Port sustainable services innovation: Ningbo port users' expectation

Zun Wang
Warrington College of Business Administration
University of Florida
Gainesville, Florida Area
gracewang1993@126.com

Nachiappan Subramanian
Nottingham University Business School
The University of Nottingham, Ningbo, China
Nachiappan.subramanian@nottingham.edu.cn

Muhammad D. Abdulrahman
Nottingham University Business School
The University of Nottingham, Ningbo, China
muhammad.abdulrahman@nottingham.edu.cn

CUI Hong*

Ningbo College of Health Sciences,
Ningbo 315100, China
* Corresponding Author

Lin Wu
Nottingham University Business School
The University of Nottingham, Ningbo, China
lin.wu@nottingham.edu.cn

Chang Liu
School of Economics
The University of Nottingham, Ningbo, China
chang.liu@nottingham.edu.cn

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Abstract

Port sustainable services innovation depends on understanding and matching customers' expectations with unique service offerings using advanced facilities. This study develops and validates a port sustainable services decision model to investigate customers' port services expectations based on the views of companies and freight services providers located in major cities nearby Ningbo port. Thus, the study will enable better understanding of the port's impact on sustainability of the economic and social prosperity of its immediate environment stakeholders by balancing three major aspects such as services, costs and facilities. The study employed a multi-criteria decision-making methodology Analytical Hierarchy Process (AHP) to analyze the model. The results show that while different port users have different views and expectations, port infrastructure improvement, cargo safety, and reductions in port charges are critical to attract businesses. Port-dependent companies that were investigated also cite reduced paper work and optimized e-business as well as reduced transport congestion as key areas for improvements. This study provides port administrators with insights on how to effectively improve business attractiveness for greater sustainability and competitive advantages with rival ports within the same geographical proximity. In addition it also suggests how to design cost-effective ways of meeting and even surpassing users' expectations.

1. Introduction

There is an increasing attention on ports and port activities integration in response to the fluctuating demands of the market with respect to efficiency and cost-effective services in contemporary supply chains (Bichou and Gray, 2004; Haezendonck and Notteboom, 2002). For ports' to sustainable production and consumption, the critical factors lie in there being engines and bridges for local and regional economic development (Rietveld

1989; Clark, Dollar and Micco, 2004). The contribution of ports to sustainable production and consumption can further be viewed from the perspective that port cities are nodes of exports, imports, migration flows and cargo transportation (Rodrigue et al., 1997; Grobar, 2008; Hesse, 2004). More importantly, the sustainability of ports in terms of their service production and consumption depends on the service quality and customer satisfaction (Yeo et al., 2015, Yeo et al., 2008). Yeo, Thai and Roh (2015) suggest that "failure or unreliability of port services can significantly influence port customers." Therefore, port activities, if improperly managed, could result in negative influences such as local traffic congestion and lack of business attraction due to customer dissatisfaction (Grobar, 2008; Hesse, 2004). This would subsequently influence port related employment and have bad effects on port cities, among other disadvantages (Grobar, 2008; Hesse, 2004).

Past studies indicate ports as key to the creation of comparative advantages for the regions and cities in which they are located (Rietveld 1989; Clark, Dollar and Micco, 2004). According to the location theory, efficient ports help their immediate environments generate more economic interest via a larger throughput of goods while inefficient ports may hamper sustainability of their location by making otherwise affordable input sources or good markets prohibitive (Notteboom et al., 2009; Warf and Cox, 1989; Danielis and Gregori, 2013). Furthermore, maritime work plays an important role in urban and socio-economic development systems as port and city are highly integrated (Comtois and Slack, 1997; Abdullah et al., 2012). The strong correlation between port size and size of the city in which it's located demonstrates that maritime affairs are some of the most significant motivators of urban development (Rodrigue et al., 1997).

Surprisingly, extant literature in location theory has almost exclusively focused on demonstrating the positive economic and social impacts of ports on their immediate environment (Rietveld 1989; Clark et al., 2004; Abdullah et al., 2012). Past studies have failed to examine the relationship between ports within the same geographic location and the nature of competition between them in order to proffer possible solutions for ports'

policymakers on key attractiveness and order/customer winning criteria. Also, while extant literature provides deep analysis of port activities and port performance based on financial and operational indicators, they have largely ignored the need to measure the efficiency and productivity using an analytically consistent method (Estache, 2002). Estache (2002) suggests that a standard analytic method is needed to evaluate port performance based on productivity and efficiency and to permit the ranking of ports at regional, international and more dynamic levels.

Furthermore, extant studies are in Western contexts that show very little knowledge about China's ports despite China having the largest global share of ports with the largest cargo volume (Song and van Geenhuizen, 2014). For instance, China has over sixty ports and in 2011, among the top 20 highest cargo volume ports in the world, 9 Chinese ports accounted for 52.9% of the global share (Song and van Geenhuizen, 2014). These Chinese ports engaged in tough competition with each other for client attraction because of their close geographical proximity. (Kim, 2011; Schednet, 2015). China's ports, especially the Ningbo port investigated in this study, face several other challenges such as infrastructure deficiencies, less than efficient services and limited capabilities.

The above clearly demonstrates the imperative of investigating the business connection between cities and port activities within its location. Typically, how to establish a business relationship with port users by balancing services, cost and facilities? This study develops and validates port sustainable services innovation decision model to investigate the expectations of Ningbo port services based on the views of companies and freight services providers located in major cities nearby Ningbo. Broadly, there are three main contributions by this study: firstly, it will enable better understanding of the port's impacts on sustainability of the economic and social prosperity of its immediate environment stakeholders. Secondly, it provides port administrators insights on how to effectively improve business attractiveness for a greater sustainability and competitive advantage with rival ports within the same geographical area. Thirdly, it provides policymakers with a means of establishing fairly accurate users' expectations and designing cost-effective ways of meeting or surpassing such expectations.

The rest of the paper is organized as follows. Section 2 provides comprehensive literature review on ports' activities and competition. This is followed by Section 3, which deals with the strategic business relationship in maritime logistics and a research framework. Section 4 deals with the methodology employed in this study, followed by Section 5, which presents the results and discussions of the findings of the investigation. Section 6 provides the conclusion and limitations of this study, in addition to suggested future research directions.

2. Literature review

2.1 Port services

The role of a port is complicated and dynamic with the most obvious being the shifting of inland cargo to shipping transport or in the reverse order (Compes Lopez and Poole, 1998). Ports are witnessing increasing change in the ownership structure and in the roles they play. Ports are now regarded as a 'service center' (UNCTAD, 1999), as they incorporate an integration of a transport network, value adding services such as transport consolidation, product mixture or cross docking activities as well as a networking place for members within various supply chains to meet (Stank, Keller and Daugherty, 2001; Paixao and Bernard Marlow, 2003). Ports play an important role in sustainable supply chains through high operational and efficient logistics activities for the benefits of collaborative firms (Lopez and Poole, 1998). These collaborative firms include warehouse operators, transport operators, ships' agents and forwarders that are involved in the 'port community' (Compes Lopez and Poole, 1998).

Like any other business entity, ports compete both locally and globally for the attention and patronage of users, using various value added terms (Baird, 1999; Li and Oh, 2010). Therefore, each seaport operator aims to maximize the port's growth using unique value additions such as speed, efficient handling of goods, cargo security and competencies of port operators amongst others. This results in the strong competition among ports, especially for ports within adjacent geographic locations. In addition to the competition among ports (within and outside their geographic location), the ports' competition is

unfolding between logistics chains because of the significance of value added-logistics and the increased range of services offered (Christopher, 1992; World Bank, 2000; UNCTAD, 2002; Yoon and Nam, 2006). Basically, if managers do not treat ports as core participants in optimizing the whole logistics chain process, they will be excluded and disregarded as ports of preference on national freight routes (Li and Oh, 2010).

2.2 Port performance evaluation

According to Tongzon (1995) exposure to the stress of global competition has pushed port authorities to improve port performance. Port performance is a measure of its effectiveness and efficiency in the activities it's engaged in as evidenced by its consumers' satisfaction (Mentzer and Konrad, 1991). The performance of ports can be evaluated by productivity indicators such as the number of containers transported through a port given that ports are throughput maximizers (Tongzon, 1995; Marlow and Paixao Casaca, 2003). In a worldwide context, port performance is uniformly evaluated in terms of 20-feet equivalent units (TEUs) or cargo volume (Sachish, 1996). However, Tongzon (1995) also state that this approach results in an obvious distinction between port efficiency and effectiveness. Accordingly, port performance indicators have been separated into financial and operational categories by UNCTAD (Table 1).

A key challenge of port's performance is achieving customer satisfaction. The reality of port is a complex one, involved in whole supply chains, each with particular needs. Networks make it possible to describe the relationships between ports actors involved in the process of customer satisfaction. To respond to the needs of its network users, ports continually engage in improving infrastructure, creating innovative operational routines and accelerate service quality development, as this sector is quite sensitive to customer satisfaction (Cariou, Ferrari and Parola, 2014).

Woodall (2001) states that 'customer' is the most significant part of any business of the service sector. So it is indispensable to remember that the activity of the sector oriented directly to the customer and its results exactly dependent on customer choice. Meanwhile, representation of expectations depends on how clients perceive and explain the

environmental factors affecting the expectation formation (Chapman, Soosay and Kandampully, 2003; Gorla, Somers and Wong, 2010). Zairi (2000) opined that the company's performance depends more on the customers. Writz (2001) also thinks that customers' satisfaction is the key element for company to promote repeated business networks and increase long-term benefits. Therefore, to understand their customers, to find out their needs and to strive to meet their satisfaction are challenges and opportunities for ports. Ports' policymakers need to understand customers and need to balance between three elements such as cost, services and facilities.

3. Port sustainable services innovation model

In maritime logistics, port may act the role of supplier, offering various services to companies from different cities who now act as the port's consumers. Because of the inconvenience of geographical location or other reasons, the freight-forwarding agency, as the intermediary, will help to take on part of the work to connect ports with ships on behalf of consumers. These three groups form a triadic relationship for repeated business interactions between the members. A triadic relationship is more powerful compared with dyadic type in grasping the dynamic elements of service networks and/or encounters (Ford and Hakansson, 2013). This explains why logistics companies have changed from focusing only on fixed transactions to establishing long-term, profitable and mutually beneficial triadic relationships (Hsiao et al., 2010).

We identify key port users' expectations based on extant literature which are then subdivided into different criteria to develop a sustainable services innovation model. The identified key port users' expectations are categorized into three general criteria of services, costs, and facilities. These criteria form the second level in our sustainable services innovation model. On the bottom of this level are nine sub-criteria that show the influential elements in port activities. These are port users' expectations that include cost, service, facility, efficiency, safety of cargo, flexibility, port infrastructure, ship calls and information transparency (Figure 2). We briefly explain each of the sub-criteria of the model in the context of this study.

Insert Figure 2 about here

3.1. Safety

Safety here refers to the 'cargo safety,' which means the avoidance of damage, loss and theft of the cargo. Since cargo will be loaded into containers, transported long distances, and then unloaded at the container terminal; keeping the cargo intact is a key requirement for all customers (UNCTAD, 1992; Murphy, Daley and Hall, 1997; Hsu, 2013). If a port has a bad reputation with cargo handling safety, potential clients will be driven away and the confidence of existing clients will be influenced (Alyami et al, 2014).

3.2 Fast response to problems

Disturbances are very common and may appear at any time in the process of loading, transport, and unloading in the port. Whenever an unplanned disturbance occurs, the port must take quick responsive action to mitigate negative effects resulting from these emergencies. For instance, in 2014, Ningbo port suffered a serious strike by the workers of container truck motorcades. Workers demanded the port authority to increase the price of freight. This incident resulted in chaos at Ningbo port and departure time for a great number of vessels was delayed. Moreover, bad weather conditions, accidents during the loading/unloading operation, emergency transportation events, and smuggled goods will also influence the port without warning (Vukadinovic' et al., 1997).

3.3 Process efficiency

According to Tongzon (1995), terminal efficiency is measured by the amount of containers loaded and unloaded per berth hour. Inefficient operations will result in indirect cost. For instance, delays either in commencing or during stevedoring can result in inefficiency. Delays may be due to meal breaks, equipment breakdown, and other events. Congestion or low berth-side efficiency will also result in delays to liner schedules. Meanwhile, the efficiency of handling clearance and declaration formalities will be included in this term.

3.4 Flexibility

Since the market that the port is facing is uncertain and the economic development and technology is changing, the variability in ports is increasingly recognizable. Flexibility is closely related to process technology and is regarded as an adaptive response to consumers in uncertain conditions. Flexibility is one of the main topics when developing the model of port service supply chain. This flexibility mostly refers to the interaction among ports and port logistics activities, by which ports are able to give feedback quickly and satisfy customers' demands for diversified services (D'Este and Meyrick, 1992; De Langen, 2007). This implies that ports have to monitor and understand ports users' needs at any given time so as to respond in the quickest way. Dimensions of flexibility include the time period taken by a company to react, the organizational adaption level to predictable and unpredictable changes, and the degree that the company's attitudes to maintain or expand their flexibility (Hakam and Solvang, 2009).

3.5 Port charge

Port charge is a very important factor that represents the monetary cost of using the port. It can be classified into several types like charges on containers, terminal handling charges, inventory fee, or charges on vessels or service charges (Tang et al., , 2008). There are many fee items that make up the port charge. Different countries, different ports, or even a country's different or same wharf have their own port charge regulations. It is also related to the type of payment pattern signed by the purchase party.

3.6 Inland transportation cost

Besides, inland distance and fees caused by inland transport are also a significant part of the total cost. Freight forwarders will always pay the trucking fee when cargo is transported from the factory to the port in containers. When there are two adjacent ports that serve the same geographical market, a shipping line has to lower its cost and the client will reduce the use of that port when its inland transportation cost is not competitive over the other one (Ng et al., , 2013).

3.7 Port infrastructure

Infrastructure contains different container berths, cranes, tugs, adequate terminal area, etc. If the maximum volume that port infrastructures can handle is less than the actual volume, it will result in port congestion and drive away port users. Hence, adequate infrastructure will reduce the ship waiting time by permitting quicker and safer transportation without any congestion so that economy of scale is easier to acquire. In this case, maritime transport costs will also be eliminated by avoiding port congestion (Sanchez et al., 2003; Marlow, 2003).

3.8 Information transparency

Information plays a significant role in the cross-boundary business especially in the port business. Especially in waterborne transportation, information exchange between ship to shore is important since the safety-related information is vital. And asymmetric or loss of information is not acceptable. With the data sharing and information flows, information and communication technology (ICT), a strong communication tool, can make information transparent. Comprising the Internet, EDI, ERP and proprietary applications, it is one of the most effective enablers from both the technological and relational point of view and has made a lot of contributions to the efficiency and responsiveness of logistics through exchanging information among members. Increasing the visibility level can improve internal decision-making and operating performance as well (Fei, 2011).

3.9 Ship calls frequency

The frequency of ship calls influences the volume of goods that can be transported through a port. According to the study of Tongzon (1995), port end-users and freight forwarders engaged in the transportation between US and Europe were surveyed to find out the port selection criteria. At that time, many people ranked the 'numbers of sailings' as the first rank among all the criteria related to port choice. Madeira et al. (2012) also indicates that the frequency of ship calls is one of the main determinants in choosing a port. It is more attractive for importers and exporters when frequency is increased (Tongzon, 1995).

4. Methodology

Multiple case studies were carried out using qualitative data gathered from four major Zhejiang metropolitan logistics firms to investigate aspects relating to the strength of their business relationships and attractiveness to Ningbo port. We utilized Analytical Hierarchy Process (AHP), one of multi criteria decision analysis (MCDA) methods by Saaty (1980). Multi-criteria decision analysis (MCDA) is a term that interprets a collection of various methods to facilitate decision-making for complicated issues and to evaluate the best of a discrete set of alternatives or criteria (Rozakis et al. , 2001). Instead of using normal methods that assumes the availability of measurements, this approach utilizes guide and rank management alternatives based on preference, weight or strength of factors in a transparent and rational way. It makes sense since different people with distinct opinions will generate different outcomes (Saaty and Vargas, 2006). Although each form is conducted differently, the similarity is that most decision-making processes are possible to be achieved by decomposing the overall assessment of alternatives into evaluations on a few conflicting factors or criteria related to the issues (Durbach and Stewart, 2012).

To understand customer satisfaction and the need of sustainable services between Ningbo port and four metropolitan cities, we assess aspects of the port users in terms of their different expectations. This way, port services could be improved in line with users' expectations rather than by projection. The current performance of Ningbo port is evaluated using the three groups of criteria on Figure 2: services, costs and facilities. Each of the group contains sub-factors to make the evaluation more specific. Moreover, the pairwise comparison approach of Analytical Hierarchy Process will be employed for criteria selection.

4.1 Data collection

Data was gathered through semi-structured face-to-face interviews and the administering a three-part questionnaire designed for exhaustive extant literature review. The first part of our questionnaire consists of basic information of respondents while the second parts relates to the quantitative ranking of the importance of listed port criteria by participants

based on Saaty's 1-9 rating scale (Satty, 1980). This part of the questionnaire was made up of open questions designed to investigate the existing business relationships and to solicit users' opinions on current Ningbo port performance. The questionnaires were distributed to five different companies including trade companies and freight forwarding agencies operating in different cities within the geographic area of the Ningbo port (one from Ningbo, one from Hangzhou, one from Wenzhou and two from Jinhua andYiwu). All responding companies have used Ningbo port for between 4 to 20 years. Besides, for the participant in Ningbo, we also had face-to-face interviews with respondents discussing open questions from the questionnaire and other information about Ningbo port. So the pilot test has already been made to ensure the accuracy and the clarity of the questionnaire.

4.2 AHP method

The uniqueness of AHP is its flexibility to be integrated with various techniques as well as its capability of weighing a great amount of different elements both qualitative and quantitative data to support decision-making (Vaidya and Kumar, 2006). In this study, two types of comparisons are carried out by responders: a) a pairwise comparison of services, costs and facilities on level 2, and b) a pairwise comparison of level three sub-criteria within their own cluster. In general, there are four steps to conduct the AHP (Ho, 2008; Subramanian and Ramanathan, 2012). Since we do not have any alternative in this research, the fourth step will be omitted.

Step 1 Create a decision making framework

The AHP model consists of three levels. Services, costs, and facilities of Ningbo port will be the major criteria that will be positioned at the top level. Their sub-criteria will be regarded at the bottom level. There are four factors (safety, fast response to problems, process efficiency and flexibility) contained in the 'Service' criteria and two factors (port charge and inland transportation cost) belong to 'Cost'. We group another three elements (port infrastructure, information transparency and ship calls frequency) in 'facilities'.

Step 2 Pairwise comparisons and judgment scale

Judgments on comparative attractiveness of criteria are evaluated by Saaty's 1-9 rating scale shown in Table 2 below.

Insert Table 2 about here

When respondents compare the importance of each pair of criteria, Saaty's 1-9 scale will be used, where '1' means the two criteria of the port are equally important. '3' means one of them is moderately important than the other one. Similarly, '5' means strong importance; '7' refers to 'very strong or demonstrated importance'; '9' is 'extreme importance'. Rates of 2, 4, 6 and 8 represent the compromise between their above values. A factor that receives a higher rating means that it is more important than the one that receives a lower mark. The comparison will repeat for all the criteria on level 2 and the sub-criteria in the same cluster on level 3 followed the guidance in Table 2.

Step 3 Local weights and consistency of comparisons

Data is organized in terms of the quantitative part form questionnaires by using the Expert Choice 2000 2nd Edition software. In particular, since there are two responses from Jinhua-Yiwu, the geometric means are computed in order to integrate different views. Local weights of corresponding elements on the second and third level of each city are shown in table 3. We checked the Consistency Ratio (CR) to appraise the reliability of responses from questionnaires. If CR is higher than 0.1, judgments should be revised once again until we reach a consistent judgment (Satty, 1990; Noble and Sanchez, 1993; Subramanian et al., , 2015). Table 3 shows the local weight of criteria.

Insert Table 3 about here

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5. Results and analysis

Table 3 summaries the local weight of criteria employed in this study. The results indicate that the firms in cities investigated hold different views about the relative importance of the key attractiveness and/or customer winning criteria for the port based on our AHP framework. For Ningbo based firms, port facility (weight = **0.481)** ranks as the most significant elements influencing their attention and attractiveness to the port, compared with Cost (weight = 0.405). Facilities are closely followed by Cost as the second important factor for Ningbo based firms. Surprisingly, services weighed very low (weight = 0.114) compared with other factors (Cost and Facility). This may be connected with the possible perception of the investigated firms that availability of efficient facilities and affordability are critical components of sustainable production and consumption of port services. Services produced and rendered by the port are highly correlated with availability of relevant facilities while the consumption of such services to a large extent will be correlated with the associated charges. In other words, efficient facilities influence the capacity of the port and how much the port charges its users. These two factors, facilities and cost, are highly objective and regulated in advance. So port users may pay more attention to the nature and attributes of the port rather than human-driven services. Similar to Ningbo's users, Hangzhou firms ranks Facility highly: (weight = 0.637), Cost (weight = 0.258) and Services (weight = 0.105). Wenzhou firms, however, demonstrated totally different results (Table 3). Over half of the total weight for Wenzhou based firms was accounted for by Services (weight = 0.594), while other weights were comparatively low: Facilities (weight = 0.249) and Costs (weight = 0.157). These results imply Wenzhou based firms place more emphasis on the human-driven factors compared with other ports users investigated. A number of reasons can be attributed to the Wenzhou based firms' high regard for the port's human-driven factors in services. Firstly, Wenzhou is geographically farther away compared with the Ningbo port, and this implies the need for more intensive interaction of different forms with port officials by firms in Wenzhou compared with firms located in Ningbo. Secondly, and related to geographic location, Wenzhou firms are more likely to experience negative influences such as traffic congestion and delays among other problems that necessitate

more attention and interactions with port authorities compared with Ningbo based firms as suggested by literature (Grobar, 2008; Hesse, 2004). Therefore, the limited visibility and observation of the internal facilities of the port by Wenzhou firms may account for the high positive correlation with human-driven factors of services requirements. Finally, in Jinhua-Yiwu firms focus more on Facilities (weight = 0.413) then on Services (weight = 0.327) and Costs (weight = 0.260).

While the results suggest these port users hold different views in terms of the importance placed on ports' criteria based on the comparisons above, the results indicates that the logistics firms from three cities (Ningbo, Hangzhou and Jinhua-Yiwu) are focused mostly on the facilities criteria as their critical attraction factor. This implies that port authorities should enhance the port infrastructure relative to cost and services to attract more businesses from firms based in these cities (Ningbo, Jinhua-Yiwu and Hangzhou). The result also indicates that improvement in port facilities will enhanced business relationships between most users in four metropolitan ports and in the Ningbo port. The improvement of port service will contribute most to the business of Wenzhou but rarely changes those of the other three cities. Our results suggest cost criteria come second to facility criteria in all cases. The implication of this is that while firms are willing to pay a premium price for quality port services, they nonetheless expect moderate and/or sustainable charges. That is, decreasing costs will generate moderate change in terms of business attractiveness and hence the sustainability of the port operations.

We calculated the global priorities of level three criteria according to the local weights of each sub-criterion as shown in Figures 3a-d.

Insert Figures 3a - d about here

For Ningbo, the top three elements of the priority are ship call frequency, port charges, inland transportation cost and infrastructure (Figure 3a). Criteria of port charges and inland transportation costs have the same weights for Ningbo firms. Our results in terms of percentages of fast response to problems and flexibility are similar and much lower

compared to other elements such as ship call frequency and port charges (see figure 3a-b) for both Ningbo and Hangzhou based firms. This indicates that if the port authority improved these high-weight factors, maritime businesses at Ningbo port will be promoted for these firms. Changes in flexibility and fast responses will not make much difference. On contrary, the response from Wenzhou (Figure 3c) considers fast response as the most significant criteria, over port infrastructure and safety. Additionally, and surprisingly also, ship call frequency and inland transportation costs are not very important with both only 3.9% of the overall weight. It shows that port users from Ningbo and Wenzhou have totally different expectations of the port. Besides, Jinhua-Yiwu based firms are more concerned with infrastructure, safety and port charge (Figure 3d). A common trend in the results is for flexibility and process efficiency Weights for all investigated firms are relatively low. This implies that process efficiency and flexibility are less important for most users and there is no hurry to improve these two aspects. Furthermore, Information Transparency is always strictly dominated by port infrastructure in the facility cluster. Likewise, port charges dominate the inland transportation cost. Hence, decreasing the port charge will be more effective to attract customers compared with decreasing inland transport fees. Overall, the results suggest that infrastructure and port charge have greater influence on the ports' business attractiveness. The implication of this is that improvements of these two criteria will stabilize the business relationship between port and port dependent companies in the four metropolitan cities investigated in this study.

5.1 Sensitivity analysis

Since weights are calculated based on subjective judgments, the stability of priorities must be tested. Sensitivity analysis is used to discover the influence of a decision maker's uncertainty about their values and priorities and to offer a different view on our study. This is conducted by changing the criteria weight to understand its effect on the results of the model. For instance, what if service is more important than other criteria? Ideally, the priorities of the sub-criteria should be stable with only minor perturbation. But under more variations in weights, the priorities may change. In our analysis we only adjust the weights of level 2 and conducted experiments with Ningbo participants as a reference. Hence to draw comparisons with initial results, local weights of elements services, costs

and facilities have been increased to 25% and to check the consequences of its impact on global priorities. We found no influence for the priority of criteria on level three from all responses from Hangzhou, Wenzhou and Jinhua-Yiwu (Figure 4). Therefore, the analysis and results are considered acceptable.

Insert Figure 4 about here

5.2 Responses integration

Finally, we combined all the responses from five questionnaires and the priorities are shown in Figure 5. There is an assumption that Ningbo port authority is not able to improve all aspects of the port, so it will get the most effective achievement in the shortest time focusing at key criteria of port improvement at a given time. Although participants on behalf of each city have distinct views, we can still try to find a general result about the importance of various criteria. Similar to what is predicted in section 4.1.2, to improve port infrastructure and decrease port charges is the optimal actions for Ningbo port. Although ship calls frequency is also important, it is less significant when Ningbo port is compared with Shanghai port as both ports share the same shipping route normally. However, inland cost is significant because the hinterland cities like Wenzhou and Jinhua-Yiwu are closer to Ningbo compared with Shanghai. Finally, flexibility and fast response to problems appears not to have significant impact on port users' attitude and decision to collaborate with the port, with the exception of port users in Wenzhou who believe quick response is very important. Therefore, when combined with all other views, Ningbo port authority can pay the least attention to flexibility and fast response aspects with no significant negative impact to the port business attractiveness.

Insert Figure 5 about here

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6. Conclusion

This study analyses customers expectations between ports and its users through sustainable services innovation model in context of Ningbo port, China. The study gives suggestions and direction for the port authority to strengthen business relationships with the four major Zhejiang metropolitan logistics businesses. The result shows that, in general, port-dependent companies in Ningbo, Hangzhou, Wenzhou and Jinhua-Yiwu view strongly the need for port infrastructure improvement and a decrease in port charges as major attractions to the port. Developing cargo safety guards, decreasing the inland transportation fee will also stabilize the business relationship to a large extent. While there may be limited opportunities for both Ningbo port authority and the Ningbo government to eliminate or minimize transport congestion, optimizing aspects such as paper work processing and enhancing e-business will significantly improve port business attractiveness. This study extends the current literature on port performance, business networks and relationships between port and its neighboring cities.

Despite our concerted effort, this study has a number of limitations. This study only uses AHP to analyze the priority of importance. Conducting AHP is a complex procedure and it is possible that respondents exhibit inconsistencies in their ranking. We suggest further research using other decision-making approaches such as Analytical Network Process (ANP) along with in depth qualitative analysis. ANP is able to provide a general framework to conduct decision-making without creating assumptions about the independence of higher-level elements from lower-level criteria.

Another issue with this study is that the relationship between port-dependent trade companies in the four metropolitan areas investigated is classified into one group to implement a dyadic business relationship model with the port. However, the influence of the intermediary on trade companies or on Ningbo port is omitted with no triadic business relationship considered. In the future, the role of intermediary or freight forwarding agencies in port business relationship should be examined to gain additional insights into how to improve port performance. . Furthermore, to confirm the result of this study and

provider more insight, we suggest a quantitative survey methodology with a larger sample size be employed in the future study.

References

Abdullah, J., Ahmad, Z., Shah, R. and Anor, N. (2012). Port City Development and Quality of Life in Pasir Gudang Port, Johor, Malaysia. *Procedia - Social and Behavioral Sciences*, 35, pp.556-563.

Alyami, H., Lee, P., Zh, Z., Riahi, R., Bonsall, S. and Wang, J. (2014). An advanced risk analysis approach for container port safety evaluation. *Maritime Policy & Management*, 41(7), pp.634-650.

Baird, A.(1999), "Container Vessels in the New Millennium: Implications for

Seaports,", *Proceedings of the 1999 Halifac Conference*, pp.125-147.

Bichou, K. (2006). Chapter 24 Review of Port Performance Approaches and a Supply Chain Framework to Port Performance Benchmarking. *Research in Transportation Economics*, 17, pp.567-598.

Bichou, K. and Gray, R. (2004). A logistics and supply chain management approach to port performance measurement. *Maritime Policy & Management*, 31(1), pp.47-67.

Cariou, P., Ferrari, C. and Parola, F. (2014). Addressing special challenges in maritime and port logistics. *Maritime Policy & Management*, 41(5), pp.425-429.

Chapman, R., Soosay, C. and Kandampully, J. (2003). Innovation in logistic services and the new business model. *International Journal of Physical Distribution & Logistics Management*, 33(7), pp.630-650.

Clark, X., Dollar, D. and Micco, A. (2004). Port efficiency, maritime transport costs, and bilateral trade. *Journal of Development Economics*, 75(2), pp.417-450.

Compes Lopez, R. and Poole, N. (1998). Quality assurance in the maritime port logistics chain: the case of Valencia, Spain. *Supply Chain Management: An International*

Journal, 3(1), pp.33-44.

Danielis, R. and Gregori, T. (2013). An input-output-based methodology to estimate the economic role of a port: The case of the port system of the Friuli Venezia Giulia Region, Italy. *Maritime Economics & Logistics*, 15(2), pp.222-255.

D'Este, G. and Meyrick, S. (1992). Carrier selection in a RO/RO ferry trade Part 1. Decision factors and attitudes. *Maritime Policy & Management*, 19(2), pp.115-126.

De Langen, P.Q., (2007). Port competition and selection in contestable hinterlands: the case of Austria. European Journal of Transport and Infrastructure Research 7(1), 1-14

Durbach, I. and Stewart, T. (2012). Modeling uncertainty in multi-criteria decision analysis. *European Journal of Operational Research*, 223(1), pp.1-14.

Estache, A., Gonzlez, M. and Trujillo, L. (2002). Efficiency Gains from Port Reform and the Potential for Yardstick Competition: Lessons from Mexico. *World Development*, 30(4), pp.545-560.

Fei, J. (2011). An empirical study of the role of information technology in effective knowledge transfer in the shipping industry. *Maritime Policy & Management*, 38(4), pp.347-367.

Gorla, N., Somers, T. and Wong, B. (2010). Organizational impact of system quality, information quality, and service quality. *The Journal of Strategic Information Systems*, 19(3), pp.207-228.

GROBAR, L. (2008). The Economic Status of Areas Surrounding Major U.S. Container Ports: Evidence and Policy Issues. *Growth and Change*, 39(3), pp.497-516.

Haezendonck, E, and Notteboom, T.(2002), "The competitive advantage of seaports", Port Competitiveness: An Economic and Legal Analysis of the Factors Determining Competitiveness of Seaports, *De Boeck,* pp.67-87

Havila, V. (1994). The role of the intermediary in international business relationships: theoretical framework. No 1993:6. Working Papers from Uppsala University. Department of Business Studies.

Havila, V., Johanson, J. and Thilenius, P. (2004). International business relationship triads. *International Marketing Review*, 21(2), pp.172-186.

Hesse, M. (2004). Land for logistics: locational dynamics, real estate markets and political regulation of regional distribution complexes. *Tijdschrift voor economische en sociale geografie*, 95(2), pp.162-173.

Ho, W. (2008). Integrated analytic hierarchy process and its applications " A literature review. *European Journal of Operational Research*, 186(1), pp.211-228.

Hsiao, H., Kemp, R., van der Vorst, J. and (Onno) Omta, S. (2010). A classification of logistic outsourcing levels and their impact on service performance: Evidence from the food processing industry. *International Journal of Production Economics*, 124(1), pp.75-86.

Hsu, W. (2013). Improving the service operations of container terminals. *The International Journal of Logistics Management*, 24(1), pp.101-116.

Kim, H. (2011). Prospect of Premier Port Competition in East Asian Region. *The Asian Journal of Shipping and Logistics*, 27(2), pp.191-215.

Li, J. and Oh, Y. (2010). A Research on Competition and Cooperation Between Shanghai Port and Ningbo-2shan Port. *The Asian Journal of Shipping and Logistics*, 26(1), pp.67-91.

Murphy, P., Daley, J. and Hall, P. (1997). Carrier selection: Do shippers and carriers agree, or not?. *Transportation Research Part E: Logistics and Transportation Review*, 33(1), pp.67-72.

Ng, A., Sun, D. and Bhattacharjya, J. (2013). Port choice of shipping lines and shippers in Australia. *Asian Geographer*, 30(2), pp.143-168.

Noble, E. and Sanchez, P. (1993). A note on the information content of a consistent pairwise comparison judgment matrix of an AHP decision maker. *Theory and Decision*, 34(2), pp.99-108.

Notteboom, T., Ducruet, C. and Langen, P. (2009). *Ports in proximity*. Farnham, England: Ashgate Pub.

Paixao, A. and Bernard Marlow, P. (2003). Fourth generation ports a question of agility? *International Journal of Physical Distribution & Logistics Management*, 33(4), pp.355-376.

Rietveld, P. (1989). Employment effects of changes in transportation infrastructure: methodological aspects of the gravity model. *Papers in Regional Science*, 66(1), pp.19-30.

Ritter, T. (2000). A Framework for Analyzing Interconnectedness of Relationships. *Industrial Marketing Management*, 29(4), pp.317-326.

Rodrigue, J., Comtois, C. and Slack, B. (1997). Transportation and spatial cycles: evidence from maritime systems. *Journal of Transport Geography*, 5(2), pp.87-98.

Rozakis, S., Sourie, J. and Vanderpooten, D. (2001). Integrated micro-economic modelling and multi-criteria methodology to support public decision-making: the case of liquid bio-fuels in France. *Biomass and Bioenergy*, 20(5), pp.385-398.

Saaty, T. (1990). How to make a decision: The analytic hierarchy process. *European*

Journal of Operational Research, 48(1), pp.9-26.

Saaty, T. L. (1980). The analytic hierarchy process. New York, NY: McGraw-Hill.

Saaty, T. and Vargas, L. (2006). *Decision making with the analytic network process*. New York: Springer.

Sanchez, R.J., Hoffman, J., et al, (2003). Port efficiency and international trade: port Efficiency as a determinant of maritime transport costs. Maritime Economics and Logistics 5, 199-218

Schednet, (2015). *Ports in China*. [online] Available at: http://www.schednet.com/port_index/port_index_china.asp [Accessed 6 Apr. 2015].

Song, D. (2002). Regional container port competition and co-operation: the case of Hong Kong and South China. *Journal of Transport Geography*, 10(2), pp.99-110.

Song, L. and van Geenhuizen, M. (2014). Port infrastructure investment and regional economic growth in China: Panel evidence in port regions and provinces. *Transport Policy*, 36, pp.173-183.

Stank, T., Keller, S. and Daugherty, P. (2001). Supply chain collaboration and logistical service performance. *Journal of Business Logistics*, 22(1), pp.29-48.

Subramanian, N. and Ramanathan, R. (2012). A review of applications of Analytic Hierarchy Process in operations management. *International Journal of Production Economics*, 138(2), pp.215-241.

Subramanian, N., Rahman, S. and Abdulrahman, M.D. (2015). Sourcing complexity in the Chinese manufacturing sector: An assessment of intangible factors and contractual relationship strategies. *International Journal of Production Economics*.

Tang, L., Low, J. and Lam, S. (2008). Understanding Port Choice Behaviorâ€'A Network Perspective. *Netw Spat Econ*, 11(1), pp.65-82.

Tongzon, J. (1995). Determinants of port performance and efficiency. *Transportation Research Part A: Policy and Practice*, 29(3), pp.245-252.

UNCTAD, (1976). Port performance indicators, TD/B/C.4/131/Supp.1/Rev.1, United Nations Conference on Trade and Development,New York, US

UNCTAD, (1999), Technical note: the fourth generation port. UNCTAD Ports Newsletter, 19, 9–12.

UNCTAD (2002) Commercial Development of Regional Ports as Logistics centres ,New York: United Nations.

Vaidya, O. and Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research*, 169(1), pp.1-29.

Vukadinovic´, K., Teodorovic´, D. and Pavkovic´, G. (1997). A neural network approach to the vessel dispatching problem. *European Journal of Operational Research*, 102(3), pp.473-487.

Warf, B. and Cox, J. (1989). The changing economic impacts of the port of New York. *Maritime Policy & Management*, 16(1), pp.3-11.

WORLD BANK (2000), Port Reform Tool Kit ,Washington DC: World Bank Transport Division.

Woodall, T. (2001). Six Sigma and Service Quality: Christian Granroos Revisited. *Journal of Marketing Management*, 17(5-6), pp.595-607.

Yeo, G.T., Thai, V.V. and Roh, S. Y. (2015). An Analysis of Port Service Quality and Customer Satisfaction: The Case of Korean Container Ports. The Asian Journal of Shipping and Logistics 31(4) (2015) 437-447

Yeo, G., Roe, M. and Dinwoodie, J. (2008). Evaluating the competitiveness of container ports in Korea and China. *Transportation Research Part A: Policy and Practice*, 42(6), pp.910-921.

Yoon, M. and Nam, K. (2006). *Journal of Korean navigation and port research*, 30(9), pp.749-754.

Zairi, M. (2000). Managing customer satisfaction: a best practice perspective. *The TQM Magazine*, 12(6), pp.389-394.

Figures and Tables

Table 1: Summary of performance indicators suggested by UNCTAD

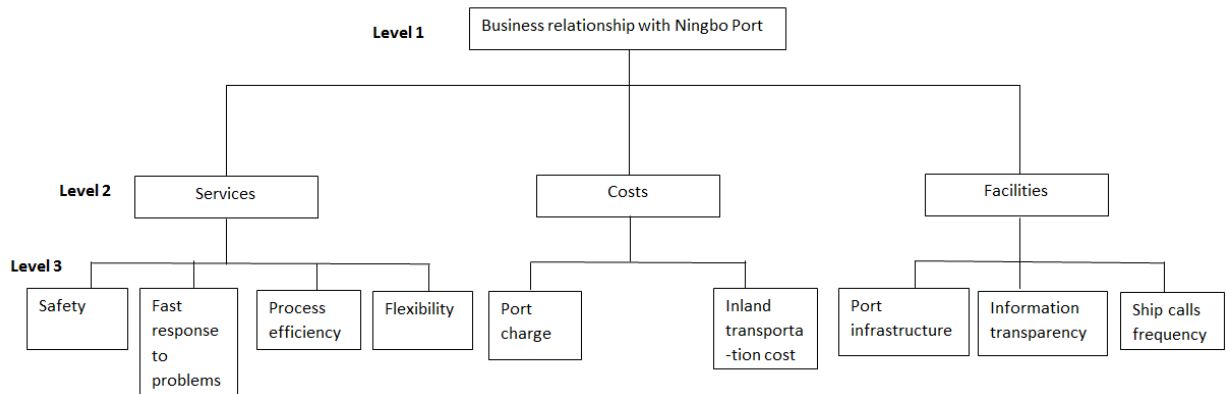| Financial indicators	Tonnage worked; Berth occupancy revenue per ton of cargo; Cargo handling revenue per ton of cargo; Labor expenditure; Capital equipment expenditure etc.
Operational indicators	Arrival late; Waiting time; Service time; Turn-around time; Tonnage per ship; Numbers of gangs employed; Tons per ship hour in port etc.

(Source: UNCTAD, 1976)

Figure 2: Port sustainable services innovation decision model

Table 2: Scale of comparative judgements

\Intensity of importance (scale)	Definition	Explanation	interpretation
1	Equal importance	Two activities contribute equally to the objective	i and j are equally important
3	Moderate	Experience and judgement slightly favour one activity over another	i is slightly more important than j
5	Strong importance	Experience and judgement strongly favour one activity over another	i is much more important than j
7	Very strong or demonstrated	An activity is very strongly and dominantly favoured over another with demonstrated dominance in practice	i is by far much more important than j
9	Extreme important	One activity favoured over another with highest possible order of affirmation	i is definitely/absolutely much more important than j
2,4,6,8	For compromise between the above values	Interpolating a compromised judgement numerically because there is no good word to describe it	intermediate values between two adjacent judgements

(Source: Satty, 1980)

Table 3: Local weights of different criteria

level	factors	Local weight			
		Ningbo	Hangzhou	Wenzhou	Jinhua-Yiwu
2	**Services**	**0.114**	**0.105**	**0.594**	**0.327**
3	Safety	0.547	0.184	0.211	0.710
3	Fast response to problems	0.082	0.097	0.569	0.141
3	Process efficiency	0.279	0.464	0.153	0.091
3	Flexibility	0.091	0.254	0.067	0.058
2	**Costs**	**0.405**	**0.258**	**0.157**	**0.260**
3	Port charge	0.500	0.800	0.750	0.667
3	Inland transportation cost	0.500	0.200	0.250	0.333
2	**facilities**	**0.481**	**0.637**	**0.249**	**0.413**
3	Port infrastructure	0.179	0.661	0.594	0.627
3	Information transparency	0.113	0.131	0.249	0.094
3	Ship calls frequency	0.709	0.208	0.157	0.280

Synthesis with respect to:

Goal: Business Relationship

Overall Inconsistency = .04

ship calls frequency	.341
port charge	.203
inland transporattion cost	.203
port infrastructure	.086
safety	.062
information transparency	.054
process efficiency	.032
flexibility	.010
fast response to problems	.009
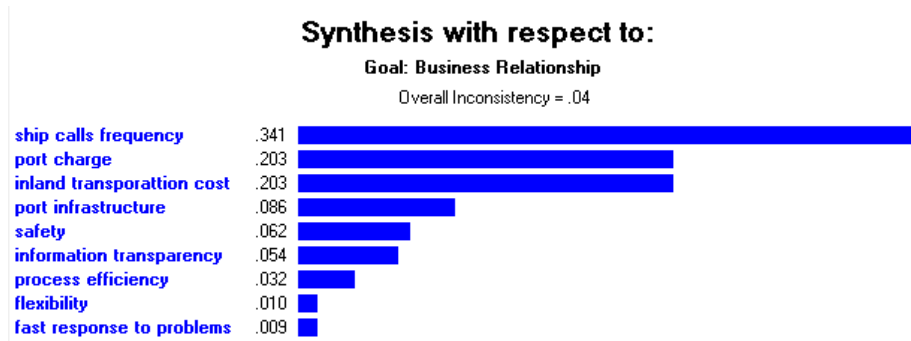
Figure 3a: global priorities of Ningbo

Synthesis with respect to:

business relationship

Overall Inconsistency = .04

port infrastructure	.421
port charge	.207
ship calls frequency	.133
information transparency	.084
inland transportation cost	.052
process efficiency	.049
flexibility	.027
safety	.019
fast response to problems	.010
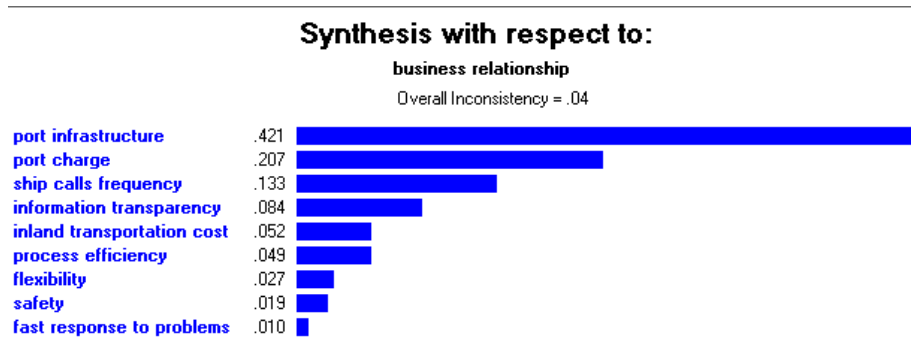
Figure 3b: Global priorities of Hangzhou

Synthesis with respect to:

Goal: Business Relationship

Overall Inconsistency = .07

fast response to problems	.338	
port infrastructure	.148	
safety	.125	
port charge	.118	
process efficiency	.091	
information transparency	.062	
flexibility	.040	
inland transportation cost	.039	
ship calls frequency	.039	
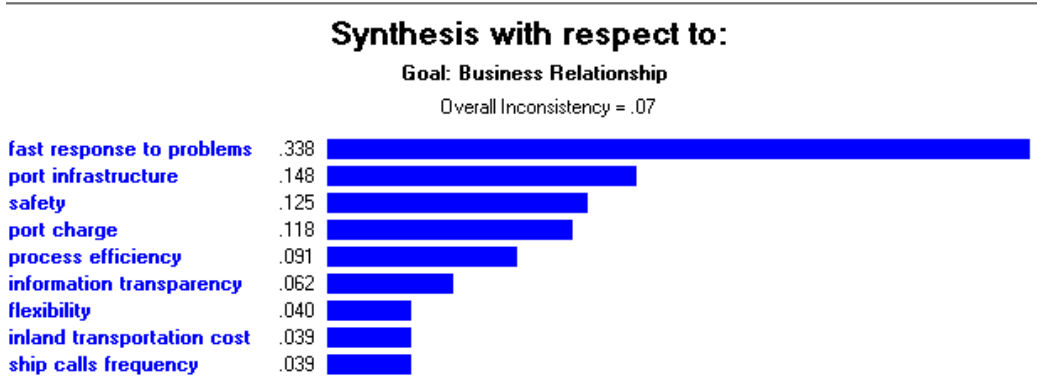
Figure 3c: Global priorities of Wenzhou

Synthesis with respect to:

Goal: business relationship

Overall Inconsistency = .06

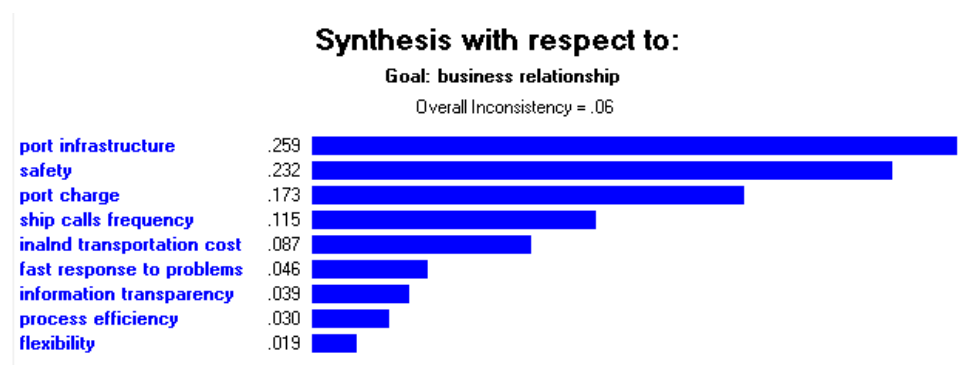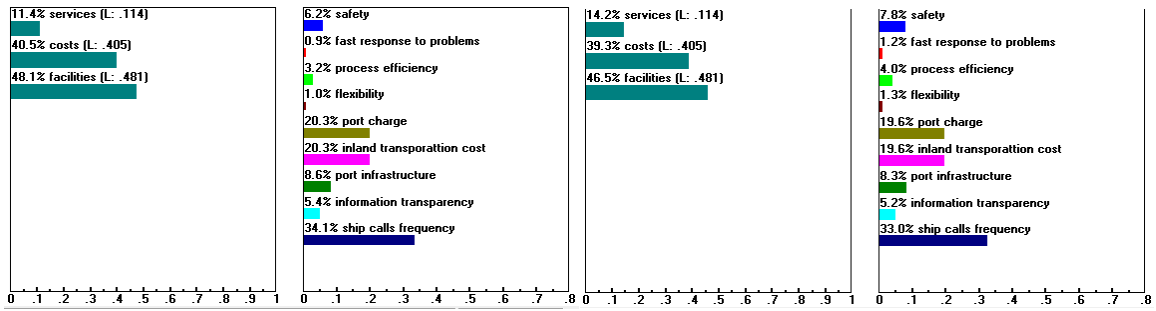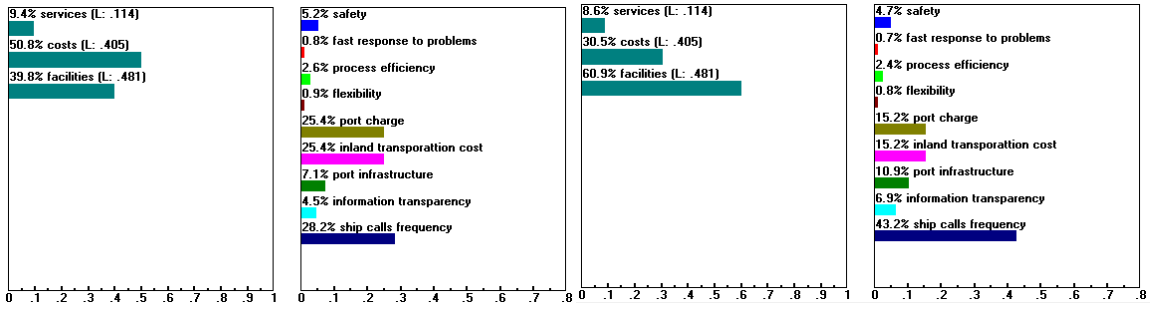|		
port infrastructure	.259	
safety	.232	
port charge	.173	
ship calls frequency	.115	
inalnd transportation cost	.087	
fast response to problems	.046	
information transparency	.039	
process efficiency	.030	
flexibility	.019	

Figure 3d: Global priorities of Jinhua-Yiwu

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a) Initial result of priorities of Ningbo   b) services increases by 25%

c) Costs increases by 25%   d) facilities increases by 25%

Figure 4: Sensitivity analysis results

Synthesis with respect to:

Goal: business relationship

Overall Inconsistency = .01

port infrastructure	.245
port charge	.201
ship calls frequency	.152
safety	.103
inland transportation cost	.091
information transparency	.073
process efficiency	.055
fast response to problems	.047
flexibility	.034

Figure 5: Integrated global priority of four cities