THREE ESSAYS ON WATERBORNE TRANSPORTATION

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By

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The supervisory committee certifies that this dissertation complies with North Dakota State University's regulations and meets the accepted standards for the degree of

DOCTOR OF PHILOSOPHY

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ABSTRACT

This dissertation introduces three different topics on waterborne transportation. River transportation is a very important alternative for freight shipments in some countries. A significant portion of United States agricultural commodities transported via river barges. The lower portion of the Missouri River has been channelized to support barge traffic. Barge traffic has been used to move agricultural commodities to the Gulf of Mexico through Mississippi River to be exported overseas. Missouri River faced some weather issues such as drought in some years and flooding in others. Alternative transportation modes are important during the post-harvest period when the river has low-flow. The results showed a positive cost to agricultural freight in three years of a five years in dry period. In the other two years rail rates were estimated to be lower than barge rates.

The second topic is using maritime distance to measure trade costs in agriculture. Maritime transportation holds an important position among other transportation means because it has some characteristics that others do not. Maritime shipping is critical to international trade because of the advantages that ships have by carry huge amounts of cargo for long distances. The impact of port-to-port maritime distance on US international trade to Europe and North and South America was tested. Unexpectedly result shows that trade increases with maritime distance. This impact decreases when the geographical distance is higher than the maritime distance.

The third paper measures the efficiency and productivity of major Middle East container ports. Ports considered the main node to link the trading partners. The results indicate that eight ports out of 21 ports have low productivity.

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In the beginning, I would like to thank Allah for all his gifts which makes me able to reach this important moment in my life. Thanks to Allah for all graces and for giving me the strength to work hard throughout my life.

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DEDICATION

Losing my mother while I am away from her was a hard thing to deal with it. She was waiting for me to back home with my degree, but I hope this work makes you happy wherever you are. I hope that I make my father happy too. Wherever you are, I hope that I make both of you proud. I would like to dedicate my work to my beloved wife Amal and my kids Fahad, Celine, and Saud, and thank you for supporting me and for being patient. I dedicate my work to my parents-in-law Maryam Alradaddi and Homoud Almohammadi

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. THE INFLUENCE OF THE MISSOURI RIVER WATER LEVELS ON BARGE FREIGHT

1.1. Introduction

The US Army Corps of Engineers (USACE) manages the six mainstem dams on the Missouri River to provide multiple services including: 1) flood control; 2) navigation; 3) irrigation; 4) municipal and industrial water supply; 5) hydroelectricity; 6) recreation; and 7) ecosystem maintenance. The USACE's decisions to store or release water from reservoirs entail tradeoffs between these services and additional tradeoffs between upstream and downstream uses. Due to low population and land unsuitable for irrigation, there is relatively little consumptive uses of water from the river. However, there remains substantial conflict between upstream and downstream states over the distribution of water between upstream recreation and downstream navigation (Hearne and Prato, 2016; Otstot, 2011). The navigation channel in the lower Missouri River potentially serves five different states: Iowa, Kansas, Missouri, Nebraska and South Dakota. Many of the valuable water uses are concentrated upstream of the navigation channel and compete for water that is vital to maintaining the channel to facilitate barge traffic.

There are many advantages to river barge freight transportation. It is generally secure, and has low cost, especially for carrying heavy commodities for long distances. Additionally, river transportation can decrease road traffic and can save the roads from congestion, accidents, and damage. On the other hand, there are some disadvantages to river freight transportation. The meandering path of rivers implies that actual distance transported is much greater than that of a straight line between the origin and destination. Usually, rivers lack the advantage of straightness which increases the distance and time. Also, seasonal water level fluctuations and water freezes during winter are disadvantages for river transportation.

Barge navigation on the Missouri River faces some difficulties. One of them is the amount of water needed to maintain a navigation channel to keep the appropriate water level for more transport efficiency. In addition, the expensive continuous channel maintenance has caused the river to lose many clients because of the high transport cost (Hearne and Prato, 2016). Indeed, a number of important commercial ports closed during the early 2000s (Fowler 2014; Stafford 2016; Danesi, 2017). All of the preceding reasons can affect freight markets and stakeholders' decisions resulting in them of foregoing Missouri River freight for alternatives.

The organization of the paper is as follows. Sections 2 and 3 explain more about the river difficulties and its history with floods and droughts, as well as, the USACE's role and how it manages the reservoirs. Section 4 and 5 introduce and show the results of a regression model based on navigation traffic data from 1980 to 2014, and which used GIS software determine the distance between different locations for costing different transportation modes between 1994 and 2014. Section 6 presents conclusions and observations.

1.2. Missouri River Background

The Missouri River flows for 3,767 kilometers and it is the longest in North America. The Missouri River basin includes parts of ten states - Colorado, Wyoming, Montana, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Minnesota, and Missouri; and two Canadian provinces - Alberta, and Manitoba; and $1/6^{th}$ of the contiguous United States. The primary land use in the basin is crop and livestock production (Mehta et al., 2013).

Climate variability including droughts, floods, cold stormy winters, hot and dry summers are an important factor that can easily affect the river condition (Hearne and Prato, 2016). In the last three decades, the Missouri River had several wet and dry periods that affected the barge navigation. One of the main objectives for the USACE's management of the series of six multi-purpose dams on the mainstem Missouri River is to maintain water in the navigation channel in the lower river (Figure 1.1) (Schneiders, 1996; Lund,1996).

The mainstem of the Missouri River features a series of interconnected reservoirs and the 1181-kilometer-long, 91-meter-wide, and 2.7-meter-deep navigation channel from Sioux City, Iowa to the confluence with the Mississippi River which is operated by the USACE. The USACE releases water from the upstream storage reservoirs with the intention of supporting navigation from April 1st until December 1st. Shortened seasons occur during dry years when there is insufficient water to maintain the channel and other water-use needs. Infrequently the presence of ice will shorten the navigation season. The required water to maintain the navigation channel is the sum of water released at the Gavins Point Dam and inflows from tributaries and riparian land downstream. Water levels and runoff in the upper and lower basin are highly positively correlated.

Thus, release requirements to maintain navigation are highest when upstream inflows are lowest (US Army Corps of Engineers, 2000).

Figure 1.1. Missouri River the Lower Basin States

Because of the unreliability of naviagation during dry periods the Missouri River navigation channel can become risky and cost shippers money (Hytrek, 2012). Both flood and drought are cyclical, but cannot be predicted with high accuracy. The USACE's Master Water Control Manual for the Missouri River Mainstem Reservoir System presents guidelines for water release decisions based the flood or drought conditions. The water level in the upstream reservoirs and in-season precipitation control the duration of the navigation season and impact the size of shipments. Normally the navigation season is 8-months, from April 1st to December 1st with a total of 245 days of full navigation, Table 1.1 shows all dry years that cause fewer days of navigation and shortened the season (USACE, 2016).

Table 1.1. Navigation Seasons on Missouri River 1980–2015

Year	Days of Navigation
1980	225
1981	222
1982-1987	245
1988	229
1989	205
1990-1992	205
1993	188
1994	245
1995	235
1996-1998	255
1999	237
2000-2001	245
2002	222
2003	239
2004-2006	198
2007	205
2008	215
2009-2015	245

Source: Waterborne Commerce Statistics Center

Despite the investment made in developing and maintaining the navigation channel, freight traffic on the river has decreased substantially. Some of this is due to factors that are related to the channel, including reduced navigation seasons caused by weather. But other reasons for reduced Missouri River freight traffic are exogenous to the channel. These include a more competitive deregulated rail freight rate and increased exports to Asia through Pacific ports (Committee on Missouri River Ecosystem Science, 2002; Bray, Dager, and Burton, 2004). Many port facilities, including public ports, were shut down because of the poor business. Also, since the river is only available for 8-months per year, stakeholders need to think about alternative transportation modes with more secure availability during the post-harvest period when the river has low-flow conditions that will not only affect the navigation season but will delay and affect the future barge activities on the river (Gehman, Sheridan, and Kittrell, 2008). The Missouri River is very important for agriculture products. However, the volume of agriculturl goods transported on the river during the normal flow conditions doesn't make it very important to agriculture (Casavant, et al., 2010).

The importance of ports is determined by their ability to perform services for barges and commodities. The ports are an important reason for carriers to choose to deal with them or not. Also, ports' services and equipment support any river and give it the advantage over others. Hanson Professional Services Inc. (2011), stated that the poor port services along the river and its infrastructure cannot deal with the high economic growth in the areas served by the Missouri River. This study is concentrating on the issues that affect the navigation of the Missouri River. The market expects economic growth in the Missouri River, but with all these matters this growth might impact the future. Consequently, the study will focus on the weather conditions and water level, the high transportation cost, and the alternative transportation modes as an optimal solution. Shippers and carriers know that Missouri River freight movements unsecured because of climate change. Return of business activity to the Missouri River increases fear many stakeholders because of the river's history. All these issues make stockholders think about alternative transportation modes such as rail or trucks. Many shippers turned to rail and trucks as alternative modes after a series of drought, economic recession, decreased commodity prices and political conflicts, but some small companies never stopped using the river, eventhough all public ports from Sioux City, Iowa to St. Louis, Missouri disappeared between 1990 and 2000 (Stafford, 2016).

1.3. Literature Reviews

There is limited literature on the management of the Missouri River. A number of academic publications provide perspective on the development and management of the navigation channel and the Pick-Sloan project infrastructure. Schneiders (1996), reported that the rapid change in western Iowa during the period between 1927 and 1969 coincided with the execution of the river navigation and channelization project. The USACE did great work to redesign the river for human purposes but was unable to control many of the river's environmental characteristics for human benefit. The Committee on Missouri River Ecosystem Science (2002), provided a review of Missouri River geography, ecology, management, and history and argued that adaptive management was a viable alternative to rule-based approaches. Hearne and Prato (2015), reviewed the evolution of the management of the Missouri River and noted that the USACE had maintained its traditional priorities of managing the river for flood control and navigation while adopting new priorities particularly ecosystem management. And the absence of an interstate compact or a river basin organization, similar to the Tennessee Valley Authority, has left the USACE as the de facto river manager. Morton and Wright (2017), claimed that agricultural lands in Iowa, Nebraska, and Missouri are counting on the reservoirs to maintain the levees and reduce flooding during the peak flow basin states.

Another body of academic literature addresses barge transportation issues, some of which focuses on the Missouri river channel. The most important feature of barge transportation is its low cost due to its great load capacity. Casavant et al. (2010), claimed that the present barge industry is driven by the central powers of free market activity, affected by an assortment of components, including weather patterns, navigation conditions, agricultural input use, crop production, trade policies, and also the value of steel. Burton (1995), examined the impact of barge transportation on railroad freight charges after deregulation and explained the existence of water transportation has reduced post-deregulation railroad rates for agricultural products. Bray, Dager, and Burton (2004), agreed that the shippers would shift their commodities to an alternative transportation mode when the barge freight rates go beyond the alternative mode freight rate.

In addition to agricultural products, Missouri River barges transport sand and gravel, commercial products such as manufactures equipment, chemicals, crude material and petroleum, and non-commercial products to improve the river. The US Government Accounting Office reported that Missouri has the highest percentage of total tonnage by 83%, Kansas has 12%, Nebraska has 3% and Iowa has 2% (GAO, 2009). The Food and Agricultural Policy Research Institute (2004), claimed that when the river is usable, the grain merchants have more power to negotiate on freight rail rates. LaRandeau (2013), stated that between 2008 and 2012 there were 87 terminals active and the most important terminals were 16 of them for discharging sand and gravel and eight commercial terminals. In addition, the river used to transport the low tonnage with a high value.

Hanson Professional Services Inc. (2011), pointed out that some commodities played a significant role in Missouri River and these commodities including agricultural dry bulk, non-metallic mineral products, fertilizer, petroleum products, animal feeds, and gravel and crushed stone. Most agriculture commodities transporting by barge at the Missouri River are prepared to be exported via New Orleans. According to Baumel and Kamp (2003), “the demand for Missouri

River barge grain export traffic is likely to continue to decline, except for temporary recoveries caused by natural disasters or short-term distortions in normal grain marketing patterns around the world" (p. 11).

1.4. Methodology

Water is valuable when it is scarce. When water levels in the Missouri River are low, the USACE will reduce releases from the lowest reservoir at the Gavins Point Dam and reduce the shipping season on the lower Missouri River. Thus, this analysis will focus on the impact of reduced reservoir releases on tonnage shipped through the Missouri River navigation channel. Once the lost tonnage is estimated, the cost of alternative shipping for that freight to Gulf of Mexico ports via rail will be estimated. After the cost of barge shipping is deducted from the rail freight costs the added cost of freight due to low water levels will be estimated.

Data for this study comes from public sources: 1) the US Geological Survey (USGS), which publishes data on releases from the Gavins Point Dam; 2) the USACE which publishes data on navigation days, and barge traffic on the Missouri river; 3) the USDA's Agricultural Marketing Service (AMS)which publishes data on barge rates for agricultural commodities; 4) the USDA's Foreign Agricultural Service (FAS) which provides data on exportr ports for agricultural commodities; and 5) the Surface Trasnportation Borad which provides data on rail rates. Much of these datasets are incomplete and this analysis requires the use of proxies, with corresponding assumptions.

The USGS National Water Information System publishes data on water releases from the Gavins Point Dam at Yankton, South Dakota. In general data on daily releases is available from 1980 until 1995. The USACE publishes data on navigation days in the Missouri River channel. This paper uses Missouri River traffic data available from USACE's Waterborne Commerce Statistics Center for the years 1980 to 2014. The first step to analyzing the impact of water levels on the value of Missouri River transportation is using regression analysis to estimate the influence of navigation days on freight traffic. Once the difference in freight between full and impaired seasons is estimated the increased cost of alternative shipping can be calculated. These data are available for three of disaggregated levels. Level one is for all commercial shipping. Level two disaggregates commercial shipping into: 1) petroleum and petroleum products: 2) primary manufactured goods; 3) chemicals and related products; and 4) food and farm products. Level three disaggregates the food and farm products to grain, oilseeds, processed grain and animal feed, and other agriculture products. Shipping is broken into three sections of the navigation channel: 1) Sioux Falls to Omaha; 2) Omaha to Kansas City; and 3) Kansas City to the Missouri River and Mississippi River confluence.

Regression analysis was used to estimate the impact of navigation days on barge freight tonnage for different commodity types. Initially, three independent variables were used for all commodities: year, days of navigation, and days of navigation for previous year. The year was included to account for a time trend of reduced river navigation use since the 1980s. The previous year's navigation days was included in order to account for the impact that one year reduced navigation might have on a shipper's expectation of the navigation availability on the subsequent year. Three more variables were added for the analysis of grain shipments, which are characterized in USACE data sources as food.

In order to account for the trend of increased experts from the Pacific Norhtwest instead of New Orleans, FAS data on exports of soybeans, corn, and wheat from the Pacific Norhtwest which includes Portland and Seattle, and from New Orleans were included as explanatory variables. Also, to account for the impact of deregulated rail rares on transportation decisions, rail rates per ton-mile which provided by Surface Transportation Board, were included as an explanatiry variable. Because of the potential for the time series data to result in autocorrelated error terms, an autoregressive model was used for all commodity types (Brocklebank and Dickey, 2003). Some models included all the independent variables. However, many tested regressors were insignificant so many models contained a subset of the tested explanatory variables. The model can be written as :

$$Y_i = \beta_0 + \beta_1 X_i + \epsilon_i. \tag{1.1}$$

Where:

β_0= Intercept when $X_i = 0$

β_1= Slope which is the change in Y_i in each unit change in X_i

X_i = Predicted value

ϵ_i $N(0, \sigma^2)$ for $i = 1, 2, ..., n$. The model used the commodity data 1980 to 2014. Through the ArcMap network data set the railways' stations geospatial data was used to determine the distance between selected locations. Then, a network analyst tool was used to create a new route between target locations (Zagel, 2006). The distance was measured in railway miles. The first distances were from Kansas City to New Orleans and Galveston. The second distance was from St. Louis to New Orleans. These distances were used for calculating the railway cost to compare them with other transportation modes. Commodities were split into two levels: different commodity types and agricultural products. Commodity movement used only the data from 1994 to 2014 to show its trend. The number of barge navigation days played an important role to show the traffic season.

1.5. Results and Discussion

Table 1.2 presents the food commoditiy analysing results which includes the exports from the Pacific Norhtwest and New Orleans with the rail rate per ton-mile. Results of analysing the impact of navigation days on barge traffic with all independent variables are shown in Table 1.3. While Table 1.4 interduced the same impact of navigation days on barge traffic, and it showed the significant models. All commodities transported in tons. Commercial commodities include all goods except sand and gravel or waterway materials. If we did not have any information about the year, days of navigation and the days of the previous year navigation then the estimated commercial commodities were 160,068,808 tons. Based on the associations between the three independent variables: 1) one extra year, 2) the days of navigation, and 3) days of navigation for the previous year being held constant the commercial commodities decreased by 80,883 tons. Since the p value for the t test for the independent variables was significant, all the predictors were significant to be included in the model to predict the commercial commodities.

From Kansas City to the mouth the expected food commodities were 83,973,181 tons if we did not have any information about all independent variables. Based on the associations between the variables for one extra year, while the days of navigation, and the days of navigation for the previous year, Pacific Norhtwest exports, New Orlenas exports, and rail rates, were held constant the food commodities decreased by 42,142 tons. While the p-value for the t-test for the year was significant, the predictor was significant to be included in the model to predict the food commodities.

The barge traffic from Omaha to Kansas City, the estimated food products were 53,776,970 tons if we did not have any information about all independent variables. Based on the associations between these variables and foe one extra year while all other variables being held constant, the food products would decrease by 26,994 tons. While the p-value for the t-test for the year was significant, the predictor was significant to be included in the model to predict the food products. On the other hand, Sioux City did not have enough barge traffic to be estimated. Therefore, in the regression model, all commodities were combined. Although the R-squared statistics demonstrate the overall fit of the models. Many insignificant results were found. While there are very few barge movements above Kansas City, more barge movements with the longer navigation season could help to build a strong relationship between the variables. However, a relationship between commodities and existing independent variables can be identified.

Table 1.2. Food Commodity Regression Results for Barges Traffic in Missouri River 1980–2014

Dependent Variables	Intercept Coff.		Year		Days of NA		Days of NA P. Y.		New Orleans		Pacific Norhtwest		Rail Rate		R^2
	Estimate	St. Err.	Estimate	St. Err.	Estimate	St. Err.	Estimate	St. Err.	Estimate	St. Err.	Estimate	St. Err.	Estimate	St. Err.	
Kansas City - the Mouth															
Food	83,973,181	16,090,937	-42,142	7,984	751.55	1,197	1,970	945	0.003	0.0024	-0.0099	0.0039	8,915,999	6,616,234	0.96
Omaha - Kansas City															
Food	53,776,970	10,303,086	-26,994	5,135	1,053	820.5			0.0029	0.0017	-0.0069	0.0027	9,163,202	4,059,336	0.94

Table 1.3. Regression Results for Barges Traffic in Missouri River 1980–2014

Dependent Variables	Intercept Coff.		Year		Days of NA		Days of NA P. Y.		R^2
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	
Commercial Commodities [1]	160,068,808	5,365,020	-80,883	2,656	7,002	1,416	5,250	1,422	0.98
* Total Traffic Commodities [2]	28,488,637	130,886,684	-13,147	65,392	873.3563	15,666	16,050	15,393	0.50
Kansas City - the Mouth									
Petroleum [3]	29,804,908	1,975,878	-14,786	977.6667	-84.5791	406.5222	70.8953	375.7283	0.91
Chemicals [4]	51,919,423	3,753,391	-26,326	1,861	3,869	708.2158	582.0016	628.8633	0.95
Primary	20,175,262	3,160,030	-10,060	1,570	-113.4667	579.0915	694.6674	506.0894	0.78
Crude [5]	326,163,848	72,276,301	-154,189	35,779	-66,361	18,097	16,906	17,240	0.54
Manufactured [6]	239,635	82,454	-119.5549	40.8897	9.6094	14.0631	-6.0784	12.1753	0.45
PPrCM [7]	375,452,656	73,948,889	-178,710	36,612	-66,769	18,327	18,056	17,406	0.56
ChF [8]	122,263,602	10,334,533	-61,960	5,125	6,532	1,655	3,650	1,413	0.94
CM	326,426,421	72,238,142	-154,320	35,760	-66,355	18,091	16,899	17,235	0.54
All Commodities [9]	528,997,065	74,587,703	-257,516	37,008	-36,909	14,208	10,145	12,573	0.75
Omaha - Kansas City									
Petroleum	10,529,976	1,403,422	-5,280	695.3044	125.4714	270.8026	240.9954	243.0700	0.78
Chemicals	30,743,817	2,310,560	-15,560	1,144	2,031	410.7915	274.6062	365.6468	0.94
Primary	8,892,512	2,069,284	-4,452	1,027	483.7767	399.8454	-262.0993	354.9353	0.60
Crude	190,980,227	154,150,895	-84,766	76,113	-180,059	38,389	97,971	37,529	0.52
Manufactured	155,860	37,477	-78.1546	18.5658	10.5408	7.2657	-5.4192	6.5350	0.57
All Commodities	134,835,428	36,004,475	-65,228	17,898	-14,523	5,880	2,065	4,978	0.66
Sioux City - Omaha									
All Commodities	31,411,114	3,924,898	-15,883	1,946	1,769	521.7717	507.7533	430.8245	0.91

Table 1.4. Regression Results for Barges Traffic in Missouri River with Selected Variables 1980-2014

Dependent Variables	Intercept Coff.		Year		Days of NA		Days of NA P. Y.		R^2
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	
Commercial Commodities [1]	160,068,808	5,365,020	-80,883	2,656	7,002	1,416	5,250	1,422	0.98
* Total Traffic Commodities [2]	-0.000000002	692,202,418	1,237,446	346,695			10,318,711	2,795,958	0.66
Kansas City - the Mouth									
Petroleum [3]	29,741,569	1,782,669	-1,4756	890					0.91
Chemicals [4]	51,634,004	3,618,020	-26,165	1,792	4,283	574.8921			0.95
Primary	20,008,255	3,481,323	-9,910	1,737					0.75
Crude [5]	323,467,765	74,004,859	-152,498	36,625	-52,569	11,963			0.51
Manufactured [6]	249,066	81,287	-123.8405	41					0.43
PPrCM [7]	372,022,714	76,296,982	-176,628	37,764	-52,051	12,328			0.53
PPrCM ***	367,837,358	76,871,305	-177,436	38,197					0.53
ChF [8]	122,263,602	10,334,533	-61,960	5,125	6,532	1,655	3,650	1,413	0.94
CM	323,738,511	73,963,247	-152,633	36,605	-52,567	11,956			0.51
All Commodities [9]	524,622,769	73,666,030	-254,927	36,509	-30,373	11,560			0.74
Omaha - Kansas City									
Petroleum	10,429,899	1,114,345	-5,233	551	386	185			0.81
Chemicals	30,681,024	2,253,523	-15,516	1,115	2,196	355			0.93
Primary	9,710,669	2,476,998	-4,833	1,236					0.60
Crude	19,452,127	6,508,662			-171,085	39,667	96,146	38,721	0.48
Manufactured	170,753	43,206	-85	22					0.52
All Commodities	132,662,774	40,352,629	-64,193	20,045	-12,071	5,517			0.68
Sioux City - Omaha									
All Commodities	31,026,591	4,266,875	-15,629	2,117	1,735	556			0.91

[1] Includes commercial tonnage except for sand and gravel or waterway materials. Tonnage compiled by Waterborne Commerce Statistics Center (WCSC).

[2] Includes commodities; sand, gravel, and crushed rock; and waterway improvement materials. Tonnage by WCSC.

[3] Includes Asphalt, Tar & Pitch.

[4] Includes Fertilizers such as Nitrogenous Fert, Phosphatic Fert, Potassic Fert, and Fert. & Mixes NEC, Inorg. Elem., Oxides, & Halogen Salts and Metallic Salts.

[5] Includes Soil, Sand, Gravel, Rock, Stone, Waterway Improv. Mat, Sulphur, Clay and Salt, Refrac. Mat, Other Non-Metal. Min., Non-Metal. Min. NEC.

[6] Includes Machinery (Not Elec), Electrical Machinery, Vehicles Parts, Aircraft Parts, Ships, Boats, Ordnance & Access., Manufac., Wood Pr., Textile Pr, Rubber, Plastic Pr., Empty Containers, Manufac. Pr.

[7] Petroleum, Primary, Crude, and Manufactured.

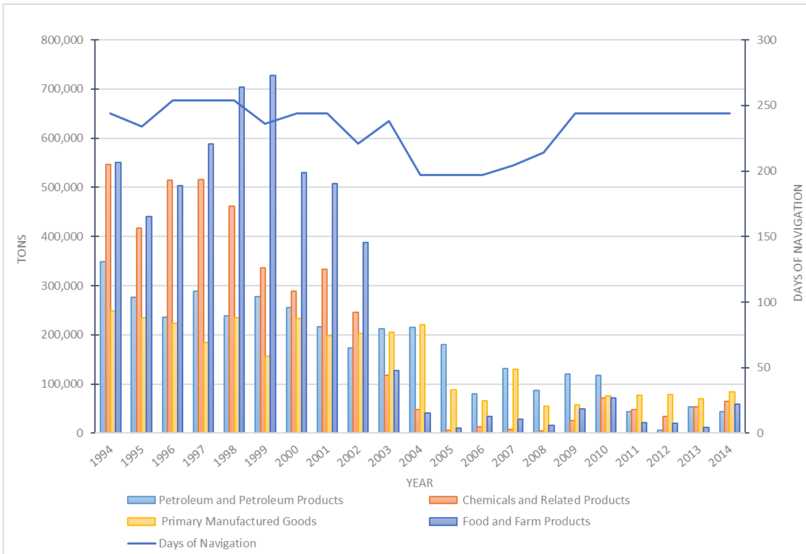
[8] Chemicals and Food.

[9] Petroleum, Chemicals, Primary, Crude, Food, and Manufactured.

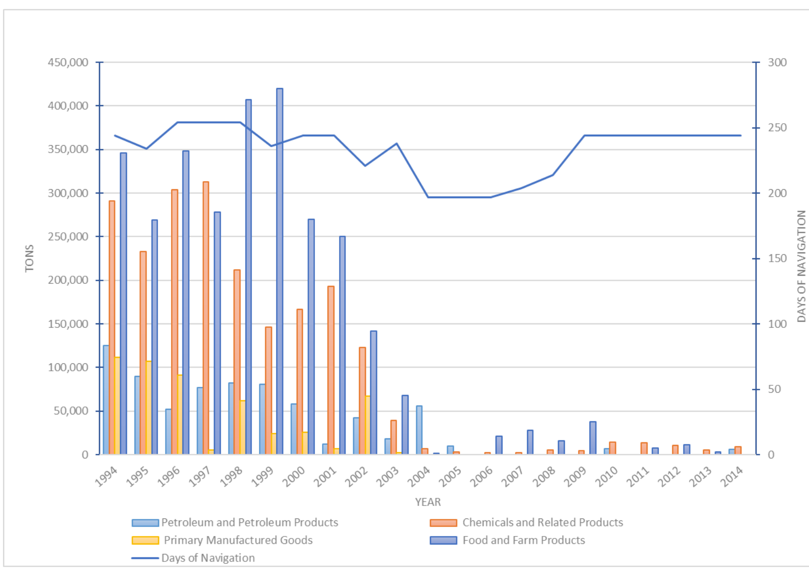
[*] Another variable exist which is Year multiply by Days of NA for the previous year, which equals to -5160 and standard error of 1401.

[***] Another variable exist which is Days of NA square, which equals to -115.6829 and standard error of 27.8355

Commodity movement from 1994 to 2004 was stable until the navigation days decreased in 2004 shown in Figure 1.2. Both Kansas City and Omaha have the highest volume movement of food and farm products. After the dry years started in 2004, the charts showed how the commodities were affected by the short navigation period. Consequently, after 2004 the river officially became unreliable.

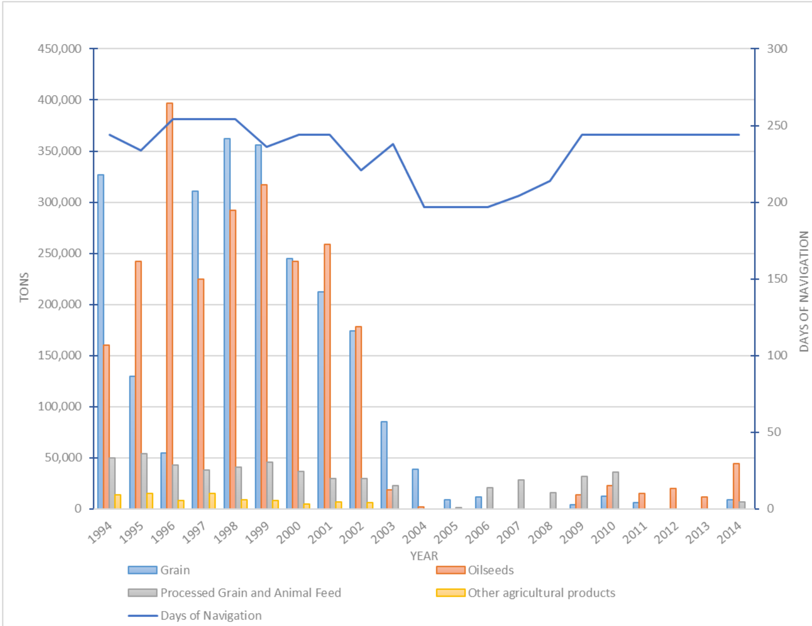


(a) Kansas City

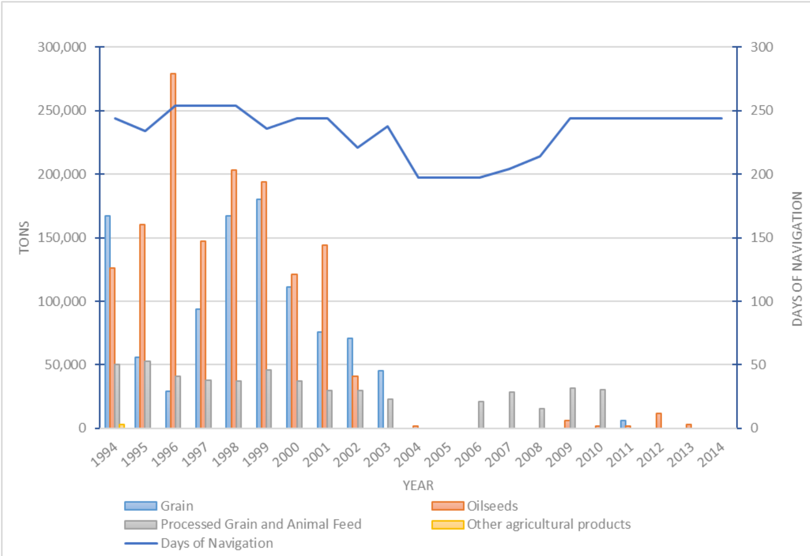


(b) Omaha

Figure 1.2. Commodities Movement Through (a) Kansas City and (b) Omaha



(a) Kansas City Agriculture Products



(b) Omaha Agriculture Products

Figure 1.3. Agriculture Products Movement Through (a) Kansas City and (b) Omaha

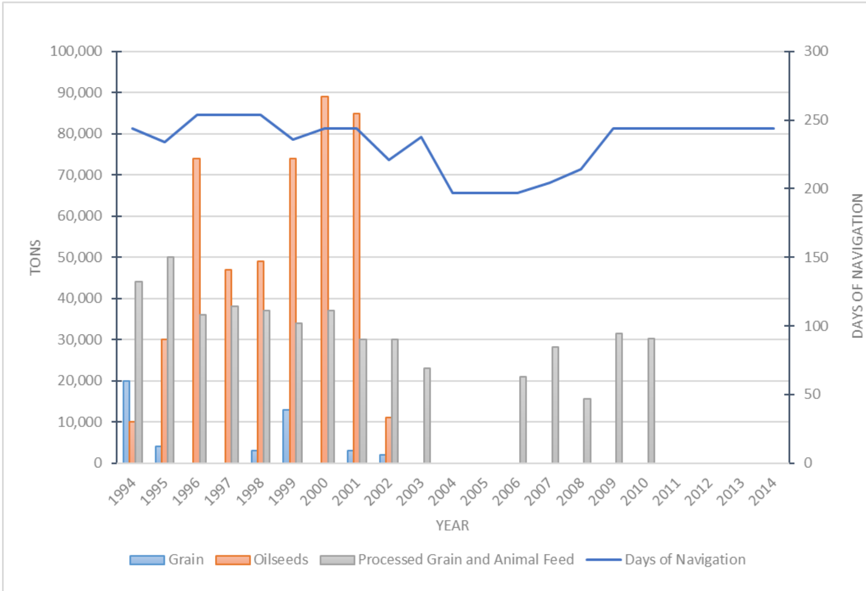


Figure 1.4. Agriculture Products Movement Through Sioux City

The dry years affected all commodity movement especially the food products. Oilseeds are the most important food products, shown in Figure 1.3. All food and farm product transportation decreased after the navigation traffic reduced during the dry years. Some of the food products disappeared such as oilseeds in Sioux City from 2004 to 2014. Also, there were no oilseeds shipped in Omaha or Kansas City between 2005 and 2008.

The decrease of all commodities and especially on food and farm products, implies the need for alternative shipping modes, especially since economic activity and agricultural production has increased. Usually, food and farm products shipped via Missouri River continue to the Mississippi River to be exported overseas. Since all these issues happened in the Missouri River which shorts the navigation season, alternative freight modes are the best solution. Trucks and rail are considered alternative transportation modes. Table 1.5 shows the freight capacity among different transportation modes.

Table 1.5. Transportation Mode Freight Capacity

Mode	Capacity
Truck Trailer	25 tons
Railroad Bulk	110 tons
Barge Dry Bulk	1750 tons

Source: A Modal Comparison of Domestic Freight Transportation Effects on the General Public

Trucks can be a costly solution to transport agricultural goods. It is known that one barge load equals 70 trucks which means 1750 tons of agricultural products would need a fleet of trucks to carry them. This large number of trucks implies substantial public and private costs to cover drivers' salaries, trucks maintenance, tires, insurance, registration fees and road charges and many additional private expenses. There are additional public expenses including congestion, accidents, and damage to road infrastructure. Because of their expenses, bulk goods are not commonly transported for long distance via trucks, and the proper means of transportation would be either barge or rail (Burton, 1995).

Rail is generally preferred transportation substitute for barge freight. One barge carried the same bulk freight as 16 railcars. A shuttle train can move 75 to 110 railcars (Agriculture U. D., 2017). The maximum load of a shuttle train is equal to 7 loaded barges. In 2007, railways transported about 33 % of all grain in the United States which means the railways play a significant role in the agriculture market (Prater and Sparger, 2013). While shippers cannot use the trucks for long distance, so barge and railway would be the best transportation methods to be used. The cost for barge and rail transportations were estimated for the dry years 2004 to 2008. Table 1.6 indicates Omaha to Kansas City estimated costs. Table 1.7 shows the estimated costs from Kansas City to the mouth.

Table 1.6. Water Discharges Effects on Costing Lost Freights from Omaha to Kansas City

Year	Navigation Days	Discharges [1]	Lost Tons [2]	Cost of Rail shipment [3]	Cost of Barge Shipment [4]	Increased Cost due to Lost Water
2004	198	326,462	49,491	$ 1,204,165	$ 1,083,062	$ 121,103
2005	198	326,462	49,491	$ 1,211,513	$ 1,574,560	($ 363,046)
2006	198	326,462	49,491	$ 1,317,049	$ 1,292,022	$ 25,027
2007	205	436,208	42,120	$ 1,167,033	$ 766,478	$ 390,555
2008	215	326,462	31,590	$ 978,985	$ 1,420,203	($ 441,218)

[1] Estimated from incomplete data in millions of cubic ft annual

[2] Includes effect of days of navigation and days of navigation of previous year

[3] Rail freight charge from Omaha to Galveston

[4] Barge rates are Mississippi Rates Omaha to New Orleans

Table 1.7. Water Discharges Effects on Costing Lost Freights from Kansas City to the Mouth

Year	Navigation Days	Discharges [1]	Lost Tons [2]	Cost of Rail shipment [3]	Cost of Barge Shipment [4]	Increased Cost due to Lost Water
2004	198	326,462	35,323	$ 817,117	$ 670,753	$ 146,364
2005	198	326,462	35,323	$ 2,977,051	$ 3,531,247	($ 554,196)
2006	198	326,462	35,323	$ 3,236,382	$ 2,897,602	$ 338,780
2007	205	436,208	30,062	$ 3,231,016	$ 1,961,987	$ 1,269,030
2008	215	326,462	22,546	$ 2,986,079	$ 3,953,546	($ 967,467)

[1] Estimated from incomplete data in millions of cubic ft annual

[2] Includes effect of days of navigation and days of navigation of previous year

[3] Rail freight charge from Kansas City to Galveston

[4] Barge rates are Mississippi Rates Kansas City to New Orleans

With limited data, a positive cost to agricultural freight was shown in three years of a five years' dry period (Showed in Tables 1.6 and 1.7). In two years, rail freight costs were estimated to be lower than barge freight costs. This cost comparison corresponds to the gradual decrease in the use of the Missouri River shipping channel for agricultural commodities. Tables 1.6 and 1.7 showed the lost tons based on the days of navigation and days of navigation of previous year effects. The cost of rail shipment included the effect of rail rate per ton-mile and the exports from New Orleans and the Pacific Norhtwest ports. While the barge shipment cost included the river distance effect from Omaha to Kansas City and Kansas City to the mouth, but the cost is based on the barge rates of Mississippi River from St. Louis to New Orleans adding to it the Missouri River distance as well.

Since rail is the significant alternative mode, there are three possible locations would commodities shipped from. One alternative route is Kansas City to New Orleans, LA and the other one to Galveston, TX. In addition, there is a third possible route from St. Louis to New Orleans, LA as shown in Figure 1.4.

Figure 1.5. Alternative Transportation Mode

When the river is not usable, the rail would be the best alternative mode even with the high operation cost (Institute, 2004). Always, rail is available during the whole year, with some congestion, and shippers can make a schedule ahead of time to move commodities. The rail rates differ based on the harvest season, especially in the Missouri River areas. As the harvest season starts, the rates change weekly. As demand increases the rates increase. The absence of competition from other transportation means gives the rail priority to control the agriculture goods movement market.

1.6. Summary and Conclusion

Agricultural commodity markets have changed substantially since the construction of the Missouri River navigation channel. Over the years the importance of barge transport has declined. Part of this decline is due to the Missouri River's history with floods and droughts. During dry years, river conditions greatly reduce navigation, especially during the harvest season between October and November. But alternative freight transport is available and deregulated railroads often are cost-effective, especially with the growth of Pacific Coast exports.

The USACE's efforts to manage the Missouri River for competing purposes implies tradeoffs. Efforts to maintain the navigation channel, with waterway maintenance and with reservoir releases, have not led to sustained and active interstate commerce. Indeed, commercial river ports have been shut down. The results of this study show that the benefits of barge freight to agriculture are negligible. USDA reported freight rates showed that rail is a cost-effective alternative. There are beneficiaries of the Missouri River navigation channel. But it increasingly appears as if these benefits cannot match the effort and water dedicated to the maintenance of the channel.

During the dry years from 2004 to 2008, agricultural barge shipments declined. These lost shipments were transported through rail. This research showed a positive cost to agricultural freight in three of the five dry years. In the other two years rail freight costs were estimated to be lower than barge freight costs.

Some of the policy implications would be less needing to maintain the whole navigation channel because it will not harm the agriculture which is basically the harvest when the shorten season happened. Also, having more natural flow and less channelization which will have certain ecological benefits.

Of course, this study does not account for the frequent use of the navigation channel to transport sand and gravel short distances. Future studies can focus more on non-agricultural commodities traffic and on the vaule of sand and gravel transport. This would require information on alternative shipping modes.

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2. MARITIME TRANSPORT AND DISTANCE EFFECT ON AGRICULTURAL TRADE

2.1. Introduction

Globalization has integrated territorial and the local markets due to reduced obstructions on trade. The maritime transportation has evolved over time and has emerged as the primary mode for global connectivity and international trading activities. For example, in 2017, United Nations Conference on Trade and Development (UNCTAD) reported that more than 80% of the total international trade by volume was transported by ships (United Nations Conference on Trade and Development, 2017). Furthermore, in 2017, commodities transported internationally by ships rose by 2.8% compared to 2016 (United Nations Conference on Trade and Development, 2017). The increase occurred in 2016 compared to 2015 and in 2015 compared to 2014 by 2.6% and 1.8%, respectively (United Nations Conference on Trade and Development, 2017). This reflects the importance of maritime transportation in international trade.

The importance of the maritime transportation has been increased with the growth of the international trade. Although there are alternative freight modes suh as air, road, rail, and pipelines, maritime transportation holds a preeminent position because ships can move containers, heavy ores crude oil, vehicles, and agricultural products over long distances (Corbett et al., 2010).

The French Center for Prospective Studies and International Information (Centre dÉtudes Prospectives et d'Informations Internationales) (CEPII) has developed a database that uses the great circle method to measures the distance between the most populated cities in each nation by using their latitude and longitude to come up with the shortest distance between bilateral trading pairs by using the earth surface (Tseng and Lee, 2007). Thus, this geographical distance may be an excellent indicators of bilateral trade barriers, however; it may not actually capture the changing transportation costs over time. The maritime distance creates an arc typically on the surface of the water and provides the actual physical distance between two ports connected by one or more global shipping routes. Therefore, we expect maritime distance to be a better instrument for global transportation cost for trade between any two ports.

Further, maritime shipping services are primarily recognized for linking seaports that serve as primary trade areas. The ports represent the trade area where the port authority is responsible to manage all real estate inside the port area. Always, port authority makes sure that the services are provided well to all users such as safety, security, ship services which includes loading and unloading goods, warehouses, and other related services (Bank, Reform, and Kit, 2010). Port authorities presents reliable statistic reports regarding exports and imports since all shipments are recorded and their origin and final destination are known. The reports can be monthly, quarterly, or annually. Usually, the port authority is serving under the high ministry of transportation or a specific committee which published by the government to ensure that all targets are met (Fair, 1961)

The organization of the study is as follows. The next section discusses the related literature on the maritime transportation. Section 3 describes the methodology. Sections 4, and 5 describe our data and present the results and discussion, respectively. Section 6 conclusion.

2.2. Literature Reviews

The maritime transportation sector is an important sector with respect to global trading practices. In 2007, maritime traffic was double that experienced in 2003. Approximately 90% of global freight, by weight, is carried by ship (Korinek and Sourdin, 2009b). Maritime transportation costs have substantial effects on trade. Different factors determine maritime transport costs. These include transport insurance, port efficiency, development of containerized transportation, geographical factors, trade and shipping restrictions, and the number of maritime routes and shipping companies that serve the region. Landlocked countries might face obstacles in international trade processes such as Bolivia in South America. Behar and Venables (2010), mentioned that transportation cost and the trade exchanging activities are depending on neighbors' policies in the case of landlocked countries. American Institute of Marine Underwriters (AIMU) reports the historical use of maritime transportation (see Table 2.1).

Table 2.1. The Beginning of a New Maritime Era

Year	Historical Milestones
1955	Malcolm McLean, a local NC trucking company owner, used $7 M loan to purchase Pan-Atlantic Steamship Company which renamed later to Sea-Land Industries.
1956	The T-2 tanker was the first container ship which was a converted from World War II era vessel, which named the SS Ideal-X First journey was on April 26th, from Port of Newark, to Houston.
1957	SS Gateway City was the first ship designed and rebuilt specifically to carry containers. Its capacity was 226 containers carried both above and below deck.
1966	The first international voyage of a container ship, the SS Fairland, sailed from the United States to the Netherlands with 236 containers on board.
1968	Container ships capacity increased to carry 1,000 TEUs.

Source: American Institute of Marine Underwriters (AIMU)

As shown by Zheng, Hu, and Xu (2017), a 10% increase in the volume of transported freight leads to a 1.1% fall in maritime transportation costs. Also, of 10% in the value of a ton of freight corresponds to a 3.7% increase in maritime transportation cost (Wilmsmeier and Martìnez-Zarzoso, 2010). Maritime distance affects international trade and plays a critical role in influencing trade patterns (Jacks and Pendakur, 2007). Despite decreasing shipping costs, the impact of distance on trade is not decreasing over the time. Disdier and Head (2004), examined 1052 distance effects which have been estimated in 78 papers and found that the distance impact on trade has increased over time. One of the most critical findings in the international economics is the negative correlation between distance and international trade (Disdier and Head, 2008; Frankel, Ernesto Stein, and Wei, 1997; Magerman, Studnicka, and Van Hove, 2016).

Maritime transport costs vary between different commodities as well as various trade routes. From the most recent OECD maritime transportation cost database, the shipping cost for agricultural products, like oilseeds and grains, stretch to 20–30 percent of total import cost in 2008 (Korinek and Sourdin, 2010). The costs of shipping grains in emerging markets have grown very high in addition to the extra cost of overland transportation. Most of the agricultural products are subject to charges, and special transportation charges increase consumer prices. The high transportation costs contract the supply of food for importing.

Despite, the existing price differential across commodities, maritime transportation still remains the most economical mode for transporting heavy goods for long distance. Trade liberalization has greatly reduced tariff related costs thereby increasing the relevance of other variable costs of international trade. Given that the transportation costs account for approximately 21% of the cost of international trade, these costs are highly relevant for international trade (van Bergeijk and Brakman, 2010; Mavroidis, 2016). Further, maritime transportation costs vary across countries and commodities, and it is cheaper to transport goods from OECD countries than from the developing countries (Korinek and Sourdin, 2010).

The quality of the maritime linkages between bilateral trading pairs also impacts the export performance (Hoffmann et al., 2017). Safe maritime routes could increase bilateral trade. As a result of the competition of freight transportation costs the seaborne trade has continued to increase year after year. Because of the increasing in the seaborne trade there has been the construction of mega vessels which carry enormous loads compared to the volumes conveyed by smaller exporting nations (Hummels, 2007). From 1970 to 2011, the maritime trade increased from 2.6 billion tons to 8.7 billion tons with an annual average growth rate of 3% (Valentine, Benamara, and Hoffmann, 2013). All these changes positively affect the economies of scale. Ninety percent of global business are shipping through the sea due to the many international trade benefits when compared to the road, air and railroad transport (Wakeman and Bomba, 2010). The global economy is growing, and this necessitates the need of shipping huge volumes of cargo in less time.

Maritime transportation has two different shipping categories, which are charter shipping and liner shipping. The cost varies for these categories based on distances, value, and volume. Liner shipping provides an important service in the maritime industry since ships work on regular routes with fixed schedules. Erol (2016), claimed that an increase in distances would increase freight costs. The ports which are located within the maritime international shipping networks, and network peripherals, might increase the global transportation costs more instead of using the geographical distance and might be a critical factor in measuring the transportation costs (United Nations Conference on Trade and Development, 2017).

Wilmsmeier and Martı́nez-Zarzoso (2010), reported that that distance between ports is has a significantly positive relationship with maritime freight costs and concluded that the maritime transportation costs will increase with longer distances. Similarly, Wilmsmeier, Hoffmann, and Sanchez (2006), found that distance had a positive and significant impact on freight costs for maritime trade between Latin American countries.

In an analysis of bilateral trade, Hummels (2001), claimed that distance had a positive relationship with imports of several commodities, but this was only statistically significant for fish. Biermann (2012), estimated the maritime distance impact on trade by using random effects model and Hausman-Taylor model and found that the distance is positive and significant. These results indicate that although transport costs increase with distance that trade might also increase with maritime distance.

For decades the maritime transportion market has grown. This growth may have increased demand for bigger ships' to transport more commodities (Greening et al., 2018). According to Notteboom and Rodrigue (2009), "With globalization widening the distance between production locations and consumer markets, demand for sea freight had been growing by double digits annually (p. 12)." Globalization makes the global markets as a world village and allows businesses to grow faster and develop communications with clients. For decades the maritime industry has changed its innovations and labors resources to the increase demands of globalization (Corbett et al., 2010). The globalization forces the maritime elements to improve such as the ships become more prominent, the canals expanded, the ports' draft become more in-depth, and the terminals have the new generation of equipment.

The globalization affects the containerized commodities by showing significant growth on container ships, which moves finished and semi-finished products (Rodrigue, 2007). The globalization supported the maritime trade strongly with other aspects as well such as the global supply chains and other networks (Grzelakowski, 2013). The gravity model has been a useful tool in explaining the relationship between the maritime distance and the transportation costs in international trade (Korinek and Sourdin, 2009a). The longer the distance, the higher the costs and the vice versa. When the distance doubles between different geographical areas that will cause increasing the transportation costs by 29% which reduces the trade activities among these areas (Wilmsmeier, 2014). The gravity model acts as one of the most powerful highly studied models among the economists (Anderson, 2011; Kimura, Lee, and Kimura, 2006). It helps in showing how the variables influence international trade. Transportation costs have a significant influence on trade flows among the nations and all trade studies were based on the straight-line distance between capital cities (Marti, Puertas, and Garcŕa, 2014).

Some factors affect the trade flow and the long distance is one of them and it can result a reduction in it because the distance will reflect the costs. Increase in transport costs by about 10% reduces trade flows by 20% (J. P. Rodrigue, Comtois, and Slack, 2016). The gravity model is the best approach that represents how the maritime distance affects the trade flow among different countries. It has been successful in estimating the trends that are related to the global trade. Hummels (2007), reported that transportation charges relative to the prices of the cargo moved is a one way to measure the economic importance of transportation costs. It is true that maritime transport costs have a significant effect on trade.

International trade can increase the possibility of more trade and industrial integration with countries having similar economic, political, religious or ethnic societies, also with non-similar countries since the benefits exist. On the other hand, the international trade can decrease and be affected by different factors. For instance, domestic, regional, and international issues such as civil wars and conflicts can easily affect the bilateral trade and decrease it see (Bayer and Rupert, 2004; Glick and Taylor, 2010; Nitsch and Schumacher, 2004; Qureshi, 2013).

2.3. Methodology

The following empirical equation is used to measure how maritime distance affects the United States' agricultual trade flows among countries:

$$\begin{aligned} \ln Y_{ij} &= \beta_0 + \beta_1 \ln(\text{Maritime Distance}_{ij}) + \beta_2 \ln(\text{GDP}_i) + \beta_3 \ln(\text{GDP}_j) \\ &\quad + \beta_4 \ln(\text{GDPCAP}_j) + \beta_5 \ln(\text{Area}_j) + \beta_6 RTA + \epsilon \end{aligned} \tag{2.1}$$

In Equation (2.1) Y_{ij} is the bilateral export between origin (i) and destination (j), Maritime Distance_{ij} is the port level distance between origin and destination, GDP_j is the gross domestic product for the origin while GDP_j is for the destination. GDPCAP, is the GPD per capita for j. Area presents the area for destination. All previous variables are transformed to the natural logarithm. RTA is a dummy variable whether the country is in a regional trade agreement. The above empirical equation in inspired by gravity model which is considered a workhorse of international trade. Following the tradition in international trade, we estimate equation similar to Equation

(2.1) with CEPII's geographical distance instead of maritime distance.

$$\begin{aligned}\ln Y_{ij} &= \beta_0 + \beta_1 \ln(\text{Maritime Distance}_{ij}) + \beta_2 \ln(\text{Du. Distance}) \\ &+\beta_3 \ln(\text{Maritime Dis.} \times \text{Du.Distance}) + \beta_4 \ln(\text{GDP}_i) + \beta_5 \ln(\text{GDP}_j) \\ &+\beta_6 \ln(\text{GDPCAP}_j) + \beta_7 RTA + \epsilon \qquad (2.2)\end{aligned}$$

Equation (2.2) is a similar to Equation (2.1) by adding a dummy variable which gives 1 whenever the maritime distance is less than the geographical distance and 0 otherwise. Also, included an interaction term between the maritime distance and the dummy variable.

2.4. Data

2.4.1. US Ports

We use data on Customs and Border Protection (CBP) ports reported in American Association of Port Authorities (2014) for US port data. Out of 149 available ports, we select 44 based on their share in total maritime exports from the United States. For each sampling year, the ports in our dataset represents 74% of US World exports (or US exports to the sample destination countries) and thus does not compromise our representativeness of the sample.

2.4.1.1. Trade Data

We use HS-6-digit agricultural trade data (2003 to 2016) retrieved from the United States Census Bureau for our analysis. The data includes port level exports from U.S. to total of 57 countries across Europe, North America, and South America. Figure 2.1, 2.2, and 2.3 showed the value of US agricultural (US dollar) exports to Europe, North America, and South America, respectively. In Europe, Turkey, Germany, United Kingdom, and Netherlands are the largest importer of agricultural commodities from US by 13%, 13%, 12%, and 12%, respectively. While Mexico has the highest share of the agricultural trade with US in North America by 96%. Finally, in South America Colombia comes in the first place by importing 27% of the agricultural goods from US followed by Brazil and Venezuela by 19% and 17%, respectively.

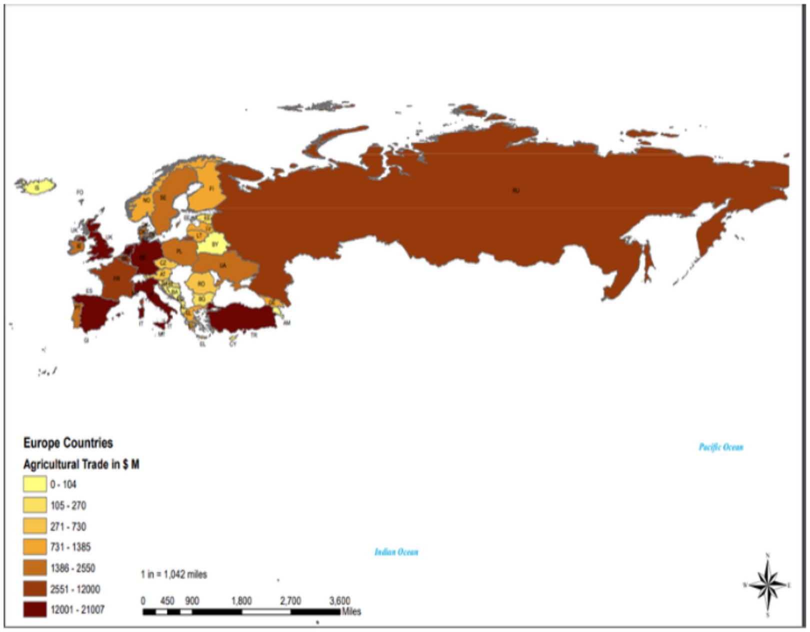

Figure 2.1. Value of US Agricultural Exports to Europe 2003–2016. Source: United States Census Bureau

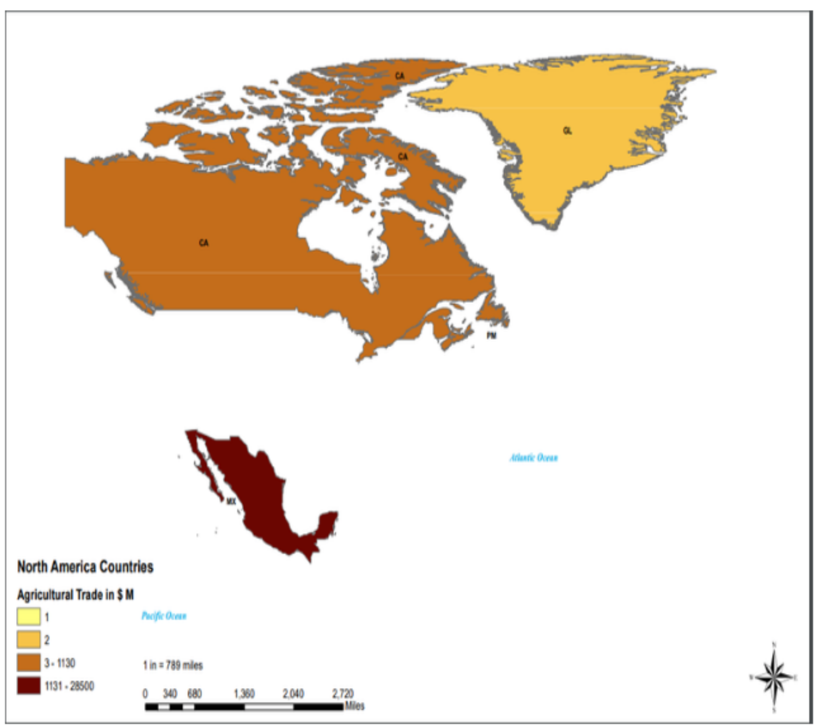

Figure 2.2. Value of US Agricultural Exports to North America 2003–2016. Source: United States Census Bureau

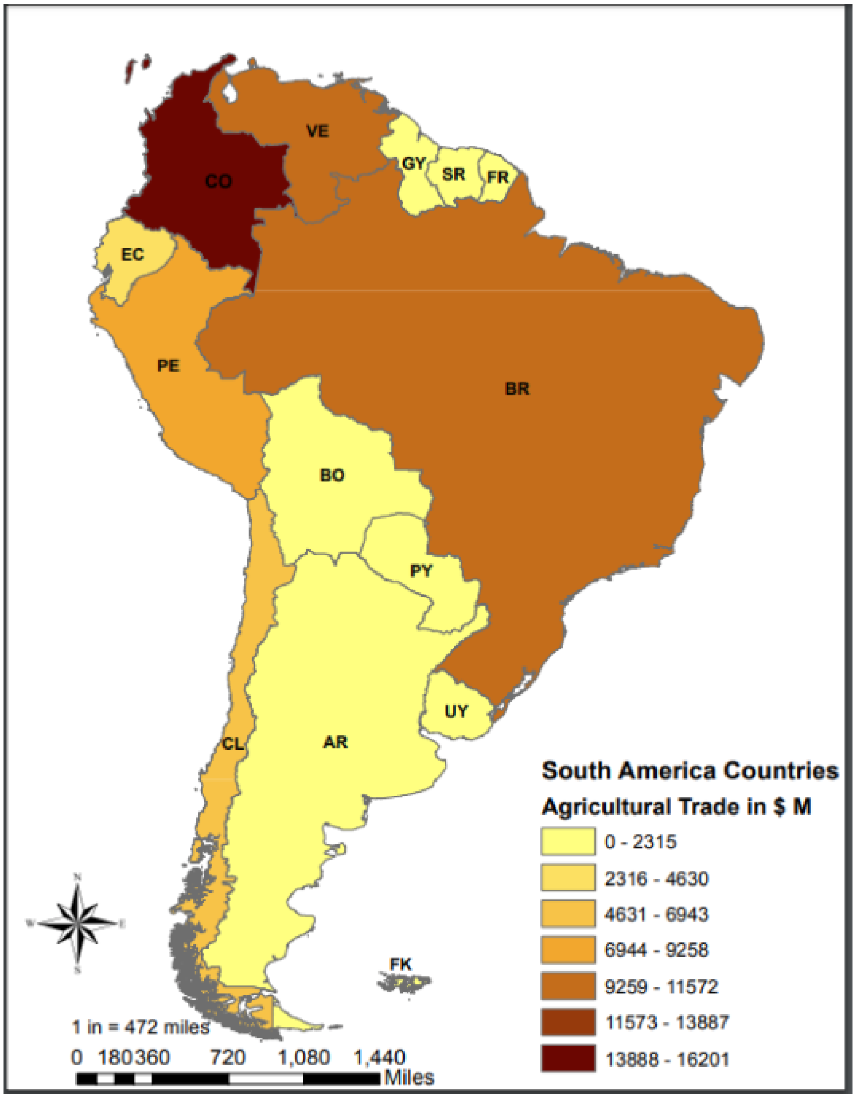

Figure 2.3. Value of US Agricultural Exports to South America 2003–2016. Source: United States Census Bureau

2.4.1.2. Destination Ports for US Agricultural Exports

We use National Geospatial-Intelligence Agency (2017) database for matching US ports to destination ports in the sample countries. National Geospatial-Intelligence Agency classifies ports into three types large, medium and small[1]. The dataset includes all large ports in any given destination country in the sample. Two filters which are “cargo quay” and “fixed cranes” were applied to select small and medium ports from all available ports in a given destination. Cargo

[1]Port size refers to harbor size and is correlated with vessel size. For example, ships over 500 feet (152.4 meters) long can be accommodated only in large ports.

quay refers to the port that has berths which is able to receive ships and provide services. While fixed cranes indicates whether a port has cranes at the berth which can load and upload containers to and from the ships. There are four different powerlifting capacity of the fixed cranes which are lifting less than 25 tons, between 25 to 49 tons, 50 to 100 tons, and lifting plus 100 tons. It was essential to choose these two factors to be the benchmark to select the ports and that for two reasons. Firstly, when the cargo quay exists that means this port has the infrastructure needs to receive ships. Secondly, having fixed cranes means the necessary and most crucial superstructure for any port has existed. Therefore, any port has these two factors can provide services easily. Thus, the dataset includes all medium and small ports that have cargo quay and fixed cranes with powerlifting between 25 to 49 and 50 to 100 tons besides the large ports. The super post-panamax ship to shore gantry cranes has 51 tons single lift capacity and 65 tons for the twin (Alabama State, 2017). Thus, the dataset includes 264 destination ports for US agricultural exports which represents 7.2% of all ports recorded in National Geospatial-Intelligence Agency in 2017 report.

2.4.2. Distance

Data on maritime distance (one nautical mile is equal to 1.15 miles) are primarily retrieved from sea-distance website (Sea-Distances, 2017). This source is complemented with marine traffic website for completeness (Traffic, 2017). For our benchmark analysis, we use the geographical distance the standard in the trade literature. Table 2.2 represents the summary statistical analysis for the maritime and geographical distances.

Table 2.2. Descriptive Statistics Analysis of Maritime and Geographical Distances

	Maritime Distance (km)	Geographical Distance (km)
Mean	9240	7377
Minimum	35	2079
Maximum	39622	10581
Std. Dev.	4393	1882

Note: 1 km = 0.54 nmi

2.5. Results and Discussion

Table 2.3 presents the results for Equations (2.1) and (2.2) . As shown, the impact maritime distance on US agricultural trade is positive and highly significant. However, the impact of geographical distance is negative sign and insignificant. The GDPs, GDP per capita, area, and the regonal trade agreement are highly significant. However, the impact of Regional Trade Agreements with Canada, Mexico, Chile, Colombia, and Peru were significantly negative.

The positive and significant coefficient for maritime distance shows the impact of globalization on maritime trade and that the long distances can actually have a positive impact on agricultural trade. This result is unexpected, but consistent with Hummels (2001) and Biermann (2012).

Table 2.3. Gravity Results Using Maritime and Geographical Distance 2003–2016

Variables	Maritime Distance	Geographical Distance
Distance	0.30***	-0.002***
	(0.002)	(0.000)
ln GDPi	0.40***	0.95**
	(0.011)	(0.42)
ln GDPj	0.25***	0.60***
	(0.002)	(0.057
ln GDPCAPj	-0.37***	-0.17*
	(0.003)	(0.087)
ln Areaj	-0.18***	0.23***
	(0.001)	(0.04)
RTA	-0.18***	0.017
	(0.005)	(0.26)
R^2	0.0322	0.6689
F (degrees of freedom)	(6,1939965) = 12130	(6,767) = 154
Number of observations	1,939,972	774

***, ** indicate p < 0.01, p < 0.05, respectively. Robust standard errors in parentheses

Table 2.4 shows the results of using the interaction term between the maritime distance with the dummy variable. Again the maritime distance showed a positive coefficient sign which implies that on an average if the maritime distance increases by one percent that will lead to a 0.70% increase in the maritime trade. In contrast, the interaction term between maritime distance and the distance dummy variable shows a negative coefficient. That is for country pairs whose geographical distance exceeds their maritime distance, as their maritime distance increases by one percent the trade between them will increase by 0.05%. On an average if the dummy distance variable switches from 0 to 1 then the maritime trade will increase by 256%.

Table 2.4. Gravity Results Using Interaction Between Maritime and Geographical Distance 2003–2016

Variables	Maritime Distance
ln Distance	0.70***
	(0.005)
Distance Du.	5.55***
	(0.055)
ln Dist.* Distance Du.	-0.65***
	(0.006)
ln GDPi	0.39***
	(0.011)
ln GDPj	-0.26***
	(0.002)
ln GDPCAPj	-0.38***
	(0.003)
RTA	-0.18***
	(0.006)
R^2	0.04
F (degrees of freedom)	(8,1939963) = 10504
Number of observations	1,939,972

*** indicate $p < 0.01$. Robust standard errors in parentheses

Table 2.5 represents the maritime coefficient yearly when using Equation (2.1). Once again bilateral trade significantly increases as the maritime distance increases. Potentially, larger the distance between countries higher is the incentive to use bigger container ships or technological intervention and thus greater are the chances for higher volume of trade between countries.

Table 2.5. Maritime Distance Coefficient (Yearly)

Year	Coefficient
2003	0.18*** (0.009)
2004	0.24*** (0.010)
2005	0.22*** (0.009)
2006	0.24*** (0.009)
2007	0.25*** (0.009)
2008	0.32*** (0.009)
2009	0.29*** (0.010)
2010	0.32*** (0.009)
2011	0.30*** (0.010)
2012	0.34*** (0.010)
2013	0.38*** (0.010)
2014	0.37*** (0.010)
2015	0.35*** (0.010)
2016	0.33*** (0.010)

*** indicate $p < 0.01$. Robust standard errors in parentheses

2.6. Summary and Conclusion

Most international commerce depends upon maritime transportation. With globalization, trade has increased and maritime freight transportation has evolved to carry more goods in bigger ships. This study uses the gravity model to examine the bilateral trade flows of agricultural products between the United States and trading partners in Europe, North America, and South America. Two different type of distances have been used, which are the maritime distance which represents the distances between ports, and the geographical distance that expresses the distances between nations' most populated cities.

The dependent variable in the gravity model is the value of trade flows. Explanatory variables generally include indicators of the trading partners' size, distance, and control variables. When maritime distance between ports is used as an explanatory variable, its coefficient was positive which means the maritime trade is positively correlated with the maritime distance between principle ports. When geographical distance between nations' principle cites is used the expected negative relationship results. The positive results for maritime distance was robust across years with positive coefficients for all years separately. All these results indicate how the globalization is playing a critical role with international trade which most of them are transported by ships. Thus, whenever the need exists and the production countries keep producing, the demand never stops regardless of the distance and time it takes for the commodities to arrive. However when geographical distance is used instead of maritime distance the expected negative correlation occurs.

The interaction between maritime and geographical distance was tested by generating a dummy variable which indicates 1 whenever the maritime distance is lower than the geographical distance and 0 otherwise. Then, by interacting the maritime distance with a dummy variable which defines both distances, the results showed negative sign. This result explained that the geographical distance is an important proxy and the maritime trade will increase whenever the geographical distance between two country pairs exceed the maritime distance.

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3. THE EFFECT OF INTERNATIONAL CONFLICT ON CONTAINER PORTS' EFFICIENCY IN THE MIDDLE EAST: AN APPLICATION OF DATA ENVELOPMENT ANALYSIS

3.1. Introduction

International trade is an important strategy to increase living standards, job opportunities, and product variety throughout the globe. Most of the world's international trade volume is facilitated by ships and handled by seaports which make ports the backbone of the world's international trade (Elbayoumi and Dawood, 2016). Container ports play a particularly significant role in the international trade process. Containers can carry many different types of non-bulk commodities such as frozen food, vegetables, cars, cloths, and many others. One strategy to foster international trade is to ensure efficient port facilities. Ports are a nation's main transport link with its trading partners and can be considered a determinant of a nation's prosperity

United Nations Conference on Trade and Development (United Nations Conference on Trade and Development, 2017), estimated that in 2017 more 80% of the total international trade by volume was facilitated by ships and handled at various seaports throughout the world. This trend is expected to continue. For instance, compared to 2016, UNCTAD reported that the global trade volumes handled by ships and seaports increased by 2.8% in 2017 (United Nations Conference on Trade and Development, 2017). In 2016 this increase was 2.6% compared to 2015, and in 2015 the increase was 1.8% compared to 2014 (United Nations Conference on Trade and Development, 2017).

Historically, ports were built by special interests, often to serve the needs of an individual industry. Currently, most ports are built and managed by government authorities. These government port authorities are responsible for enabling commerce while ensuring safety and security. Tanner and Williams (1967), mentioned that planning, developing, upgrading, and maintaining ports are often part of national and local government plans. Also, port development needs to be part of a comprehensive transportation planning effort that includes all transportation infrastructure so that transportation to and from destinations and origins is available.

This trend and the ever-increasing globalization of world economies require that all stakeholders in the maritime transport, especially seaports, perform at the highest efficiency possible (Bergantino, Musso, and Porcelli, 2013). The efficient performance of maritime transport stakeholders usually increases the competitiveness of seaports. Therefore, in order to ensure that their seaports are ever competitive internationally, seaport authorities have always been under pressure to improve their efficiencies which will result into an improvement of the efficiencies of their ports (Elbayoumi and Dawood, 2016). According to Liu (2008), the seaport's efficiency is one of the major indicators of a nation's economic development and an important parameter in measuring the performance of seaports. The Middle East is a very critical region for international trade. The area includes 15 countries, seven of them are in the Arabian Peninsula which are Saudi Arabia, United Arab Emirates, Kuwait, Oman, Qatar, Bahrain, and Yemen. The rest countries are Egypt, Jordan, Syria, The Palestinian Territories, Iraq, Lebanon, Iran, and Israel. Figure 3.1 shows the map of the Middle East major container ports. This area is important for the maritime trade which connects shipping routes between the East and the West which considers a vital node in the maritime shipping. The region has expanded the pace of trade integration reforms to harness the opportunities offered by changing international markets (López, Walkenhorst, and Diop, 2010). In 2016, The Middle East GDP counts as 3.15% of the world's GDP and in the same year it is representing almost 4% of the world's population (World Bank, 2019).

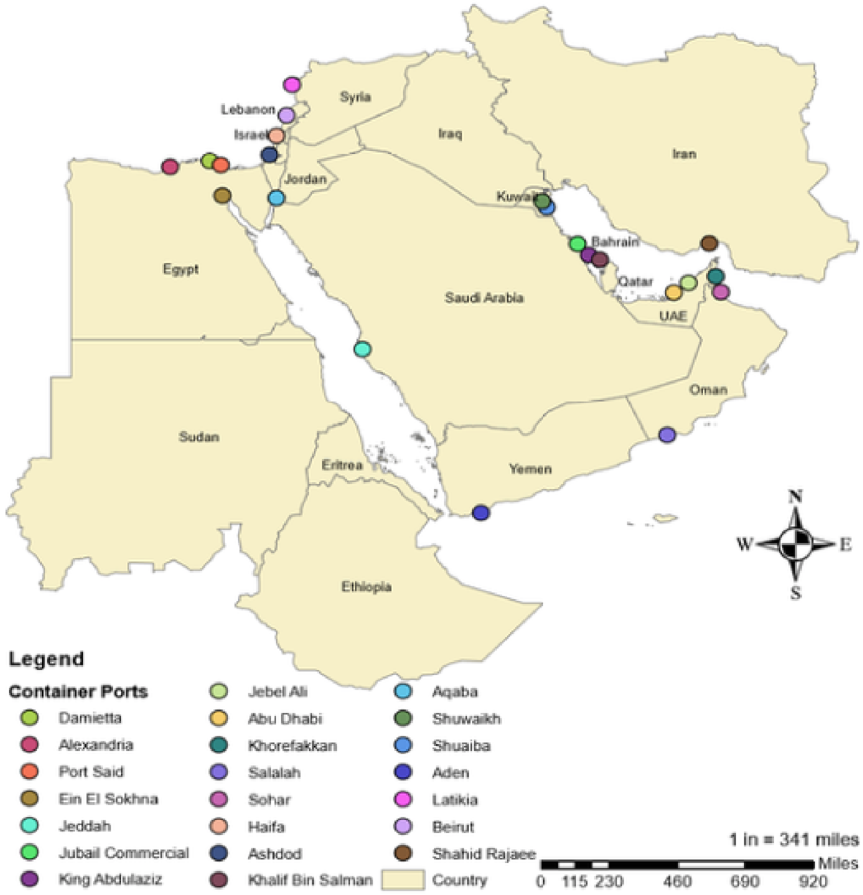

Figure 3.1. Major Container Ports in the Middle East

The Indian Ocean plays an important role by connecting the Australia, East Asia, Southeast Asia, and South Asia with the Middle East and the Suez Canal. The Middle East is considered the main exporter for oil to most of Asia. In 2005, one half of the crude oil exported from the Middle East went to China, and this is expected to increase to 70% by 2020 (Kāzemi and Chen 2014). The trade between the Middle East and other Asia countries is more than oil. For example, between 2005 and 2009, China trade volume with the Middle East increased by 87%. China was the top destination for the Middle East region exports in 2010 (Kāzemi and Chen 2014). All different commodities between the Middle East region and Asia are transported via the Indian Ocean. Should mention that any political conflict can easily affect the trade between the countries. For instance, the Middle East's conflicts affected China economic interests by putting their political relationship in danger (Singh, 2014).

The importance of the ports is based on their ability to move commodities which support the economic activities in the hinterland. Chai (2005), confirmed that the port is the main transport link with trading partners and a significant economic multiplier for the nation's prosperity. Port operations typically focus on loading and unloading cargoes, receiving and relaying passengers, and catering to ships' needs such as fuel, food, water, repairs, maintenance, crew recreation, and other services. The terminal's berth is considered the most critical facility in the port. The port's benefits and profits depend upon the number of berths with sufficient size, depth, and equipment to fully execute the job with a high level of safety and speed (IMO, 2014).

Given the significance proportion of container ships in international trade, the handling of containers at the ports needs to be as efficient as possible. The efficiency of handling containers at seaports is critical to overall port performance (Elbayoumi and Dawood, 2016). An increase of a port performance means that operating systems at the port such as port infrastructure and resources are being put into better use, and are optimally used (Bierlaire, Salani, and Vacca, 2010).

Data Envelopment Analysis (DEA) is commonly used to evaluate seaport efficiency. Many studies have previously been carried out to determine the efficiency of seaports using DEA. However, very few studies have been carried out in the Middle East and most of these few studies have measured the port's performance using tonnage as the input not the TEUs (Twenty-Foot Equivalent Unit which is the standard unit to measure the container ship capacity) as the input. This research evaluates the efficiency and productivity of container seaports in the Middle East and focusing on the area conflicts which plays a critical role in the regional economy. This study uses Data Envelopment Analysis technique and TEUs as the input.

There are different factors can affect the ports' efficiency and their performance overall. For instance, which sector is managing the ports' authority, is it a government or private sector? Haarmeyer and Yorke (1993), reported that many countries restructured their seaports to be run by the private sector and the government rule is just to ensure that the seaports are run efficiently. Also, inter-and intra-countries' conflicts such as the Arab Spring can affect the economy, shipping line, security, and the efficiency of the ports (Elbayoumi and Dawood, 2016). Maritime security in the Gulf of Aden is in high risk, and it is threatened by the piracy which spreads from Somalia because of the nation's economic and political weakness and poverty (Shelala, n.d.).

The next section of this paper will review pertinent literature and introduces the estimation of port efficiency and productivity by using the application of DEA. Section 3.3 and 3.4 represent the methodology and the DEA results and discussion, respectively. Section 3.5 presents pertinent conclusions of this paper.

3.2. Literature Reviews

There are various studies that use DEA to assess the efficiency within different transportation fields. For example, the DEA approach has been applied to airports (Martín and Román, 2001; Curi, Gitto, and Mancuso, 2011), roads (Egilmez and McAvoy, 2013; Husain, Abdullah, and Kuman, 2002), railways (Graham, 2008; Jitsuzumi and Nakamura, 2010; Roets and Christiaens, 2015), and seaports (Al-eraqi, Barros, Adli, and Khader, 2007; Baran and Górecka, 2015; Güner, 2015; Panayides, Maxoulis, Wang, and Ng, 2009). The use of DEA is not limited to the field of transportation. DEA has been used to analyze efficiency in numerous fields, such as health (Hu, Qi, and Yang, 2012; O'Neill, Rauner, Heidenberger, and Kraus, 2008), banks (Jemric and Vujcic, 2002; Mostafa, 2009), and education (Altamirano-Corro and Peniche-Vera, 2014; Thanassoulis, Kortelainen, Johnes, and Johnes, 2011).

Ports primarily provide services to vessels, cargo and internal transporters. Cullinane, Song, Ji, and Wang (2004), suggested that ports provide services to ships, cargo, and internal transporters; therefore, it is possible that a seaport may offer an excellent service to freight and domestic transport operators and in the same time it might provide unsatisfactory services to the ships. It is for this reason that the performance of a seaport cannot be evaluated based on a single factor. However, the use of multiple indicators to determine a port's performance is often associated with a major drawback. In an effort to solve this problem; previously, attempts have been made by researchers to develop a single performance indicator. For instance, Talley (1994), attempted to develop such a model as "the shadow price of variable port throughput per profit dollar," and it was used to evaluate the performance of a port. In recent years, a more advanced method has increasingly been in the estimation of port performance, and this technique is the Data Envelopment Analysis (DEA).

The main idea of measuring the efficiency of a seaport is to determine the ratio of the total outputs to the total inputs. The efficiency's calculated value will adjust to a value which ranges between 0 and 1(Al-eraqi et al., 2007). The above equation means that the more the outputs produce the less the outputs produced, and the more efficient is a decision-making unit (DMU) (Al-eraqi et al., 2007).

It is quite clear that efficiency plays an important role in the competitiveness and survival of container ports. Because of this, the efficiency of seaports in the Middle East and elsewhere in the world, need to be continuously evaluated. Constant evaluation of the seaports gives the port decision makers up to date information regarding operations of the port so that appropriate improvement decisions can be made on time. Such information may include the needed to improve infrastructure, superstructure, financial, and operation and management. In this regard, Güner (2015), studied port efficiency in terms of these four factors: 1) financial efficiency, 2) superstructure efficiency, 3) infrastructure efficiency, and 4) port operations efficiency. Infrastructure efficiency of a port deals with how land is being utilized and measures whether the port's land is efficiently used or not. To measure this unmovable type of efficiency, all related port's property which considers as input should be included. These include terminals area, quays length, number of the berths, terminals length, yard space and so on. The second port efficiency factor is superstructure efficiency. This port's efficiency deals with port equipment utilization such as cranes, forklift, stacker, container trucks and many others. Thirdly, the financial efficiency which deals with how efficient port capital is utilized and the current financial status of the port. Finally, the port's efficiency can be measured in terms of operating and management efficiency which is the port's ability to generate outputs.

Hajizadeh, Saeidi, Kaabi, Yousefi, and Zaredoost (2016), evaluated the relative efficiency of major container ports in the Middle East using Data Envelopment Analysis (BCC-O technique of DEA) for the period 2011 to 2013. The results of the efficiency of evaluated these ports were ranked by using Anderson-Peterson model, and the results of this study showed that the port that had the highest average efficiency coefficient pure technical efficiency between 2011 to 2013 was Bushehr, Jebel Ali, Khorfakkan, and Alexandria.

Al-eraqi, Mustafa, Khader, and Barros (2008), evaluated the efficiency of 22 seaports in both the Middle East and the East African regions for six years between 2000 and 2005. Two efficiency analysis methods were employed by the researchers: DEA window analysis and Standard DEA analysis. This study used berth length, storage area, and cargo handling equipment as input indicators; on the other hand, as for the outputs, Al-eraqi et al. (2008), used two indicators the throughput load (this is the general movement cargo and containers in port) which measured in terms of tonnage and the ships calls. They found out that in terms of the DEA-BCC model results, nine ports out the evaluated 22 ports were efficient, and seven ports in terms of DEA-CCR were efficient. Regarding both methods DEA-CCR and DEA-BCC, seven ports were found to be efficient during the considered period. These ports include Dubai Port, Mukalla, Yandu, Djibouti, Kuwait, Khor Fakkan, and Hodeidah (Al-eraqi et al., 2008).

Güner (2015), employed DEA with the aim of identifying sources of inefficiency in 13 Turkish ports and found that the ports are inefficient mainly due to high expenses and low labor productivity. This result means that even in the Middle East ports should also assess in terms of these efficiency factors. Other studies have also been carried out in other countries to determine efficiency ports using DEA. For instance, Yuen, Zhang, and Cheung (2013), used DEA and Tobit regression analysis to identify factors influencing the efficiency of Chinese ports. The results of the study demonstrated that if port ownership is greater than 50% the efficiency of these ports will be reduced. Wanke (2013), used DEA technique which is a two-stage network-DEA approach to determine factors affecting the efficiency of Brazillian ports. The study found out that if the port administration is private, the efficiency of the various port operations is high. Moreover, the study showed that the size of the hinterland and the operations of cargoes have significant effects on Brazillian ports.

3.3. Methodology

The Data Envelopment Analysis (DEA) technique for assessing efficiency was developed by (Charnes, Cooper, and Rhodes, 1978). The method is based on linear programming, and it tends to convert the input and output variables to linearity technique to measure efficiency (Elsayed and Khalil, 2017). This process depends on the inputs and outputs of the decision-making units (DMU). There are two ways in which efficiency can be measured in the DEA model: standard CCR and standard BCC. The standard BCC is used to measure the variable return to scale efficiencies (VRS) while standard CCR is used to measure constant returns to scale efficiencies (CRS) (Elsayed and Khalil, 2017). These two models have two classifications of DEA: output oriented which is based on maximizing the output and input oriented that is based on minimizing the inupt (Almawsheki and Shah, 2015). That is the efficiency score of a seaport measured as shown in Equation (3.1).

$$\text{Efficiency} = \frac{\sum \text{weighted of outputs}}{\text{weighted of inputs}} \tag{3.1}$$

This research evaluates the efficiency of 21 container ports in the Middle East as showed above in Table 3.1, using DEA with TEUs (Twenty-foot Equivalent Unit) as the output and inputs include terminal area, quay length, number of quay cranes, number of yard equipment, and the maximum draft.

Cullinane et al. (2004), pointed that the model orientation should be input-oriented if the study targets the operational and managerial issues. The main objective of using the DEA in this research is to examine the container ports operation which means the input-oriented will be used. Since the data is a time series, the DEA-based Malmquist Productivity Index (MPI) will be used. Malmquist (1953), proposed using an index to analyze the inputs consumption. Later, the MPI was developed to measure the productivity change within a given years (Fare, Grosskopf, and Norris, 1994). The MPI can measure the change in technical efficiency and the technology frontier. Fare et al. (1994), explained all necessary equations to compute the MPI by starting define x_{ij}^t, y_{rj}^t which indicates inputs and outputs for the DMU_j at any specific point in time t as shown in Equation (3.2). Also, they mentioned that the MPI used the CRS model to calculate the efficiency in time period t. Cook and Seiford (2009), explained the equation that calculates the input oriented based MPI which measures the productivity change over years (t and $t+1$) as shown in Equation (3.3).

$$MPI = \left(\frac{\theta_o^t(x_o^t, y_o^t)}{\theta_o^t(x_o^{t+1}, y_o^{t+1})} \frac{\theta_o^{t+1}(x_o^t, y_o^t)}{\theta_o^{t+1}(x_o^{t+1}, y_o^{t+1})} \right)^{\frac{1}{2}} \tag{3.2}$$

$$MPI = \left(\frac{\theta_o^t(x_o^t, y_o^t)}{\theta_o^{t+1}(x_o^{t+1}, y_o^{t+1})} \right) \left(\frac{\theta_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{\theta_o^t(x_o^{t+1}, y_o^{t+1})} \frac{\theta_o^{t+1}(x_o^t, y_o^t)}{\theta_o^t(x_o^t, y_o^t)} \right)^{\frac{1}{2}} \tag{3.3}$$

The first part of equation (3.3) represents the efficiency change (EFFCH), and the second part is the technical change (TECHCH). Therefore, when the MPI is less than 1 the productivity decreases, equal to 1 there is no change in productivity, greater than 1 the productivity increase from t and $t+1$ (Grilo and Santos, 2015). Also, the MPI can be calculated by either one of the following:

MPI = efficiency change (EFFCH) $\times$ technical change (TECHCH).

MPI = technical change (TECHCH) $\times$ pure technical efficiency change (PECH) $\times$ scale efficiency change (SECH).

While the efficiency change (EFFCH) = pure technical efficiency change (PECH) $\times$ scale efficiency change (SECH).

The MPI is the most common metric used to evaluate ports' performance in terms of efficiency. The MPI will enable the analyses of ports' productivity change over the years. Thus, the DEA-MPI study can show if the international conflict affects the container ports' efficiency negatively in the Middle East. The results will show how port efficiency changes during years in which this was significant during the international conflict. This study will help port authorities to maintain productivity and improve efficiency. The DEAP software version 2.1 was used to conduct the MPI. This software found and developed by (Tim and Coelli, 1996).

Besides the efficiency, the performance of a container seaport can be determined in terms of productivity. Whereas efficiency involves measurement of the maximum possible output which can be obtained with inputs available, the productivity of the container port involves outputs of the port's infrastructure (Baran and Górecka, 2015). The productivity can be measured in terms of two factors: ship operation, and receiving and delivering operation (Baran and Górecka, 2015). Ship operation generally involves loading and unloading the containers, while receiving and delivering operation is to transfer containers to and from trucks.

Other than measurement of outputs of the port's infrastructure as mentioned in the previous paragraph, the productivity of the container port is also an important parameter for the determination of costs associated with the provision of container stevedoring services (Baran and Górecka, 2015). According to Meyrick and Associates, and Pacific (1998), the productivity of a seaport can be studied by using two partial productivity measures which are the labor productivity and the net crane rates. Labor productivity is known as the annual lifts per employee which is the number of container lifts or moves per employee per terminal; on the other hand, the net crane rate is the number of container lifts per net crane-hour. Elbayoumi and Dawood (2016), claimed that the factors that determine the performance of a seaport or terminal are: labor relations, port access channel, the efficiency of the customs, land-side access, international-terminal operators' concessions, type and number of cargo handling facilities at the port, backhaul area quality, and so on.

This paper uses the container throughput for the period between 2009 and 2016 for 21 ports in 12 countries which are: Egypt, Saudi Arabia, United Arab Emirates, Oman, Israel, Bahrain, Jordan, Kuwait, Yemen, Syria, Lebanon, and Iran (see Table 3.1). These data were extracted from the port authorities reports, terminal operators' websites, and containerization year books. Data on conflicts comes from the Uppsala Conflict Data Program (UCDP) at the Department of Peace and Conflict research at Uppsala University.

Table 3.1. Data Sample of Container Ports (DMUs)

No.	Country	Port	Conflict Period
1	Egypt	Damietta	2011-2016
2		Alexandria	2011-2016
3		Port Said	2011-2016
4		Ein El Sokhna	2011-2016
5	Saudi Arabia	Jeddah Islamic	2015-2016
6		Jubail Commercial	2015-2016
7		King Abdulaziz	2015-2016
8	United Arab Emirates	Jebel Ali	2015-2016
9		Abu Dhabi	2015-2016
10		Khorefakkan	2015-2016
11	Oman	Salalah	
12		Sohar	
13	Israel	Haifa	2009-2012, 2014
14		Ashdod	2009-2012, 2014
15	Bahrain	Khalif Bin Salman	2015-2016
16	Jordan	Aqaba	2015-2016
17	Kuwait	Shuwaikh and Shuaiba	2015-2016
18	Yemen	Aden	2009-2016
19	Syria	Latikia	2012-2016
20	Lebanon	Beirut	2011-2016
21	Iran	Shahid Rajaee	2015-2016

Note that the period of study encompasses many international conflicts that can impact trade, security costs, labor, and shipping. These conflicts include the Arab Spring which started in 2011 and the war between Houthi rebels and the coalition which is led by Saudi Arabia in Yemen in 2015. The war led to the closure of Yemen's most important ports and these ports are Hodeidah and Saleef which are located along the Red Sea. The Arab Spring caused serious social and economic upheaval in Syria and Yemen (Qadirmushtaq and Afzal, 2017). The Arab Spring turned to civil wars in some countries such as Syria and Yemen. According to Almawsheki and Shah (2015), "Some seaports in the Middle East region continue to be affected by geopolitical conflict, turbulence, and instable environment, especially during the movement of the Arab Spring in February 2012, which impacted maritime and terminal flows, especially in Yemen, Syria and Egypt" (p. 480). Therefore, the Arab Spring might be one of the reasons to make the ports inefficient. Due to the absence of data, the Palestinian Territories, Qatar, and Iraq are excluded from this study. Descriptive statistics analysis of the inputs and output variables are represented in Table 3.2.

Table 3.2. Descriptive Statistics Analysis of Inputs and Output

Variable	Observations	Mean	Minimum	Maximum	Std. Dev.
Inputs					
Terminal area (ha)	168	94	20	579	116
Quay length (m)	168	2132	520	12112	2370
Quay Cranes	168	18	3	117	24
Yard equipment	168	89	8	314	76
Draft (m)	168	16	13	18	1
Output					
Throughput (TEU)	168	2050	121	15592	2864

The conflict years are presented in Table 3.1. Egypt's ports and Beirut have conflict since 2011. While Saudi Arabia and the United Arab Emirates their conflicts started when the war with Houthi rebels began in 2015. Israel conflict started even before its established in 1948 by the British government when the Balfour Declaration issued in 1917 during the World War I (Becker, 2011). Occupation of Palestinian territories was the major conflict in the region which affected other countries and because of this there was decades of conflict, including wars in 1948, 1956, 1967, and 1973 (Gacayan, Jones, and Kirk, n.d.). Also, from 1987 until 2015 there were there major war between Israel and Palestinian Guerillas in 1987, 2000, and 2015. There are other kinds of conflicts in the Middle East that have had a major impact on the region for a while. For instance, the conflict between Sunni and Shia, and religious parties as well. According to Hawley (2012), "conflict in the Muslim world has also not fallen along Sunni-Shia lines, even organizations like al-Qaeda and Hezbollah focus on anti-Western Zionist frameworks rather than divides within Islam." Bahrain, Lebanon, Yemen, and Iraq have been affected by the religious parties' conflict. Kuwait has a conflict between 2010 to 2011 and in 2015 and 2016. Jordan has conflict between 2012 and 2016. Iran represented a one-year conflict which is in 2016. However, Oman didn't show any conflict in the period of this study.

3.4. Results and Discussion

The results of the DEA analyses are divided into two different parts. The first part, is the distance measurement summaries which shows the technical efficiencies under CRS and VRS as shown in Table 3.3. Also, in Table 3.3 periods of conflict are highlighted in green. In Table 3.3, those ports which have the greatest CRS or VRS efficiency have scores equal to 1. Other ports, which are less efficient, have scores that reflect their efficiency relative to the most efficient port. From the same table Jabel Ali and Khorefakkan ports showed that they are the most efficient under both CRS and VRS for the whole years. Then, Beirut, Port Said, Salalah, and Jeddah got 0.94, 0.92, 0.82, and 0.70, respectively. This means these ports need to increase their output or decrease the inputs by 6%, 8%, 12%, and 30%, respectively to become technically efficient. Similarly, for the rest of the ports over all years. On the other hand, 10 ports under the VRS mean efficiency scores are efficient.

Latikia port represents an example of how the Syrian revolution affected the ports efficiency. The revolution started in 2011, in 2009 under CRS the port was efficient. After that, in 2010 the score of efficiency was 0.96. The main drop occurred between 2011 and 2016 when the port's scores efficiency for these years became 0.73, .042, 0.25, 0.33, 0.23, and 0.22, respectively. Thus, there was a substantial decline in port efficiency that corresponded to the period of the conflict.

Aden is another example of the impact of conflicts-including the Yemeni revolution in 2011; and the subsequent conflict between Houthi rebels and a Saudi-led coalition which began in 2015 - on port efficiency. In the period between 2009 and 2016, Aden had low CRS efficiency scores. The highest efficiency score was 0.74 in 2009. The lowest score was 0.33 in 2011 when the revolution started. Between 2012 and 2016 the efficiency scores were 0.44, 0.49, 0.52, 0.41, and 0.40, respectively.

The analysis of variance of the unbalanced block design used to analyze the impact of conflict on the efficiency scores Table 3.4. The explanatory variable no conflict is significant at 0.05% level. Also, the results showed that the conflict has impact on the efficiency scores because when there is conflicts the average of efficiency is equal to 50.17%, while if there is no conflict the average of efficiency score will increase by 0.8%. therefore, we can conclude that the conflict affected the container ports and during the conflict, efficiency scores were substantially lower.

Some ports such as Damietta, Alexandria, Jeddah, Jubail, Haifa, Ashdod, Shuwaikh and Shuaiba, and Shahid Rajaee have consistently low efficiency scores. These low scores could reflect economies of size, national policies, poor technology, or consistently bad management. Further study on these ports is needed to identify the main reasons for these inefficiencies.

Table 3.3. Efficiency Scores for CRS and VRS

Port	2009		2010		2011		2012		2013		2014		2015		2016		Mean	
	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS	CRS	VRS
Damietta	0.82	0.99	0.72	0.94	0.67	0.97	0.38	0.91	0.68	0.96	0.42	0.92	0.34	0.91	0.36	0.91	0.55	0.94
Alexandria	0.60	0.91	0.58	0.91	0.49	0.91	0.40	0.91	0.47	0.92	0.52	0.92	0.47	0.93	0.44	0.93	0.50	0.92
Port Said	1.00	1.00	1.00	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.98	1.00	0.80	1.00	0.69	1.00	0.92	1.00
Ein El Sokhna	0.45	0.87	0.65	0.88	0.55	0.90	0.38	0.87	0.47	0.87	0.51	0.88	1.00	1.00	1.00	1.00	0.63	0.91
Jeddah Islamic	0.62	0.78	0.74	0.78	0.67	0.77	0.82	0.85	0.78	0.79	0.71	0.78	0.66	0.79	0.62	0.80	0.70	0.79
Jubail	0.21	0.88	0.19	0.88	0.24	0.88	0.29	0.88	0.32	0.88	0.48	0.89	0.27	0.88	0.73	0.88	0.34	0.88
King Abdulaziz	0.81	1.00	0.76	1.00	0.60	1.00	0.48	1.00	0.47	0.99	0.66	1.00	0.65	1.00	0.56	1.00	0.62	1.00
Jebel Ali	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Abu Dhabi	0.31	0.99	0.29	0.98	0.41	1.00	0.34	0.99	0.40	1.00	0.51	1.00	0.62	1.00	0.61	1.00	0.44	1.00
Khorefakkan	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salalah	1.00	1.00	1.00	1.00	0.90	0.91	0.83	0.90	0.80	0.89	0.73	0.87	0.57	0.84	0.70	0.87	0.82	0.91
Sohar	0.37	1.00	0.33	1.00	0.32	1.00	0.35	1.00	0.38	1.00	0.42	1.00	0.91	1.00	1.00	1.00	0.51	1.00
Haifa	0.58	0.88	0.56	0.88	0.43	0.88	0.39	0.89	0.45	0.89	0.39	0.88	0.36	0.88	0.35	0.89	0.44	0.88
Ashdod	0.45	0.92	0.48	0.93	0.44	v0.93	0.42	0.94	0.44	0.94	0.47	0.93	0.43	0.92	0.45	0.93	0.45	0.93
Khalif	0.47	1.00	0.61	1.00	0.40	1.00	0.66	1.00	0.56	1.00	0.57	1.00	0.40	1.00	0.32	1.00	0.50	1.00
Aqaba	0.65	1.00	0.57	1.00	0.37	1.00	0.31	1.00	0.40	1.00	0.40	1.00	0.38	1.00	0.35	1.00	0.43	1.00
Shuwaikh & Shuaiba	0.47	0.93	0.36	0.92	0.49	0.94	0.42	0.94	0.49	0.95	0.52	0.95	0.46	0.94	0.44	0.93	0.46	0.94
Aden	0.74	1.00	0.65	1.00	0.33	1.00	0.44	1.00	0.49	1.00	0.52	1.00	0.41	1.00	0.40	1.00	0.50	1.00
Latikia	1.00	1.00	0.96	1.00	0.73	1.00	0.42	1.00	0.25	1.00	0.33	1.00	0.23	1.00	0.22	1.00	0.52	1.00
Beirut	1.00	1.00	1.00	1.00	0.73	1.00	0.91	1.00	1.00	1.00	1.00	1.00	0.95	1.00	0.93	1.00	0.94	1.00
Shahid Rajaee	0.83	0.88	0.95	0.95	0.75	0.86	0.63	0.86	0.63	0.85	0.52	0.83	0.44	0.83	0.53	0.85	0.66	0.87

Periods of conflict are highlighted in green

Table 3.4. Conflict Impact on Efficiency Scores

Explanatory variable	Coefficient	P-value	R^2
Intercept	0.5017	0.0001	0.77
No Conflict	0.008	0.0213	

The second part of this analysis, is the Malmquist productivity index which provides five results which are: 1) efficiency change (EFFCH), 2) technical change (TECHCH), 3) pure technical efficiency change (PECH), 4) scale efficiency change (SECH), and 5) total factor productivity change (TFP). The TFP represents the MPI. Table 3.5 shows the MPI mean container ports results for the period between 2009 and 2016. Not all ports experienced growth in the productivity. The result indicates that the MPI shows a positive increase by 4% per year for the sample. The TFP shows that eight container ports have negative growth in the productivity. These ports are Damietta, Port Said, Salalah, Haifa, Aqaba, Aden, Latikia, and Shahid Rajaee. These have all been impacted by conflicts or are located near to conflict zones. Latikia port recorded the lowest TFP, the results show that Jubail port has the highest TFP and it is over the average by 24%. However, the TFP growth was due to the technical change or innovation rather than the efficiency change since the average value of technical change is higher than the efficiency change. The average of efficiency change showed a negative growth by 2% while the the technical change has increasing by 6%. The scale efficiency change indicates that Jebel Ali and Khorefakkan don't represent any issues with the scale. This implies that they are operating at the optimal CRS range.

Figure 3.2 represents the change in the average of all MPI results for all years. Also, it indicates that 43% of ports showed improvement in efficiency change, technical change improved by 86%, pure technical efficiency change improved by 57%, and scale efficiency change by 43%. The efficiency change trend started low in the years between 2009 and 2012. While the highest peak occurred in 2012–2013 period by 7.3%. On the other hand, the TFP level was high in all years and the highest period was 2015–2016 by 8.7%.

Table 3.5. MPI Container Ports Results 2009–2016

Port	EFFCH	TECHCH	PECH	SECH	TFP
Jubail	1.20	1.07	1.00	1.20	1.28
Ein El Sokhna	1.12	1.11	1.02	1.10	1.25
Sohar	1.15	1.07	1.00	1.15	1.23
Abu Dhabi	1.10	1.06	1.00	1.10	1.17
Khorefakkan	1.00	1.07	1.00	1.00	1.07
Ashdod	1.00	1.07	1.00	0.99	1.07
Shuwaikh and Shuaiba	0.99	1.07	1.00	0.99	1.06
Jeddah Islamic	1.00	1.03	1.01	0.99	1.04
Jebel Ali	1.00	1.04	1.00	1.00	1.04
Khalif	0.95	1.10	1.00	0.95	1.04
Beirut	0.99	1.03	1.00	0.99	1.02
Alexandria	0.95	1.06	1.00	0.95	1.01
King Abdulaziz	0.95	1.06	1.00	0.95	1.01
Salalah	0.95	1.05	0.98	0.97	0.99
Haifa	0.93	1.06	1.00	0.93	0.99
Shahid Rajaee	0.94	1.06	0.99	0.94	0.99
Port Said	0.95	1.03	1.00	0.95	0.98
Aden	0.92	1.07	1.00	0.92	0.98
Aqaba	0.91	1.06	1.00	0.92	0.97
Damietta	0.89	1.06	0.99	0.90	0.94
Latikia	0.81	1.09	1.00	0.81	0.88
Mean	0.98	1.06	1.00	0.98	1.04

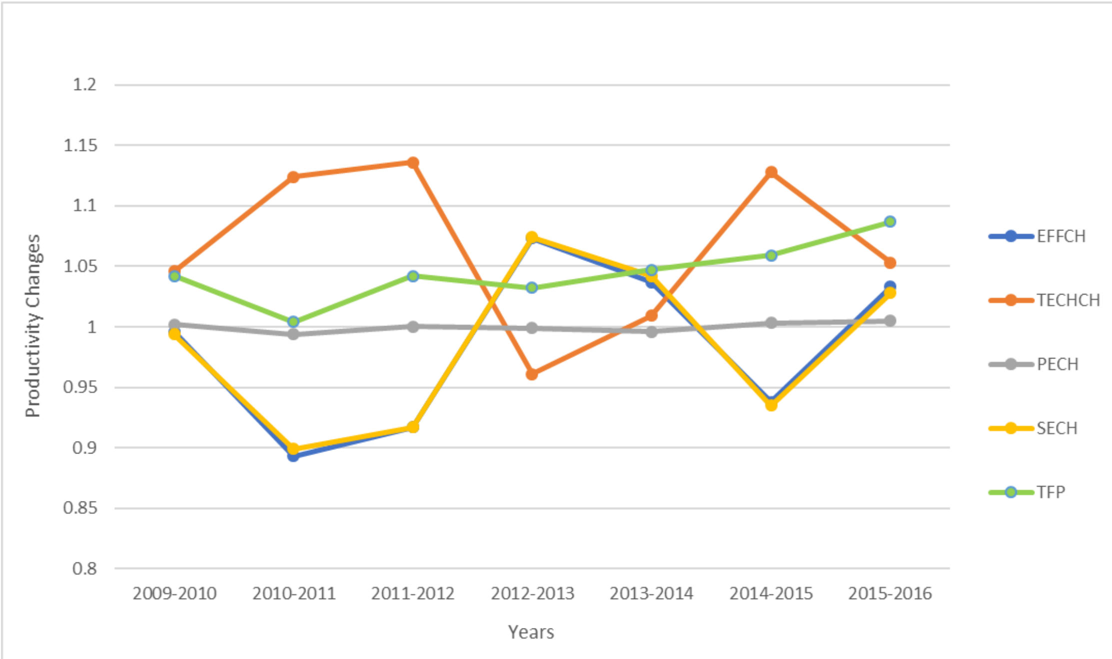

Figure 3.2. Trend of Malmquist Productivity Index Annual Means

Table 4.5 reported the Malmquist frontier shift for container ports sample. The results showed that there is slight increase in the technology frontier from 2009 to 2010, 2013 to 2014, and 2015 to 2016 by 4%, 1%, and 5%, respectively. While there is improvement from 2010 to 2011 by 12%, and improvement by 14% from 2011 to 2012 and 2014 to 2015. On the other hand, there is decreasing from 2012 to 2013 by 4%.

Table 3.6. Malmquist Frontier Shift for Container Ports 2009–2016 Color Code for Conflict

Port	09-10	10-11	11-12	12-13	13-14	14-15	15-16
Jubail	1.10	1.07	1.24	0.95	1.00	1.10	1.05
Ein El Sokhna	1.01	1.17	1.12	0.95	1.00	1.46	1.14
Sohar	1.10	1.07	1.24	0.95	1.00	1.10	1.05
Abu Dhabi	1.10	1.05	1.23	0.95	1.00	1.09	1.04
Khorefakkan	1.10	1.09	1.24	0.95	1.00	1.10	1.04
Ashdod	1.06	1.12	1.17	0.95	1.00	1.14	1.06
Shuwaikh and Shuaiba	1.09	1.09	1.21	0.95	1.00	1.11	1.05
Jeddah Islamic	1.04	1.16	0.96	1.01	1.01	1.06	1.01
Jebel Ali	1.04	1.12	1.02	1.03	1.12	1.02	0.95
Khalif	1.01	1.17	1.12	0.95	1.00	1.40	1.013
Beirut	0.95	1.10	1.10	0.98	1.08	0.98	1.04
Alexandria	1.03	1.17	1.12	0.95	1.00	1.10	1.05
King Abdulaziz	1.03	1.17	1.12	0.95	1.00	1.12	1.06
Salalah	1.08	0.98	1.23	0.95	1.00	1.10	1.04
Haifa	1.03	1.17	1.12	0.95	1.00	1.11	1.05
Shahid Rajaee	1.03	1.17	1.12	0.95	1.00	1.11	1.05
Port Said	1.03	1.17	0.95	1.01	0.99	1.07	1.02
Aden	1.09	1.09	1.21	0.95	1.00	1.11	1.05
Aqaba	1.03	1.17	1.12	0.95	1.00	1.11	1.05
Damietta	1.03	1.17	1.12	0.95	1.00	1.12	1.05
Latikia	0.96	1.17	1.12	0.95	1.00	1.35	1.12
Mean	1.04	1.12	1.14	0.96	1.01	1.14	1.05

Periods of conflict are highlighted in green

3.5. Summary and Conclusion

The efficiency of container ports is an important determinant of economic growth and development. This is especially true in the Middle East which is an area that is very dependent upon international trade. This paper assesses port efficiency using Twenty-Foot Equivalent Units as the output. This output measure is the best mechanism to assess container port productivity.

This study measured the efficiency and productivity of 21 ports in the Middle East. The DEA-Malmquist productivity index has been used for the period between 2009 and 2016. Among the 21 container ports evaluated in this study, Jabel Ali and Khorefakkan are the most efficient under the CRS (Table 3.3). Results of CRS show that VRS scores are generally higher, perhaps because returns to scale are not constant.

The TFP results showed that eight container ports have low productivity. Only Salalah port is not located within a conflict while other ports inside the conflict zones. In addition, Latikia port presented the lowest value of TFP which is decreased by 12% while Jubail port has recorded the highest TFP value that is higher than the sample average by 24%.

The Malmquist productivity index of annual means showed that most years do not show an overall increase in efficiency. Technical change, pure technical efficiency change, and scale efficiency change improved by 86%, 57%, and 43%, respectively. Based on the scale efficiency change, only Jebel Ali and Khorefakkan are the most efficient. These results imply that container ports have invested in improved technology in order to reduce production-related costs.

The conflicts such as the Arab spring revolutions and the Yemen war were one of the reasons behind being some ports inefficient since the conflict showed a positive impact on the efficiency scores. For example, in 2010 Syria reach the highest population in its history by over 21 million. In 2016, Syria population decreased by 14% which indicates the economy dropped in the absence of purchasing power. Other things that might affect the container ports efficiency in the Middle East are the social and political structures differences.

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