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Financial variables influencing the performance of refined crude oil products at North-West European cargo markets

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Abstract. The main aim of this paper is to empirically examine the influence of the selected financial indicators on the prices of refined oil products at European cargo market using the VAR regression model. In order to test the influence of well-known market indicators – EUR/USD exchange rates, EURIBOR interest rates and Euro Stoxx 50 index on oil products' prices, the weekly data was collected for the four-year period. The authors decided to test the impact of the selected data on the following four oil products traded at the physical North-West European market: Gasoline 10 PPM (GSLN10), ULSD 10 PPM, Diesel 10 PPM NWE, Gasoil 0.1%. The results demonstrate that the coefficients of EUR/USD exchange rates as well as Euribor rates are statistically significant, whereas the coefficient of ESX50 index is not significant. These results follow the trend, since it is quite common that increase in the EUR/USD exchange rate leads to increase in oil products' prices.

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1. INTRODUCTION

It is well known that fluctuations in oil prices (also known as oil price shocks) have always had strong direct and indirect impact on the world economy, occupying the central stage in global politics and economics. The findings of (Bjornland, 2008) suggest that higher oil prices stimulate economic growth. Also, the studies of (Ji and Guo, 2015) confirm that "oil-related events have increased the uncertainty and complexity of the worldwide oil market". Decline in oil prices has been regarded by economists as a boost for global economy, higher spending and economic growth (IMF, 2015). Similarly, rapid price increases are considered as a threat pushing the world economy back into recession and viewed as a cause for economic instability (World Energy Outlook, 2012). High oil prices may also be a factor contributing to the periods of excessive inflation, reduced productivity, lower economic growth (Barsky & Kilian, 2004) and a trigger of global economic downturn. The findings of Filis et al. (2011) confirm that economic booms or crises are triggered by a strong positive link between oil prices and stock markets. Vezina and von Below (2016) suggest that oil prices affect the geography of the global trade, as rise of oil prices results in slower globalization of foreign trade and overall slowdown of globalization pace.

However, in its turn, various economic factors, changes in global supply and demand, wars and armed conflicts nearby oil refineries, OPEC statements, weather and climate collisions, vital environmental initiatives and requirements and even news in mass media (Kleinnijenhuis et al., 2015) could have their impacts on oil prices' volatility.

Drastic rises and declines in crude oil prices have also influenced the inflation rate (Hooker, 2002), unemployment (Davis & Haltiwanger, 2001), GDP (Hamilton, 2003), exchange rates (Bénassy-Quéré et al., 2007), the volatility of stock markets (Apergis & Miller, 2009; Ardalan et al., 2017), and the increased co-movement among different commodities (Juvenal & Petrella, 2015). These fundamentals are believed to be very sensitive to market instability.

Figure 1 illustrates high volatility experienced by crude oil prices over the last 60 years (e.g., 10.97 USD per barrel in 1970 as compared to 117.09 in 2011).

The oil crisis of 1973-1974 has revealed how much economists actually care about oil shocks. For example, considerable fluctuations of oil prices have become a distinct feature of the US economy at that time (Kilian, 2008). It has also revealed that further steps need to be taken in boosting the understanding of oil price changes. As a result, the last years were marked by the emergence of vast amount of publications dedicated to economic, geopolitical and environmental factors influencing oil price volatility. However, oil price fluctuations are still difficult to predict, despite the recent developments of relevant economic tools of market analysis and evaluation (Baumeister & Kilian, 2016). Understanding of oil shocks, their nature and predictability is crucial for market professionals in making vital decisions.

These developments have raised the question whether price volatility of refined oil products is influenced by changes in various financial fundamentals.

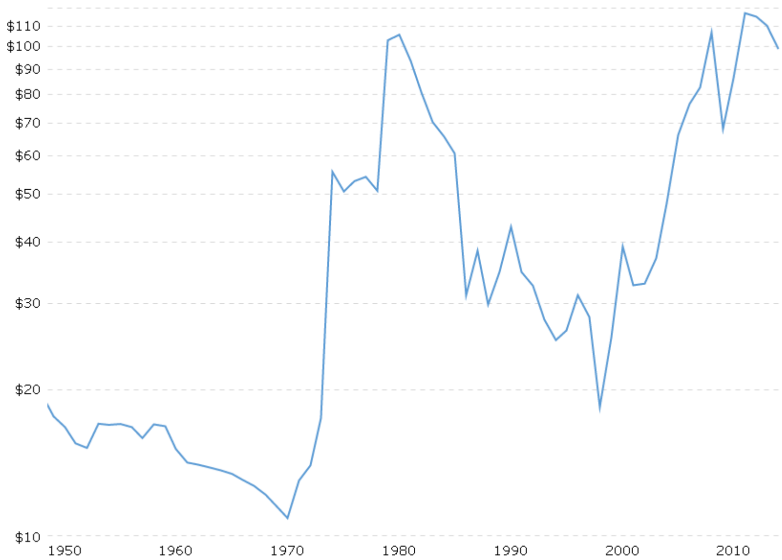

Figure 1. Historical chart of Brent (European) crude oil prices per barrel since 1950

Source: http://www.macrotrends.net

The main aim of this paper is to empirically examine the influence of financial variables on the prices of refined oil products at European cargo market. The authors establish a link between various financial indicators, such as exchange rates and financial indices, and prices of several refined oil products traded at the North-West European cargo market. The authors believe there is a direct linkage between the prices for refined oil products and the selected financial variables. And they also would like to suggest that fluctuations of the selected variables will have their impact on the prices of the selected refined oil products. In the present paper the authors use such research methods as analysis of scientific literature and vector autoregressive model (VAR).

The remainder paper is organized as follows: after the linkage of the topic to current scientific literature, the authors provide a detailed explanation of the selected research design and the chosen research methods. Furthermore, the authors perform a regression analysis of the selected variables. The results of the research are taken as a basis for further discussion and concluding comments.

2. LITERATURE REVIEW

Within the contemporary research about relationship between oil prices and financial variables, the following trends are widely investigated and discussed: (i) a link between exchange rates and oil prices (Austvik, 1987; Nusair & Kisswani, 2015; Dreger et al., 2016; Jiang & Gu, 2016;) and (ii) relationship between oil price volatility and stock markets (Andrei et al., 2016; Ciner, 2001; Hedi & Fredj 2010; Mohamed, 2012; Gogineni, 2016; Maghyereh et al., 2016).

Among the most important findings, we may cite the results of Huang et al. (1996), who investigated a possible link between oil and stock prices during the 1980-s using the vector autoregressive (VAR) approach, and arrived to the conclusion that returns on oil futures are not correlated with stock market returns. The same approach was used by Sadorsky (1999) and Bjornland (2008) to investigate the oil price and stock market relationship. The results of Sadorsky (1999) research confirmed that oil prices and oil price volatility have an important impact on real stock returns. Findings of Pradhan et al. (2015), who used a panel vector autoregressive model show robust long-run economic relationship between economic growth, oil prices, stock market depth, real effective exchange rate, inflation rate, and real rate of interest.

The relationship between oil prices and exchange rates has been extensively studied over the last decade. Austvik (1987) examined the impact of changes in US dollar exchange rates on the oil market, suggesting that increase in the exchange rate of the dollar against other currencies leads to a lower oil price in dollars and vice versa. The results of this research made by Akram (2004) clearly demonstrated negative relationship between oil prices and Norwegian Krone exchange rate. Azar (2013) concluded that oil prices and foreign exchange rates have a close and highly significant statistical relation. Chang et al. (2013) investigated the correlations of oil prices, gold prices and the New Taiwan dollar versus U.S. dollar and concluded that the selected variables remain independent from one another. Coudert & Mignon (2016) also investigated the relationship between oil price and the US dollar and established a negative relationship in most cases, except in the periods when dollar surged to an extremely high level. Rahmanifard et al. (2016) performed causality test and co-integration, in order to establish relationship between crude oil prices and US dollar for the period of 1990-2013. The results of their research confirm the significant negative relationship between the selected variables.

Ciner (2001) examined dynamic link between oil prices and the stock market S&P 500 index; the results confirm the significant relationship between the selected variables. Park & Ratti (2008) investigated the impact of oil price shocks on stock markets in the US and 13 European countries within the period of 1986-2005 using a multivariate VAR analysis (Radivojević, Ćurčić & Vukajlović, 2017). Their findings suggest that the effects of oil price shocks vary within countries and in case of many European countries but increase in volatility of oil prices significantly impacts real stock returns occurring within the same time period. Lescaroux & Mignon (2008) established relationship between oil and share prices in a short term. Mohamed (2012) determined a strong significant influence of oil price changes on volatility and returns of European stock market sector. Eryigit (2012) performed a study in case of Turkey and the results suggest the existence of dynamic relationship between oil price shocks, Istanbul stock market index, exchange rate and interest rate. Similar findings were obtained later by Mishra (2015) revealing that in case of India's long-term relationship between global crude oil price, exchange rate volatility and stock prices.

The results of investigation of existence of a long-term relationship between oil prices and stock markets made by Arouri & Rault (2013) show an evidence of co-integration between oil prices and stock markets valid for Gulf Cooperation Council countries. Their findings also suggest that for all sampled countries except Saudi Arabia, increase in oil prices positively affects stock prices. Creti et al. (2014) analysed the interdependence between oil price and stock market indices for both oil-importers and oil-exporters using the evolutionary co-spectral analysis. Their findings suggest that interdependence between the oil price and the stock market is stronger in exporters' markets.

Review of literature shows that various indicators and methods have been applied to measure the relationship in question; therefore, the authors have selected the regression analysis as the most appropriate method to suit the objectives of this research.

It should also be noted that despite widely discussed relationship of oil prices, exchange rates and stock indices, in authors opinion relatively little is known about the relationship between refined oil products' prices in the physical cargo market, exchange rates and stock indices. The refined crude oil prices in the physical cargo market are affected by the real-time trades and volumes and do not necessarily change in the same way as oil prices in the futures market. Therefore, in this paper the authors used physical trade market prices in the commodity market as well as real physical price changes over the prolonged period of time. It is important to outline that different refined oil products experienced different volatility rates and may fluctuate in opposite directions. All these factors had influenced present research.

3. METHODOLOGY

In order to test the influence of well-known market indicators – EUR/USD exchange rate, interest rates of EURIBOR and Euro Stoxx 50 index on oil products prices, the weekly data was collected for a period starting January 1, 2012 to June 26, 2016. The impact of the selected indicators was tested on four oil products traded in the physical North-West European market: Gasoline 10 PPM (GSLN10), ULSD 10 PPM, Diesel 10 PPM NWE, Gasoil 0.1%. Data on these four products was obtained using Platts European Marketscan database. Respectively, the weekly historical data on EUR/USD exchange rates, as well as data on Euro Stoxx 50 index was collected via investing.com website. EURIBOR weekly rates were obtained by employing www.euribor-rates.eu database.

It was decided to employ a VAR (vector autoregressive) model to detect a relationship between oil products' prices and selected market indicators. In total, four models have been tested, one for each type of oil products. VAR model application is justified when analysing time-series data in order to eliminate autocorrelation effect and is in accordance with previous research in this field. The model is called autoregressive due to the presence of a lagged value of a dependent variable (oil products' prices) on the right side (Heryan & Ziegelbauer, 2016).

4. EMPIRICAL RESULTS AND DISCUSSION

Taking a look on correlations of the oil products prices with selected market prices and using the observations for the period from January 1, 2012 to June 26, 2016 (235 weeks) with 5% critical value (two-tailed), it can be noted that the highest correlation coefficients are observed between all four oil products' prices (dependent variables) and EUR/USD exchange rates (independent variable). In the same way, EURIBOR interest rates are also highly correlated with all oil products prices, where coefficients range from 0.67 to 0.70. On the other hand, the Euro Stoxx 50 index prices are negatively correlated with the oil products' price values. The correlation between independent variables is not higher than the one between dependent and independent variables, implying that there is no multicollinearity in the model. Also these were checked with VIF (Variance Inflation Factors) and likewise after these tests no multicollinearity was detected (the highest VIF stood at 5.32, which is less than the critical value of 10.0).

Table 1

Correlation coefficients, using observations in the time period 01.01.2012-26.06.2016 with 5% critical value (two-tailed) for n = 235 for Gasoline 10ppm, USLD 10, Diesel 10ppm, Gasoil 0.1% sulphur

ESX50	EUR/USD	Euribor	GSLN10	ULSD10	Diesel10	Gasoil01	
1.0000	-0.4637	-0.6734	-0.5697	-0.5754	-0.5519	-0.5660	ESX50
	1.0000	0.5356	0.8786	0.9005	0.8842	0.9080	EUR/USD
		1.0000	0.6877	0.6960	0.6737	0.6954	Euribor
			1.0000	0.9817	0.9591	0.9812	GSLN10
				1.0000	0.9769	0.9994	ULSD10
					1.0000	0.9766	Diesel10
						1.0000	Gasoil01

Source: authors' analysis

The aim of the research is to determine what effect the above market indicators have on the selected oil products' prices. For this purpose, four regression models were tested, one for each of the oil products – Gasoline 10 PPM, ULSD 10 PPM, Diesel 10 PPM NWE, Gasoil 0.1%. In employed VAR (vector autoregressive) model, three lagged values of the dependent variable (oil products' prices) were used as regressors on the right side (lag order 3, since other lagged values were not retained in the regression due to insignificance). Consequently, these models can be estimated by OLS (ordinary least squares) method. The results obtained from the first VAR model with dependent variable GSLN10 showed that estimated coefficients of Price GSLN10_1, Price GSLN10_3, Price EUR/USD and EURIBOR rates were significant, whereas the coefficient of Price ESX50 was not. Therefore, it can be inferred, also taking into account the signs of the coefficients, that values of EUR/USD and EURIBOR rates have positive influence on GSLN prices and, consequently, an increase in these values is accompanied by growth of GSLN prices.

Table 2

VAR system, lag order 3 for Gasoline 10 ppm

OLS estimates, observations 2012-01-22-2016-06-26 (T = 232)
Log-likelihood = -1 094.1366
Determinant of covariance matrix = 730.9426
AIC = 9.4926
BIC = 9.5966
HQC = 9.5345

Equation 1: Price_GSLN10
Heteroscedasticity-robust standard errors, variant HC0

	Coefficient	Std. Error	t-ratio	p-value	
const	-72.6804	40.4299	-1.7977	0.07357	*
Price_GSLN10_1	1.08597	0.102422	10.6029	<0.00001	***
Price_GSLN10_2	-0.0371269	0.122651	-0.3027	0.76240	
Price_GSLN10_3	-0.105819	0.0530032	-1.9965	0.04709	**
Price_EUR/USD	81.0585	35.1209	2.3080	0.02191	**
Euribor Yield	16.2978	5.17593	3.1488	0.00186	***
Price_ESX50	0.00326489	0.00553875	0.5895	0.55614	

Mean dependent var	833.2317	S.D. dependent var	236.0230
Sum squared resid	169 578.7	S.E. of regression	27.45329
R-squared	0.986822	Adjusted R-squared	0.986471
F(6, 225)	4 150.276	P-value(F)	2.6e-227
rho	-0.005973	Durbin-Watson	2.006922

F-tests of zero restrictions:
All lags of Price_GSLN10 F (3, 225) = 829.97 [0.0000]
All vars, lag 3 F (1, 225) = 3.9858 [0.0471]

Source: authors' analysis

Some variables are not significant, which means it is unclear to what extent they explain the dependent variables. Since the coefficient of Price ESX50 is not statistically significant, it is unknown what effect it has on the dependent variable.

In a similar way, the results produced by the second VAR model with dependent variable ULSD10 indicate that estimated coefficients of Price ULSD10_1, Price ULSD10_2, Price EUR/USD and EURIBOR rates are statistically significant, while the same cannot be inferred for the coefficient of Price ESX50.

Likewise, it can be concluded that values of EUR/USD and EURIBOR rates have positive influence on ULSD10 prices and the increase in these values is accompanied by growth of ULSD10 prices. Since the coefficient of Price ESX50 is not statistically significant, it is unknown what effect it has on the dependent variable.

Table 3

VAR system, lag order 3 for ULSD 10 ppm

OLS estimates, observations 2012-01-22-2016-06-26 (T = 232)
Log-likelihood = -991.3946
Determinant of covariance matrix = 301.45721
AIC = 8.6068
BIC = 8.7108
HQC = 8.6488

Equation 1: Price_ULSD10
Heteroscedasticity-robust standard errors, variant HC0

	Coefficient	Std. Error	t-ratio	p-value	
const	-53.8177	27.5878	-1.9508	0.05233	*
Price_ULSD10_1	1.29828	0.0636512	20.3968	<0.00001	***
Price_ULSD10_2	-0.321135	0.102094	-3.1455	0.00188	***
Price_ULSD10_3	-0.0184649	0.0646979	-0.2854	0.77560	
Price_EUR/USD	66.4182	24.6467	2.6948	0.00757	***
Euribor Yield	8.76624	3.91966	2.2365	0.02630	**
Price_ESX50	-0.000972988	0.00394971	-0.2463	0.80564	

Mean dependent var	772.3417	S.D. dependent var	239.4681
Sum squared resid	69 938.07	S.E. of regression	17.63054
R-squared	0.994720	Adjusted R-squared	0.994580
F(6, 225)	7 050.239	P-value(F)	5.1e-253
rho	0.010875	Durbin-Watson	1.959116

F-tests of zero restrictions:
All lags of Price_ULSD10 F (3, 225) = 1 742.3 [0.0000]
All vars, lag 3 F (1, 225) = 0.081454 [0.7756]

Source: authors' analysis

In a similar way, the results obtained from the VAR models with dependent variables Diesel10 and Gasoil01 also reveal that estimated coefficients of PriceEUR/USD and EURIBOR rates are significant in the first model and estimated coefficients of Price_Gasoil01_1, Price_Gasoil01_2, Price EUR/USD and EURIBOR rates are significant in the second model, whereas the coefficient of Price ESX50 is not significant in any model. Therefore, it can be inferred also taking into account the sign of the coefficients that values of EUR/USD and EURIBOR rates have positive influence on Diesel10 and Gasoil01 prices and that increase in these values is accompanied by growth of Diesel and Gasoil prices.

Table 4

VAR system, lag order 3 for Diesel 10 ppm

OLS estimates, observations 2012-01-22-2016-06-26 (T = 232)
Log-likelihood = -1 296.9753
Determinant of covariance matrix = 4 200.4402
AIC = 11.2412
BIC = 11.3452
HQC = 11.2831
Equation 1: Price_Diesel10
Heteroscedasticity-robust standard errors, variant HC0

	Coefficient	Std. Error	t-ratio	p-value	
const	-248.947	98.1119	-2.5374	0.01185	**
Price_Diesel10_1	0.355404	0.252385	1.4082	0.16046	
Price_Diesel10_2	0.27589	0.211531	1.3043	0.19348	
Price_Diesel10_3	0.186047	0.15813	1.1765	0.24062	
Price_EUR/USD	322.103	109.111	2.9521	0.00349	***
Euribor Yield	26.8114	10.4118	2.5751	0.01066	**
Price_ESX50	-0.00920598	0.0120875	-0.7616	0.44709	

Mean dependent var	778.6633	S.D. dependent var	247.1166
Sum squared resid	974 502.1	S.E. of regression	65.81125
R-squared	0.930918	Adjusted R-squared	0.929075
F(6, 225)	1 999.291	P-value(F)	4.2e-192
rho	-0.017603	Durbin-Watson	2.033507

F-tests of zero restrictions:
All lags of Price_Diesel10 F (3, 225) = 73.335 [0.0000]
All vars, lag 3 F (1, 225) = 1.3842 [0.2406]

Source: authors' analysis

Table 5

VAR system, lag order 3 for Gasoil 0.1% sulphur

OLS estimates, observations 2012-01-22-2016-06-26 (T = 232)
Log-likelihood = -989.20413
Determinant of covariance matrix = 295.81811
AIC = 8.5880
BIC = 8.6920
HQC = 8.6299
Equation 1: Price_Gasoil01
Heteroscedasticity-robust standard errors, variant HC0

	Coefficient	Std. Error	t-ratio	p-value	
const	-69.5843	28.0235	-2.4831	0.01376	**
Price_Gasoil01_1	1.28979	0.062495	20.6383	<0.00001	***
Price_Gasoil01_2	-0.330472	0.0957942	-3.4498	0.00067	***
Price_Gasoil01_3	-0.00907239	0.0600462	-0.1511	0.88004	
Price_EUR/USD	81.2707	25.6864	3.1640	0.00177	***

Euribor Yield	10.2988	4.36507	2.3594	0.01916	**
Price_ESX50	-0.000237314	0.00397779	-0.0597	0.95248	

Mean dependent var	754.5877	S.D. dependent var	234.2137
Sum squared resid	68 629.80	S.E. of regression	17.46486
R-squared	0.994584	Adjusted R-squared	0.994440
F(6, 225)	6 754.262	P-value(F)	6.1e-251
rho	0.017370	Durbin-Watson	1.949288

F-tests of zero restrictions:

All lags of Price_Gasoil01 F (3, 225) = 1 404.6 [0.0000]

All vars, lag 3 F (1, 225) = 0.022828 [0.8800]

Source: authors' analysis

In general, utilizing correlation analysis and VAR model testing, the authors identified a relationship between oil products' prices and selected market indicators. In total, four VAR models were tested, one - for each type of selected oil products. Similarly, EURIBOR interest rates are also highly correlated with all four selected oil products' prices.

5. CONCLUSION

Sharp fluctuations of oil prices always had a high direct or indirect impact on the world economy. During the period of last 60 years, oil prices experienced high volatility as well as did the volatility of currency rates and stock markets. These developments raised a question whether the volatility of cargo market is related and influenced by the changes of various financial fundamentals.

The results obtained from all four VAR models with dependent variables GSLN10, ULSD10, Diesel10 and Gasoil01 partially agree with findings of other researchers, as produce the same outcome – that generally estimated coefficients of price EUR/USD and EURIBOR rates are statistically significant in all the models, whereas the coefficient of Price ESX50 is not significant in any model. Therefore, it can be inferred that values of EUR/USD exchange rate and EURIBOR rates have positive and significant influence on GSLN10, ULSD10, Diesel10 and Gasoil01 prices, and that increase in these indicators' values is accompanied by the increase in price for all four selected oil products. These results do not contradict existing studies, since it is quite common that positive change in EUR/USD exchange rate leads to increase of oil products' prices.

The study has several limitations, as for the current research, authors used only some financial variables and selected light refined products only. For the future research authors consider it necessary to broaden the scope and to investigate influence of non-financial variables such as significant events (political, economic and environmental) on the refined oil products in both European and non-European cargo markets.

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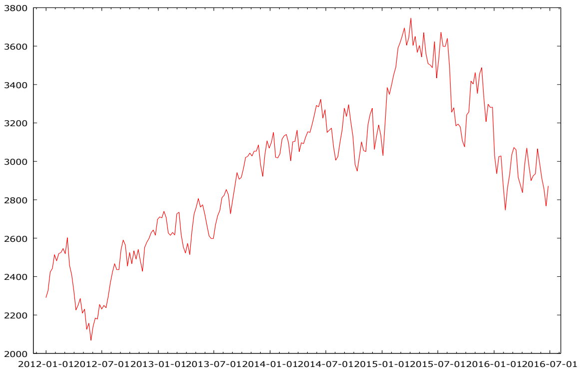
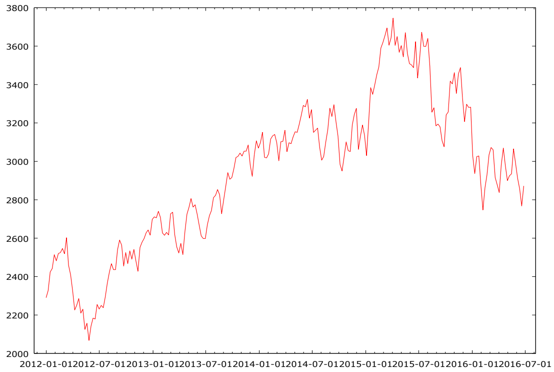
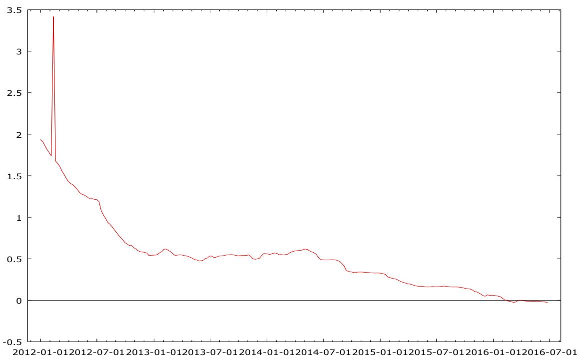
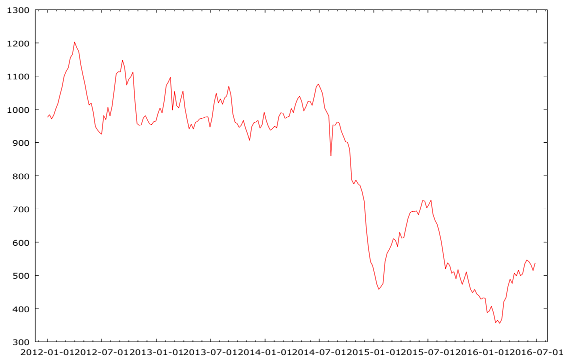
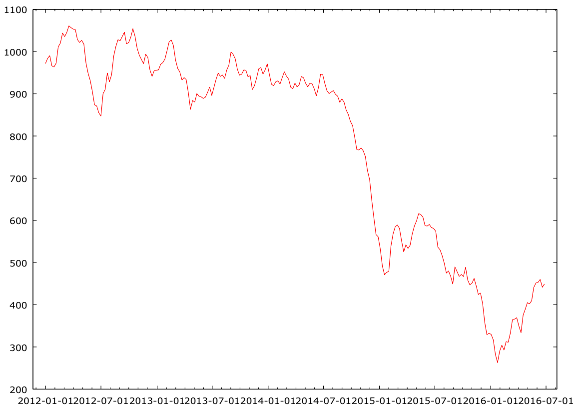
APPENDIX 1. GRAPHS OF ALL VARIABLES

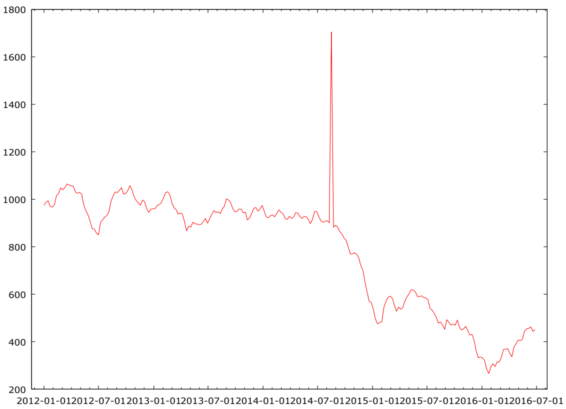


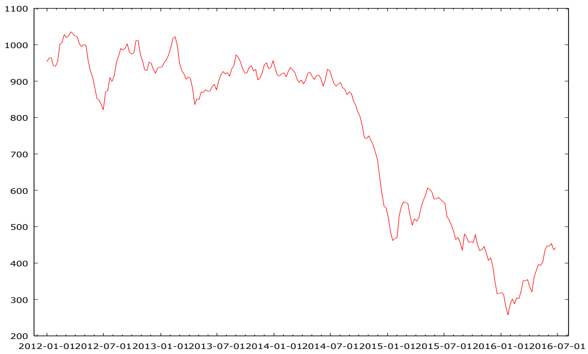












APPENDIX 2. STATIONARITY CHECK

The independent variables Price ESX50, Price EUR/USD and Euribor as well as all the dependent variables were checked for stationarity utilizing the Augmented Dickey Fuller Test. The data is non-stationary according to the test results for Price ESX50, Price EUR/USD and the dependent variables (the results are presented below) and is stationary for Euribor. To make a time series stationary the differences between consecutive observations were computed (a.k.a. differencing).

1. Augmented Dickey-Fuller test for Price_ESX50 including 10 lags of (1-L)Price_ESX50
(max was 12, criterion modified AIC), sample size 224
unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.015
lagged differences: F(10, 211) = 0.773 [0.6545]
estimated value of (a - 1): -0.0158565
test statistic: tau_ct(1) = -0.635243
asymptotic p-value 0.9766

Augmented Dickey-Fuller test for d_Price_ESX50 including one lag of (1-L)d_Price_ESX50
(max was 12, criterion modified AIC) sample size 232
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.008
estimated value of (a - 1): -1.07662
test statistic: tau_nc(1) = -11.5308
asymptotic p-value 1.375e-023

2. Augmented Dickey-Fuller test for Price_EUSD including 3 lags of (1-L)Price_EUSD
(max was 12, criterion modified AIC) sample size 231
unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.019
lagged differences: F(3, 225) = 1.970 [0.1192]
estimated value of (a - 1): -0.0186088
test statistic: tau_ct(1) = -1.37587
asymptotic p-value 0.8681

Augmented Dickey-Fuller test for d_Price_EUSD including 11 lags of (1-L)d_Price_EUSD
(max was 12, criterion modified AIC) sample size 222
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.005
lagged differences: F(11, 210) = 0.900 [0.5408]
estimated value of (a - 1): -0.888118
test statistic: tau_nc(1) = -3.69854
asymptotic p-value 0.0001

3. Augmented Dickey-Fuller test for Yield including 11 lags of (1-L)Yield
(max was 12, criterion modified AIC) sample size 223
unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.030
lagged differences: F(3, 225) = 29.086 [0.0000]
estimated value of (a - 1): -0.123353
test statistic: tau_ct(1) = -3.22731
asymptotic p-value 0.07903

4. Augmented Dickey-Fuller test for Price_GSLN10 including one lag of (1-L)Price_GSLN10
(max was 12, criterion modified AIC) sample size 233
unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.017
estimated value of (a - 1): -0.0399581
test statistic: tau_ct(1) = -2.51666
asymptotic p-value 0.3199

Augmented Dickey-Fuller test for d_Price_GSLN10 including 7 lags of (1-L)d_Price_GSLN10
(max was 12, criterion modified AIC) sample size 226
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.005
lagged differences: F(7, 218) = 0.596 [0.7588]
estimated value of (a - 1): -0.639991
test statistic: tau_nc(1) = -4.43687
asymptotic p-value 1.004e-005

5. Augmented Dickey-Fuller test for Price_ULSD10 including one lag of (1-L)Price_ULSD10
(max was 12, criterion modified AIC) sample size 233

unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.003
estimated value of (a - 1): -0.0238376
test statistic: tau_ct(1) = -2.17803
asymptotic p-value 0.5014

Augmented Dickey-Fuller test for d_Price_ULSD10 including 4 lags of (1-L)d_Price_ULSD10 (max was 12, criterion modified AIC) sample size 229
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.002
lagged differences: F(4, 224) = 0.755 [0.5558]
estimated value of (a - 1): -0.526488
test statistic: tau_nc(1) = -5.10834
asymptotic p-value 4.43e-007

6. Augmented Dickey-Fuller test for Price_Diesel10 including 3 lags of (1-L)Price_Diesel10 (max was 12, criterion modified AIC) sample size 231
unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.001
lagged differences: F(6, 219) = 9.421 [0.0000]
estimated value of (a - 1): -0.0909541
test statistic: tau_ct(1) = -2.24397
asymptotic p-value 0.4644

Augmented Dickey-Fuller test for d_Price_Diesel10 including one lag of (1-L)d_Price_Diesel10 (max was 12, criterion modified AIC) sample size 232
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.027
estimated value of (a - 1): -1.80558
test statistic: tau_nc(1) = -16.505
asymptotic p-value 2.925e-035

7. Augmented Dickey-Fuller test for Price_Gasoil01 including one lag of (1-L)Price_Gasoil01 (max was 12, criterion modified AIC) sample size 233

unit-root null hypothesis: a = 1

with constant and trend
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.002
lagged differences: F(2, 227) = 15.284 [0.0000]
estimated value of (a - 1): -0.0233327
test statistic: tau_ct(1) = -2.11907
asymptotic p-value 0.5345

Augmented Dickey-Fuller test for d_Price_Gasoil01 including 4 lags of (1-L)d_Price_Gasoil01
(max was 12, criterion modified AIC) sample size 229
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.004
lagged differences: F(4, 224) = 0.707 [0.5880]
estimated value of (a - 1): -0.545788
test statistic: tau_nc(1) = -5.19674
asymptotic p-value 2.875e-007

APPENDIX 3. COINTEGRATION

All the four regression models were checked for cointegration utilizing Engle-Granger cointegration test. The results of these tests are provided in this section. After the regressions were run, the residuals from the equations were saved and then these residuals were tested with Augmented Dickey Fuller Test. As for the first, the second tests (dependent variables – GSLN10, ULSD10, Diesel10 and Gasoil01), the residuals are stationary (according to p-value) and there is at least one cointegration relationship.

1. Augmented Dickey-Fuller test for uhat1_1 including 12 lags of (1-L)uhat1_1
(max was 12, criterion modified AIC) sample size 210
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.004
lagged differences: F(12, 197) = 0.173 [0.9992]
estimated value of (a - 1): -0.834861
test statistic: tau_nc(1) = -3.41635
asymptotic p-value 0.0006231

2. Augmented Dickey-Fuller test for uhat1_2 including 7 lags of (1-L)uhat1_2
(max was 12, criterion modified AIC) sample size 224
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.003
lagged differences: F(7, 216) = 0.805 [0.5842]
estimated value of (a - 1): -0.737361
test statistic: tau_nc(1) = -4.30867
asymptotic p-value 1.76e-005

3. Augmented Dickey-Fuller test for uhat1_3 including 7 lags of (1-L)uhat1_3
(max was 12, criterion modified AIC) sample size 224
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.001
lagged differences: F(7, 216) = 0.569 [0.7804]
estimated value of (a - 1): -0.861138
test statistic: tau_nc(1) = -4.40268
asymptotic p-value 1.167e-005

4. Augmented Dickey-Fuller test for uhat1_4 including 7 lags of (1-L)uhat1_4
(max was 12, criterion modified AIC) sample size 224
unit-root null hypothesis: a = 1

test without constant
model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: 0.002
lagged differences: F(7, 216) = 0.884 [0.5201]
estimated value of (a - 1): -0.707439
test statistic: tau_nc(1) = -4.21171
asymptotic p-value 2.67e-005