et al 1996). Gronroos (2005) argued that the model was more suitable for measurement of performance rather than service quality while Cronin & Taylor (1992) proposed a modification of the model and called it SERVPERF. Teas (1993) also addressed the aspect of measurement of expectations and developed the Normed Quality and Evaluated Performance model. Durvasula et al, (1999) have contended that the SERVPERF model has better prediction ability as compared to the gap model. In spite of such adverse critical comments Parsuraman *et al*. (1994) has maintained that their model has much wider perspective when it comes to measurement of service quality, especially with regards to practical measures which need to be undertaken for improvement of service quality.

Unlike physical goods, quality of which can be measured unambiguously for durability or defects, service quality is abstract and elusive because of three factors viz; intangibility, heterogeneity and inseparability of production and consumption. (Parsuraman *et al.*, 1993). Thus in the absence of objective measures, the service quality of a dry port can only be assessed by measuring the stakeholders expectations/perceptions. However there is no quantitative yardstick available for gauging these perceptions precisely. It goes without saying that without a clear and unambiguous definition of service quality the dry port operator would issue vague instructions for improving service quality which would further complicate matters (Lehtinen & Lehtinen, 2002). In such circumstances the focus shifts to the service process from service outcomes (Asubonteng et al., 1996). In other words process quality assumes greater importance rather than final outcomes. This is particularly applicable in case of dry ports as the stakeholders compare their expectations against their experiences than eventual outcomes and develop impressions of service levels.

5.3 Research Design

The concept of service quality from the perspective of the different stake holders varies sharply. The number of service quality dimensions depends upon the complexity of the service offered by the service provider. By attempting to examine the service quality of dry port in conjunction with sustainable competitive advantage derived by the user and aligning it with the stated objectives/visions of the dry port, this study expect to highlight hitherto unknown facets of service quality concept. By attempting to analyze the gaps in service quality provided by the dry port operator this paper will assist in closing them and improving service quality.

5.3.1 Research Methods

The methodology adopted for measuring service quality is equally important as it allows for comparison before and after alterations / changes made with regards to quality related problems as well as for the establishment of set standards of service delivery. Thus measurement and analyses of service standards become the starting point of developing quality in service. While there have been efforts to study service quality, there has been no consensus on the measurement of service quality concept. The SERVQUAL (Parsuraman et al., 1988) model is in an effort to satisfy this demand. The model identifies any actual or perceived gaps between expectations of the customer on one hand and his perceptions of service offered on the other hand. As increased customer satisfaction levels is one of the important objectives of the dry port service provider, the SERVQUAL model assists him in achieving this objective. Thus the dry port operator can become more competitive in terms of cost, quality, delivery and flexibility.

The model acts as an effective approach in analyzing the difference between customer expectations and perceptions. The model also assists in closing service quality gaps associated with customer services. Further, the model is helpful in developing the skills of the service providers themselves (Berry and Parsuraman, 1991). The primary objective of this exercise is to ascertain how to meet the expectations of the customer and satisfy him. This is done essentially by measuring the service quality delivered and matching it against the customer’s expectations. These perspectives can also be negative as well as positive gaps help the operator in prioritizing and implementation of steps that need to be taken to improve the performance.

Dry port operators like other organizations are realizing the significance of customer-centered business models (Bebko and Garg, 1995). As far as the Ahmadabad dry port is concerned there are nine major gaps which have been identified in the services offered by it. However the most important gaps are those which are associated directly with the customers. The rest are associated with the dry port employees and vendors. They are enumerated hereunder:

- **Gap 1:** Customers Expectations versus Management perceptions – This gap arises out of inadequate market research and lack of communication (Brown and Swartz, 1989).

- **Gap 2:** Management Perception versus service specifications – This gap arises out of inadequate commitment to service quality and absence of goal setting (Lehtinen, U. 1992).

- **Gap 3:** Service Specifications versus Service Delivery – This gap is a result of role ambiguity, poor employee job fit and lack of supervisory control systems.

- **Gap 4:** Service Delivery versus external communication – This gap is a result of insufficient horizontal communications and propensity to over-promise.

- **Gap 5:** Discrepancy between Customer Expectation and their perceptions of service delivered – This gap is due to the influence exerted by the customer and short fall on part of the dry port operator. The customer expectations are influenced by his needs, past experiences, etc (Teas, K. 1993).

- **Gap 6:** Discrepancy between Customer Expectation and perception of the dry port operator – This gap is a result of misunderstanding of customer expectations by the dry port operator.

- **Gap 7:** Discrepancy between Dry Port Employees Perception and Management Perception – This gap arises due to improper communication between management and employees of the Dry Port (Buttle, 1996).

- **Gap 8:** Discrepancy between the Expectations of the dry port management personnel and dry port vendors – This gap arises due to difference in objectives of the management and vendors.

- **Gap 9:** Discrepancy between the Perceptions of dry port vendors and customers – This gap also arises due to difference in objectives.

From the above, it is obvious that the discrepancies or gaps arise due differences in the perceptions of the dry port operator and those of the customers on one hand and the true / actual quality of service delivered on the other hand. All the gaps apart from No 5 gap are functions of the way in which service is delivered where as the Gap 5 is pertains to the customer and as such is considered to be the true measure of service quality. The SERVQUAL methodology studies this very gap.

The original version of the gap model developed by Parsuraman et al (1988) is deployed to measure the expectations and perceptions of service quality of the customers and employees of a bank. They had constructed a questionnaire covering 5 dimensions and 22 items. On the other hand the opinions of the dry port management personnel and vendors in addition to the employees are taken into consideration in this research. Furthermore the customers are broadly divided into 3 major groups in the modified model depending on the kinds of services enjoyed by them. The developed questionnaire for data collection under this purpose is completely modified has 5 dimensions and 21 items. In this manner 9 major gaps between the expectations and perceptions between all involved stakeholders can be identified.

Though the SERVQUAL model is fairly well-known, it is modified for the purpose of measuring the service quality especially by considering the added perspectives of the vendors and dry port employees in addition to the dry port customers and dry port management. An important issue concerning the necessity for adopting parameters for measurement of dry port service quality is whether the issue can be related to performance improvement by identifying the rectification measures to be undertaken. The benefits for adopting performance measurement models have been well documented. The logistics service provider with a better service capability will attain better service performance (Lai, 2004). For a better understanding of the possible factors which influence the dry port service quality a number of semi structured questions are asked in a face to face setting to numerous experts and academics specializing in the fields of hinterland logistics, dry port operations and quality control. These interviews are helpful to understand the factors that influence the dry port users to patronize the port and the advantage/benefits derived by them. They also provide valuable inputs in development of the survey questionnaire which was subsequently administered to the sample respondents. In order to eliminate bias the questionnaires are administered to various sample respondents for successive nine years. It should be noted that a majority of the respondents are not repeated.

Service quality describes a comparison of expectations with performance for every service business, also the customer expectations may vary from industries. A dry port with high service quality will meet customer needs while remaining marketing competitive. This aim may be achieved by understanding and improving operational processes; identifying problems quickly and systematically; establishing valid and reliable service performance measures and measuring customer satisfaction and other performance outcomes. Improving government and employee communications helps to find problems in operational processes and suit the aim of the SERVQUAL model.

The service items too are reduced to 21 from the original 25 after conducting an exploratory factor analysis. The groupings of the measurement items under their respective factors are summarized as under;

Tangibles – Physical facilities, equipment, personnel, etc.

- Appearance and Outlook of Equipment and Facilities (Visual Appeal).
- Modern Equipment (Use of New Technology).
- External Appearance of Employees.
- Complementation of Equipment and Facilities with service.

Reliability – Ability to perform the promised service dependably and accurately

- Promise of Delivery at specific time.
- Enthusiasm and keenness of the operator to solve problems of the customer / user.
- Competency, knowledge and experience of the operator.
- Error free service.

Responsiveness – Willingness to help customers and provide prompt service

- Prompt and Accurate Feedback from the Operator.
- Prompt service
- Helpful attitude of the Operator and his employees
- According highest priority to customers requests

Assurance – Ability to inspire trust and confidence.

- Confidence inspiring behavior of Dry Port Employees
- Feeling of Security imparted to the customer
- Consistently courteous behavior of employees
- Knowledgeable employees capable of anticipating and solving customer's problems

Empathy – Access ability, communication and understanding received by customer from the operator

- Individual and Attention
- Convenient working hours
- Convergence of mutual interests
- Ability to understanding needs of customers
- Personal Attention

The above twenty-one aspects covering all the five dimensions will reveal the difference between expectations and perceptions of the customers. The average dimension scores of expectation and perceptions scores, which measures what is anticipated in an ideal service and those aspects of service actually delivered or experienced respectively, are tabulated and the difference between the two scores reveal the gaps. Listed hereunder are five features pertaining to dry ports and the services they offer. The total of the products of weights allotted according to the significance of the below five aspects the customer believed and average dimension scores divided by five gives the weighted SERVQUAL score,

a) External Appearance of Facilities, Equipment, Personnel, etc;

b) Competence of Operator to perform promised service;

c) Willingness to assist and provide prompt service;

d) Knowledge and Ability of operator to inspire trust of confidence;

e) Provision of Individual and Personnel Attention.

5.3.2 Data Collection and Analysis

Ahmadabad as stated above is the capital of Gujarat located in the western part of India. It is also an old city with a population of 5 million spread over an area of 50 square kilometers and well connected by road, rail and air to all parts of the country. It is famous for its textile mills which were set up in early years of the last century. Apart from textiles there are several other industries like pharmaceuticals, paper, sheet glass, chemicals and agricultural products like oilcake and edible oil. As shown in Table 5.1, the container terminal is spread over an area of 10 hectares and has an annual throughput of approximately 130000 TEUs both exports and imports. The exports mainly comprise of garments and denim cloth, chemicals, granite and marble blocks and agricultural products like groundnuts. The imports comprise of newsprint and steel/iron scrap. The dry port is well connected by road and rail to the gateway ports of Mundra, Pipavav and JNPT

Table 5.1 – TEU handled by the Ahmadabad Dry Port

Year	Throughput	Growth
2001	57643	
2002	68543	18.90949465
2003	74968	9.373677837
2004	80362	7.195069896
2005	88614	10.26853488
2006	96113	8.462545422
2007	112616	17.17041399
2008	122476	8.755416637
2009	131684	7.518207649

The data for the analysis on the Ahmadabad Dry Port utilizing the SERVQUAL model are collected by the same group of scholars motioned in Chapter 4. Based on the responses collected from the interviews, it can be classified that the customer respondents into 3 groups. The dry port operator respondents are also classified into 3 groups, such as Management personnel, Employees and vendors. The sample respondents were divided as under:

Dry port Customers

Shipping lines: 23.

Freight forwarders/NVOCC: 22.

Consignees/clearing agents: 20.

Total: 65

Dry port Operator

Dry port Management personnel: 13.

Dry port employees: 12.

Dry port vendors: 10.

Total: 35

Grand Total : 100

The survey questionnaire of the secondary data consists the mentioned 21 items which are used to measure the factors affecting the dry port customers as well as operators in patronizing and operating the dry port. All the measurement items are anchored on a 7-point Likert type scale (i.e. 7= strongly agree and 1= strongly disagree). The stages of patronizing the dry port are related with the extent to which the dry port is used which ranges for simple transportation to and from the gateway port under custom bond to consolidation, storage, stuffing, custom inspection and delivery to destination. The respondents are requested the extent to which they were patronizing the Ahmadabad dry port in terms of TEU per month for the last three years. The extents of the customers patronizing the dry port are evaluated on a five point scale as follows:

1 - Simple Transportation.

2 - Custom clearance and transportation.

3 - Custom clearance, Storage, transportation.

4 - Custom clearance, storage, consolidation and transportation.

5- Custom clearance, storage, consolidation, value added services and transport.

The survey instrument is divided into two main sections as Expectations (E) and Perceptions (P). Thus Satisfaction (S) can be defined as the gap between Expectations and Perceptions, namely S = E – P**.** The results of exploratory factor analysis are listed in Table 5.2.

Table 5.2 - Results of Exploratory Factor Analysis

	Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	Appearance of Facilities	0.888	0.441	0.324	0.462	0.322
2	Modern Equipment	0.892	0.325	0.421	0.410	0.523
3	Appearance of Employees	0.736	0.532	0.232	0.423	0.541
4	Equipment/Service	0.891	0.145	0.216	0.436	0.563
5	Promise of on time delivery	0.462	0.857	0.254	0.425	0.413
6	Eagerness of service provider	0.542	0.809	0.366	0.236	0.236
7	Competency & Knowledge	0.314	0.792	0.256	0.315	0.436
8	Error free service	0.231	0.881	0.214	0.341	0.355
9	Prompt and Accurate feedback	0.462	0.576	0.851	0.301	0.430
10	Prompt service	0.451	0.264	0.872	0.236	0.520
11	Helpful attitude	0.321	0.356	0.749	0.532	0.531
12	According priority to customer	0.134	0.452	0.802	0.420	0.234
13	Confidence inspiring behavior	0.212	0.536	0.200	0.855	0.244
14	Feeling of security	0.112	0.301	0.106	0.814	0.361
15	Courteous behavior	0.342	0.533	0.201	0.756	0.540
16	Knowledgeable Employees	0.314	0.361	0.321	0.933	0.610
17	Individual Attention	0.241	0.245	.0322	0.189	0.800
18	Convenient working hours	0.9624	0.261	0.253	0.456	0.714
19	Convergence of mutual interests	0.309	0.323	.0.421	0.411	0.966
20	Understanding customer needs	0.322	0.543	0.329	0.165	0.899
21	Personal attention	0.345	0.436	0.132	0.222	0.752

5.4 Result and Gap Analysis of Ahmadabad Dry Port

A total of 65 questionnaires are distributed to customer group stakeholders. In addition 35 questionnaires are also distributed to the dry port operator group of stakeholder respondents. The response rate is 100 percent. The mean annual summary of responses obtained from the customers/users, the dry port management personnel, dry port employees and dry port vendors are mentioned in Table 5.3, 5.4, 5.5 and 5.6 respectively. An overall mean of all the responses is plotted in Figure 5.1.

5.4.1 Analysis of Stakeholder Responses

For the purpose of this study, four stakeholders are assumed to be involved in the Ahmadabad dry port operations. They are the customers, dry port management personnel, dry port employees and dry port vendors responsible for container transportation, container handling and storage, cargo handling, warehousing operations etc. The responses of all the four different groups of stakeholders are solicited and analyzed. The summary of their responses and its analysis are as under;

5.4.1.1 Customer Response Analysis

As is noticed from the Table 5.3, all the Gap scores are negative. The overall weighted SERVQUAL score is -0.43, indicating an overall failure on the part of the dry port operator to entirely meet the expectations of the customers/users across all the service areas and dimensions. The summary scores of each dimension are also shown in the table with the weighted average scores being totaled to achieve the overall score. As can be seen the highest gap scores are in respect of Reliability, Responsiveness and Assurance.

It is obvious that the customer/user is most concerned with Reliability. He expects the dry port operator to be competent enough to deliver on the promises made by him or accept liabilities for service failures and compensate him. As a policy, the Ahmadabad dry port operator does not accept liabilities for service failures as it is a public sector. It also does not pay any compensation except in special circumstances where it can be conclusively proved that goods in its custody are lost due to negligence of its employees or contractors. Thus the customer/user has no alternative but to suffer the consequences of service failure of the dry port operator.

Table 5.3 - SERVQUAL Scores according to Customers

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
Tangibles	-0.18	-0.21	-0.20	-0.19	-0.22	-0.20	-0.27	-0.31	-0.29	-0.23
Reliability	-0.78	-0.65	-0.88	-0.77	-0.81	-0.91	-0.89	-0.99	-0.92	-0.84
Responsiveness	-0.50	-0.55	-0.51	-0.57	-0.61	-0.61	-0.68	-0.72	-0.74	-0.61
Assurance	-0.34	-0.21	-0.27	-0.32	-0.33	-0.42	-0.44	-0.42	-0.46	-0.36
Empathy	-0.04	-0.11	-0.09	-0.12	-0.14	-0.08	-0.11	-0.12	-0.13	-0.10
Average	-0.37	-0.35	-0.39	-0.39	-0.42	-0.44	-0.48	-0.51	-0.51	-0.43

Furthermore the customer also expects the dry port operator to respond promptly to his demands and understand his needs. In addition he expects the dry port operator to positively express his willingness and display his keenness/enthusiasm in trying to satisfy his demands. The Customer/User definitely wants assurance of service quality from the dry port operator. But he is not willing to be satisfied with mere words of assurance. Instead he demands that the dry port operator accept contractual liability for service failures and compensate him monetarily which the operator is un-willing to do.

The comparatively smaller gap score in respect of tangibles signifies that the customer is not particularly concerned with the physical appearance of facilities and equipment. It also indicates that he would be quite satisfied with the deployment of necessary equipment, availability of suitable warehousing and other facilities and skilled and competent employees. The smallest Gap score in respect of empathy suggests that the customer will not particularly insist upon personnel and individual attention. This signifies that the customer would be satisfied with courteous behavior of the dry port operator and his employees.

5.4.1.2 Management Personnel Responses Analysis

As can be seen from the Table 3.4 the Gap scores of three responses were negative while two are positive. The overall weighted SERVQUAL score was -0.16, indicating a more satisfactory meeting of expectations across two out of five service areas and dimensions

Table 5.4 - SERVQUAL Scores according to Dry Port Management

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
Tangibles	0.18	-0.02	0.02	0.19	0.22	-0.01	-0.27	0.11	0.29	0.08
Reliability	-0.47	-0.25	-0.21	-0.37	-0.31	-0.37	-0.39	-0.28	-0.49	-0.35
Responsiveness	-0.28	-0.25	-0.21	-0.25	-0.26	-0.26	-0.26	-0.27	-0.27	-0.26
Assurance	-0.12	-0.12	-0.12	-0.13	-0.11	-0.14	-0.14	-0.15	-0.12	-0.13
Empathy	0.11	-0.12	-0.09	-0.14	-0.14	-0.18	-0.17	-0.18	-0.18	-0.12
Average	-0.12	-0.15	-0.12	-0.14	-0.12	-0.19	-0.25	-0.15	-0.15	-0.16

The dry port operator could not guarantee complete reliability at all times due to infrastructure (such as rail and road connections to gateway ports) bottlenecks and fluctuating demand for dry port services causing congestion during seasonal peaking. He also mentions that constructing adequate infrastructure was beyond their control. The weakness of insufficient responsiveness is due to the inherent character of the dry port was management as a public sector organization. The bureaucratic structure and decision making process of the dry port management resulted in insufficient sensitivity to customer demands and delayed responsiveness. The shortcoming in respect of assurance is on account of two factors, the incorrect perceptions of the customer with regards to public sector dry ports; and the limitations on the part of the dry port management/employees to effectively communicate with the customers and rectify the wrong perceptions.

With regards to the dimension of empathy, the dry port management personnel are aware of the importance of the dimension of tangibles in determination of service quality. But as the dimension had financial implications the decision for meeting the expectations of the customer/user were constrained by budgetary allocations and existence of other priorities. The dry port management personnel do understand the different needs, demands and priorities of their customers/users and attempt to provide individual and personal attention to satisfy their demands.

5.4.1.3 Employees Responses Analysis

As can be seen from Table 5.5, the gap scores of 1 dimension are negative while others are positive. The average weighted SERVQUAL score is -0.02 indicating almost complete matching of expectations and perceptions and expectations. The responses of the dry port employees can be summarized as under:

Table 5.5 - SERVQUAL Scores according to Dry Port Employees

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
Tangibles	0.12	0.09	0.08	0.19	0.22	-0.01	-0.27	-0.11	0.02	0.04
Reliability	-0.15	-0.15	-0.12	-0.13	-0.13	-0.18	-0.18	-0.20	-0.23	-0.16
Responsiveness	0.08	-0.01	0.02	0.02	0.06	0.08	0.06	0.07	0.07	0.05
Assurance	0.01	0.02	0.01	-0.01	-0.01	-0.04	-0.01	-0.05	-0.11	-0.02
Empathy	0.03	0.09	0.11	0.12	-0.01	-0.01	-0.11	-0.14	-0.15	-0.01
Average	0.02	0.01	0.02	0.04	0.03	-0.03	-0.1	-0.09	-0.08	-0.02

The employees states that they are not consulted nor played any significant role in the decision making process concerning investments in setting up facilities or purchase of equipment. Generally they fell the available tangible infrastructure is adequate most of the time. However inadequacy is experienced at times of peak demand. In the opinion of the dry port employees the dry port provided reliable service at most of the time. However they admit to occasional service failures due to reasons beyond their control. The employees also fell that they responded quite promptly to the demands and needs of the customers. However they fell in addition that the customers at times made unreasonable demands which could not always be satisfied. Furthermore the employees are of the opinion that they tried their best to provide service assurance to the customers but were in no position to accept liability for service failures nor could offer compensation. The employees add that they tried their utmost to provide personal and individual attention but were not always successful.

5.4.1.4 Vendor Responses Analysis

It can be seen from Table 3.6 that the gap scores of all except one dimension are positive. The average weighted SERVQUAL score is + 0.04 signifying satisfactory meeting of expectations across all but one dimension. The response of the dry port vendors is summarized as under;

Table 5.6 - SERVQUAL Scores according to Dry Port Vendors

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean
Tangibles	0.11	0.12	0.12	0.15	0.15	0.11	-0.02	0.01	0.22	0.11
Reliability	-0.07	-0.22	-0.24	-0.31	-0.32	-0.31	-0.33	-0.29	-0.39	-0.28
Responsiveness	0.08	0.05	0.02	0.09	0.16	0.14	0.22	0.24	0.21	0.13
Assurance	0.06	0.12	0.11	0.16	0.14	0.14	0.11	0.14	0.12	0.12
Empathy	0.04	0.11	0.09	0.11	0.12	0.12	0.17	0.11	0.01	0.10
Average	0.04	0.03	0.02	0.04	0.05	0.04	0.03	0.04	0.03	0.04

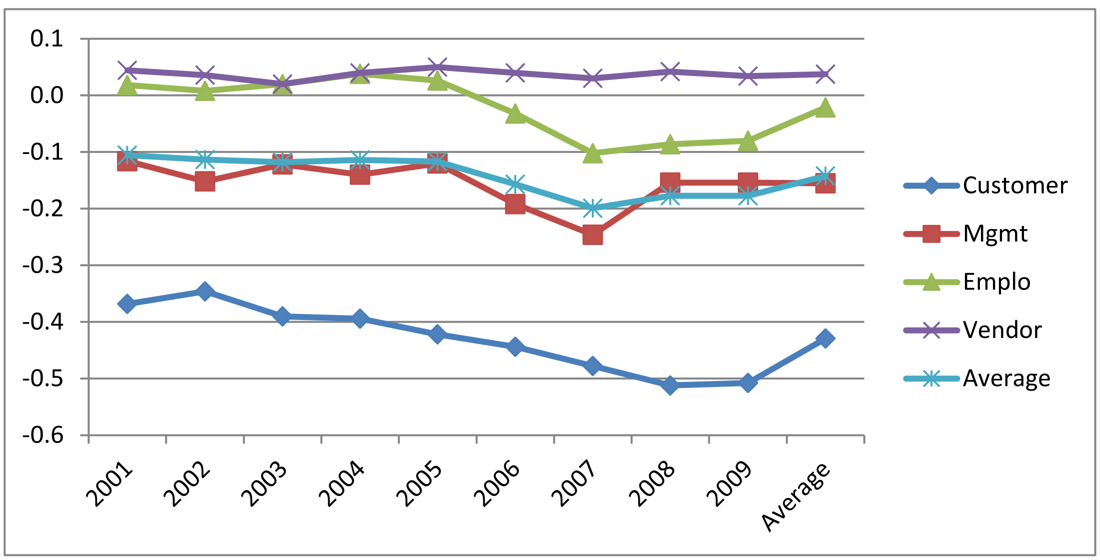
According to the vendors, their ability to deploy more and better equipment is constrained by their revenue earnings and costs incurred. As the revenue factor is directly connected with the throughput of the dry port and rates obtained by them in open tenders, their capacity to provide service was thus constrained by the fluctuating throughput. Furthermore as the dry port do not guarantee minimum throughput and yet demanded specific performance, it made the vendors vulnerable to losses.

The main objective of the vendors is to provide service, stipulated in their service contracts with the dry port, at minimum cost. Satisfaction of the demands of the dry port customer is not very high on their priorities. The vendors state that they respond to the demands of the dry port within the time period stipulated in their service contracts and are liable to be penalized for delayed responses. The vendors also respond that the scope of their service conditions was stated in their service contracts entered into with the dry port. Furthermore they felt assuring the customer is not their stated priority. In addition the vendors mention that they have no intention to provide individual and personal attention to the dry port customers as it is not stipulated in their service contracts.

5.4.2 Combined Analysis of Different Type Responses

A comparison of the SERVQUAL scores of all the four stakeholders reveals the gaps between the Expectations and Perceptions of the four groups of responses. The mean of all the SERVQUAL scores during the research period is -0.14 as shown in Table 3.7. It can be seen from the accompanying graphs that the gap begins to widen in year 2006, when the monopoly of the public sector in the dry port industry was eliminated.

Figure 5.1 - Mean SERVQUAL Scores of the Ahmadabad Dry Port



As the construction of required infrastructure is solely the purview of the national government, the task of setting up of dry ports is assigned to the Ministry of Railways of the Indian government. A public sector organization Container Corporation of India Ltd was set up by the Railway Ministry for this purpose in 1998. In order to make container transportation viable as well as to eliminate the risk of exploitation, private sector is not permitted to operate in the dry port sector. As such the customer had no option but to patronize the public sector dry ports. This state of affairs continued till 2006 when the Indian government permitted limited competition by way of private sector participation in the dry port sector. The reason of the permission is that the government of India realizes the exhaustion of dry port capacity in near future and the need for additional capital for dry port capacity augmentation invited the private sector to invest in the dry port industry.

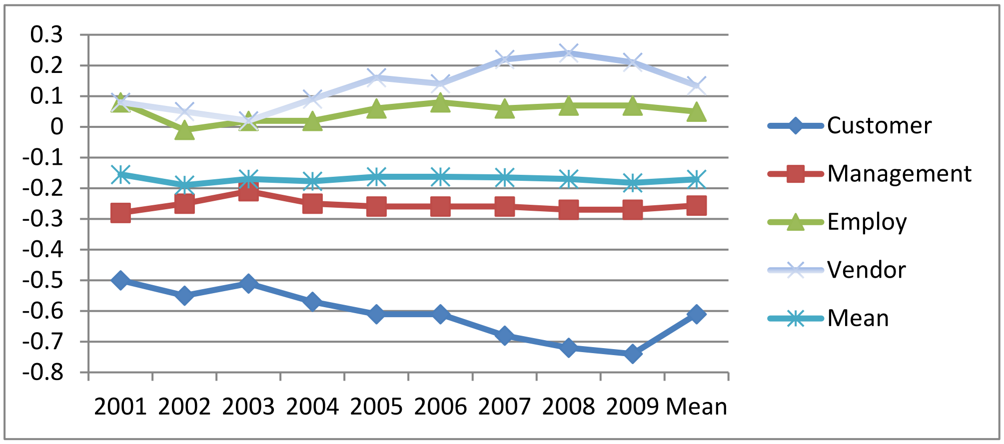
Thus the customer for the first time has a choice of dry port service providers and could compare and benchmark the service quality of the public sector dry port operator. This fact is reflected in the customer group respondent's expectations and perceptions of the Ahmadabad dry port and causes the SERVQUAL scores of the two categories of respondents to sharply diverge in 2006. It can be empirical evidences have suggested that changes in service quality of a transport servicer can affect the market share of all competitors (Wardman, 2001; Jou *et al.*, 2008). Intensifying competition and rapid deregulation has a fairly large impact on the concept of service quality. This is mainly due to drastic change in the mindset of the customer as well as other stakeholders involved in the dry port operations. It has been noticed that there is a rise in the level of dissatisfaction (difference between expectations and perceptions) as the number of choices regarding dry port availability increases (Buttle, 2003). The level of dissatisfaction of the other stakeholders falls as they strive to differentiate themselves by offering innovative and better service. This results in widening of the perception regarding service quality between the different stakeholders. This is precisely the fact noticed with regards to the service quality of the Ahmadabad dry port.

The service quality scores for different 5 dimensions are also analyzed. All the scores of the dimensions explore the similar situation of what we find from the total service quality scores except the responsiveness dimensions. The scores of this dimensions is shown in Table 5.7.

Table 5.7 - Mean SERVQUAL Scores of the Responsiveness Dimension

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Mean**
Customer	-0.37	-0.35	-0.39	-0.39	-0.42	-0.44	-0.48	-0.51	-0.51	-0.43
Mgmt	-0.12	-0.15	-0.12	-0.14	-0.12	-0.19	-0.25	-0.15	-0.15	-0.16
Employ	0.02	0.01	0.02	0.04	0.03	-0.03	-0.10	-0.09	-0.08	-0.02
Vendor	0.04	0.04	0.02	0.04	0.05	0.04	0.03	0.04	0.03	0.04
Mean	-0.11	-0.11	-0.12	-0.11	-0.12	-0.16	-0.20	-0.18	-0.18	**-0.14**

Figure 5.2 - Mean SERVQUAL Scores of the Responsiveness Items



It can be noticed from the graphs shown in Figures 4 that there is a wide gap between the perceptions regarding the dry port service quality of the two groups of respondents viz; the customer group and the operator group. Furthermore this gap seems to widen over the time period under consideration. The reasons for this state of affairs, as also discussed earlier are as under;

(1) The business environment of the customer undergoes a constant change. As such his needs, demands and expectations are also in a state of flux. These changes in expectations are not quite overt. On the contrary they are subtle and difficult to perceive;

(2) Due to lack of real time communication between the two groups of respondents, the operator is ignorant of these subtle alterations in expectations with regards to dry port service quality and continues to offer standardized service;

(3) By the time the operator becomes aware of the change in the expectations of the customer and undertakes remedial measures, the needs of the customer have undergone a further change. Thus the service quality gaps are not closed;

(4) With the introduction of competition in 2006, the dry port customer could compare and benchmark the quality of service offered by the Ahmadabad dry port with other dry ports. This resulted in further widening of the gaps which is indeed reflected in the graphs shown in Figure 4.

The results of this study also signify the critical importance of nascent concept of customer relationship management especially for service providers. Due to the increasing complexity of globalization the demands and needs of the customer are going to be in a constant state of flux. As such the dry port operator needs to keep himself abreast of the customer needs in real time. This solution could be implemented with the help of especially designed software and training of their management and personnel.

In such circumstances it becomes imperative for the dry port operator to evaluate the objectives/vision/strategy of the dry port operator in the light of the responses solicited from the different stake holders and then decide to consider only certain responses which are in alignment with the stated objectives of the dry port. Subsequently the operator should implement only those remedial measures which will further assist in the attainment of the stated objectives. On the other hand the operator might also decide to alter his objectives in order to align them with the stake holder’s expectations and perceptions. It should also be noted that the concept of service quality is ephemeral in nature and is expressed in the context of a certain time frame and circumstances. Thus if analysis remedial measures are not conducted in real time then the dry port runs the risk of lag and hunting.

5.5 **Conclusion**

It is relevant to note that service quality measurement systems adopted are often inadequate as the respondents are confused at times and are not sure about their priorities. In order to eliminate bias and prejudice, research regarding measurement of service quality, has usually focused on the process of actual service delivery in addition to precisely quantifiable facts such as actual time taken to provide service, quantum of customers to whom service was provided in a given time period, rather than mere opinions expressed at a particular time by the customers. The SERVQUAL model to a certain extent does manage to ascertain the demands/needs and priorities of the customer. It would be helpful and could get further credibility if the survey was repeated regularly. Furthermore the selection process of respondent targets and construction of questionnaire should be paid more attention to achieve wider acceptability.

In order to improve service quality, it is critically important to understand the environment and the circumstances in which the demanded service was delivered. It will only then be possible to objectively judge and measure the performance of the dry port and remedial steps could be undertaken to improve service quality. The dry port operator also needs to differentiate the varying needs of different customers. It is inappropriate on their part to offer standardized service quality when the needs of their customers/users are not only non - standardized but also vary from one transaction to another. In conclusion it could be said that the Ahmadabad dry port to a great extent does manage to satisfy, most if not all the demands of the customer. The inability of the dry port to completely satisfy the demands of the customer is mainly due to reasons beyond its control such as infrastructure bottlenecks. But it would definitely be of assistance in improvement of service quality if the dry port operator and their employees endeavor to communicate more often with the customer and explain the reasons for occasional service failures and the remedial steps undertaken to prevent re-occurrences of such failures. To summarize, understanding of different stakeholder's perceptions of service quality and ability to measure it can be beneficial for the dry port operator.

Chapter 6

A Framework for Dry Port Location Modeling

6.1 Introduction

The concept of dry ports has been brought to the maritime logistics chain as extension of gateway ports. Academic discussion on dry ports is a very recent phenomenon. Development of the dry ports can smooth the intermodal transport as well as improve the efficiency of transport services, and further reduce the unwanted environmental influences yield from the inland logistics activities. With connection to dry port, seaport can effectively decongest the transportation inside port area and upgrade the capacity without concerning the limited landscape and tremendous capital investment. It will consequently increase the operational efficiency in addition. In such circumstances, the question of how to develop such a dry port that promoting the integrated transport network involving gateway ports, railway and road transport with inland nodes becomes an important issue. As an initial step of the dry port development, the location problem achieves inadequate attention and research from the academy, industry and governmental authority. The location decision for dry port desires a practical framework contains analytical models and evaluation criteria. Suggesting such a framework for the port operators, port authorities and other stakeholders of maritime transport is the objective of this research.

A dry port is an inland intermodal terminal connecting seaports and customers with railway, as well highway and road, with providing the loading and unloading services for the cargo shipped from or to the gateway seaports as well as other custom service. The idea of dry port has been reemerged in the maritime and transportation studies under the trend of closer integration between maritime and inland freight transport network and environment-oriented consideration. Dry ports contribute on improving the freight transshipment and distribution in broadened inland fields with better operational efficiency. Benefits brought by a well performed dry port on maritime transportation and inland distribution involve reducing the congestion nearby port terminal facilities, easing the land limitation for terminal expansion. Dry port offers hinterland access to seaport and physically expands the port capacity while saving considerable cost and effort. In addition, the dry ports also have been seen as a tool for supporting the environment-friendly integrated transport system.

Hence stakeholders as seaport operators, shipping lines and public authorities have been developing inland cargo distribution schemes and articulating the schemes within their logistics integration frameworks. The policy makers including port authorities are becoming favor and proactive in the coordination of freight distribution within their hinterland through setting dry port within commercial strategies, such as those of ocean shipping companies (Van Der Horst & De Langen, 2008;Vernhoeven, 2009; Frémont, 2009). Seaports have involved themselves to the development of dry port by planning or controlling dry port through different financial scheme. Participation of seaport in the idea of dry port can be found in different ownership structure as private and state ownership (Roso *et al.,* 2009; Rodrigue *et al*., 2010).

6.2 Literature Review

Various decisions have to be made for the dry port planning by participators, including the decision on where to set and physically develop an inland intermodal port as the primary one. Decision makers need available indications and approaches with useful insights to determine the first move of their projects planning. The location problem is a well studied topic of operations research and logistics management (Revelle & Laporte, 1996; Alumur & Kara, 2008; Melo *et al.*, 2009). Several researchers have suggested and developed different models for optimizing the intermodal inland hub location (Gunnarsson *et al.*, 2006; Konings, 2006; Rahimi *et al.*, 2008). However, dry port planning in practice is much more complicated than the assumptions and hypothesis of the research projects. Strategic decision in real business barely only depends on particular planning model but relies on a group of managers and experts. The emergence of a gap between the modeling research and industrial analysis requirements recalls the necessity of the group decision-making methods. Group decision-making can be defined as a process that involves two or more individuals, with the same access to information but different preferences, attempting to achieve a collective decision for a common problem. The group members usually do not reach a same decision as having conflicted beliefs.

Different approaches have been released to solve the conflict, such as Decision Support Systems (DSS), Single Objective Decision Making methods (SODM) and Multi Criteria Decision Making methods (MCDM). MCDM methods are the most commonly used group decision-making methods while the analytic hierarchy process (AHP) are most used among the MCDM methods. As the most popular and powerful methods for group decision-making used in project selection, AHP forms a systematic framework by arranging the decision factors in a hierarchical structure (Imoto et al., 2008). The classical and fuzzy AHP models have been also introduced to study the location problem of logistics sectors, but the AHP model remains consistent limitations in evaluation. This paper propose a new alternative method to dry port location modeling with the insight from group decision-making and the geometric least square method, and in addition the literature on transport theory. Associated critical factors that need to be considered during the dry port location decision-making process is raised and analyzed as supplement of the analytical framework. After a general literature review regarding the dry port location decision-making in the next part, the developed methodical framework and experimental application will be presented sequentially. Significance and limitation of this research will be concluded in the last part of this paper.

Dry ports provides services for the handling and temporary storage of containers, and general and/or bulk cargoes that enter or leave the dry port by any mode of transport, including roads, railways, inland waterways or airports (ESCAP, 2010). It's also suggested by ESCAP that full customs-related services and other related services, such as essential inspections for cargo export and import, should be put in place in dry port whenever possible. Dry port is not a new concept to academy but was neglected for decade. Academic research on dry ports can be dated back to 1986 (Hanappe, 1986) and in transport-related trade journals in 1980 (Munford, 1980). The role of ports and spatial coverage have been dealt with researchers (Heaver et al. 2001, Notteboom, 2002; Robinson, 2002), and gradually dry port is involved in the discussion of port due to the development of intermodal transport network and the decarbonization trend in the global supply chain. The increasing interest of port authorities and terminal operators in controlling and optimizing a larger part the intermodal transport chain leads to demands of inland terminals as extended gates for seaports. Road and rail are the key connection for a conventional hinterland transport for the shippers outside the seaport community. Hubs that associate road and rail for the cargo inland transshipment and distribution withal address studies. Moreover, the role of logistics sectors, such as dry port, in decrease environmental impacts has drawn extensive attention recently (Aronsson & Brodin, 2006; Roso, 2007).

Definitions have been established for dry port and inland terminal (Notteboom and Rodrigue, 2009). The dry port concept is based on a seaport directly connected by rail with inland intermodal terminals where shippers can leave and/or collect their goods in intermodal loading units as if directly at the seaports (Woxenius *et al.*, 2004). As a concept deriving from the term “freight nodal terminal”, dry port provides transshipment from one mode to another, as well as auxiliary services such as warehouse, customs, maintenance workshops and insurance office (Roso, 2010). Dry port could be inland terminals in the hinterland of one or more seaports (UNCTAD, 1991). Dry port supplies regions with an intermodal terminal or a merging point for traffic modes – rail, air and truck routes – involved in distributing merchandise that comes from water ports (Roso, 2005). Dry port plays an important role in integrating modes of transport, reducing border crossing and transit delays, facilitating the use of energy efficient and cutting emission means of transport, and brings benefits as creating new clusters of economic growth and job creation to the local area (UNESCAP, 2009).

Roso *et al.* (2009) categorize dry ports into distant, midrange and close dry ports, based upon their function and location. The authors emphasize that the existence of a dry port in a seaport's immediate hinterland increases a seaport's terminal capacity that might result in increased productivity as bigger container ships will be able to call at the seaport. With dry port development, seaport congestion from numerous trucks is avoided, as well as CO_2 emissions, as in Europe one train can substitute for approximately 35 trucks (Roso, 2007). Roso *et al.* (2009) introduces the benefits from distant dry ports derive from the modal shift from road to rail, as resulting in reduced congestion at the seaport gates and its surroundings as well as reduced external environmental effects along the route. Distant dry port actively enlarges the hinterland of seaport and becomes interface between the seaport and the shipping lines (Beresford and Dubey, 1990 and Tsilingris and Lagradia, 2007). Although dry ports located closest to the production base are often chosen by shippers, but it is not necessarily the optimal solution in terms of minimizing transport costs, mainly because of government policies and dry ports' inability of providing custom services needed by the shippers.

Under the strained circumstances surrounding logistics network through environmental issues related to growing integrated environmentally-friendly transport chain, performance of the hinterland access by means of intermodal terminals will be sufficient complement for the entire transportation chain to function. Slack (1999) claims four functions should be taken place at a freight terminal: transfer of cargo between two modes; the assembly of freight in preparation for its transfer; the storage of freight awaiting pickup; and delivery and the logistical control of flow. In addition to the above four functions, researchers also suggest that dry port should provide services such as maintenance of containers, customs clearance and other value-added services in accordance with customers' needs. The functions and proposed services of dry port postulate broader for dry port planning consideration. As scoured the previous studies, various projects is found as be conducted on improving the efficiency of rail-road terminals (Koning, 1996; Ballis & Golias, 2002; Kozan, 2006) and optimizing the location for inland intermodal terminals (Rutten, 1998; Arnold *et al.*, 2004; Racunica & Wynter, 2005; Pekin & Macharis, 2007; Rahimi *et al.*, 2008).

Besides the theoretical facility location model from operations research, more methods has been applied to dry port location problem to capture the properties of dry port industry and present inability in practical applications. Some research employs the geographic information system (GIS) – based location analysis models (Marcharis, 2000; Standifer & Walton, 2000; Sirikijpanichkul *et al.*, 2007; Marcharis *et al.*, 2010). Furthermore, group decision-making models also have been employed by scholars for the location analysis of inland terminals. Chen (2001) studies the location selection of distribution center using multiple criteria decision-making method under fuzzy environment. In the proposed method, the ratings of each alternative and the weight of each criterion are described by linguistic variables which can be expressed in triangular fuzzy numbers. Yu (2002) employs the property of goal programming to treat a fuzzy AHP problem and incorporates and absolute term linearization technique and a fuzzy rating expression into a GP-AHP model for solving group decision-making fuzzy AHP problems. Pedrycz & Song (2011) offers flexibility to exploit different aggregation mechanisms and navigate a process of interaction among decision makers, by admitting membership degrees, to achieve an increasing level of consistency within the group. The authors concerns with an extension of the well-know analytic hierarchy process to the group decision-making scenario. A uniform allocation of granularity and non-uniform distribution of granularity are considered, where the levels of allocated granularity are also subject to optimization.

The potential benefits of dry ports would be seen if they are planed and applied successfully. The previous researches either developed mathematical models for location selection and optimization or discuss the state of art of dry port development with qualitative analysis. But, the dry port planning and location is a complicate problem which contains several dimension to be evaluated. The relative field exist a lack of criterion series for deciding the dry port location accordingly. In this context, the dry port location problem requires a resultant framework that containing practical analyzing methods and available indicators for soft consideration. Location selection for dry port projects, a key and initial factor in the success of the dry ports, is a complex process. Main models offered by the literature based on the optimization theory limit themselves on dealing with only part of the problem without systematic consideration of the entire site plan; and fail to provide adequate solutions for the evaluation of soft factors. Aiming at providing a general solution, the theoretical operations research model is required simplify the problem and consequently to lose their ability to reflect the project’s complexity and its unique contextual conditions; fail to provide for the incorporation of the subjective, intuitive judgment of the decision makers (Shapira & Goldenberg, 2005). Limitations also exist in the AHP models that the likelihood of the occurrence of the “rank reversal” phenomenon (Dyer, 1990) and imposed inconsistency of the judgment matrix. To overcome the limitation of other methods and to explore an appropriate rout for dry port location selection, a new model under group decision-making scheme is necessary.

6.3 Indicators for Dry Port Location

Location selection for dry port projects, a key and initial factor in the success of the dry ports, is a complex process. Main models offered by the literature based on the optimization theory limit themselves to dealing with only part of the problem without systematic consideration of the entire site plan; and fail to provide adequate solutions for the evaluation of soft factors; aim at providing a general solution, which requires the models to simplify the problem and consequently to lose their ability to reflect the project’s complexity and its unique contextual conditions; fail to provide for the incorporation of the subjective, intuitive judgment of the decision makers (Shapira & Goldenberg, 2005). Scholars have also applied other alternative models under the group decision-making framework mainly as analytic hierarchy process (AHP) to solve the location problem for inland freight hubs. However, limitations exist in the AHP models that the likelihood of the occurrence of the “rank reversal” phenomenon (Dyer, 1990) and imposed inconsistency of the judgment matrix. To overcome the limitation of other methods and to explore an appropriate rout for dry port location selection, a new model under group decision-making scheme is necessary.

The nature of dry ports decides that the competition among them will be advanced at the location selection stage. Evaluating the feasible dry port location requires concerns on the key factors and attributes that will jointly influence the potential choice behavior of shippers, seaport operators and the other clients. The significance of location to a successful intermodal transport terminal is undoubted. Competitiveness of intermodal terminals, such as seaport and airport, depends not only on their operational performance but also the infrastructure investment and the business environment. Likewise, the intermodal terminal location problem cannot be solved only by detecting the optimal geographic solution but also the optimal economic and political solution. Consequently, elementary determinants, which beyond the operator's control, of the dry port competitiveness should be concerned for selecting location. As duplicating some activities of seaport inland, dry port especially shares similar client requirements with seaport.

The literature provides a wealthy list of factors that significantly affect the intermodal terminal competition (Veldhuis *et al.*, 1999; Starkie, 2002; Tiwari *et al.*, 2003; Warnock-Smith & Potter, 2005; Bruno & Guy, 2006; Magala & Sammons, 2008; Lorena & Joaquin, 2009; Tongzon, 2009). Furthermore, the optimized network integration raises the necessity of viewing seaport and/or dry port as an element of a system or supply chain. Decision upon a location has to concern the location potential for decongesting the seaport service and smoothing the connection of the system. According a summary of literature, following four categories of determinants is suggested to be incorporated in the location modeling for dry port: (1) politics &

regulation; (2) social & economic; (3) land & infrastructure; (4) environment. Each category contains sub-criteria for the evaluation on individual location.

Politics & Regulation Concern

The political environment and regulation varies in different regions or countries. Political support and regulation transparency is critical for any business. Implementation of dry port requires cooperation from the local government by providing necessary policy guides, credit guaranty and tax incentives. Concerns on political environment and regulation should involve the governmental plans for transport development; positioning in the relevant supply chain and logistics network; policy preference on cargo transport type; environmental requirements of the local authorities; local political stability; and the past relationship between the local government and dry port investor.

Economic& Social Concern

The economic and social environment of a proposed location for dry port development influences the possible overall cost and quality of the future operation. Decision maker is suggested to consider the average salary and education level of local community; local land costs and other expenditures; quality of local human resource; local accommodation capacity; scale of the effective economic hinterland; possible calls from the shipping lines; relative projects of the competitor in the neighboring region; and local culture.

Land & Infrastructure Concern

The connectivity though the network of the location is the most important determinants under the optimized logistics network. To select dry port location, several determinants related to the utilization of land and infrastructure including the optimal land capacity for terminal area and storage; accessibility to railway, road and inland water; connectivity and level of transport mode integration; the maximize traffic volume of handling; distance to the served gateway seaport(s); and distance to the target hinterland. The railway connection should be preferred for its advantages in economics of scales and environmental impacts. Indicators considering the potential reliability of land and infrastructure significantly influence the following concerns, the concerns on environment.

Environmental Concern

Pressures of environmental protection and carbon emission reduction force the logistics sectors to improve their operational efficiency to reduce the unexpected environmental products. The environmental-friendly policies will not bring only social fame but also competitive advantages to the dry ports. Factors such as, capacity of dealing the pollution; possible carbon emission of the whole routes passing through; and tradeoff between the network profitability and environmental efficiency; need to be considered with precise evaluation and simulation.

The indicators are selected based on wide literature review in port and logistics hub planning studies. The selected indicators for the framework summarize suggestions of various scholars and catch the characteristics of the port-oriented system. Typical indicators will be employed in the numerical application of the framework to represent the determinants for the possible sites.

Some of the suggested variables relevant to the dry port location modeling are quantitative, others are qualitative. Attaining the overall score for particular location alternative by combining the measurement of the variables therefore is determined largely by the preference of experts. In group decision-making process, the focus is not on unifying the weights of the variables but on obtaining a consistent decision through the alternative locations. The method of incorporating judgments of different experts to evaluate the potential sites in the sight of geometric least square method is proposed below.

6.4 Two-Step Eigenvector Model for Group Decision-Making

Under the group decision-making framework, decisions for project selection puzzle are normally made according to the ranking of the alternatives based on the supportive evaluation scores. The core objective of such decision process is to find the ultimate solution by unifying the professional opinions and judgments of the experts due to the benchmarking, but not to investigate how much the experts appreciate each objective. The question of how to unify the priorities of experts with different preferences and psychological status still has not been thoroughly answered. This research suggests a two-step geometric least square method as a modification of the group eigenvector method that firstly developed by Qiu (1997) for attaining the optimal decision.

The model can be specified with supposing a judgment system G is formed with experts denoted by $S_i, i = 1, \dots m$, indicators denoted by $C_k, k = 1, \dots p$ to rate the objects denoted by$D_j, j = 1, \dots n$, with the overall evaluation. The score given by S_i on C_k for D_j therefore can be denoted by $x_{ij}^k, i = 1, \dots m; j = 1, \dots , n; k = 1, \dots , p$,

$$X = x_{ij}^k = \begin{pmatrix} x_{11}^k & \cdots & x_{1n}^k \\ \vdots & \ddots & \vdots \\ x_{m1}^k & \cdots & x_{mn}^k \end{pmatrix}$$

6.4.1 Basic Model

For each indicator, assuming there will be an virtual ideal expert who summarizes the overall judgment, denoted by x_*, of the experts on each objective based on the score they rated, then the value vector of x_* on all objectives will be,

$$x_* = (x_{*1}, x_{*2}, \cdots , x_{*n})^T \in E^n$$

It is reasonable to suggest that the virtual expert's judgment ought to have the least general difference with the experts S_i within G. The ranking of objectives achieved though x_* should be consistent with the ranking achieved by the overall evaluation through the judgment system G.

Definition: The vector which has the minimum sum of angles with the judgment vectors of all experts is the judgment vector of the virtual ideal expert.

Consequently x_*will be the vector which satisfies the maximum value of the function as,

$$f = \sum_{i=1}^{m} (b^T x_i)^2 \qquad (1)$$

Where $x_i = (x_{i1}, x_{i2}, \cdots, x_{in})^T$; $\forall b = (b_1, b_2, \cdots, b_n)^T \in E^n$ and without loss of generality can be defined as $\|b\|_2 = 1$, means

$$\max_{\substack{b \in E^n \\ \|b\|_2 = 1}} \sum_{i=1}^{m} (b^T x_i)^2 = \sum_{i=1}^{m} (x_*^T x_i)^2 \tag{2}$$

According to the Perron-Frobenius Theorem [2], if a real $n * n$ matrix $Q \geq 0$ is irreducible, then Q has the greatest eigenvalue and the simple root, ρ_{max}; the eigenvectors V of Q with ρ_{max} such that all components of V are positive and there are no other positive eigenvectors except positive multiples of V. The matrix $F = X^T X$ composed by the score matrix X obviously satisfies the conditions of the Perron-Frobenius Theorem. Sequentially, the score vector x_* can be proved as the positive eigenvector corresponding to the ρ_{max}.

Theorem: For $\forall b \in E^n$,

$$\max_{\|b\|_2 = 1} \sum_{i=1}^{m} (b^T x_i)^2 = \sum_{i=1}^{m} (x_*^T x_i)^2 = \rho_{max} \tag{3}$$

Where ρ_{max} is the greatest eigenvalue of the matrix $F = X^T X$, x_* is the positive eigenvector of ρ_{max} corresponding to F, and $\|x_*\|_2 = 1$.

Brief Proof: From equation (1),

$$f = \sum_{i=1}^{m} (b^T x_i)^2 = \sum_{i=1}^{m} (b^T x_i b^T x_i) = b^T \left(\sum_{i} x_i \, x_i^T \right) b = b^T x^T x b$$

---

[2] The Perron-Frobenius theorem, proved by Oskar Perron (1907) and Georg Frobenius(1912), asserts that a real square matrix with positive entries has a unique largest real eigenvalue and that the corresponding eigenvector has strictly positive components, and also asserts a similar statement for certain classes of nonnegative matrices.

Applying the Lagrange Multiplier Method to find the maximum of f, this yields that,

$$Fb = \rho b; \|b\|_2 = 1$$

Therefore when f achieves the maxima, ρ and b are the eigenvalue and eigenvector of F. As the eigenvector corresponding to the largest eigenvalue ρ_{max} of F, x_* is unique and has all positive components. It not difficult to prove that x_* lead f to its maximum. Detail of the above proof can be referred in Qiu (1997).

6.4.2 Step 1 of the Two-Step Model

The reliability of individual expert's judgment depends not only on his expertise and capability but also on the preference and mental conditions which cannot be exactly controlled and monitored. Forming a group of experts with similar professional ability can increase the reliability of the final decision by combining the uncertainties. The virtual ideal expert can be assumed to provide the most reliable decision to be consistent with the judgment of the real expert group. The consistency is due to that the decision of the expert is made on standard professional capability and expected minimum evaluation error impacted by the unbiased preference and the well metal conditions. Given the basic model, the judgment vector $x_*^k, k = 1, \dots p$ of the virtual ideal expert based on the k^{th} indicator for the objective can be supposed as,

$$x_*^k = (x_{*1}^k, x_{*2}^k, \cdots, x_{*n}^k)^T$$

Then a judgment matrix of the virtual ideal expert on all indicators for the objectives can be attained as,

$$Y_{n*p} = \begin{pmatrix} x_{*1}^{1} & \cdots & x_{*n}^{1} \\ \vdots & \ddots & \vdots \\ x_{*1}^{p} & \cdots & x_{*n}^{p} \end{pmatrix}$$

6.4.3 Step 2 of the Two Step Model

The preferred alternative of the virtual ideal expert is required to be extracted from the judgment matrix Y. Merits of the objective options vary from different indicators and need to be aggregate for general evaluation. Assuming a virtual aggregate indicator that can be utilized to comprehensively evaluate the objectives, it should compromise the advantages and disadvantages of the objectives and can measure their value as a whole.

Judgment of the ideal expert on the aggregate indicator can be denoted as y^*, which will be the positive eigenvector of the matrix Y^TY according to the basic model,

$$y^* = (y_1^*, y_2^*, \cdots, y_n^*)^T$$

The final decision of the group-decision system G on location selection for dry port development can be completed with the ranking information offered in the judgment vector y^* of the hypothetical ideal expert.

6.5 Model Application: Tianjin Port Extension

It is necessary to discuss the application of the suggested modeling framework. The advanced application concerns the Tianjin Port, China. As the starting point of the Eastern section of the Eurasian Continental Bridge, Tianjin Port occupies an important position in the national and global integrated logistics system. Domestic hinterland of Tianjin Port ranges a total area of nearly 5 million square-kilometers including Beijing city, Tianjin city, Hebei province in addition with 14 other provinces located in the Central and Western China. About 70% of cargo handled in Tianjin Port and more than 50% of the value of the freight throughput of Tianjin Port ships from/to the hinterlands beyond the Tianjin city. Tianjin Port builds dry ports in more than 14 cities located in Central China until the year of 2010. The port operator intend to develop the inland feeding network by constructing or controlling 3 to 4 intermodal hubs annually to dominate the cargo market of the common hinterland shared with Qingdao Port, Dalian Port and the undergoing Caofeidian Port.

A numerical example is used to illustrate the proposed location decision model. Seven experts, who have the similar professional background, are invited to attend the location selection experiment of the dry port for Tianjin Port. Each expert is required to evaluate 6 alternative site for develop a close dry port for Tianjin Port according to the listed indicators from four categories. The six decision alternatives are real geographic existence around Tianjin Port, but the experts are only informed with the features and descriptive information rather than the place name. The experts is required to grade the locations with eight dimensions including Governmental Support (GS), Environmental Requirements of the Local Authorities (ER); Local

Land Costs and Other Expenditures (LL), Scale of the Economic Hinterland (EH); Connectivity and Level of Transport Mode Integration (TM), Distance to the Served Gateway Seaports (DS); Capacity of Dealing the Pollution (DP) and Possible Carbon Emission (CE) based on the real data and the subjective views. However, most of them feel hard to give score on Possible Carbon Emission. Then this item was detected from the questionnaire. Scores of the dry port then are rated based on 7 indicators. The score for the indicators ranged from 0 to 9 as given by the experts; and 9 means the best while 0 means the worst. Table 1 lists the overall scores of the decision alternatives based by the invited experts.

Table 1 – Scores given by the Ideal Expert

	Indicator 1	**Indicator 2**	**Indicator 3**	**Indicator 4**	**Indicator 5**	**Indicator 6**	**Indicator 7**
Site 1	0.4064	0.4210	0.4114	0.3988	0.4045	0.4308	0.3877
Site 2	0.4503	0.4436	0.4069	0.3989	0.4074	0.4309	0.3815
Site 3	0.4111	0.4291	0.4185	0.4274	0.3992	0.3929	0.3843
Site 4	0.4140	0.3626	0.4269	0.4375	0.3935	0.3964	0.4247
Site 5	0.3937	0.3863	0.3785	0.3877	0.4261	0.4016	0.4683
Site 6	0.3697	0.4014	0.4056	0.3967	0.4178	0.3948	0.3959

Then the scoring matrix G can be attained though,

$$G = y^T y = \begin{pmatrix} 1.1702 & 1.1946 & 1.1701 & 1.1656 & 1.1599 & 1.1369 \\ 1.1946 & 1.2214 & 1.1948 & 1.1886 & 1.1826 & 1.1592 \\ 1.1701 & 1.1948 & 1.1724 & 1.1675 & 1.1596 & 1.1376 \\ 1.1656 & 1.1886 & 1.1675 & 1.1689 & 1.1600 & 1.1344 \\ 1.1599 & 1.1826 & 1.1596 & 1.1600 & 1.1599 & 1.1299 \\ 1.1369 & 1.1592 & 1.1376 & 1.1344 & 1.1299 & 1.1068 \end{pmatrix}$$

The eigenvector can be calculated using MATLAB as shown following,

$$y_* = (0.4092, 0.4176, 0.4095, 0.4085, 0.4065, 0.3979)^T$$

Accordingly, the ranking of the site alternatives for dry port location is,

$$S_3 > S_1 > S_4 > S_5 > S_2 > S_6$$

Sustained resource should be therefore allocated to the site No.4 for developing a close dry port serving Tianjin Port. As a matter of fact, the 3rd site is one of the planning logistics hubs to be further constructed and developed, which is designed by the government of Tianjin City.

6.6 Conclusion

Dry port is an intermodal terminal connecting gateway seaport and customers, which provides delivery and storage services as well as other value-added services. With the implementation of dry port, port capacity can be actually physically expanded at a distance without paying the considerable cost and effort. The emergence of dry port development also will improve the overall performance of the integrated logistics network through the higher operational efficiency, less traffic congestion and hence the reduced carbon emission and other environmental impacts. The advantages brought by dry port also include the creation of job opportunity and economic growth to the region, which are especially significant to the local community under the present global economic environment.

During the review of research literatures, the idea of dry port is reborn in relative academic discussion after decades of neglecting. However, few projects concern the planning and location selection problem of dry port. Some of the projects employed optimization models to find an optimal solution for dry port location, while the others applied the group decision-making models for selecting a site based on the decisions of group of experts. This paper argue that the current approaches to dry port location modeling are not effective enough and consequently supposes a new framework contained necessary determinants and scientific model to deliver a better understanding and practical application of the dry port location choice. The model combines the advantages of group decision-making models and the geometric least square methods. The numerical example presents the application process of the modeling framework and shows that the suggested model can be pragmatically introduced to the relevant problems.

A successful dry port system can support the seaport with numerous benefits. It will be valuable in changing the competitive situation better for seaports under the new decarbonization era. As one of the major actors of dry port development, gateway seaport is obligated to establish their connection to the inland intermodal terminals with different ownership structure. The suggested framework in this research could be utilized by port operators, port authorities and other policy makers for planning the inland transport system around the seaport. Empirical studies will be conducted in the future to test and detect the significant indicators for dry port location selection and dry port choice as supplements of the framework.

Chapter 7

Analysis on Investor's Behavior on Port Selection

7.1 Introduction

The worldwide economic crisis started in 2007 cause fearful recession of global production industry. As the main joints of global supply chain, container port industry also has started to suffer the unexpected decline of demand, which will lead a digressive financial performance to port operators in the coming time periods. This recession reminds a fact, which always be ignored, that the port industry is a risk-sensitive industry. The operation of container ports is usually based on long-term plans and is weak on dealing with sudden risk of service demand or supply ability. Therefore, the risk-avoidance should be highlighted during the whole process of container port development. As the beginning step of port development, port investment follows the risk-avoidance concept exactly for its sizeable amount and long-term return period.

Under the economic crisis, governments are prevalently preparing to invest heavily on infrastructure construction to recover from the crisis as soon as possible. Among the options governments are willing to invest, the container ports have undoubted crucial meaning in regional communities for the economic and social contribution that they bring to their hinterland; and always provide their communities with thousands of direct or indirect employment positions, relative transportation service business, and benefits of economic development from international trade. For the important role it plays in community economy, global supply chain, the container port and its related traffic system has been listed as the emphasis of strategic investment by several governments.

The port authorities and local governments are no longer the only main contributor of container port industry under the distinctive trends toward market principles and devolution principles in container port industry which have been introduced and analyzed by various scholars (e.g., Cullinane & Song, 2001; Wiegmans *et al.*, 2002; Tongzon & Heng, 2005). The dominate role of public sector in container port industry has been increasingly questioned for the effectiveness of privatization on enhancing efficiencies and lowering costs, that was strongly suggested by experience and research, especially in port finance (Kent & Ashar, 2001). More and more container terminals are operated, even controlled by private port operation companies. Under the trends of privatization, deregulation and decentralization, the public port authorities are eager to launch programs which aim to attract private capital into both port infrastructure and operation, chasing for high efficiency and competitive advantages. Public port authorities always suppose to invest considerable public resource to develop their container port or terminal, chasing for the community social welfare boons. Thus, it is significant for port authorities to understand the investment behavior of private investors on port choice. The analysis is critical for guiding the relative construction according to private investors' preference and consequently for improving the efficiency of the governmental investment.

7.2 Literature Review

The importance of port investment study can be evoked by amount articles analysed the operation of container port from different angle. Cullinane *et al.* (2002, 2005) emphasize the developing trends in container port industry toward market principles. Wiegmans *et al.* (2002) state that the container ports are rapidly transfer to normal market-based companies through the private investment that ensure the greater competition, higher productivity and lower cost, and both parties of the public private partnership can be beneficial by financing the container terminal infrastructure. Moglia & Sanguineri (2003) examine the challenges that a port faces in achieving its primary objectives as outlined in its master plan, took into account different elements including port financing. The article mentions that very few questions are being asked in the widely discussed in technical and engineering articles and manuals on port development and planning instrument. The result of Tiwari *et al.* (2003), attain by utilizing a discrete choice model, indicated that the distance of the shipper from port, distance to destination and from origin, port congestion and played important role in shipper's port selection behavior. The initial nature condition thus should be considered by port investor in choice decisions. Olivier (2005) focuses on strategic alliances among mega-carriers neglected the role of terminals in defining firms' global strategies in logistical expansion. A multilayered network framework is introduced to build a conceptual link between private entry and emerging partnerships in the container terminal industry, and supported by evidence from Asian ports and Asian port-operating corporations. The paper stresses the need to recognize heterogeneity among strategic entry paths available to private entrants in their stake over container terminal operation and finance. Niekerk (2005) introduces that most of developing ports pursue private participation in order to generate funds for investment; increase efficiencies; and ensure cost-effective services. The option to increase the traffic volume and consequently the revenue is proved to be significant if there is competition, or competitive uncertainty.

However, only few scholars have studied evaluation or operation of port investment projects. Kakimoto & Seneviratne (2000) introduce the risk estimation model of financial risk analysis for representing market, cost and competitive uncertainty, and demonstrated the application of Monte Carlo simulation for scrutinizing sources of uncertainty and their impact on investment risk. The authors conclude that the risk may be minimized by risk estimate with minimizing estimation errors through better data and forecasting models. Ho & Ho (2006) investigate the merits of viable seaport infrastructure investment, typically ‘lumpy’ and requiring large capital expenditure and long payback period, with case study on Singapore’s Jurong Port. The original risk management strategy of Jurong Port is analyzed in 1996, and deploys risk simulation for scenario planning in conjunction with constraint optimization. The authors stated that a key feature of such an infrastructure investment is to structure a defensible risk management strategy to deal with uncertainties. The risk management strategy provided responsive alternatives to new opportunities. Allahviranloo & Afandizadeh (2007) formulate an integer-programming model, which captured cargo operation, investment costs, cargo-handling capacity, cargo transportation network and the world maritime fleet constraints, to determine the optimum investment on port development from national investment prospective. The fuzzy number is used to capture the uncertainty in cargo handling forecast.

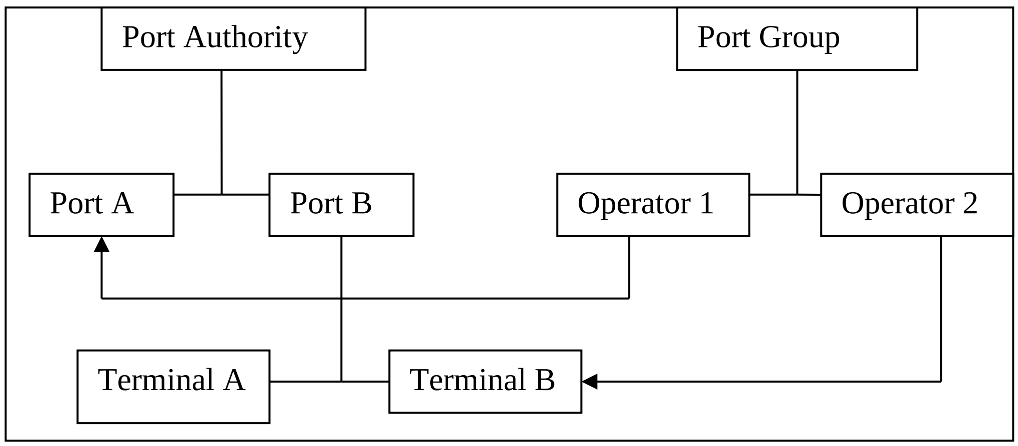
Given the widely accepted description of investment projects as the “real options”, it is rational to analyze investors’ choice behavior by employing discrete choice models used for consumer behavior analysis by considering port investors as the consumers of an option promoted by local governments. Most of disaggregate choice models are based on Random Utility-Maximization (Marschak, 1960; Manski, 1977). These random utility-maximization models assume that a consumer, when faced with a number of consumption options, chooses the one that has highest utility for him/her. The deterministic part of utility is generally specified as an additive linear function of observables and parameters (Train, 2003), whereas the added random error specified as the unobservable factors of the utility for a given consumer and choice situation. Different specifications of the random part of utility give rise to different specifications for the choice probability that a traveler chooses a particular travel alternative from a set of available options. The random utility-maximization models are widely applied not only in marketing but also in economics for demand analysis, such as traveler demand. Examples of random utility-maximization models that have been applied in demand research are Multinomial Logit, Nested Logit, Multinomial Probit and Mixed Logit. Several scholars have provided an elaborate literature review on these models, such as Chorus *et al.*(2008) and Malchow & Kanafani (2004).

While the random utility-maximization models have successfully works on demand analysis, there are still much spaces for the exploration of alternative behavioral frameworks for modeling investor behavior, especially for approaches that aim to combine spatiality of the decision-making process of port investors with random utility-maximization models. Under the developing trends toward market principles and devolution principles, multinational port investors entered the global port investment market for different reasons. Two types of port-operating transnational corporation have emerged in the lead for global private terminal ownership and operation: terminal operators and ocean carriers (Olivier, 2005).

The market structure of global port industry seriously influenced by macro economic factors, has been undergoing a trend of transformation for the economy globalization and particularly, the development of new economic units (e.g. China, India, and Brazil). Various successful ports located in developed countries has started to lose their market share in global container port market not for their poor operation, but for the factors they can't control, such as the shift of global production base. The reduction in revenue would push the operators of the successful ports to seek new business for living. One optimal choice is to directly invest on the developing ports with potential exciting earnings, and operate the chosen ports with the customers, operational manner and successful experience which they accumulated before.

Moreover, the organizational structure of global port industry is more complex than before. Besides port authorities and terminal operators, as another trend, big port operators (*i.e.* HPH, PSA, P&O Ports and SSA) have became port groups which controlled different container terminals within different ports, as shown in Figure 7.1. Finally, the ocean carriers also begin to invest on and control container port/terminal to support their main shipping business. Through the investment on ports, the ocean carriers can attain transportation base port, relative policy benefit, and developing chance; can release the competitive pressure; and can fight against the oligopoly in regional container port market. The sizeable amount and irreversibility of port investment determines that both kind of private investors are risk averse.

Figure 7.1 - Organizational Structure of Container Port Industry



This paper presents an approach rooted in risk-minimization, which asserts that an individual make choice between alternatives according to the wish to minimize the risk of the decision, as opposed to maximizing utility. As the partly unobservable risk leading to the addition of random error components, the approach can be coined as random risk-minimization approach. This approach contributes to the investment demand analysis in the following way; it captures the intuition that decision-making of risk averse may be more about avoiding downside risk rather than high return or profit. It's the first application in the maritime study and also investment demand analysis. This approach captures the port investors' behavior in a more precise way by exploring the real objective of port investors when making investment decisions.

This paper is structured as follows: Section 7.2 provides model specification of random risk-minimization approach. Section 7.3 describes the data collection effort.

Section 7.4 discusses the results of model estimation on the dataset, and Section 7.5 draws conclusions and discusses avenues for further research.

7.3 Research Method

Risk minimization model is to consider the situation where investor faces a choice among risky alternatives, such as different container ports. The investor is assumed to choose one container port to invest rather than other alternatives based on the minimized expected risk of the options. The risk is characterized as a probability distribution of the downsides loss and the scale of loss for each probability. Consider the risk of investment project of container port i, at time t,

$$R_{it} = F(X_{it-1}) + \varepsilon_{it}$$

Where X_{it-1} is the factor of the container port container port i at time $t-1$ that will influence the possibility of the loss and the scale of loss, which includes the impacts of managers' previous decision, ε_{it} is the error term, which is a random variable $\varepsilon_{it} \sim N(0, \sigma_\varepsilon)$. Thus, the decision maker choose a container port which could minimize the systematic risk R_{it}, acknowledging that minimization of random risk is mathematically equivalent to maximizing $-R_{it}$, the probability P_m that the individual investor chooses container port container port i, at time t can be derived using the well known mixed multinomial logit formulation:

$$P_m = \frac{\exp(-R_{it})}{\Sigma_j \exp(-R_{jt})} = \frac{\exp\{-[F(X_{it-1}) + \varepsilon_{it}]\}}{\Sigma_j \exp\{-[F(X_{jt-1}) + \varepsilon_{it}]\}}$$

Characterize the risk measures using general linear model, the above equation can be derived as,

$$P_m = \frac{\exp\{-[\alpha_{it-1} + \beta \cdot X_{it-1} + (u_{it-1} + \varepsilon_{it}]\}}{\Sigma_j \exp\{-[\alpha_{it-1} + \beta \cdot X_{jt-1} + (u_{jt-1} + \varepsilon_{it})]\}}$$

Where u_{it-1} is the error term of risk function, which is a random variable $u_{it-1} \sim N(0, \sigma_u)$. Note that, in the above equations, a lower risk measure results in a higher probability that the travel alternative is chosen. Consider a long-term situation, the above equation can rewritten as,

$$P_m = \frac{\exp[-(\alpha_{it-1} + \beta \cdot X_{it-1} + \varepsilon_{it-1})]}{\Sigma_j \exp[-(\alpha_{it-1} + \beta \cdot X_{jt-1} + \varepsilon_{it-1})]}$$

7.3 Data Collection

There's always risk in investment projects, proposed by whatever public or private founders. Some main factors can be identified as the most likely elements of financial risk of an investment. One is project risk or risk arising from over estimating or underestimating project costs (Kakimoto *et al.*, 2000). The second is competitive risk. Market share of particular container port remains highly uncertain quantity, which could be influenced by strategy taken by the competitors. Thirdly, the risk of market, arisen mainly by unanticipated changes in project cash flows created by changes in interest rates, inflation rates, political and economic environment. Furthermore, there are also initial risks associated with the new type of service and technology (Shil & Allada, 2007). This research consequently chooses variables as listed in Table 1.

Table 7.1 – Variables List

Sort	Variables
Market Risk	Trade values of Hinterland
Competitive Risk	Number of terminals, Total TEU of main competitor
Initial Risk	Depth of Water, Location (Dummy Number)
Others	Government Support (Dummy Number, including performance of relative logistic system)

Container ports of Chinese Mainland developed fast during the last decade, mainly due to the economic and international trade development of China. The Chinese container ports have already attracted many major port investors to launch projects with local port authorities by investing on port operation, infrastructure or related industry for the expected bright future. However, under the global economic crisis, the prediction of throughputs of Chinese main container ports shows a distinct decrease caused by the stagnancy of international trade, including both export and import. Chinese central government announces to invest 4000 billion RMB on infrastructure construction to stimulate the economy, where infrastructure construction of container port industry and related traffic system are one of the focuses of this exciting plan. Thus, this paper focused on the analysis of foreign port investors' behavior on investment of Chinese main container ports to suggest a direction of the governmental investment on policy issue. Also, the results of China market, as the most active container traffic market will be representative and valuable for studying the investment behavior of maritime business.

The dataset of this research records the main foreign port investors' choice facing 8 major Chinese container port (Dalian, Tianjin, Qingdao, Shanghai, Ningbo, Guangzhou, Shenzhen, Xiamen), based on various characteristics of the ports, from 1998 to 2005, where is obviously the most active period of foreign port investment. The data are collected from the Containerization International Yearbook 1999-2006, the Chinese National Bureau of Statistic, Newspapers and published government documents.

7.4 Empirical Results

Stata 10 is utilized for model estimation. Regarding the set up of dataset and Multinomial Logit model, the investors' choice and all risk indicators are coded as dependent variable and independent variables, as listed in Table 7.2.

Table 7.2 – Estimation Result

Variables	**Coefficient**	**Std.Err.**	**z**
α, Constant	1.407467	0.331708	4.54
β_1, Trade Values of Hinterlands	0.599282	0.101287	2.95
β_2, Number of TEU of Main Competitor	-0.137058	0.043695	0.31
β_3, Number of Terminals	-0.234825	0.085643	1.57
β_4, Government support	0.382692	0.084756	0.98
β_5, Depth of Water	0.178661	0.065529	2.73
β_6, Yangzi Delta	0.281253	0.038653	0.73
β_7, Pearl Delta	0.195824	0.053808	4.75
ε_{it-1}, Variance of error	0.400759	0.157929	

The results indicate that the trade values of hinterland and government support are important determinants of port choice. The foreign port investors are willing to invest on the Chinese container ports has hinterland with active international economic activities. The government support is still a critical factor that influenced the foreign investors' decision of investment. This explores that the government still played significant role in Chinese economy, which implies that government should be more cautious on the policy stability. Noting that the variable government support concludes whether the individual container port was supported by integrated logistics system, the logistics system is also importantly determines the foreign port investors' preference. If a container port contains many terminals in it, the probability of it being chosen decreases, as same as the competitors of a container port yields large amount of throughputs. The location of the port is an important port characteristics variable.

The foreign port investors are more probable to invest on the ports located in Yangzi-river Delta than the ports located in Pearl-river Delta. Reminding the influence of competitive risk, the intense competition among the container ports and terminals located in Pearl-river Delta should be the explanation of the above finding. The depth of water, as a measure of supply ability of container terminal, is positive connected with the probability of a container port being chosen. The estimation results explore the indicators of foreign port investors' choice on port investment in China, based on risk avoidance.

7.5 Conclusions

The analysis of investors' behavior with respect to choice of container ports is significant for policy formulation regarding construction and development of port infrastructure and related logistics system. This research is one of the few studies on the modeling investor's demand by using an empirical model in maritime study, and the first one attempted to model the choice of investors by employing random risk-minimization approach. The dataset of this research are reliable and unique, which is collected from different data source, some are in Chinese. Research on the choice of foreign investors on Chinese major container ports indicates that the trade values of hinterland and government support are the most critical parameters.

The results indicate that the foreign port investors prefer to invest Chinese container ports with highly active economic hinterland, strong government support, and integrated logistic system, whereas less competitive market environment. The finding suggests Chinese government should formulate policy to encourage cooperation rather than competition among the major container ports. At the same time, Chinese government should keep the policy stabilization and keep investing on logistics infrastructure construction according to the 4000 Billion RMB economy stimulation plan. Given the indicators of foreign port investors' preference, the container ports located in Bohai economic circle will attract the foreign investors and will meet a notable improvement not only in container throughput but also in operational efficiency. The government should continue support the development of these ports by announcing more flexible policies and sustaining investment on the relative infrastructure and economic environment.

The random risk-minimization model rises in this paper can be applied to any other industry to analysis the investors' behavior. It will be useful to understand the investors' demand under the global economic crisis, which leads the investors are more risk-avoidance in the uncertain economic future. The results of the research utilizing the random risk-minimization approach are expected useful and significant for the policy issue of government. Government and authorities can attain clearly direction and guideline of the governmental investment. The financial and welfare efficiency will be improved based on the understanding of the findings using random risk-minimization model. Also, a firm basic can be established for the future economy after recovering from the crisis. The future study may involve analyzing the global investors' preference on container port, studying the investors' choice behavior in other industries, and comparing the random risk-minimization approach to the traditional random utility-maximization approach in terms of their goodness-of-fit on same dataset.

Basically, selection of port investment projects is not different from selection of other investment projects. The investors make decisions according to their objective and the expectation on the investment return of different projects. Rarely works has been done in this area. The reasons could be that as a traditional industry, information of port investment are normally very confidential; and it is a new area in port studies as it will be more important under the global economic downturn. The findings of this research take the lead in explore the preference of port investors which are actually risk averse.

Chapter 8

Conclusion

8.1 Findings Summary

This thesis has investigated issues on port-oriented system development and operations under the changing business circumstances with qualitative analysis, empirical study and modeling research. The port industry is suffering new stresses due to the decarbonization through the global logistics and the worldwide economic crisis. With port capacity extension regarding to the emergence of dry port, the concept of port has been also extended to the concept of port-oriented system/network. Seaport and dry port should be considered both as the elements of the new concept of port. Six essays study the port implementation from different dimensions: port investment, port planning, port operation, and the influence of competitive, economic, politics environment on port. The main findings and contributions are summarized below.

The first essay suggests that a successful port operator must constantly prepare to adopt new strategies in order to cope with the changing environmental-friendly market. It has been explored that the traditional approach which cares only improving the port capacity and inner infrastructure development does not provide all necessary tools to cope with the highly competitive market environment and to secure their position in the global transport network. The analysis advices that the ports operators have to reduce the greenhouse gas (GHG) emission during their operations activities;

to improve the operational efficiency and to strengthen the port networking with inland transport to provide a reliable, in time and environmentally friendly subsystem to the clients for gaining the competitive advantages.

The second essay provides a comprehensive and macro view on port efficiency based on the features of port industry. By adopting the *Marginal Output* as new output factor, this research is the attempts to analyze the container terminal efficiency using DEA methods capturing the macroeconomic effects on each container terminal in China, and its developing logistics system. The heterogeneous effects of efficiency evaluation applying DEA can be reduced by applying this ratio output in order to carry out a comparatively impartial evaluation through the model. The results exhibited in this study reveal that the average efficiency of the Chinese container terminals could be not as high as it seems like; and the risk of misunderstanding and misevaluation might be hidden in the previous relative DEA application research.

The first inference of the third essay is that the quantum of minimum capital investments should be of a critical mass before economies of scale can be achieved. There is an unintended consequence of such capital investments which is creation of excess capacity to cater to future demand and growth which in turn adversely affects the dry port efficiency. The applied DEA model reveals that large throughput is likely to be associated with higher efficiency score. It has been also noticed that the privately organized dry ports have managed to fare better than those operated by the government due to evaluated average efficiency.

The forth essays proposed that the dry port operator should differentiate the varying needs of different customers. In order to improve service quality, it is critically important to understand the environment and the circumstances in which the demanded service was delivered. It is inappropriate on their part to offer standardized service quality when the needs of their customers/users are not only non - standardized but also vary from one transaction to another. Understanding of different stakeholder's perceptions of service quality and ability to measure it can be beneficial for the dry port operator. Moreover, the impact of competition regulation of a particular regional market on the service quality from different perspectives significantly is found.

The fifth essay argues that the current approaches to dry port location modeling are not effective enough and consequently supposes a new framework contained necessary determinants and scientific model to deliver a better understanding and practical application of the dry port location choice. The model combines the advantages of group decision-making models and the geometric least square methods. The numerical example presents the application process of the modeling framework and shows that the suggested model can be pragmatically introduced to the relevant problems. This research is one of the scare research that analysis the location allocation problem for inland intermodal terminal.

The sixth essay which is on analyzing the choice of foreign investors on Chinese major container ports indicates that the trade values of hinterland and government support are the most critical parameters. The results indicate that the foreign port investors prefer to invest Chinese container ports with highly active economic hinterland, strong government support, and integrated logistic system, whereas less competitive market environment. It is suggested to the government to continuously support the cooperation among the regional seaport competitors, and the cooperation among the seaport and inland hubs.

8.2 Future Research

The future research can be continued on studying the problems of port system under decarbonization and economic crisis. First of all, the shipper's choice under the carbon reduction can be empirically clarified and/or modeled to verify the undergoing optimization of the logistics integration. Finding the optimal route for shippers can provide valuable insights for port operators and shipping lines in planning their competitive strategy under the new environment.

Secondly, the carbon trading mechanism with the port industry stakeholders, such as oversea ports, neighboring ports and shipping lines, need to be concerned. Carbon trading under the carbon tax regulation has been discussed in other transport sections but is still rarely considered for port industry. Carbon trading supplies port opportunity in the environmental-friendly logistics network as being one of the value-adding service and determinant of profitability for well operated port without a strong hinterland.

Furthermore, the heterogeneity problem and the unwanted output in port efficiency analysis can be researched with alternative methods. Stochastic frontier analysis can be employed to deal with the heterogeneity problem of port efficiency. Besides the hinterland economy, more factors can be involved to investigate the operational performance of port. The measurement of unexpected output is important for evaluating the port efficiency under environmental requirements. Some scholars have documents method within DEA framework to assess the efficiency considering the impact of environment cost. However, the implication of such thoughts in port industry remains spaces to be followed.

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