Shippers' Changing Priorities in Port Selection Decision – A Survey Analysis Using Analytic Hierarchy Process (AHP)

by Neha Mittal and Dale McClung

This paper analyzes different criterion that shippers employ in their port selection process. It uses results from a survey conducted on regional shippers from the chemical and life sciences industries that ship full container and LCL cargo of hazardous and non-hazardous chemicals westbound (from U.S. east coast to Asia). Using an Analytic Hierarchy Process (AHP) framework and participants' comparative scores, factors affecting a shipper's port choice are prioritized. Findings suggest that port congestion and delays on the west coast ports in the U.S. and its effect on shippers' supply chains have changed their priorities; price and port characteristics are no longer their primary decision factors.

INTRODUCTION AND RESEARCH PROBLEM

Marine ports are of vital importance to modern day businesses. With extensive and complex supply chains, businesses today work in a global environment. It has become imperative for them to import/ export to deliver their products to the market. Since maritime shipping provides the most economical way to transport large quantities of freight, businesses or shippers frequently make the decision to identify their port of choice.

Several previous studies and industry articles have made efforts to understand a shipper's port choice selection criterion, but the complexity and dynamic nature of international trade and logistics industry has kept this area as an ongoing research subject. Historical studies showed price and characteristics of a carrier (shipping line) as the most important criterions for shippers; a port's infrastructure or its location did not carry much significance (Slack 1985). However, these factors have changed dramatically over the years.

Selecting a port is surely a challenging task for shippers. On the other hand, port officials are under constant fear of losing their customers/ attractiveness; often not due to the deficiencies in their physical port infrastructure, but due to the shippers' constantly changing requirements and priorities. This makes it vital for the port officials and marine terminal operators to understand and adapt to the changing needs of their customers. Results and conclusions from the study provide port managers with essential information on key factors that come into the decision process of port users.

Through this paper, we intend to understand how some of the recent events and changes in the shipping industry have led to shaping a shippers' port selection decision in recent times. While the subject has been well studied, our paper adds value in terms of its timing, study analysis and interpretation of results. We present the paper as a survey of different decision factors in a port selection process, and present an AHP-based analysis on data obtained from regional shippers. The remainder of this paper is organized as follows. In the second section of the paper, we provide a chronological survey of articles on how shippers' port selection criterion has changed over time. Following the literature review, we discuss the research methodology, present the survey analysis, results, and present conclusions. We believe our study findings will serve as a set of recommendations for port officials and terminal operators.

LITERATURE REVIEW

There is a significant amount of literature on factors important to shippers' port selection process. During the survey of articles, we found that the problem of port selection is studied under two different perspectives – one where shipping lines are selecting their port of calls and another in which the shipper is making the port choice decision.

Table 1 presents a chronological survey of papers that have dealt with the problem and lists different criterions that were found important in each of those studies.

Older studies, such as by Slack (1985), established that the choice of port depends more on the price and quality of service offered by land or ocean carriers than the port's characteristics. Among the factors, such as the port's security, its size, inland freight rate, port charge, quality of custom handling, congestion, port equipment, number of trips (sailings or departures of ships at the port), and possibility of intermodal links, Slack found that while connection to inland transport services and availability of container facilities is relevant, the number of sailings or voyages from the port and the inland shipping rates were at the highest mark.

Bird (1988a and 1988b), based on his analysis of European freight forwarders, found that the frequency of ship service is the main factor in a port choice. Tongzon (1995) also confirmed that the frequency of shipping service is the major determinant of time, and time is essential in the freight forwarding industry.

Jamaluddin (1995) with reference to the Far East/Europe trade, defined the six service attributes from both the shipper and the carrier's perspective. It described that the six service factors which shippers find most important are freight rate, cargo care and handling, knowledgeability, punctuality, transit time, and service frequency. In case of carriers, the six most important service attributes are knowledgeability, freight rate, cargo care and handling, punctuality, transit time, and service frequency.

Research conducted by Tiwari et al (2003) found additional factors that influence a shipper's port choice decision. These factors included the shipper's distance from the port, the number of ship calls at the port (i.e., the number of scheduled intermediate stops by ships at the port, which determines the value of cargo that can be moved through that port), the efficiency of the port infrastructure, and the number of routes offered at the port.

Blonigen and Wilson (2006) developed a model for port choice. They estimated the impact of ocean transport rates, efficiency of ports, and internal transport systems on a shipper's port choice. Based on sample data on trade volumes between U.S. ports and several foreign countries from 1991 through 2003, the study provided strong evidence on the importance of economic factors in port choice. While distance and transport prices were found significant, unlike previous studies, it found that an individual port's efficiency plays an important role in determining its activity.

Chinonye et al. (2006) determined the service characteristics that shippers consider important when selecting a port. Based on a survey and analytic hierarchy process tool, he prioritized the characteristics according to their importance. Seven criteria for the port selection decision and four ports were identified for analysis in his study. Findings suggested that shippers consider efficiency, frequency of ship visits, and adequate infrastructure more important in their decision making process than a quick response time to port users' needs.

For determining a shipping lines' port choice factors, Tongzon and Sawant (2007) used a revealed preference approach. They found port costs and range of port services to be two significant factors. They discussed the evolving role of shipping lines in the logistics business and how they now connect a shipper with a customer in modern days, then the traditional approach of linking the shippers/freight forwarders with the ports. The study emphasized how this fact is of great importance for port officials when considering their competition with others.

Wiegmans (2008) addressed three dimensions in his study: buying decision characteristics; port choice strategy; and terminal selection. Results showed that for the port choice decision, the

Table 1: Chronological Review of Literature for Factors Influencing Port Selection

Author	Year	Perspective	Criterion found significant
B. Slack	1985	Shipper	Price and number of sailings
J. Bird	1988(a), (b)	Shipping Line	Frequency of shipping service
Tongzon	1995	Shipping Line	Frequency of shipping service
Jamaluddin	1995	Shipping Line	Freight rate, cargo care and handling, knowledgeability, punctuality, transit time, and service frequency of the shipping line
Tiwari et. al.	2003	Shipper	distance of the shipper from the port, number of ship calls at the port, efficiency of port infrastructure, and number of routes offered at the port
Blonigen and Wilson	2006	Shipper	distance and transport prices are very significant factors
Chinonye et. al.	2006	Shipper	efficiency, frequency of ship visits and adequate infrastructure
Tongzon and Sawant	2007	Shipping Line	port charges and range of port services available
Wiegmans et. al.	2008	Shipper	availability of hinterland connections; reasonable tariffs; and immediacy of consumers
Tongzon	2009	Shipper	port efficiency was the most important factor followed by shipping frequency, infrastructure and location of the port
Chou	2009	Shipper	inland freight costs and frequency of ship callings
Ruriani D.C.	2009	Shipper	Proximity to port, efficiency of workforce, infrastructure
Chou	2010	Shipper	hinterland economy, port charges, port loading/ discharging efficiency
Tang et. al.	2011	Shipper	Shipping line: port efficiency and scale economies
Fung, Sun and Bhattachariya	2013	Shipper	Their own supply chain arrangements influence their port selection
Zarei	2015	Shipping Line	Quality of products delivered (packaging, freshness), Advanced port management (Promptness of issuing document, service speed, custom services, port operation policy, port safety), and port infrastructure.

most important criteria from a carrier's perspective are: availability of hinterland connections, reasonable tariffs, and immediacy of consumers (large hinterland). In addition to these criteria, shipping lines find feeder connectivity, environmental issues, and the ports' characteristics important in their decision making. The study pointed out that port selection is not the same as terminal selection, and in case of the latter, handling speed, handling costs, reliability, and hinterland connections become more important. The analysis showed that these decisions often change based on the carrier, trade, and port type.

In a slightly different study, Tongzon (2009) evaluated factors influencing port choice decision from the freight forwarders' perspective. He focused on the Southeast Asian freight forwarders in his study. The paper highlighted the increasing role of 3PLs in the growing supply chains and why it is important to consider studying the port choice decision based on their decision-making style and port selection process. Results found that the port's efficiency (i.e., the speed and reliability of port services), shipping frequency, infrastructure, and location are the most dominant factors from the freight forwarder's perspective.

Chou (2009) developed a mathematical programming model for port choice of shippers. It highlights the fact that shippers focus on minimizing the total logistics costs, and not only the inland costs, which was ignored by many past studies. It said that the port choice of the shipper is not only dependent on the transportation costs, but also on the value of the cargoes being shipped through the port. In other words, shippers aim to not only minimize the inland freight costs but also consider the frequency of ship callings (number of ships that consider it as their "port of call"). The study proposes the model, tests it using a Taiwanese port, and concludes that the frequency of ship calling (i.e., the number of scheduled intermediate stops by ships at the port, which determines the value of cargo moved through the port), is important to shippers.

In an article, Ruriani (2009) discussed guidelines when selecting the right port from a shipper's perspective. It suggests considering the location of the port, in terms of proximity to the customer and labor availability. A port's infrastructure investment (in terms of navigation channel access, landside transportation, terminal capacity, and intermodal options) should be high on the list. Additionally, knowing the port's restrictions, Foreign Trade Zone (FTZ) access, its technological capability, and operating hours must be considered when selecting the port.

Chou (2010), discussed the choice of port callings from the shipping carrier's point of view. The study highlighted the importance of port choice decision in the international trade and transportation industry and how the optimal selection of port callings can reduce the total transportation cost. It constructed an AHP model to simulate the behaviors of carriers' port choices and identified the weight of influential factors influencing carriers' port choices in the multiple-ports region.

Tang et al. (2011) developed a network-based choice evaluation model that integrated the elements of a port service network with observational port attributes to identify important characteristics on which liner shipping companies base their port choices. Based on an empirical study, it found that port efficiency and economies of scale are the two important dimensions influencing liner shipping companies' selections in Asia.

Fung et al. (2013) examined how the supply chain arrangement of a shipper affects its port of O/D selection and vice versa. It investigated the interaction between the port of call selections of shipping lines and shippers in Australia. Based on their interviews with shipping lines, freight forwarders, and importers they found that shippers' supply chain arrangements influence their port of O/D selections, but are not considered important by shipping lines in their port of call selections. The author mentioned that this may be due to the restricted port choices of both the shippers and the shipping lines, a result of the spatial characteristics of Australia.

Zarei (2015) aimed to identify the key factors in a shipping company's port selection process. To identify and rank factors that play a role in selecting the port, it adopted a questionnaire-based survey approach. Responses from the main shipping companies' operators in Iran revealed that the

level of services of supplying companies and customs rules play an important role in selecting the ports.

From this review/discussion, we can see that the existing literature reveals a considerable range of factors affecting the decision of port choice. Some of these factors are quantitative, while others are qualitative. By quantitative factors, we mean the ones that can potentially be measured and compared in an unbiased way. Qualitative factors, on the other hand include feelings and experiences of a shipper with a port. Factors such as a port's marketing efforts, its flexibility and ease in processes, cargo care, influences of port rules, and policies on shippers are subjective. Our focus in this paper is to consider a shippers' viewpoint in selecting a port. (Please note, by shipper, we mean the firms who supply or own the commodities shipped. A shipping line or carrier is a company that transports goods for the shipper; they are the vessel operators and carrier of the cargo. The decision of port selection is made by the shipper or the shipper's agents [freight forwarders].)

For a shipper in its quest to choose the right port, distinction between quantitative and qualitative factors often becomes unimportant and, in many cases, perceptions take precedence over actual performance of the port. For this reason, we adopt an AHP-based methodology in this paper. The advantage of AHP is it allows using logic, human intuition, experience, and information to estimate relative magnitudes and compare alternatives in pairs. The method decomposes the goal of the problem and builds a problem structure comprised of its criteria and alternatives. In the next section, we describe our research methodology.

RESEARCH METHODOLOGY

To meet our study purpose, we adopt the following methodology:

1. Develop a list of factors that may influence a shipper's port choice. The criterions were identified based on the literature survey and our knowledge/experience in the industry (please note the co-author of this paper works for a large freight forwarding company in Pennsylvania and serves as a shipper for large vendors).
2. Structure the problem in an AHP framework.
3. Create a survey form using an MS Excel spreadsheet for customers/shippers in the region, so the participants can input their comparative scores.
4. Analyze the data received from the survey respondents and prioritize factors important to shippers when choosing a port using an Analytic Hierarchy Process.
5. Present the results, validate them, and provide conclusions from the study.

Developing a List of Factors

Based on the literature review, interviews with local shippers, and our experience, the following factors that influence a shipper's port choice decision were identified:

- Port Infrastructure – equipment availability, adequacy of port facilities
- Cost - port charges, delivered price, cost of pilotage, towage, customs
- Port's efficiency – turnaround time and facilities for loading/unloading freight, grouping, and freight consolidation
- Congestion at the port – delays (speed of getting through ports), labor problems
- Cargo volume – total TEUs handled at the port and current volume at the port, number of sailings, average size of vessel handled at the port
- Pickup and delivery times
- Information conveyance (the action or process of transmitting and communicating information from one place to another) concerning shipments, availability of technology, and communications systems

- Intermodal/connecting links – sailing frequency of deep-sea and feeder shipping services (the service that transports shipping containers from different ports and brings them to a central container terminal where they are loaded to bigger vessels)
- Empty container management – storage and distribution
- Quality and reputation of terminal operators – their efficiency of cargo handling, and the internal competition (the nature of competition that exists among the different terminal operators within a given port)

Some additional factors were also considered in the beginning of the study, but they were left out later from the research after consulting with industry experts. These excluded factors were:

- Special freight/odd-size shipment handling capability
- Loss and damage frequency
- Port's services – on-site custom clearance, assistance in claims handling and loss & damage performance
- Port security – safety and environmental profile of the port
- Involved government bodies

Structure the Problem in AHP Framework

Analytic Hierarchy Process (AHP) is one of the multi-criteria decision-making methods (Saaty 1999). It uses a system of pair-wise comparisons that determines the dominance of one element over another, with respect to a given attribute. AHP uses qualitative and quantitative approaches to solve decision-making problems. Qualitatively, the problem is decomposed into a hierarchy of elements and then analyzed. Quantitatively, the set of attributes is prioritized to distinguish the more important alternatives from the less important ones.

To understand the applicability of AHP, let's take a simple example and then tie it to the research problem in this paper. Consider a company that aims to maximize its profit. The company is looking for a product that may fit its specific needs of easy installation, easy learning/adoption, reliability, and product safety. The company finds three different products in the market that can help increase its profits, but there is not one product that will meet all its four criteria. Each product provides the company with a unique advantage; one saves the company on energy bills, the second increases its labor productivity, and the third brings automation and increases its existing process efficiency. The company is now in a dilemma as to which product to buy. At this point, the company may adopt AHP methodology and by placing relative weights on each criterion with respect to each product, it can come to a conclusion and make a rational decision on its product choice. Similarly, this paper's goal is to identify the right port to ship a shipper's cargo. Considering the right port selection as a profit maximizing goal and different product alternatives as different port regions in the country, the two problems will carry similar AHP problem structures. The criteria (such as ease of installation, ease of adoption, product reliability, and product safety), can be compared to the criteria for the port selection decision, as listed above.

Understanding AHP Methodology

The AHP is a tool of measurement based on pairwise comparisons. It relies on the judgments of experts to derive priority scales. The process helps measure intangible factors in relative terms. The comparisons are made using a scale of absolute judgments that represent how dominant one factor is in comparison to another (Saaty 2008).

To make an organized decision, AHP requires a clear problem definition. Once the problem is defined, a structural hierarchy of the decision from top to the bottom is created. The goal of the decision (problem statement) is at the top, followed by the intermediate levels (criteria and sub-criteria), to the lowest level (which usually are alternatives).

AHP uses a set of pairwise comparison matrices, where each element in an upper level is compared with the elements in the level immediately below. First, priorities are derived for the criteria in terms of their importance to achieve the goal. Then priorities are derived for the performance of the alternatives on each criterion. To make comparisons, AHP provides a scale of numbers that indicates how many times one element is more important than another with respect to the criterion to which they are compared. A weighting and adding process is used to obtain overall priorities for the alternatives as to how they contribute to the goal. With the AHP, a multidimensional scaling problem is thus transformed to a unidimensional scaling problem.

Step-by-Step AHP Process

Step 1. Develop a pairwise comparison matrix for a criterion by rating the relative importance between each pair of decision alternatives. In our case, these comparative scores are provided by the survey respondents (shippers). Respondents are provided with the standard AHP scale (Table 2 below) to fill the relative scores in the matrix.

Table 2: The Fundamental AHP Scale of Absolute Numbers (Saaty 1999)

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Step 2. Develop a normalized matrix by dividing each number in a column of the pairwise comparison matrix by its column sum.

Step 3. Develop the priority vector (weight) for the criterion by averaging each row of the normalized matrix.

Step 4. Measure the consistency of the inputs in the matrix by calculating a consistency ratio (explained below). A consistency ratio of less than 10% is preferred, while up to 20% is acceptable.

Step 5. Summarize the results in the priority matrix by listing the decision alternatives horizontally and the criteria vertically.
Step 6. Repeat steps 2–5 to develop a similar matrix with another criterion.
Step 7. Lastly, construct an overall priority vector by multiplying the priority matrix (from step 5) by the criteria priority vector (from step 6).

Steps in Calculating the Consistency Ratio

Step 1. For each row of the pairwise comparison matrix, determine a weighted sum by summing the multiples of the entries by the priority of its corresponding (column) alternative.
Step 2. For each row, divide its weighted sum by the priority of its corresponding (row) alternative.
Step 3. Determine the average (known as lambda-max) of the results of step 2.
Step 4. Compute the consistency index, Cl, by using CI = (lambda max - n)/(n -1), where n = number of criterion in a given matrix.
Step 5. Determine the random index, RI using the standard table (Table 3) provided by Saaty (1999).

Table 3: Saaty's Standard Random Index (RI) Scale

Number of Decision Alternatives (n)	2	3	4	5	6	7	8
Random Index, RI	0.16	0.58	0.9	1.12	1.24	1.32	1.41

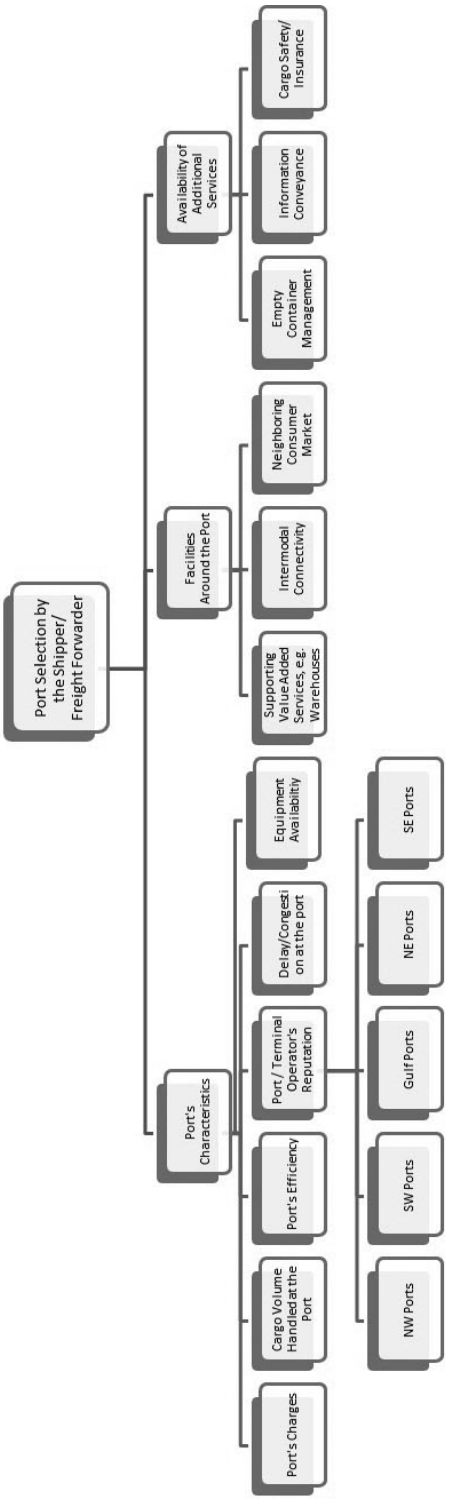
In our paper, the goal is to determine the shipper's choice of port. The criterion and sub-criterion illustrate factors that influence a shipper's port choice decision, and the alternatives are different port regions in the country. Priorities and weights are provided by industry experts (shippers or freight forwarders). For this study, a hierarchy is built with the goal, criteria, sub-criteria, and alternatives, as shown in Figure 1. The goal is to identify some of the critical factors that influence a shippers' port choice.

Table 4 provides a clear list of all criteria and sub-criteria used in this study's AHP framework.

Table 4: AHP Framework for Port Selection Decision

Criteria	Sub-criteria
	Port's charges Cargo volume handled at the port Port's efficiency Port/terminal operator's reputation Delay/congestion at the port Equipment availability
Facilities Around the Port	Supporting value-added services (warehousing) Intermodal/hinterland connectivity Neighboring consumer market
Availablity of Additional Services	Empty container management Information conveyance (EDT) Cargo safety and insurance

Figure 1: AHP Structured Problem on Shipper's Port Selection



Survey

After developing the AHP framework, an Excel-based survey was created for regional shippers. The participants in this survey are involved in the chemical and life sciences industries in the northeast region of the United States. They represent mid- and high-volume containerized cargo shippers in the chemical industry. Lower volume shippers may be more "anchored" to a smaller group of ports due to a limited capability to control transportation costs. The sourcing and logistics management teams from these companies were asked to complete the survey. The responses came from clients' sourcing teams along with feedback from clients' logistics specialists and 3PL supply chain analysts. The decision to use mid- and high-volume shippers was based on the belief that there would be a more agnostic response to the survey if we targeted audiences that have the resources and capabilities to choose ports that best fit their commercial needs.

Survey participants move both package and bulk liquid cargo internationally. They range in annual global volume shipped from 20,000 to 60,000 containers shipped annually. Approximately 80% of the cargo is non-hazardous and 20% is hazardous. The majority of the products are bulk commodity chemicals with a smaller portion (approximately 10%) being specialty chemicals. A variety of equipment types are used in this industry group with standard, dry 20-ft and 40-ft containers making up a large portion of shipments. This includes the use of refrigerated and other temperature controlled containers. Products reach the ports of export by truck, rail, and intermodal operation. Bulk commodities leaving the U.S. tend to move via rail and intermodal to reduce the transportation costs. Specialty and smaller volume products tend to move via truck to reduce the uncertainty of transit times and risk of delayed arrival to port. The shippers' overseas markets of the shipments are in China, Europe, and Latin America.

In all, 14 surveys were sent to different clients, of which five responses were obtained. While the number of responses (35%) received were low, the respondent weights and relative scores were close enough to run the analysis and validate the survey results. Respondents were asked not to consider bulk vessel transportation when considering their response to the questions. We also asked to only consider recent (past year) performance from ports and to take an objective approach in their evaluation.

Data Analysis

After receiving the raw relative scores on each criterion and sub-criterion from our survey respondents, we started performing the AHP analysis. Our complete analysis in an Excel worksheet can be found at this link: http://sites.temple.edu/nmittal/2016/05/06/port_selection/

Factors under the first criterion of "Port's Characteristics" are analyzed first. Table 5 shows the subjective assessment of the importance of one factor over another; these comparative scores are provided by the survey respondents.

In this table, a value of "3" between cargo handled at port and port's changes indicates that shippers consider volume handled by the port to be three times more important than the charges at the port when making their port selection decision. The value of "1/3" (reciprocal) indicates that for the comparative pair, shippers consider port charges as three times less important than the cargo (volume) handled at the port. Survey respondents were asked to fill values only in the upper triangular matrix since the lower left is only a reciprocal of the upper triangular matrix.

Table 5: Raw Relative Scores Received on "Port Characteristics"

	Cargo Handled at Port	Port's Charges	Port's Efficiency	Operator's Efficiency	Delay/ Congestion	Equipment Availability
Cargo Handled at Port	1	3	1	5	1/9	1/8
Port's Charges	1/3	1	1/8	1/6	1/9	1/8
Port's Efficiency	1	8	1	3	1/9	1/8
Operator's Efficiency	1/5	6	1/3	1	1/9	1/8
Delay/ Congestion	9	9	9	9	1	9
Equipment Availability	8	8	8	8	1/9	1

The next step is to normalize the scores. We calculate the overall weight that the respondent assigns to each criterion by taking each entry and divide it by the sum of the column it appears in. We then average the normalized quantities (row-wise) to come up with weight for each sub-criterion (such as Cargo Handled at Port, Port's Charges, Port's Efficiency, Operator's Efficiency, Delay/ Congestion, and Equipment Availability) within the "Port Characteristics" criterion. By averaging across each row, we correct for any small inconsistencies in the decision-making process. This average is between 0 and 1, and the total weights add up to 1. At each stage, the values are checked for consistency ratio. Table 6 shows the average normalized weights (importance) of factors under "Port Characteristics."

Table 6: Weightage on Sub-Criterion Under "Port Characteristics"

Factors	Weight
Cargo Handled at Port	9.0%
Port's Charges	2.6%
Port's Efficiency	10.3%
Operator's Efficiency	6.2%
Delay/ Congestion	43.3%
Equipment Availability	28.5%

This suggests that the Delay or Congestion at the port at 43.3% is the most important sub-criteria for shippers, followed by equipment availability at 28.5%, within the "Port Characteristics."

Our next step is to evaluate all sub-criterion separately within 'Port Characteristics' to determine their choice of a port region (NW, SW, Gulf, NE, and SE). For instance, if we take "Cargo Handled at Port," we determine if the shippers prefer one region over another, based on that particular factor. Similarly, the weights are calculated for each sub-criterion under the "Port Characteristics" criterion. Table 7 shows the summarized evaluation of port regions based on all sub-criterions within the "Port Characteristics."

Table 7: Evaluation of Port Regions Based on "Port Characteristics"

NW ports	SW ports	Gulf ports	NE ports	SE ports
0.200	0.213	0.305	0.089	0.192

Results show that with 30.5%, Gulf port region is the most preferred port region by our survey respondents. Similar analysis is performed on the other two criterions – "Facilities around the port" and "Additional services available at Port," as shown in Tables 8, 9, 10 and 11.

Table 8: Weightage Calculated on Sub-Criterion Under "Facilities Around the Port"

Factors	Weight
Nearby Warehousing Services	0.26
Intermodal Connectivity	0.92
Consumer Market	0.08

Table 9: Evaluation of Port Regions Based on 'Facilities Around the Port'

NW	SW	Gulf	NE	SE
0.043	0.058	0.532	0.147	0.220

Considering "Facilities Around the Port," at 53.2% Gulf port region is most preferred, followed by Southeast, Northeast, Southwest and Northwest port regions.

Table 10: Weightage Calculated on Sub-Criterion Under "Additional Services"

Factors	Weight
Empty Container Management	6.9%
Information Conveyance	29.8%
Cargo safety/ Insurance Policy	63.2%

Table 11: Evaluation of Port Regions Based on "Additional Services"

NW ports	SW ports	Gulf ports	NE ports	SE ports
0.1357	0.1380	0.3544	0.1832	0.1887

Considering "Additional Services," at 35.44% Gulf port region is most preferred.

After individually evaluating all the sub-criterion for port selection criterion, analysis was summarized using the relative importance among the three primary criterion. After normalization, the weightage on three primary criterions is calculated and results are shown in Table 12.

Table 12: Weightage on Port Selection Decision-Making Criterion

Criterion	Weight
Port Characteristics at Port	0.723506
Facilities Around the Port	0.193186
Additional Services at Port	0.083308

After calculating the weights and relative importance of each criterion and sub-criterion in the problem, final calculations are made by multiplying priority weights for each criterion in Table 12, by their criterion-based weights in Table 7, Table 9, and Table 11. These final values highlight the port region that is most attractive to our survey respondents (shippers who are shipping both full container and LCL cargo of hazardous and non-hazardous chemicals westbound – from U.S. to Asia). Table 13 shows the final results.

Table 13: Evaluation of Port Regions Based on Port Selection Criterion

Region	NW ports	SW ports	Gulf ports	NE ports	SE ports
Weight	16.5%	17.7%	35.3%	10.8%	19.7%

RESULTS INTERPRETATION AND VALIDATION

Let us now understand the results from above tables and see if they can be validated using our knowledge and industry literature. Table 6 above shows that within the Port Characteristics, delay/ congestion at the port (with 43.3% weightage) is the most important factor for shippers in recent times. Ports play a significant role in goods movement and any delay in a product's transportation increases costs and disrupts its sales and inventory levels for all players (supplier → manufacturer → retailer/ customer). While Table 6 highlights the importance of delay at the ports, Table 7 identifies ports in the Gulf region as most preferred to shippers. Industry articles (Garrett 2016) highlight this pattern and report that West Coast ports have lost their market share to eastern and Gulf ports in the last two years due to problems with delays and congestion at the port. The article estimates that east and Gulf ports receive approximately 34% of containerized imports from Asia today, compared to 29%, just two years ago.

Table 8 shows that among all different sub-criterion within the "Facilities Around the Port," "intermodal connectivity" is of utmost importance to shippers. By intermodal connectivity, we mean the capability of the port to move cargo inland using trains and trucks. Table 9 indicates the preference of Gulf ports over other port regions. This result can be validated given the massive public and private investment in the Gulf port region for hinterland connectivity and their improved links (Federal Maritime Commission 2015).

Table 10 highlights the importance of safe cargo to shippers when compared with the empty container management or conveyance of information at the port terminals. With rising security risks, cargo safety stood out to be an important factor for shippers. Table 11, again indicates the preference for Gulf ports (at 35.44%) over eastern and western port regions under the criterion of "Additional Services."

Table 12 shows the weightage of individual three criteria, indicating that "Port Characteristics" is most important to shippers when compared against "Facilities Around the Port" and "Additional Services." Within "Port Characteristics," we found that Delay/ Congestion is most important to the shipper, and not the volume handled or cost or efficiency of the port. Table 13 shows the final decision; at an overall weightage of 35.3%, Gulf ports are the most preferred.

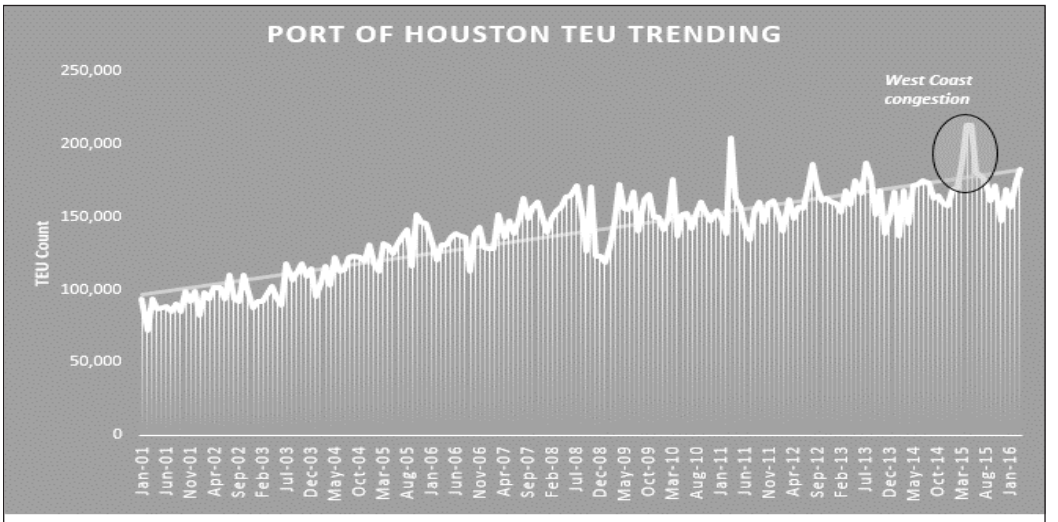
We infer from this analysis that port regions can lose their competitive advantage and market leadership if they are unable to keep up with increasing demands of trade. The unsettled scene at West Coast ports in the latter part of 2014 and early 2015 has changed the shipper's criterion for port selection and "congestion at the port," has become foremost important of all factors that decide a shipper's port of export today.

We found that these findings are synchronous with some of the recent industry news reports and surveys that showed an increased attractiveness of Gulf ports due to the congestion at West Coast ports. In February 2015, National Public Radio (Northan 2015) reported that "The ongoing disruptions at the West Coast seaports are forcing companies to put on more ships and reroute them." It also indicated that while the first inclination to divert the cargo was toward the West Coast ports of Canada, but soon due to the insufficient rail and road network in that region, U.S. shippers leaned toward using alternatives in ports of Mexico and along the Gulf Coast.

During the same period, a *Journal of Commerce* (Szakonyi 2015) article also noted that 65% of shippers in its own survey expressed an interest in diverting their cargo from West Coast. Of this, nearly 23% of the shippers said the majority of their freight would head to U.S. Southeast ports, which experienced virtually no congestion over the recent past, while 16% said they would move the majority through U.S. Gulf Coast ports. In our case, since the shippers moved cargo

westbound, Gulf ports were more attractive than the eastern region. In another article from August 2015 (Mongelluzzo 2015), it was reported that East and Gulf Coast ports experienced double-digit increases in container volumes due to cargo diversions from the West Coast. Figure 2 below shows the surge in TEU-volume at the Port of Houston.

Figure 2: Container Volume Surge at Port of Houston due to West Coast Congestion



Source: PHA Marketing and External Communications based on raw data from PHA Accounting. Date: April 14, 2016. Unaudited data. Contains some estimates. May not match other sources. May containe miscellaneous other errors. Note: Only includes containers handled at Port of Hourston Authority-owned facilities (including Bayport Terminal, Barbours Cut Terminal, APM Houston). These facilities handle the vast majority of Houston-area containers. Does not include a small number of containers handled at private terminals in the Houston area. http://www.portofhouston.com/static/gen/business-development/Origination/Container_Volume_TEU_stats_in_depth_March_2016.pdf

In October 2016, Food Logistics (Garrett 2016) reported that due to the Panama Canal expansion, the increases in the Gulf are anticipated and planned for. Studies predict as container shipping lines adjust their schedules and services to include post-Panamax ships, Gulf ports' cargo share will see cargo increases in the range of 8% to 12% in 2017.

Congestion at all major gateways on the West Coast grew worse in early 2015 when the Pacific Maritime Authority retaliated by withholding lucrative night and weekend work opportunities from longshoremen. This occurrence changed the dynamics for the global maritime shipping industry, and a significant change was noticed in the shipper's behavior and their port selection criterion.

CONCLUSION

This research study focuses on how shippers' port choices are influenced by maritime events and disruptions in their supply chains. The survey and presented analysis emphasizes the dynamic nature of international trade and shipping.

Shippers' port choice decision is a well-studied subject in the literature. However, to the best of our knowledge, this paper is the first of its kind that indicates the impact of delays and port congestion on shippers' priorities when making a port selection decision. Traditionally, only price and port characteristics were the two primary decision factors. Operationally, this finding can help terminal operators and port authorities strategize their resources and gain a competitive advantage for their port. Maritime industry is an ever changing industry, and with higher reliance on just-in-time delivery and lean inventory management in addition to our complex and elongated supply chains, transportation delays can be very expensive for shippers and their customers.

The paper finds that shippers now view their global supply chains with ever increasing clarity. Evolving changes in ocean transportation, such as the widening of the Panama Canal, ocean carriers adding larger vessels to their fleet, and global maritime policy changes such as SOLAS, can now be built into risk and supply chain models, helping the shipper determine the impact to supply chain performance and their expenditure spend. Shippers are using these risks and spend models along with the current imbalance of vessel space supply and demand, low bunker (ship fuel) rates, and carrier alliances to optimize their transportation lanes and ocean port selections. While the results obtained in this study could be a special case because of the nature of the products shipped, it is important to understand that in today's competitive environment, it is imperative that port managers develop the ability to determine the critical port selection factors their users desire and form policies that support their objective.

LIMITATION AND FUTURE WORK

AHP is a concise analytical method for decision making, but often considered subjective. To ensure the reliability of the results, a comparison of results from different methods may be observed to explain the superiority of the chosen method. Another research direction could look into a correlation analyses between influencing factors and shippers' selection decision.

Notwithstanding the caveats to our results due to the underlying model selection and formulation, we feel this analysis will be very valuable to port managers and planning authorities in strategically creating and implementing viable and effective policies for attracting shippers. In an era of intense port competition, where it has become essential for port authorities, port managers, and terminal operators to have a thorough understanding of the factors that influence shippers' port choice, this article helps them recognize and understand the factors that have recently become more significant and directly affect their (port) performance and viability.

Acknowledgements

This work is supported by a grant from the British Council's UK-India Education and Research Initiative (UKIERI) program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the sponsoring organization or BDP International.

References

Bird, J. "Freight Forwarders Speak: The Perception of Route Competition via Seaports in the European Communities Research Project- Part I." *Maritime Policy and Management* 15(1), (1988a): 35–55.

Bird, J. "Freight Forwarders Speak: The Perception of Route Competition via Seaports in the European Communities Research Project- Part II." *Maritime Policy and Management* 15(2), (1988b): 107–125.

Blonigen, B.A., and W.W. Wilson. "International Trade, Transportation Networks and Port Choice." (2006). Available online at: https://www.aeaweb.org/annual_mtg_papers/2007/0105_1430_2103.pdf

Chinonye, U., U. Ogochukwu, and I.C. Ogwude. "An Analytic Hierarchy Process (AHP) Approach to Port Selection Decisions – Empirical Evidence from Nigerian Ports." *Maritime Economics & Logistics* 8(3), (2006): 251-266.

Chou, C.C. “An Empirical Study on Port Choice Behaviors of Shippers in a Multiple-Port Region.” *Marine Technology Society Journal* 43(3), (2009): 71-77(7).

Chou, C.C. “AHP Model for the Container Port Choice in the Multiple-Port Region.” *Journal of Marine Science and Technology* 18(2), (2010): 221-232.

Federal Maritime Commission. “US Container Port Congestion & Related International Supply Chain Issues: Causes, Consequences & Challenges.” Bureau of Trade Analysis, (2015). Available online at: http://www.fmc.gov/assets/1/Page/PortForumReport_FINALwebAll.pdf.

Fung, Ng AS, D. Sun, and J. Bhattacharya. “Port Choice of Shipping Lines and Shippers in Australia.” *Asian Geographer* 30(2), (2013): 143-168.

Garrett, R. “Gulf Coast Ports Think Ahead.” Food Logistics News Article, (2016). Available online at: http://www.foodlogistics.com/article/12265134/gulf-coast-ports-think-ahead-cover-story-october-2016.

Jamaluddin, T.T.M.S. “Marketing of Freight Liner Shipping Services with Reference to the Far East-Europe Trade: A Malaysian Perspective.” Dissertation (Ph.D.). Department of Maritime Studies and International Transport, University of Wales College of Cardiff, UK, 1995.

Mongelluzzo, B. “US West Coast Ports Slow Cargo Bleed to East Coast.” *Journal of Commerce,* (2015), Available online at http://www.joc.com/port-news/us-ports/shipping-patterns-west-coast-slowly-returning-normal_20150815.html.

Northan, J. “U.S. West Coast Port Dispute Forces Shippers to Find Alternatives.” NPR (2015). Available online at http://www.npr.org/sections/thetwo-way/2015/02/20/387305541/u-s-west-coast-port-dispute-forces-shippers-to-find-alternatives.

Ruriani, D.C. “Selecting the Right Port for Your Transport Needs.” *Inbound Logistics* (2009). Available online at: http://www.inboundlogistics.com/cms/article/selecting-the-right-port-for-your-transport-needs/.

Saaty, T.L. “Basic Theory of the Analytic Hierarchy Process: How to Make a Decision.” *Journal of the Spanish Academy of Science* 93 (4), (1999): 395–423.

Saaty, T.L. “Decision Making with the Analytic Hierarchy Process.” *International Journal of Services Sciences* 1(1), (2008): 83-98. Available online at: http://www.colorado.edu/geography/leyk/geog_5113/readings/saaty_2008.pdf

Slack, B. “Containerization, Inter-Port Competition, and Port Selection.” *Maritime Policy & Management* 12(4), (1985): 293-303.

Szakonyi, M. “65% of Shippers in JOC Survey Say They’ll Divert from West Coast.” *Journal of Commerce*, (2015). Available online at http://www.joc.com/maritime-news/trade-lanes/65-percent-shippers-surveyed-say-they%E2%80%99ll-divert-west-coast_20150225.html.

Tang, L.C., J.M.W. Low, and S.W. Lam. “Understanding Port Choice Behavior—A Network Perspective.” *Networks and Spatial Economics* 11(1), (2011): 65-82.

Tiwari, P., H. Itoh, and M. Doi. “Containerized Cargo Shipper’s Behavior in China: A Discrete Choice Analysis.” *Journal of Transportation and Statistics* 6(1), (2003). Available online at: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/journal_of_transportation_and_statistics/volume_06_number_01/html/paper_05/index.html.

Tongzon, J.L., and L. Sawant. "Port Choice in a Competitive Environment: From the Shipping Lines' Perspective." *Applied Economics* 39(4), (2007): 477-492.

Tongzon, J.L. "Port Choice and Freight Forwarders." *Transportation Research Part E: Logistics and Transportation Review* 45(1), (2009): 186–195.

Tongzon, J.L. "Determinants of Port Performance and Efficiency." *Transportation Research: Part A,* 29(3), (1995): 245–252.

Wiegmans, B.W., A. Van Der Hoest, and T.E. Notteboom. "Port and Terminal Selection by Deep-Sea Container Operators." *Maritime Policy & Management* 35(6), (2008): 517-534.

Zarei, S. "The Key Factors in Shipping Company's Port Selection for Providing Their Supplies." *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering* 9(4), (2015): 1317-1321.

Neha Mittal *is an assistant professor of operations and supply chain management at Fox School of Business, Temple University in Philadelphia, PA. Her research focuses on freight transportation, transportation sustainability, network optimization, logistics, and project management. She has published in highly ranked journals such as* Journal of Transport Policy, Transport Reviews, Transportation Research Record (*National Academy of Sciences*), Research in Transportation Economics, International Journal of Production Research*. Mittal has won many awards for excellence in education in her bachelor's and graduate degree programs. At Temple University, she is the recipient of the "Excellence in Teaching" Award (2013), Service Award (2014), and Crystal Apple Award for being the Dean's Teaching Fellow (2014). Mittal received her M.S. and Ph.D. in transportation engineering from Rutgers University and her bachelor of engineering from Gujarat University, India.*

Dale McClung *works as the director for 360° Predictive Logistics and Supply Chain Management at BDP International in Philadelphia, PA. He is an experienced supply chain manager with more than 20 years of experience specializing in strategic supply chain innovations. McClung holds a bachelor's degree in chemical engineering, Lean Six Sigma Green Belt, and APICS, CSCP, and CPIM certifications. He is also an APICS instructor for both the CPIM and CSCP programs.*