THE EFFECT OF FREIGHT RATES ON FLEET PRODUCTIVITY: AN EMPIRICAL RESEARCH ON DRY BULK MARKET

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Abstract

Fleet productivity generally increases in two directions. First one is achieved by increasing the speed of the vessels in the market conditions where high freight rates are observed, this causes an increase on the amount of cargo per unit capacity they carry at the unit time. The other one is related to the short run inelastic supply curve in shipping because of the time to build effect. When the demand increases occur, the amount of cargo carried per unit capacity increases since increase in the supply is limited in the short run. In this context, it is aimed to determine the relationship between freight rates and the amount of cargo carried per unit capacity in this study. The Baltic Dry Index (BDI) was selected as a measure of the freight rates, and the tonnage carried per DWT from the portion of the total cargo tonnage carried by the sea to the dry cargo fleet capacity during that year was selected as an indicator of the fleet productivity. The dataset used in the study consists of annual observations covering the period from 1985 to 2016. Correlation and regression methods were used to determine the econometric relationship between the variables. As a result of the study, a significant strong relationship was found between freight rates and productivity in the positive direction. According to the developed model, a 10% increase in the freight rate causes an increase of about 0.9% in fleet productivity.

Keywords: *Dry bulk market, Freight rates, Fleet, Productivity*

NAVLUN ORANLARININ FİLO VERİMLİLİĞİ ÜZERİNE ETKİSİ: KURU DÖKME YÜK PİYASASI ÜZERİNE AMPİRİK BİR ÇALIŞMA

Özet

Filo verimliliği genellikle iki şekilde artar. Bunlardan ilki yüksek navlun oranlarının gözlemlendiği piyasa koşullarında gemilerinin hızlarının artmasıyla elde edilir. Hızın artması birim zamanda birim taşıma kapasitesi başına taşınan yük miktarının artmasına neden olur. Diğeri ise, inşa için zaman etkisinden dolayı denizcilikteki kısa dönemdeki inelastik arz eğrisiyle ilgilidir. Talep artışı meydana geldiğinde kısa dönemde arz artışı sınırlı olduğu için, birim taşıma kapasitesi başına taşınan yük miktarı artar. Bu çerçevede, bu çalışmada birim taşıma kapasitesi başına taşınan yük miktarı ile navlun oranları arasındaki ilişkinin tespit edilmesi amaçlanmıştır. Baltık Kuru Dökme Yük Endeksi (BKDYE) navlun oranlarının bir ölçüsü olarak seçilmiştir. Ve bu yıldaki toplam taşınan kuru yük miktarının toplam kuru yük filosunun kapasitesine oranlanmasıyla da DWT başına taşınan yük miktarı verimliliğin bir göstergesi olarak elde edilmiştir. Çalışmada kullanılan veri seti 1985 ve 2016 yılları arasını kapsayan yıllık gözlemlerden oluşmaktadır. Değişkenler arasındaki ekonometrik ilişkinin tespit edilmesi için korelasyon ve regresyon yöntemleri kullanılmıştır. Çalışmanın sonucunda değişkenler arasında güçlü anlamlı ve pozitif yönde ilişkisi tespit edilmiştir. Kurulan modele göre ise, navlun oranlarındaki %10'luk bir artış filo verimliliğinde yaklaşık %0,9'luk bir artışa neden olmaktadır.

Anahtar Kelimeler: *Kuru dökme yük piyasası, Navlun oranları, Filo, Verimlilik*

1. Introduction

Maritime transport is today still the only possibility for transporting larger volumes of cargoes in an acceptable price across the oceans and without the maritime transport, the development of the modern industrialized world would be impossible (Heidbrink, 2011:49). Despite this very important role, the maritime market is very fragile. Because, the demand for shipping services is a derived one and the main driver behind this derived demand is the world merchandise trade (Tamwakis, 2011:52). So even the small fluctuations in the world economy are felt strongly in this market. Therefore, the effective use of the maritime fleet, which is the capital of the shipowners, varies according to the situation in the economy.

In general, the productivity of the fleet may increase due to two reasons; the first is the increase in demand for maritime transport due to revival in the economy and the second is the increase in short-term transport capacity by increasing ship speeds (Karakitsos and Varnavides, 2014:43). Both of which are mainly due to inelastic short-run supply curve in the maritime market.

It would be useful to first address the inelastic supply curve in the short run. The supply of shipping services can be categorized as short-run and long-run. If the stock of the fleet is fixed, it is called short-run, if the stock of the fleet is variable, it is called long-run (Karakitsos and Varnavides, 2014:42). As can be seen in Figure 1, the freight rates are elastic until the 80% of the fleet up to the point of use, but when the next 20% of the limit is passed, it begins to become inelastic, and freight demanded by shipowners starts to increase (Glen and Christy, 2010:379). The other version of this model, including demand lines, is presented in Figure 2.

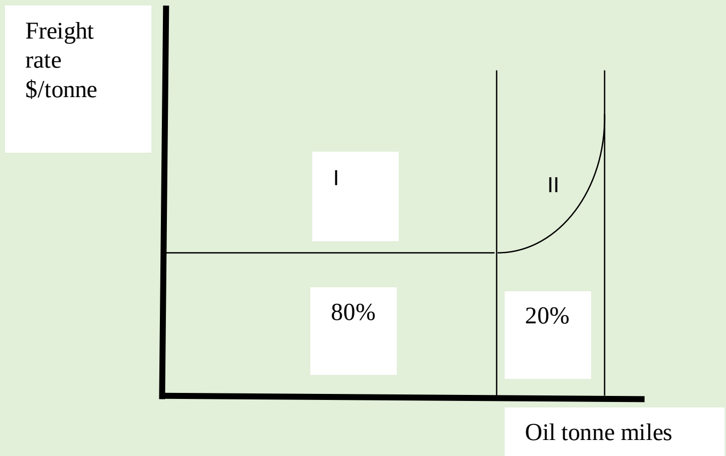

Figure 1. Short Run Supply Curve for Shipping Services
Source: Glen and Christy, 2010:379

According to the Figure 2, there is a very small increase in freight rates, although there is a very large increase between D0 and D1. Later on in the upright, a small increase in the amount causes a large increase in freight, for instance when there is an increase from D2 to D3 (Glen and Christy, 2010:381). This situation is a result of the fixed short-term fleet volume.

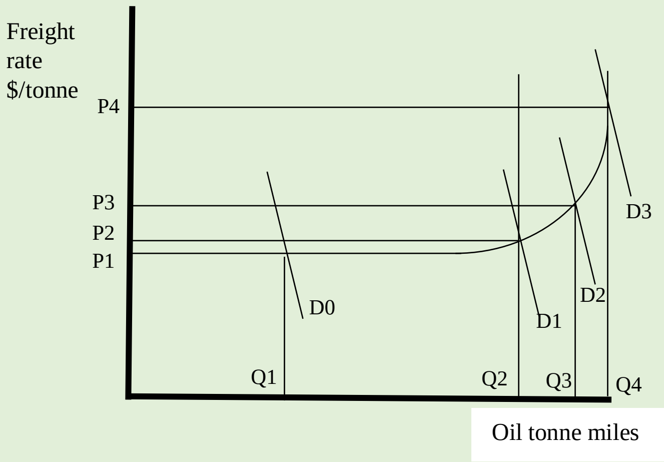

Figure 2. Modelling Shipping Demand and Supply in the Short Run
Source: Glen and Christy, 2010:381

Due to this inelastic supply curve, there is an increase in freight rates in case of demand increase. At this point, it is inevitable that this increase in demand will also increase the transportation productivity of the fleet. In addition, ship owners who wish to benefit more from higher freight rates increase their voyage speeds, since lower speed means less cargo is delivered (Stopford, 2009:244). This further increases the amount of cargo carried per unit time per dwt. According to all these, it is quite natural that there is a positive relationship between fleet productivity and freight rates.

The graphical representation of the dataset used in the analyzes was presented in Figure 3 and was thought to facilitate the understanding of the above-mentioned relationship.

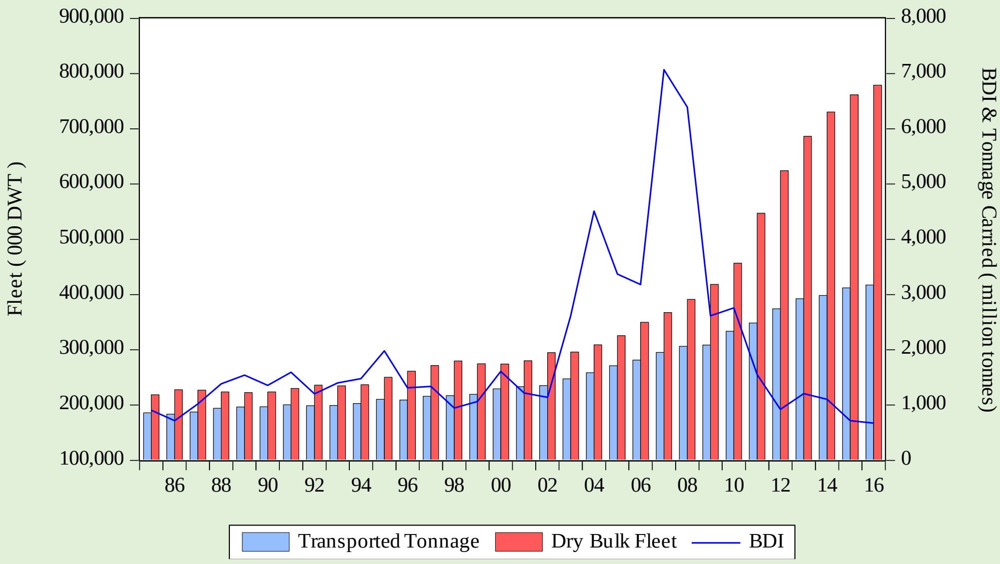

Figure 3. Transported Tonnage, Dry Bulk Fleet and BDI Variables

Source: UNCTAD, Bloomberg

The graph presented includes the fleet, the tonnage carried and the BDI variables. When the tonnage carried is considered as demand, it is clearly seen how the difference between the supply (fleet) and demand has been opened after 2008. Of course there are many factors that affect freight rates, however this opening between supply and demand has also caused a severe collapse in freight rates. This difference is also mathematically indicative of a decrease in the amount of cargo carried per dwt (productivity). Hence a positive relationship between fleet productivity and freight rates is inevitable. However, no study employing empirical test for this relationship has spotted in the literature. This lack has also generated the motivation for this study.

The fleet productivity can be tracked in several ways. Some of these measurements are ton-miles performed per dwt and tonnage carried per dwt. For the fleet productivity measurement in this study, the total amount of dry bulk carried and the dry bulk fleet volume variables were used. The cargo carried was divided into the fleet volume and the amount of cargo carried per dwt was obtained, and so the fleet productivity variable was generated. For freight rates, BDI variable, which has become one of the primary indicators on the cost of shipping in the world since its establishment (Lin and Sim, 2013) and has reflected the changes in dry bulk freight transport as a component indicator (Angelopoulos, 2017), was used. In the model established, other factors affecting the freight rates were assumed to be fixed in order to be able to see the relationship between the two variables clearly. As a result of the research, the relationship between freight rates and fleet productivity was empirically tested and the positive relationship was confirmed. Thus, it was thought that gap in the empirical literature have been filled.

The remainder of the study was organized as follows; the methods used in the study were introduced in section two; the results obtained from the analysis were presented in the section three; then lastly, the findings were interpreted and discussed in the conclusion section.

2. Methodology

The methods used in the study consist of two methods; correlation analysis and regression analysis. Correlation analysis was used to determine the direction and strength of the relationship, and a regression analysis was used to determine the causal relationship. Both methods are briefly introduced in the following sections.

2.1. Correlation Analysis

Correlation analysis helps us to determine the degree of the relationship between two or more variables (Sharma, 2005:3). Correlation does not show causality but shows the direction and strength of the movements of the variables. Correlation coefficients range between 1 and -1, and coefficients equal to 1 or -1 means that data points lying exactly on a straight line (Chang, 2014:78). Basically two methods are used for correlation calculations; Pearson's correlation and Spearman's correlation. While the two methods give similar results, their use varies according to the distribution of the variables. Pearson correlation coefficient assumes that the data are normally distributed while Spearman correlation can be used in circumstances where data investigation are not normally distributed (Osborne, 2008:39).

Evaluation of the correlation analysis depends on the degree and direction of the correlation coefficient. The closer the absolute value of the correlation coefficient is to 1, the stronger the relationship. Generally, correlation coefficients are classified in 5 groups; the coefficient between 0.00-0.20 is called very weak; the coefficient between 0.20-0.40 is called weak; the coefficient between 0.40-0.60 is called moderate; the coefficient between 0.60-0.80 is called strong; and lastly, the coefficient between 0.80-1.00 is called very strong (Soh, 2016:40).

2.2. Regression Analysis

Regression analysis aimed at discovering how one or more variables affect other variables. The affected variables are called dependent variables or response variables while affecting variables are called independent variables, predictor variables or regressors (Sen and Srivastava, 1990:1). Regression analysis allows researchers to quantify how the average of one variable systematically varies according to the levels of another variable (Gordon, 2015:5).

The following equation (1) shows the contents of a simple linear regression. Dependent variable is represented by y_i, while independent variable represented by x_i. β_0 and β_1 variables are the coefficients of the equation. β_1 gives the slope of the regression line, and if it is positive, it indicates a relation in the same direction, otherwise it indicates a relation in the opposite direction. The part unexplained in the model is aggregated into ϵ_i and forms the error terms of the model. Error terms are very important for the process of developing consistent and unbiased regression models. So that after the model is estimated, there are many tests on the error terms.

$$y_i = \beta_0 + \beta_1 x_i + \epsilon_i \quad (1)$$

3. Findings and Results

Descriptive statistics of the data used in the study were presented in Table 1. The first two columns of the table belong to the "loaded tonnage" and "fleet" values used in the productivity calculation. Loaded cargo tonnage is divided by the total fleet to reach transported ton value per dwt during the year. That is, equation (2) was used and the productivity value (ton per dwt) was obtained.

$$Productivity = \frac{Transported\ Cargo}{Fleet} \quad (2)$$

The descriptive statistics of the Baltic Dry Index, another variable used in the study, were also included in the table. The BDI and productivity variables were used in econometric analyzes in the direction of the study, so logarithms were taken in advance. Taking logarithms of the variables makes discrete data continuous and facilitates processing of the data. Then the unit root test was performed on logarithmic variables and the results were presented in Table 2.

Table 1. Descriptive Statistics for Raw and Converted Data

	Loaded (tons)	**Fleet (dwt)**	**BDI**	**Prod**	**ΔLn BDI**	**ΔLn Prod**
Observations	32	32	32	32	31	31
Mean	1613 m	360 m	1933.734	4.487106	-0.009596	0.001215
Median	1313 m	280 m	1369.998	4.347215	-0.058493	0.006228
Maximum	3172 m	779 m	7070.256	5.313672	0.833368	0.086339
Minimum	834 m	219 m	673.1200	3.665116	-0.892940	-0.118277
Std. Dev.	747 m	174 m	1530.540	0.452558	0.386240	0.045595
Skewness	0.873124	1.370588	2.135771	0.461266	0.150969	-0.267995
Kurtosis	2.402205	3.494231	7.014042	2.181043	3.054525	3.237160
Jarque-Bera	4.542317	10.344410	45.81147	2.029009	0.121596	0.443727
Probability	0.103193	0.005672	0.000000	0.362582	0.941013	0.801025

Source: Bloomberg, UNCTAD

In the time series analyzes, deviations and inconsistencies arise in estimates in the case of the series containing the unit root. For this reason, the Augmented Dickey-Fuller unit root test was applied to BDI and productivity variables and the results were presented in Table 2. According to the results, the series were found to contain unit roots and become stationary when the first differences were taken, in other words, the series are I(1). After this phase, correlation analysis was started to determine the directional relationship between the variables.

Table 2. Augmented Dickey-Fuller Test Results

	BDI	Prod.		BDI	Prod.
Level	-1.684167	-1.413197	First Dif.	-5.226223*	-5.060424*
1% level	-3.661661		1% level	-3.670170	
5% level	-2.960411		5% level	-2.963972	
10% level	-2.619160		10% level	-2.621007	

Significance levels = * 1%

Correlation analyzes were used to determine whether there was a directional relationship between the movements of the variables. The different analysis method applied according to the distributions of the variables. When the Table 1 was examined, it was determined that both of the ΔLn BDI variable and the ΔLn Productivity variables were normally distributed. Thus Pearson method was more suitable but both Pearson and Spearman analysis methods were used and results were presented in Table 3. According to the results, significant strong degree correlations were found between the two variables in the positive direction. But this analysis only shows the direction and strength of the relationship, but not the causal relationship, therefore, a regression model was adopted.

Table 3. The Results of the Correlation Analysis between Variables

	ΔLn BDI	
	Pearson	Spearman
ΔLn PRODUCTIVITY	0. 730968 (5.768345) 0.0000*	0.763306 (6.362691) 0.0000*

Significance levels = * 1%

The regression model of our study was presented below. The BDI, which is the independent variable, represents the revenues of the shipowners, and the dependent variable is the PRODUCTIVITY that reflects the transferred tonnage per dwt in the fleet. The hypothesis we have established is that there is a positive relationship between shipping revenue and productivity. Then the model was established and predicted this way.

$$\Delta LnPRODUCTIVITY_i = Ln\beta_1 + \beta_2 \Delta LnBDI_i + u_i$$

The results of the estimated regression analysis were presented in Table 4. According to the results, the F statistic indicating the significance of the model is significant at 99% confidence interval (0.000003<0.01), and the independent variable BDI is also significant at %99 confidence interval. The coefficients of the model show the elasticity of the productivity with respect to the revenue, and according to the results, the 1% increase in the revenue causes an increase of 0.086% in the productivity. R-squared value showing the explanatory power of the model is relatively low, but it is good for the differenced variables used models. The value is 53, which means that 53% of the changes in the dependent variable are explained by the independent variable. On the other hand, this moderate value may be due to the irrelevance of the selected variables, or structural break and outliers in the model may decrease explanatory power. Thus it is useful to examine some stability tests and graphs from the regression equation.

Table 4. Regression Equation Results of Model 1

Dependent Variable: ΔLn PRODUCTIVITY

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.002043	0.005686	0.359406	0.7219
ΔLn BDI	0.086290	0.014959	5.768345	0.0000*
R-squared	0.534315	**F-statistic**		33.27381
Adjusted R-squared	0.518257	**Prob (F-statistic)**		0.000003*

Significance levels = * 1%

We first looked at the actual, fitted, residual graph showing the relationship between the estimated value and the actual value. It was included in the appendices section, and according to the graph, there were small deviations but no big deviation was spotted, which means our model fits well. The second visual we examined is the influence statistics, and according to these statistics deviations did not exceed the critical value so much and there were no large deviations that could be solved with the dummy variables. The last test on the stability of the model was the CUSUM square test. The CUSUM Square test, which shows the structural break in the models, was applied and the result was shown in appendices. According to the test, the blue line did not exceed the red critical values and followed a stable course. All these graphs were presented in the appendices. All of these tests indicated that the model fitted well in a satisfactory way.

Some tests are applied to residuals of the model to test the stability of the model in regression estimations. The most important of the conditions that the residuals must provide for the model to be consistent and stable are no autocorrelation, no serial correlation, homoscedasticity and normal distribution. The test for autocorrelation was performed and the results were presented in Table 6. The null hypothesis of this test is that there is no autocorrelation in the residuals and according to the results the null hypothesis could not be rejected in all 16 lags.

Table 6. Autocorrelation and Partial Correlation Check for the Residuals of the Model

Lags	AC	PAC	Q-Stat	Prob	Lags	AC	PAC	Q-Stat	Prob
1	0.012	0.012	0.0050	0.944	9	0.076	0.125	6.0708	0.733
2	-0.139	-0.139	0.6838	0.710	10	0.094	0.004	6.5016	0.772
3	-0.061	-0.059	0.8206	0.845	11	0.101	0.121	7.0233	0.797
4	-0.063	-0.083	0.9694	0.914	12	0.063	0.016	7.2342	0.842
5	0.088	0.074	1.2757	0.937	13	-0.214	-0.144	9.8368	0.707
6	0.056	0.033	1.4057	0.966	14	-0.232	-0.237	13.076	0.521
7	0.030	0.046	1.4441	0.984	15	0.043	0.062	13.197	0.587
8	-0.313	-0.309	5.8009	0.670	16	0.082	-0.115	13.653	0.625

The results of the remaining tests were presented collectively in Table 7. The LM test is used for the serial correlation test and the null hypothesis is that there is no serial correlation. The null hypothesis in our model could not be rejected according to the F statistic used in small samples. The white test was used for the heteroscedasticity in the residuals and the null hypothesis of this test is that there is no heteroscedasticity. According to the results the null hypothesis could not be rejected and the residuals were homoscedastic. The final test is the JB test, which tests whether the residuals are normally distributed, and the null hypothesis of this test is that the residuals are normally distributed. The null hypothesis could not be rejected by looking at the results presented in the table below. All these results showed that our model is healthy and the coefficients are consistent. So the model can be used in estimation and interpretation relievedly.

Table 7. Robustness Check for Residuals of the Model

Breusch-Godfrey Serial Correlation LM Test	F-statistic	0.285782	Prob. F(2,26)	0.7537
	Obs*R-squared	0.642636	Prob. Chi-Square(2)	0.7252
Heteroskedasticity Test: White	F-statistic	0.252314	Prob. F(3,27)	0.7787
	Obs*R-squared	0.548804	Prob. Chi-Square(3)	0.7600
	Scaled explained SS	0.393706	Prob. Chi-Square(3)	0.8213
Jarque-Bera Normality Test	Skewness	-0.397582	Jarque-Bera	0.9845
	Kurtosis	2.639503	Probability	0.6112

Conclusion

The positive relationship between fleet productivity and freight rates is clearly evident when the literature is examined, but no empirically tested study has been spotted. So in this study it was tried to test the econometric significance of this relationship and it was aimed to contribute to the literature.

The variable obtained from the portion of the total carried dry bulk to the total fleet capacity was used as a productivity variable. The result gave us the amount of dry bulk cargo carried per dwt. For the freight rates variable, the BDI value converted to the year is used by taking the average of the daily values of the BDI variable. By this way, the data set was formed from annual observations covering the years 1985 and 2016. For the determination of the econometric relationship, the unit roots were fundamentally eliminated from both of the variables, and correlation and regression analyzes were applied.

The positive relationship between the two variables was confirmed according to the obtained results. Correlation analysis showed strong positive significant correlations (0.73 and 0.76) between the two variables. Regression analysis showed that the 1% increase in the revenue causes an increase of 0.086% in the productivity, and according to the R-squared value, 53% of the changes in the dependent variable (productivity) are explained by the independent variable (freight rate). Then some tests were applied to the model and residuals obtained from it, and the reliability and the stability of the model was tested. There was no problem in these tests and the statistical validity of the model was strengthened.

One of the most important limitations of the study is the annual frequency of the data. Better results could be obtained with more frequent data sets. Further studies may examine this relationship in other maritime markets such as liquid bulk and container. In addition, other factors affecting freight rates can be added to the model, and the model can be varied.

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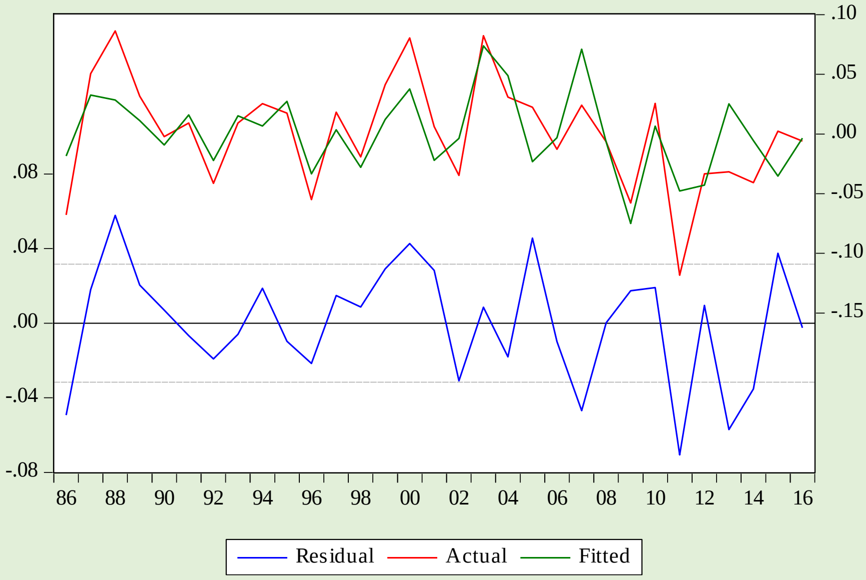
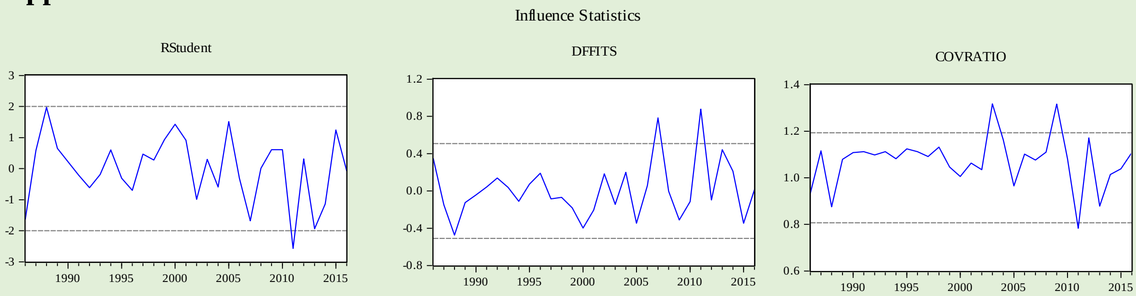
Appendices

Appendix 1. Actual, Fitted and Residual Values of the Model



Appendix 2. Influence Statistics of the Model



Appendix 3. Cusum Square Tests for Model