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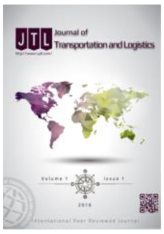
Journal of Transportation and Logistics

2 (2), 2017



Received : November 11, 2017   Accepted : November 30, 2017

http://dx.doi.org/10.22532/jtl.349766

Economies of Scale in Seaborne Coal Transportation: A Case Study of İSDEMİR Port

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Keywords :

Economies of Scale
Bulk
Transportation
Coal Trade
Transport Costs

ABSTRACT

Economies of scale has a vital role in keeping transport costs low in shipping. It makes possible to merchandise with far destinations. Economies of scale reduces the transportation costs per unit. Importing a commodity from a far country may cost less than importing it from neighboring country. The purpose of this study is to determine the extent to which this cost advantage is used in practice by industrial firms and to test the operative field validity of the theory. In this study, it is assumed theoretically that the larger vessels would have lower transport costs and the model is simplified by eliminating transport costs and coal prices. . In other words, as the distance increases, the size of the ship will also increase according to our basic hypothesis. ISDEMIR Port is selected as a sample for this study because of its geographical proper position and its high volume of coal import for its power plant that is placed to close position to the port. The data covers the years between 2008 and 2011. In these years totally 14.032.392 tons of coal imported by 313 bulk cargo ships. Correlation and regression analysis are implemented to determine the degree of the relationship. Volume is selected as a dependent variable and distance is selected as an independent variable. Results shows that there is a strong significant positive correlation between these variables. Also regression results show that change in distance explains big proportion of change in volume.

Deniz Yoluyla Kömür Taşımacılığında Ölçek Ekonomileri: İSDEMİR Limanı Örneği

Anahtar Sözcükler :

Ölçek Ekonomisi,
Dökme Yük
Taşımacılığı
Kömür Ticareti

ÖZ

Nakliye işlemlerindeki taşımacılık maliyetlerinin düşük tutulmasında ölçek ekonomisi hayati bir role sahiptir. Ölçek ekonomisi birim başına taşıma maliyetlerini düşürür ve uzak mesafelerle ticaret yapılabilmesini mümkün kılar. Uzak bir ülkeden bir malın ithalatı, onu komşu ülkeden ithal etmekten daha aza mal olabilir. Bu çalışmanın amacı, bu maliyet avantajının endüstriyel firmalar tarafından ne ölçüde kullanıldığını belirlemek ve teorinin pratikteki geçerliliğini test etmektir. Bu çalışmada, teorik olarak, daha büyük gemilerin daha düşük nakliye maliyetlerine sahip olacağı varsayılmıştır ve nakliye maliyetleri ile kömür fiyatları göz ardı edilerek model basitleştirilmiştir. Başka bir deyişle, mesafe arttıkça geminin boyutu da temel hipotezimize göre artacaktır. İSDEMİR Limanı, coğrafi olarak uygun konumu ve limana yakın konumda bulunan enerji santrali için yüksek kömür ithalat hacmi nedeniyle bu çalışma için örnek olarak seçilmiştir. Analizde kullanılan veriler 2008 ve 2011 yıllarını kapsamaktadır. Bu yıllarda 313 dökme yük gemisi tarafından toplam 14.032.392 ton kömür ithal edilmiştir. İlişkinin yönünü ve derecesini belirlemek için korelasyon ve regresyon analizi yöntemleri uygulanmıştır. Yük hacim bağımlı değişken ve mesafe bağımsız değişken olarak seçilmiştir. Sonuçlar, bu değişkenler arasında güçlü anlamlı bir pozitif korelasyon olduğunu göstermektedir. Ayrıca regresyon analizi sonuçları, mesafedeki değişimin hacim değişiminin büyük kısmını açıkladığını göstermektedir.

1. Introduction

One of the most essential component in the economics of the shipping is economies of scale. But actually it shouldn't be forgotten that the term of economies of scale isn't used in shipping only. The normal definition of an economy of scale means that larger firms have lower average costs in comparison with the smaller ones. In shipping economies often refer to ship size rather than firm size. Also a division can be made between economies at the firm size level and at the plant (ship) level (Cowie, 2010:302).

Scale economies are very important in bulk shipping. The ratios of freight payment to the vessel gross weight tend to increase in parallel with size. Also construction costs per ton of capacity decline as ship size increases. It is more important that the operating costs of a vessel do not increase by comparison with its size. Water resistance per ton is less with larger hulls. So horsepower and fuel consumption per ton are reduced for any gıven speed. Besides the ratio of labor cost to ton-miles performed tends to decline as vessel increases in size (Song and Panayides, 2012:169)

There are two types of economies of scale that directly related to shipping. These are external economies of scale and internal economies of scale. In external economies of scale, the unit cost depends on the size of the shipping company. In internal economies of scales, the unit costs depend on the size of the individual transporting unit (ship, container, port, shipment). Long-run production cost decreases when output increases. So in both cases economies of scale occur. For example, when output increases a factor of two, the cost of production increase less than a factor of two (Wilmsmeier, 2014:17)

When the unit cost function is examined, it can be understood that why investors go for bigger ships. The unit cost of transporting a ton of cargo on a voyage is defined as; the sum of the capital cost of the ship (LC), the cost of operating the ship (OPEX) and the cost of handling the cargo (CH), divided by the parcel size (PS), which for bulk vessels is the tonnage of cargo it can carry:

$$Unit\ Cost = \frac{LC + OPEX + CH}{PS}$$

The unit cost generally falls as the size of the ship increases. Because capital, operating and cargo-handling costs do not increase proportionally with the cargo capacity. For example, cost of a 330,000 dwt tanker is twice as much as cost of 110,000 dwt tanker. But it can carry three times as much cargo. So the cost per tonne of shipping a 110,000 tonne parcel of oil is much higher than shipping a 330,000 tonne parcel (Stopford, 2009:77).

A single ship can carry several different bulk cargoes. Each of the cargoes may occupy separate holds or they are placed in a single hold as classic tramping operation. However this is less common than it used to be. The foundation of bulk shipping is mainly taking advantage of economies of scale. Moving from a Handy bulk carrier to a Handymax saves about 22% per tonne, whilst upsizing to a Panamax bulk carrier saves 20% and the much bigger jump to a Capesize an additional 36%. So the biggest dry bulk ships can more than halve the cost of transport (Stopford, 2009:78).

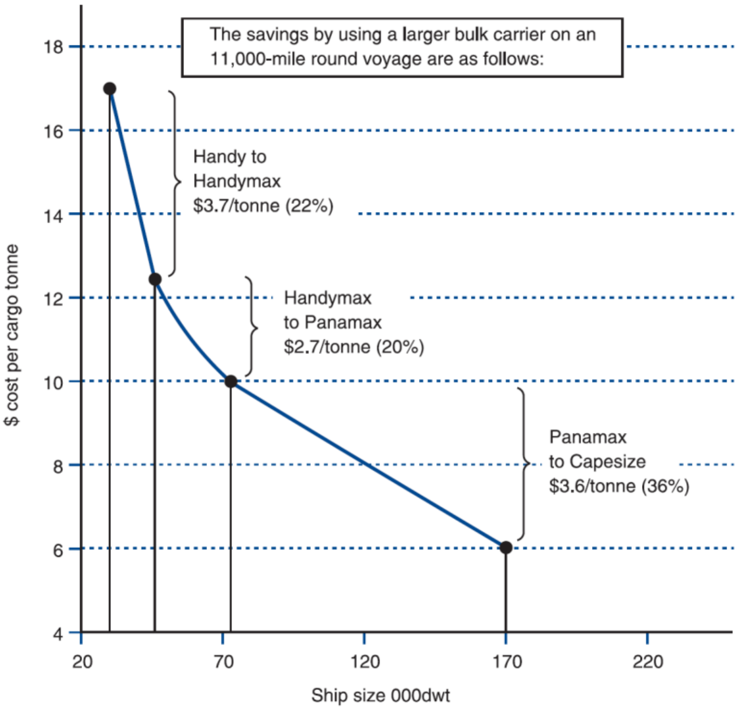

Figure 1. Economies of scale related to ship size for bulk carriers (Stopford, 2009:78)

All this information reveals that bigger vessels significantly reduce the cost per ton in maritime transport. This cost advantage is also discovered and used in world trade for a very long time. The purpose of this study is to determine the extent to which this cost advantage is used in practice by industrial firms and to test the operative field validity of the theory. In this study, it is assumed theoretically that the larger vessels would have lower transport costs and the model is simplified by eliminating transport costs and coal prices. For this purpose, the hypothesis that distance is a decisive variable in describing ship size has been put forward. In other words, as the distance increases, the size of the ship will also increase according to our basic hypothesis.

2. Methodology

Firstly, descriptive analysis of the data are examined. Then scatterplot matrix is developed to see whether a linear relationship between variables exist or not. The scatterplot (or X-Y plot, or scattergram) is a plot that displays the joint distribution of two variables. While the stem-and-leaf and boxplot are univariate (one variable) graphs, the scatterplot is bivariate (two variables). The basic scatterplot consists of two axes, one for the dependent variable, usually indicated by Y. This is by tradition the vertical axis. The horizontal axis is for the independent variable, which is usually called X (Dietz and Kalof, 2009:156). In our analysis X is distance and Y is cargo volume.

Then a correlation analysis is implemented to determine degree of directional relationship between variables. Pearson's correlation is used for this correlation analysis. Pearson's correlation coefficient R, a measure of the strength and direction of the linear relationship between two variables, is defined as the (sample) covariance of the variables divided by the product of their (sample) standard deviations. The absolute value of Pearson correlation coefficients is no larger than 1. Correlations equal to 1 or -1 correspond to data points lying exactly on a straight line. The Pearson correlation coefficient is symmetric, i.e., the correlation between X and Y is the same as that between Y and X (Chang, 2014:78).

After all, a regression model is developed to determine the explanatory power of distance over cargo volume. The term regression is attributed to Francis Galton. Regression analysis allows scientists to quantify how the average of one variable systematically varies according to the levels of another variable. The former variable is often called a dependent variable or outcome variable and the latter an independent variable, predictor variable, or explanatory variable (Gordon, 2015:5). Least squares method is selected as estimation method. Our regression model is as follows;

$$VOLUME_t = \beta_0 + \beta_1 DISTANCE_t + \varepsilon_t$$

2.1. Data Collection

ISDEMIR Port is selected as a sample for this study because of its geographical proper position and its high volume of coal import for its power plant that is placed to close position to the port. Energy Import Statistics between 2008 and 2011 are gained from Transport, Maritime Affairs and Communications Ministry. Then they are used for cargo volume data. In these years totally 14.032.392 tons of coal imported by 313 bulk cargo ships. So our sample includes 313 observations. The distances between origin and destination points are calculated by the author via marine traffic website.

SPSS 22 software and Eviews 9 software are used for data analysis. SPSS is used for descriptive analysis and correlation analysis, and Eviews is used for regression analysis.

Descriptive statistics for ports are showed below. The table includes means, numbers, standard deviations, minimums and maximums of the shipments. High range between minimum and maximum and standard deviation shows the volatility of the shipments.

Table 1. Descriptive Statistics for Ports

PORT	Distance to İSDEMİR	Mean of Cargo	N	Std. Deviation	Minimum	Maximum
AUSTRALIA-ABBOT POIN	9511	138542,89	9	33985,914	77133	164994
AUSTRALIA-GLADSTONE	9039	138105,57	7	39141,304	75045	164982
AUSTRALIA-HAYPOINT	9510	129093,58	12	44936,376	49142	165000
AUSTRALIA-NEWCASTLE	9656	74630,38	8	5984,475	66415	84541
AUSTRALIA-NEWPORT	9380	75107,33	3	1650,525	73989	77003
AUSTRALIA-PORT KEMBL	10315	138437,00	1	.	138437	138437
BELGIUM-ANTWERPEN	3458	4966,00	1	.	4966	4966
BELGIUM-GHENT	3361	32999,00	1	.	32999	32999
CANADA-VANCOUVER	10555	155755,36	11	27011,820	75527	170001
CHINA-JING TANG	8207	55717,00	1	.	55717	55717
COLOMBIA-BARRANQUILL	6111	9425,25	4	4498,755	6196	15759
CROTIA-PLOCE	1208	5870,33	3	1774,616	3954	7457
EGYPT-ALEXANDRIA	455	8033,00	2	391,737	7756	8310
INDONESIA-BANJARMASI	6281	161150,00	1	.	161150	161150
IRAN-BANDAR ABBAS	3295	23743,67	3	2314,885	21133	25546
ITALY-PIOMBINO	1417	5628,00	1	.	5628	5628
ITALY-SAVONA	1542	3969,50	2	2164,454	2439	5500
LATVIA-VENTSPILS	4225	22500,00	1	.	22500	22500
MOZAMBIQUE-MAPUTO	5378	35041,00	1	.	35041	35041

PORT	Distance to İSDEMİR	Mean of Cargo	N	Std. Deviation	Minimum	Maximum
POLAND-GDANSK	4132	64621,80	5	18405,859	32000	76055
ROMANIA-CONSTANTA	1016	4154,80	5	1830,117	2095	6386
RUSIA-ROSTOV ON DON	1468	4414,00	5	1249,164	2969	5729
RUSIA-TEYMRUK	1306	21631,00	1	.	21631	21631
RUSIA-TUAPSE	1314	10687,43	7	2144,142	9290	15380
RUSIA-YEİSK	1396	4898,00	3	181,868	4688	5004
RUSSIA-AZOV	1429	4239,87	15	908,780	3065	5439
RUSSIA-MURMANSK	5065	32108,67	3	8043,092	22857	37439
SOUTH AFRICA-DURBAN	5572	30975,00	2	9124,506	24523	37427
SPAIN-CARTAGENA	1813	40170,00	1	.	40170	40170
UKRAINE-BERDYANSK	1355	8803,30	27	2854,818	4044	12364
UKRAINE-KERCH	1264	10619,17	6	3906,440	5178	15430
UKRAINE-KHERSON	1239	5196,20	5	177,622	5002	5408
UKRAINE-MARIUPOL	1378	9887,42	57	3490,855	3450	22345
UKRAINE-NIKOLAYEV	1231	5968,00	1	.	5968	5968
UKRAINE-YUZHNYY	1179	15240,69	16	7228,324	9657	35143
USA-BALTIMORE	5528	69286,00	1	.	69286	69286
USA-GRAMERCY	9380	69815,00	2	813,173	69240	70390
USA-LAKE CHARLES	6894	58886,50	2	1574,727	57773	60000
USA-MOBILE	6720	70170,22	9	5378,671	61706	79633
USA-NEW ORLEANS	6742	70138,44	9	11671,562	41999	82500
USA-NEWPORT NEWS NOR	5455	74916,00	8	2877,248	71571	80351
USA-NORFOLK	5455	73088,31	32	2974,132	66877	77092
USA-PROVIDENCE	5168	31034,00	1	.	31034	31034
VENEZUELA-JOSE TERM	5642	50713,82	11	3045,482	47275	57009
VENEZUELA-MARACAIBO	6059	43394,00	4	3912,789	37846	46236
VENEZUELA-PUNTA CARD	5943	36801,00	3	25693,123	8000	57367
Total		45322,09	313	47641,225	2095	170001

3. Results

This part includes scatter plot matrix, correlation analysis and regression analysis. The figure below shows the scatterplot matrix of volume and distance variables. It can be seen that there is a linear relationship between two variables. Volume increases as distance increases.

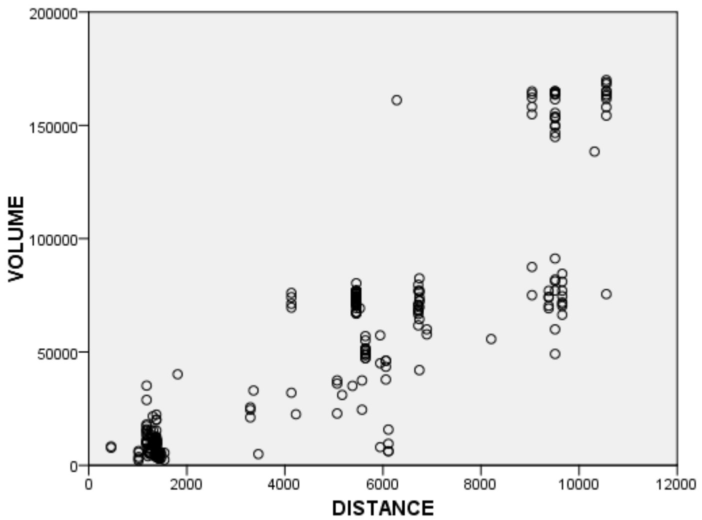

Figure 2. Scatter Plot of Volume and Distance

To see the degree of the linear relationship between variables, correlation analysis is implemented. According to the correlation analysis results it can be seen that there is a strong positive significant correlation between two variables. Volume increases as distance increases. But this analysis don't show the causal relationship between variables. So a regression analysis is implemented.

Table 2. Correlation Matrix of Volume and Distance

	VOLUME	**DISTANCE**
VOLUME	1.000000 ----- -----	
DISTANCE	0.875544*** (31.95853) 0.0000	1.000000 ----- -----

*** means significant at 0.01 level, t-statistics in parenthesis ()

Our regression model is;

$$VOLUME_t = \beta_0 + \beta_1 DISTANCE_t + \varepsilon_t$$

According to our mode, cargo volume is selected as dependent variable and distance selected as independent variable. Cargo volume depends on distance. Economies of scale theory that is explained in previous sections supports that. Results of the regression model estimation are presented at the table below:

Table 3. Results of Regression Analysis

Dependent Variable: VOLUME				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
DISTANCE	12.9429	0.4049	31.9585	0.0000
C	-9014.470	2124.506	-4.2430	0.0000
R-squared	0.766577	**F-statistic**		1021.348
Adjusted R-squared	0.765827	**Prob(F-statistic)**		0.000000

According to the regression results, our adjusted R-squared is 0.76 which is a satisfactory score. T statistic is very high. Probabilities are smaller than 0.05. Probability of F is smaller than 0.05. And F-statistic value is very high. These variables shows that our model is meaningful and explains 76% of cargo volume. But the robustness tests must be implemented to understand reliability of our results. These tests are autocorrelation test, heteroskedasticity test and normality test those are used for testing whether the model meets assumptions of regression or not.

The first test is autocorrelation test which assumes that there is no relationship between residuals. Q-statistic tests of software is implemented and null hypothesis is rejected which denotes there is an autocorrelation problem in our model. Also LM serial correlation test is implemented to the model. In small samples F statistic is used, in big samples Chi-Square statistic is used. According to the F statistic results that are shown below, null hypothesis is rejected. The null hypothesis denotes that there is no serial correlation problem. So our model includes serial correlation problem

Table 4. Breusch-Godfrey Serial Correlation LM Test Results

F-statistic	16.37581	**Prob. F(2,309)**	0.0000
Obs*R-squared	29.99622	**Prob. Chi-Square(2)**	0.0000

Another assumption of the least squares method is having no heteroskedasticity problem. White test is implemented to examine whether there is a heteroskedasticity or not. Null hypothesis denotes that there is no heteroskedasticity problem. According to F statistic results, null hypothesis is rejected. So our model has a heteroskedasticity problem.

Table 5. White Heteroskedasticity Test Results

F-statistic	75.63383	**Prob. F(2,310)**	0.0000
Obs*R-squared	102.6449	**Prob. Chi-Square(2)**	0.0000
Scaled explained SS	255.1155	**Prob. Chi-Square(2)**	0.0000

Normal distribution of the residuals is another assumption of the least square method. Jarque-Bera test is implemented to determine whether distribution is normally or not. Null hypothesis again denotes that residuals are normally distributed. According to the Jarque-Bera test results below, probability of the test is smaller than critical values. So, null hypothesis is rejected which means residuals are not normally distributed.

Table 6. Histogram Normality Test Results

Skewness	-0.354694
Kurtosis	6.034975
Jarque-Bera	126.6907
Probability	0.000000

According to the robustness test results, our equation doesn't meet the assumptions of least squares method. The model has normality, autocorrelation, partial correlation and heteroskedasticity problems. At this point the residuals are assumed to be normally distributed. Then HAC (Newey-West) covariance method is applied to the regression model to overcome autocorrelation and heteroskedasticity problems. After this method is applied, the results become as follow:

Table 7. New Regression Model

Dependent Variable: VOLUME				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 6.0000)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
DISTANCE	12.9430	0.743617	17.40543	0.0000
C	-9014.470	1799.822	-5.008535	0.0000
R-squared	0.766577	**F-statistic**		1021.348
Adjusted R-squared	0.765827	**Prob(F-statistic)**		0.000000
		Prob(Wald F-statistic)		0.000000

According to the new results, our equation can be written as:

*CARGO VOLUME= -9014.470+12.9430*DISTANCE*

Results show that if the distance increases 1 nautical mile, cargo volume increases nearly 13 tonnes. And change in distance variable explains nearly %77 of change in cargo volume variable.

4. Conclusions

All relevant literature comes to agree that bigger vessels significantly reduce the cost per ton in maritime transport. The purpose of this study is to determine the extent to which this cost advantage is used in practice by industrial firms and to test the operative field validity of the theory. In this study, it is assumed theoretically that the larger vessels have lower transport costs and the model is simplified by eliminating transport costs and coal prices. For this purpose, the hypothesis that distance is a decisive variable in describing ship size has been put forward. In other words, as the distance increases, the size of the ship will also increase according to our basic hypothesis.

İSDEMİR Port selected as a sample for this study because of data availability and its proper geographical position for calling ships from all around the world. Also same company has a power plant near the port, so it requires regular coal transshipments for the plant. The data covers the years between 2008-2011 and includes 313 observation. In these years totally 14.032.392 tons of coal imported by 313 bulk cargo ships.

Scatterplot matrix, correlation analysis and regression analysis are applied this dataset. Results of the descriptive analysis shows that there is a strong linear relationship between distance and volume. Volume increases as distance increases. To understand direction of this relationship, correlation coefficient analysis is implemented. According to the results, Pearson correlation coefficient is 0,887 and significant which means there is a strong correlation between variables in the same direction. To understand explanation degree of our model, a regression model is developed which is based on least squares method. According to the model, it is assumed that cargo volume is a function of distance. According to the regression results R-squared value is 0.76 which is relatively high score. Change in distance explains 76% of change in cargo volume. Coefficient of dependent variable which is distance in this model shows if the distance increases 1 nautical mile, cargo volume increases nearly 13 tonnes.

The results prove that economies of scale has a vital role in business life in spite of technological developments. Cargo volume increases as distance increases. That means big volume of coal can be imported from far distances as it is imported in small volumes from close distance. Even importing from far distances may be cheaper than importing from close ones. So business plans should be adjusted according to these situations to preserve competitive position in the global world.

This study is implemented for coal transportation in a single port. Further studies may research about other bulk cargoes in many ports in order to test economies of scale theory in different sectors.

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