The Relationship between Spot & Future Price of Crude Oil with basic Risk & reserves Using ARCH family models

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Abstract
Oil has a Physical nature and also it is traded as financial asset in the financial markets.so different factors have effects on the Crude oil spot & future prices and these factors make this analysis very hard.
The main aim of this paper is to study the relationship between Spot & future price and also impact of the reserves & basic risk effect on those prices.
For this study we use the monthly time series data of spot & future price of West Texas
Intermediate (WTI) crude oil ,USA crude oil reserves & Basic risk between the Jan.1990 to Dec.2012.
Due to existence of Unpredictable Volatility & also Uncertainty in our variables, we use ARCH family models.
Results imply that there is positive & significant relationship between Spot & future prices.
Also the basic risk changes can affect the future & spot prices.
The American reserves of crude oil have negative effect on Spot Prices.

Keywords: Crude Oil, Spot, Future, GARCH, USA
JEL Codes: C15; C50; Q41

Introduction & literature review

Oil is a vital source of energy for the world and will likely remain so for many decades to come, even under the most optimistic assumptions about the growth in alternative energy sources. Most countries are significantly affected by developments in the oil market, either as producers, consumers, or both. In 2008, oil provided about 34% of the world's energy needs, and in the future, oil is expected to continue to provide a leading component of the world's energy mix.

The International Energy Agency (IEA) projects that oil will provide 30% of the world's energy mix in 2030. In the United States and Canada about 2/3 of oil is used for transportation. In most of the rest of the world, oil is more commonly used for space heating and power generation than for transportation. Oil is a key product for the world's agriculture industry, which helps feed the world's population of more than six billion.

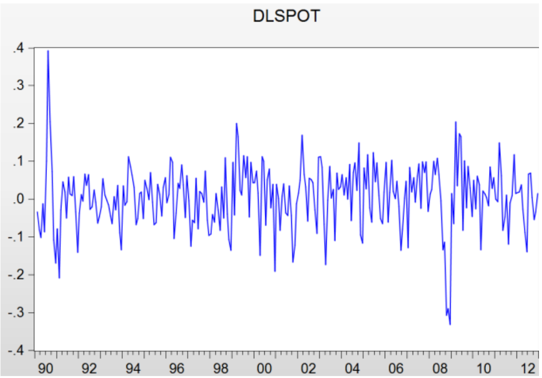
Future & spot contracts of crude oil are become very popular nowdays and they used so much in the trading of crude oil.

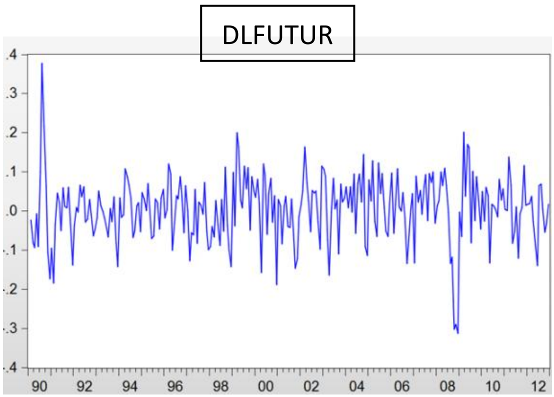
So investigate the relationship between these two prices plays very important role in energy economic studies.

There are different factors that can be effect the Market of crude oil.

But according to previous studies,the most imporatnt ones are the commercial reserves of crude oil and also the basic risk that can be computed based on the financial market.

In the most of previous studies they investigate about the causality using VAR[1] or VECM[2] models but my idea is to use ARCH family models as we have high level of volatility & uncertainty in the oil market specially in the spot & future prices as can see this high rate of volatility in the below graphs.





Ates & George H. K.,[3]examine the role of fundamentals in inter-temporal pricing relations in natural gas and heating oil spot and futures markets. Using non-linear error correction models with bivariate GARCH error process, it is found that fundamentals are the partial sources of variation in price changes in both markets. Extreme cold weather and inventory surprises affect the variation in basis, spot and futures price changes.

Furthermore, the conditional volatility of natural gas and heating oil spot and futures markets are higher in winter and lower in summer months. The conditional correlations between spot and futures markets are lower in winter and higher in summer months.

Their results are consistent with the implications from the theory of storage.

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[1] Vector Autoregressive Model
[2] Vector Error Correction Model
[3] Price Dynamics in Energy Spot and Futures Markets: The Role of Inventory and Weather, Ates , Aysegul and Wang, George H. K. (2007)

Steve Ohana[4] at his study about the price volatility in oil and natural gas market.his result indicate that The role of inventory is explaining the shape of the forward curve and spot price volatility in commodity markets.

Also he found that the slope of the forward curve can be used as a proxy for inventory in the case of oil and natural gas.

Maria Caporale[5], she investigated the role of crude oil spot and futures prices in the process of price discovery by using a cost-of-carry model.

They provide evidence that futures markets play a more important role than spot markets in the case of contracts with shorter maturities, but the relative contribution of the two types of market turns out to be highly unstable, especially for the most deferred contracts. The implications of these results for hedging and forecasting crude oil spot prices are also discussed.

Data & Methodology

We used the Monthly Spot & future prices of WTI crude oil from Jan.1990 to Dec.2012 that gathered from Energy Information Administration – EIA; also I used the data of the American commercial WTI crude oil from EIA.

And in order to Basic risk we used the 3-Month American Treasury bill Rate, Auction Average (Discounted Series)

Used Variable in this Model

DLSPOT(C)	Spot Prices of FOB[6] WTI Crude Oil $/barrel
DLFUTRE(F)	1-Monthly(Contract1)FOB future prices of WTI crude Oil $/barrel
DSTOCK(inv)	Commercial Reserves of WTI Crude Oil(Thousand Barrels)
DBASİS	3-Month Treasury Bill Rate: Auction Average (Discounted Series)

We used the Eviews7 software in order to do the tests and for run the model.

We use below two models to investigate the relationship between these variables:

$$\Delta \log C_t = \alpha_0 + \sum \alpha_i \Delta \log C_{t-i} + \sum \beta_i \Delta \log F_{t-j} + \sum \theta_k \Delta basis_{t-k} + \sum \rho_m inv_{t-m} + \varepsilon_t$$

$$\Delta \log F_t = \alpha_0 + \sum \alpha_i \Delta \log F_{t-i} + \sum \beta_j \Delta \log C_{t-j} + \sum \theta_h \Delta basis_{t-h} + \sum \rho_n inv_{t-n} + \eta_t$$

As we can seen,these two models are very simillar.

4 Forward curves, scarcity and price volatility in oil and natural gas markets, Steve Ohana(2009)

5 Time-Varying Spot and Futures Oil Prices Dynamics, Maria Caporale(2010)

6 Free on board

In the fisrt one we define the spot prices as the dependent variable and in the second Future price as dependent variable.

At begining we should check the Unit root test absed on Augmented Dickey-Fuller test as well as Correlogram for all variables.(see the appendix for result.)

We can see that the variables has unit root at level or in the other words they are non-stationary but with one lag they will be stationary(as the calculated ADF shown below)

	DLSPOT	DLFUTURE	DSTOCK	DBASIS
ADF test statistic	-12.20913	-12.15599	-14.11966	-5.520553
Critical Value at 1%	-3.454263	-3.454263	-3.454263	-3.454263
Critical Value at 5%	-2.871961	-2.871961	-2.871961	-2.871961
Critical Value at 10%	-2.572396	-2.572396	-2.572396	-2.572396

Source:calculations of the author

And then we should check the lag criteria based on Schwars(sc) or Akaike(AIC) for all variables in order to find the optimal lag.

Firstly use OLS to estimate these equation but since there is serial correlation problem as we can test by Breusch-Godfrey Serial Correlation LM Test(as shown in below), so i add AR model in order to solve this problem.

Breusch –Godfrey LM Test for Spot Prices before removal serial correlation Problem

F-Statistic	13.84272	Prob.	0.0000
Obs*R-Squared	26.17594	Prob.	0.0000

Source:calculations of the author

Breusch –Godfrey LM Test for future Prices before removal serial correlation Problem

F-Statistic	13.91048	Prob.	0.0000
Obs*R-Squared	26.29170	Prob.	0.0000

Source:calculations of the author

Breusch –Godfrey LM Test for Spot Prices after removal serial correlation Problem

F-Statistic	2.794441	Prob.	0.0631
Obs*R-Squared	5.815651	Prob.	0.0546

Source:calculations of the author

Breusch –Godfrey LM Test for future Prices after removal serial correlation Problem

F-Statistic	2.671583	Prob.	0.0711
Obs*R-Squared	5.565294	Prob.	0.0619

Source:calculations of the author

Then also check ARCH effect in the OLS residual and since there is arch effect so we try to use ARCH/GARCH models in next step that can be defined as:

AutoRegressive Conditional Heteroskedasticity or ARCH(q):

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_q \epsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2$$

generalized autoregressive conditional heteroskedasticity or GARCH(p,q):

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_q \epsilon_{t-q}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_p \sigma_{t-p}^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

In order to ACF & PCAF,then we can use the GARCH(1,1),GARCH(0,1) & ARCH(1)or maybe TARCH(1,1,1).

So we try all of them and at the end i should compare them with respect to Log-Likehihood(the model with biggest Log-Likelihood is the best).

Also we check TARCH model,this model is a asymetric model.

But since the corresponding coefficient is insignificant so it seems that the TARCH(1,1,1) can't be a proper model.

The results of the all ARCH family models for spot prices(first model) are summarized in the table as we can see in the following:

	GARCH(1,1)	GARCH(0,1)	ARCH(1)
Dlspot(-1)	-0.443454	-0.389653	0.103014
dlfuture	1.007748	1.007396	1.010044
Dlfuture(-1)	0.439062	0.386092	-0.10646
dstock	-5.37E-08	-5.49E-08	-3.21E-08
dbasis	-0.003585	-0.003626	-0.00227
Dbasis(-1)	0.003876	0.003743	0.002858
R-squared	0.997956	0.997980	0.997833
Log-likelihood	1131.308	1131.075	1144.587

Source:calculations of the author

Afetr that we run the ARCH family model we should recheck the ARCH Heteroskedasticity Test to see that is the ARCH effect still remain in the residuals or not(as shown in below):

Results of ARCH LM Test for residuals ARCH(1) model for SPOT prices

F-Statistic	0.053749	Prob.	0.8168
Obs*R-Squared	0.054145	Prob.	0.8160

Source:calculations of the author

Results of ARCH LM Test for residuals ARCH(1) model for FUTURE prices

F-Statistic	0.118240	Prob.	0.7312
Obs*R-Squared	0.119082	Prob.	0.7300

Source:calculations of the author

Results

Results of the eviews 7 software implies that the ARCH(1) is the best model since the corresponding log Likelihood is highest in both Models for Spot & Future.

Also we can say that GARCH(1,1) can't be the good model since GARCH corresponding coefficient in Variance equation(as shown in the appendix) is insignificant in both Spot & Future Prices Models.

We can see the coefficient of the previous variance in GARCH(1,1) Model which shows the persistency too is 0.81 that is very high or we can say the shocks in this model are very persistent.

The approximate 99% of R-Squared level which is very high shows that the model fits nicely.

And since the Durbin-Watson stat is close to 2 that shows there isn't serial correlation problem in the model.

According to the coeeficients of ARCH(1) model we can see that there is Positive & Significant relationship between Spot and future prices in both models.

The Reserves amount of Crude Oil has negative effect on Spot prices and that is consistent with the basic theories in Economics.

Also there is negative relationship between basic risk & spot prices,about the reason of this effect we can say When Basic Risk decreases,then uncertaintly in the market decreases and it causes an increase in the level of crude oil demand in the market then Spot prices increases consequently.

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Appendix for the software results

Null Hypothesis: DLSPOT has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.20913	0.0000
Test critical values:	1% level	-3.454085	
	5% level	-2.871883	
	10% level	-2.572354	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLSPOT)
Method: Least Squares
Date: 06/04/13 Time: 19:38
Sample (adjusted): 1990M03 2012M12
Included observations: 274 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLSPOT(-1)	-0.707685	0.057964	-12.20913	0.0000
C	0.003615	0.004920	0.734759	0.4631

R-squared	0.354016	Mean dependent var	0.000177
Adjusted R-squared	0.351641	S.D. dependent var	0.100987
S.E. of regression	0.081315	Akaike info criterion	-2.173695
Sum squared resid	1.798508	Schwarz criterion	-2.147322
Log likelihood	299.7962	Hannan-Quinn criter.	-2.163110
F-statistic	149.0629	Durbin-Watson stat	2.009234
Prob(F-statistic)	0.000000		

Null Hypothesis: DLFUTURE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.15599	0.0000
Test critical values:	1% level	-3.454085	
	5% level	-2.871883	
	10% level	-2.572354	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLFUTURE)
Method: Least Squares
Date: 06/04/13 Time: 19:41
Sample (adjusted): 1990M03 2012M12
Included observations: 274 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLFUTURE(-1)	-0.703873	0.057903	-12.15599	0.0000
C	0.003600	0.004869	0.739373	0.4603

R-squared	0.352023	Mean dependent var	0.000150
Adjusted R-squared	0.349641	S.D. dependent var	0.099772
S.E. of regression	0.080461	Akaike info criterion	-2.194820
Sum squared resid	1.760913	Schwarz criterion	-2.168447
Log likelihood	302.6903	Hannan-Quinn criter.	-2.184234
F-statistic	147.7681	Durbin-Watson stat	2.004598
Prob(F-statistic)	0.000000		

Null Hypothesis: DSTOCK has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-14.11966	0.0000
Test critical values:	1% level	-3.454085	
	5% level	-2.871883	
	10% level	-2.572354	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DSTOCK)
Method: Least Squares
Date: 06/04/13 Time: 19:42
Sample (adjusted): 1990M03 2012M12
Included observations: 274 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DSTOCK(-1)	-0.847534	0.060025	-14.11966	0.0000
C	430.4693	621.9019	0.692182	0.4894

R-squared	0.422952	Mean dependent var	-14.81387
Adjusted R-squared	0.420831	S.D. dependent var	13509.38
S.E. of regression	10281.06	Akaike info criterion	21.32127
Sum squared resid	2.88E+10	Schwarz criterion	21.34764
Log likelihood	-2919.014	Hannan-Quinn criter.	21.33185
F-statistic	199.3649	Durbin-Watson stat	1.931869
Prob(F-statistic)	0.000000		

Null Hypothesis: DBASIS has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.520553	0.0000
Test critical values:	1% level	-3.454263	
	5% level	-2.871961	
	10% level	-2.572396	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DBASIS)
Method: Least Squares
Date: 06/04/13 Time: 19:44
Sample (adjusted): 1990M05 2012M12
Included observations: 272 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DBASIS(-1)	-0.375636	0.068043	-5.520553	0.0000
D(DBASIS(-1))	-0.216328	0.067818	-3.189823	0.0016
D(DBASIS(-2))	-0.248789	0.058916	-4.222786	0.0000
C	-0.010617	0.010507	-1.010506	0.3132

R-squared	0.319609	Mean dependent var	0.000404
Adjusted R-squared	0.311992	S.D. dependent var	0.205400
S.E. of regression	0.170371	Akaike info criterion	-0.687074
Sum squared resid	7.779087	Schwarz criterion	-0.634048
Log likelihood	97.44210	Hannan-Quinn criter.	-0.665786
F-statistic	41.96368	Durbin-Watson stat	1.972687
Prob(F-statistic)	0.000000		

Lag Criteria for DLSPOT

VAR Lag Order Selection Criteria
Endogenous variables: DLSPOT
Exogenous variables: C
Date: 06/04/13 Time: 15:08
Sample: 1990M01 2012M12
Included observations: 267

Lag	LogL	LR	FPE	AIC	SC	HQ
0	293.0813	NA	0.006567	-2.187875	-2.174439	-2.182478
1	302.2653	18.23045*	0.006176*	-2.249178*	-2.222307*	-2.238384*
2	302.4600	0.385091	0.006214	-2.243146	-2.202840	-2.226956
3	302.8776	0.822537	0.006241	-2.238783	-2.185042	-2.217196
4	304.0183	2.238710	0.006234	-2.239837	-2.172660	-2.212853
5	304.3055	0.561569	0.006268	-2.234498	-2.153886	-2.202117
6	306.1119	3.517985	0.006230	-2.240538	-2.146491	-2.202760
7	306.4155	0.589069	0.006262	-2.235322	-2.127839	-2.192147
8	306.4242	0.016746	0.006309	-2.227896	-2.106978	-2.179324

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Lag Criteria for DLFUTURE

VAR Lag Order Selection Criteria
Endogenous variables: DLFUTURE
Exogenous variables: C
Date: 06/04/13 Time: 15:10
Sample: 1990M01 2012M12
Included observations: 267

Lag	LogL	LR	FPE	AIC	SC	HQ
0	295.2763	NA	0.006460	-2.204317	-2.190881	-2.198920
1	304.7607	18.82670*	0.006062*	-2.267870*	-2.241000*	-2.257077*
2	304.8939	0.263326	0.006101	-2.261377	-2.221071	-2.245187
3	305.2437	0.689175	0.006131	-2.256507	-2.202765	-2.234919
4	306.5336	2.531469	0.006118	-2.258678	-2.191502	-2.231694
5	306.7335	0.390957	0.006155	-2.252686	-2.172073	-2.220304
6	308.1997	2.855330	0.006133	-2.256177	-2.162129	-2.218399
7	308.6991	0.968914	0.006156	-2.252428	-2.144944	-2.209252
8	308.7046	0.010732	0.006202	-2.244978	-2.124060	-2.196406

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Lag Criteria for Dstock

VAR Lag Order Selection Criteria
Endogenous variables: DSTOCK
Exogenous variables: C
Date: 06/04/13 Time: 15:11
Sample: 1990M01 2012M12
Included observations: 267

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2841.218	NA	1.03e+08	21.29002	21.30346	21.29542
1	-2837.606	7.170249	1.01e+08	21.27046	21.29733*	21.28125*
2	-2837.566	0.078489	1.02e+08	21.27765	21.31796	21.29384
3	-2837.459	0.210767	1.03e+08	21.28434	21.33808	21.30593
4	-2834.210	6.375874*	1.01e+08*	21.26749*	21.33467	21.29448
5	-2833.661	1.073739	1.01e+08	21.27087	21.35148	21.30325
6	-2833.659	0.003950	1.02e+08	21.27835	21.37239	21.31612
7	-2832.473	2.300605	1.02e+08	21.27695	21.38444	21.32013
8	-2831.156	2.545101	1.02e+08	21.27458	21.39550	21.32315

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Lag Criteria for Dbasis

VAR Lag Order Selection Criteria
Endogenous variables: DBASIS
Exogenous variables: C
Date: 06/04/13 Time: 15:13
Sample: 1990M01 2012M12
Included observations: 267

Lag	LogL	LR	FPE	AIC	SC	HQ
0	52.51022	NA	0.039807	-0.385844	-0.372409	-0.380447
1	84.19215	62.88923	0.031633	-0.615672	-0.588801	-0.604878
2	84.91776	1.434910	0.031698	-0.613616	-0.573310	-0.597425
3	93.46709	16.84249	0.029956	-0.670165	-0.616424*	-0.648578
4	93.83695	0.725875	0.030097	-0.665445	-0.598268	-0.638461
5	93.92835	0.178682	0.030303	-0.658639	-0.578027	-0.626258
6	98.89541	9.673680	0.029416	-0.688355	-0.594307	-0.650577*
7	99.67752	1.517353	0.029464	-0.686723	-0.579240	-0.643548
8	101.8120	4.125147*	0.029215*	-0.695221*	-0.574303	-0.646649

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

OLS for Spot Price

Dependent Variable: DLSPOT
Method: Least Squares
Date: 06/04/13 Time: 15:31
Sample (adjusted): 1990M05 2012M12
Included observations: 272 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.60E-05	0.000259	0.100255	0.9202
DLSPOT(-1)	-0.502700	0.054334	-9.252067	0.0000
DLFUTURE	1.009100	0.003203	315.0665	0.0000
DLFUTURE(-1)	0.500719	0.054742	9.146877	0.0000
DSTOCK	-5.14E-08	2.59E-08	-1.983569	0.0483
DSTOCK(-1)	-2.37E-08	2.57E-08	-0.922756	0.3570
DBASIS	-0.004301	0.001522	-2.825723	0.0051
DBASIS(-1)	0.003048	0.001600	1.904367	0.0580
DBASIS(-2)	0.001153	0.001610	0.716420	0.4744
DBASIS(-3)	0.001002	0.001494	0.670708	0.5030

R-squared	0.997688	Mean dependent var	0.005742
Adjusted R-squared	0.997608	S.D. dependent var	0.084781
S.E. of regression	0.004146	Akaike info criterion	-8.097155
Sum squared resid	0.004504	Schwarz criterion	-7.964588
Log likelihood	1111.213	Hannan-Quinn criter.	-8.043934
F-statistic	12560.41	Durbin-Watson stat	2.270574
Prob(F-statistic)	0.000000		

Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	13.84272	Prob. F(2,260)	0.0000
Obs*R-squared	26.17594	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/04/13 Time: 15:33
Sample: 1990M05 2012M12
Included observations: 272
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.22E-05	0.000247	0.049299	0.9607
DLSPOT(-1)	0.111504	0.175949	0.633731	0.5268
DLFUTURE	0.000730	0.003073	0.237452	0.8125
DLFUTURE(-1)	-0.111964	0.177577	-0.630509	0.5289
DSTOCK	-6.61E-09	2.48E-08	-0.266156	0.7903
DSTOCK(-1)	-1.45E-08	2.58E-08	-0.560420	0.5757
DBASIS	-0.000219	0.001457	-0.150239	0.8807
DBASIS(-1)	0.000642	0.001663	0.385982	0.6998
DBASIS(-2)	-0.000782	0.001767	-0.442656	0.6584
DBASIS(-3)	0.000220	0.001440	0.152626	0.8788
RESID(-1)	-0.294903	0.172907	-1.705562	0.0893
RESID(-2)	-0.222404	0.108378	-2.052118	0.0412

R-squared	0.096235	Mean dependent var	2.25E-19
Adjusted R-squared	0.057999	S.D. dependent var	0.004077
S.E. of regression	0.003957	Akaike info criterion	-8.183635
Sum squared resid	0.004071	Schwarz criterion	-8.024555
Log likelihood	1124.974	Hannan-Quinn criter.	-8.119770
F-statistic	2.516857	Durbin-Watson stat	2.039794
Prob(F-statistic)	0.004998		

Heteroskedasticity Test

Heteroskedasticity Test: ARCH

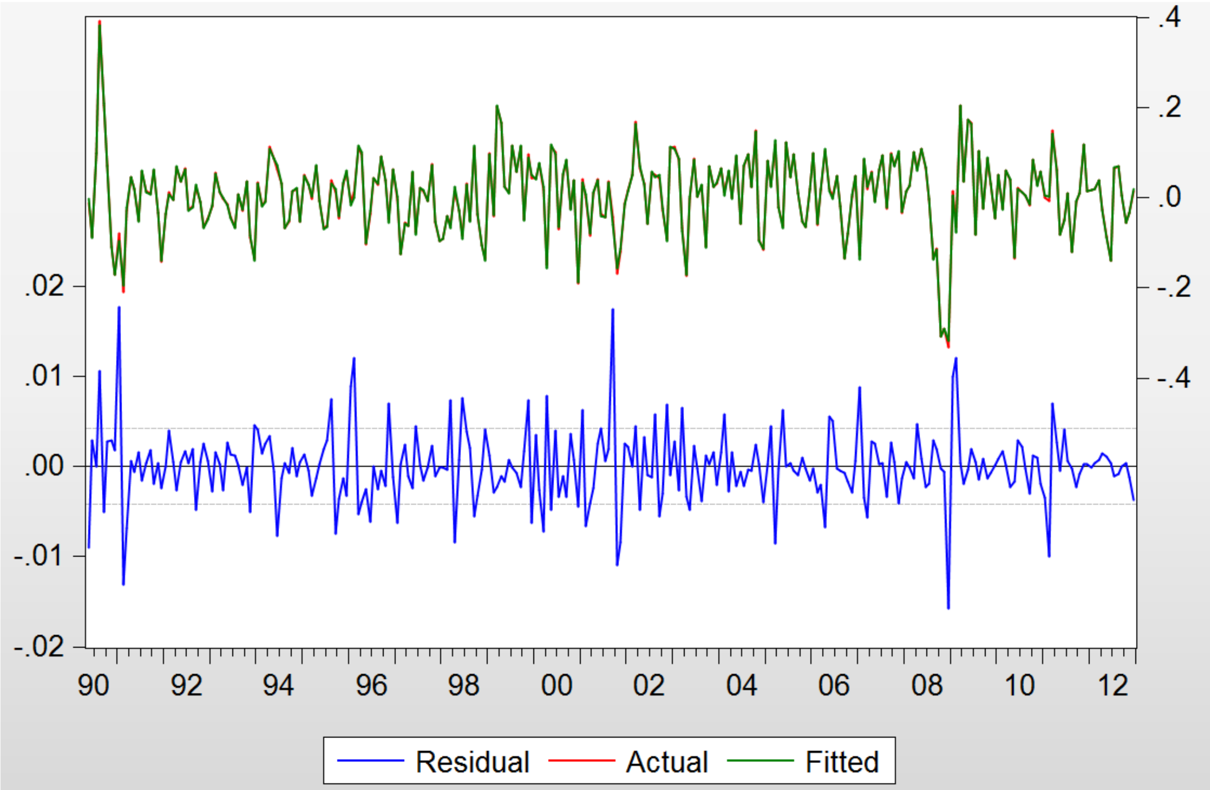
F-statistic	36.13710	Prob. F(1,269)	0.0000
Obs*R-squared	32.09428	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/04/13 Time: 15:35
Sample (adjusted): 1990M06 2012M12
Included observations: 271 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.06E-05	2.37E-06	4.494975	0.0000
RESID^2(-1)	0.342264	0.056936	6.011415	0.0000

R-squared	0.118429	Mean dependent var	1.63E-05
Adjusted R-squared	0.115152	S.D. dependent var	3.80E-05
S.E. of regression	3.58E-05	Akaike info criterion	-17.63169
Sum squared resid	3.44E-07	Schwarz criterion	-17.60510
Log likelihood	2391.094	Hannan-Quinn criter.	-17.62101
F-statistic	36.13710	Durbin-Watson stat	1.985539
Prob(F-statistic)	0.000000		

Residuals of OLS Model



After Remove Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.794441	Prob. F(2,251)	0.0631
Obs*R-squared	5.815651	Prob. Chi-Square(2)	0.0546

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/04/13 Time: 16:51
Sample: 1990M10 2012M12
Included observations: 267
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.17E-06	8.00E-05	0.039621	0.9684
DLSPOT(-1)	0.081412	0.211873	0.384247	0.7011
DLFUTURE	8.93E-05	0.002972	0.030053	0.9760
DLFUTURE(-1)	-0.082391	0.213030	-0.386757	0.6993
DSTOCK	1.59E-09	1.90E-08	0.083928	0.9332
DBASIS	0.000393	0.001338	0.293738	0.7692
DBASIS(-1)	-0.000285	0.001332	-0.214085	0.8307
AR(1)	-0.014989	0.512468	-0.029248	0.9767
AR(2)	0.598459	0.319569	1.872706	0.0623
AR(3)	0.257735	0.230667	1.117348	0.2649
AR(4)	0.218824	0.167108	1.309477	0.1916
AR(5)	0.145326	0.168516	0.862389	0.3893
AR(6)	0.154467	0.106025	1.456890	0.1464
AR(7)	0.036233	0.099577	0.363871	0.7163
RESID(-1)	-0.071184	0.505890	-0.140711	0.8882
RESID(-2)	-0.614823	0.263585	-2.332542	0.0205

R-squared	0.021781	Mean dependent var	-8.04E-15
Adjusted R-squared	-0.036678	S.D. dependent var	0.003618
S.E. of regression	0.003684	Akaike info criterion	-8.311490
Sum squared resid	0.003407	Schwarz criterion	-8.096524
Log likelihood	1125.584	Hannan-Quinn criter.	-8.225139
F-statistic	0.372592	Durbin-Watson stat	2.014479
Prob(F-statistic)	0.984779		

GARCH(1,1) for Spot

Dependent Variable: DLSPOT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/04/13 Time: 18:22
Sample (adjusted): 1990M10 2012M12
Included observations: 267 after adjustments
Convergence achieved after 93 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(15) + C(16)*RESID(-1)^2 + C(17)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.54E-06	8.09E-05	0.031412	0.9749
DLSPOT(-1)	-0.443454	0.246686	-1.797649	0.0722
DLFUTURE	1.007748	0.002899	347.6272	0.0000
DLFUTURE(-1)	0.439062	0.248178	1.769141	0.0769
DSTOCK	-5.37E-08	1.87E-08	-2.868614	0.0041
DBASIS	-0.003585	0.001456	-2.462862	0.0138
DBASIS(-1)	0.003876	0.001578	2.456135	0.0140
AR(1)	-0.387961	0.248689	-1.560024	0.1188
AR(2)	-0.490126	0.062208	-7.878772	0.0000
AR(3)	-0.322131	0.142382	-2.262438	0.0237
AR(4)	-0.376078	0.069306	-5.426362	0.0000
AR(5)	-0.229947	0.097252	-2.364455	0.0181
AR(6)	-0.221125	0.062808	-3.520645	0.0004
AR(7)	-0.099661	0.069119	-1.441871	0.1493
Variance Equation				
C	2.45E-06	6.52E-07	3.751036	0.0002
RESID(-1)^2	-0.019840	0.018330	-1.082426	0.2791
GARCH(-1)	0.810156	0.051319	15.78680	0.0000

R-squared	0.997956	Mean dependent var	0.003610
Adjusted R-squared	0.997851	S.D. dependent var	0.080884
S.E. of regression	0.003750	Akaike info criterion	-8.346875
Sum squared resid	0.003558	Schwarz criterion	-8.118474
Log likelihood	1131.308	Hannan-Quinn criter.	-8.255128
Durbin-Watson stat	1.861487		

Inverted AR Roots	.58+.59i	.58-.59i	.01+.74i	.01-.74i
	-.51	-.52-.50i	-.52+.50i	

Heteroskedasticity Test

Heteroskedasticity Test: ARCH

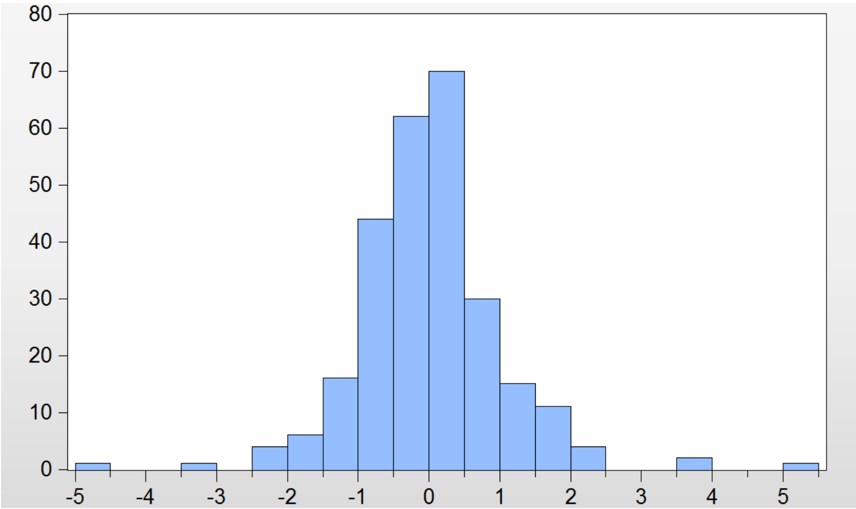
F-statistic	0.228792	Prob. F(1,264)	0.6328
Obs*R-squared	0.230325	Prob. Chi-Square(1)	0.6313

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 06/04/13 Time: 18:25
Sample (adjusted): 1990M11 2012M12
Included observations: 266 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.988746	0.180853	5.467130	0.0000
WGT_RESID^2(-1)	0.029426	0.061519	0.478322	0.6328

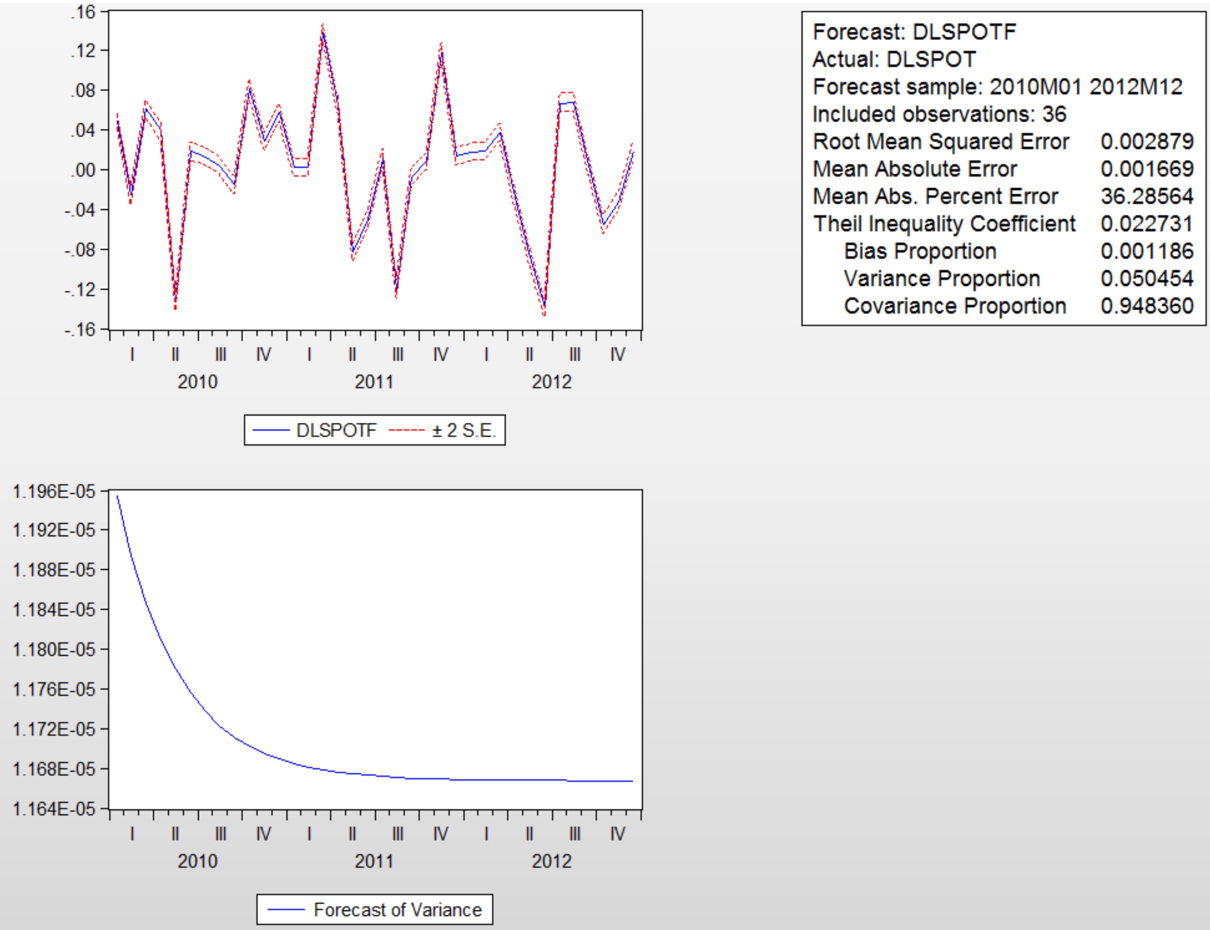
R-squared	0.000866	Mean dependent var	1.018606
Adjusted R-squared	-0.002919	S.D. dependent var	2.764298
S.E. of regression	2.768329	Akaike info criterion	4.881856
Sum squared resid	2023.203	Schwarz criterion	4.908799
Log likelihood	-647.2868	Hannan-Quinn criter.	4.892680
F-statistic	0.228792	Durbin-Watson stat	2.000169
Prob(F-statistic)	0.632817		

Normality Test

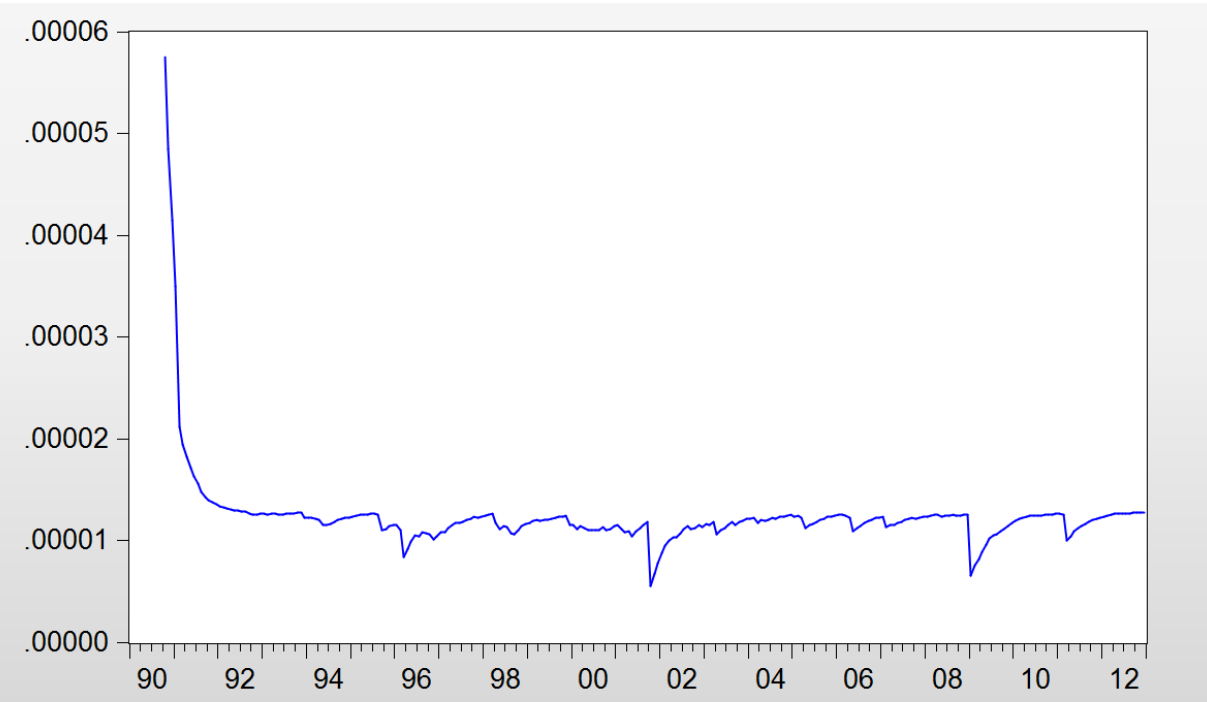


Series: Standardized Residuals	
Sample 1990M10 2012M12	
Observations 267	
Mean	0.015257
Median	-0.003820
Maximum	5.263933
Minimum	-4.944811
Std. Dev.	1.010060
Skewness	0.365186
Kurtosis	8.319314
Jarque-Bera	320.7176
Probability	0.000000

Dynamic forecasting



Volatility



GARCH(0,1) for SPOTS

Dependent Variable: DLSPOT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/04/13 Time: 20:52
Sample (adjusted): 1990M10 2012M12
Included observations: 267 after adjustments
Convergence achieved after 76 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(15) + C(16)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.05E-06	8.23E-05	0.012808	0.9898
DLSPOT(-1)	-0.389653	0.265581	-1.467174	0.1423
DLFUTURE	1.007396	0.002801	359.6334	0.0000
DLFUTURE(-1)	0.386092	0.267137	1.445298	0.1484
DSTOCK	-5.49E-08	1.88E-08	-2.911660	0.0036
DBASIS	-0.003626	0.001435	-2.526782	0.0115
DBASIS(-1)	0.003743	0.001606	2.330227	0.0198
AR(1)	-0.404472	0.268168	-1.508278	0.1315
AR(2)	-0.455386	0.068803	-6.618695	0.0000
AR(3)	-0.312872	0.139440	-2.243769	0.0248
AR(4)	-0.352099	0.079203	-4.445526	0.0000
AR(5)	-0.212960	0.099656	-2.136947	0.0326
AR(6)	-0.207100	0.069565	-2.977059	0.0029
AR(7)	-0.092685	0.069250	-1.338418	0.1808
		Variance Equation		
C	2.37E-06	7.11E-07	3.338626	0.0008
GARCH(-1)	0.794483	0.057567	13.80107	0.0000

R-squared	0.997980	Mean dependent var	0.003610
Adjusted R-squared	0.997876	S.D. dependent var	0.080884
S.E. of regression	0.003727	Akaike info criterion	-8.352624
Sum squared resid	0.003515	Schwarz criterion	-8.137658
Log likelihood	1131.075	Hannan-Quinn criter.	-8.266274
Durbin-Watson stat	1.948074		

Inverted AR Roots	.57+.58i	.57-.58i	.01+.73i	.01-.73i
	-.51	-.53-.49i	-.53+.49i	

ARCH(1) for Spot

Dependent Variable: DLSPOT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/04/13 Time: 19:08
Sample (adjusted): 1990M10 2012M12
Included observations: 267 after adjustments
Convergence achieved after 57 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(15) + C(16)*RESID(-1)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-6.29E-05	5.01E-05	-1.256225	0.2090
DLSPOT(-1)	0.103014	0.199271	0.516952	0.6052
DLFUTURE	1.010044	0.001802	560.5845	0.0000
DLFUTURE(-1)	-0.106469	0.201318	-0.528859	0.5969
DSTOCK	-3.21E-08	1.01E-08	-3.179561	0.0015
DBASIS	-0.002271	0.000914	-2.485094	0.0130
DBASIS(-1)	0.002858	0.000820	3.484890	0.0005
AR(1)	-0.807274	0.207251	-3.895149	0.0001
AR(2)	-0.636597	0.192472	-3.307477	0.0009
AR(3)	-0.472857	0.154860	-3.053435	0.0023
AR(4)	-0.383406	0.114852	-3.338256	0.0008
AR(5)	-0.246324	0.098878	-2.491181	0.0127
AR(6)	-0.151981	0.067853	-2.239868	0.0251
AR(7)	-0.112324	0.047341	-2.372669	0.0177
		Variance Equation		
C	4.99E-06	5.81E-07	8.589508	0.0000
RESID(-1)^2	1.020454	0.177006	5.765067	0.0000

R-squared	0.997833	Mean dependent var	0.003610
Adjusted R-squared	0.997722	S.D. dependent var	0.080884
S.E. of regression	0.003860	Akaike info criterion	-8.453836
Sum squared resid	0.003770	Schwarz criterion	-8.238870
Log likelihood	1144.587	Hannan-Quinn criter.	-8.367486
Durbin-Watson stat	2.055155		

Inverted AR Roots	.48+.54i	.48-.54i	.01+.71i	.01-.71i
	-.53+.54i	-.53-.54i	-.73	

Heteroskedasticity Test

Heteroskedasticity Test: ARCH

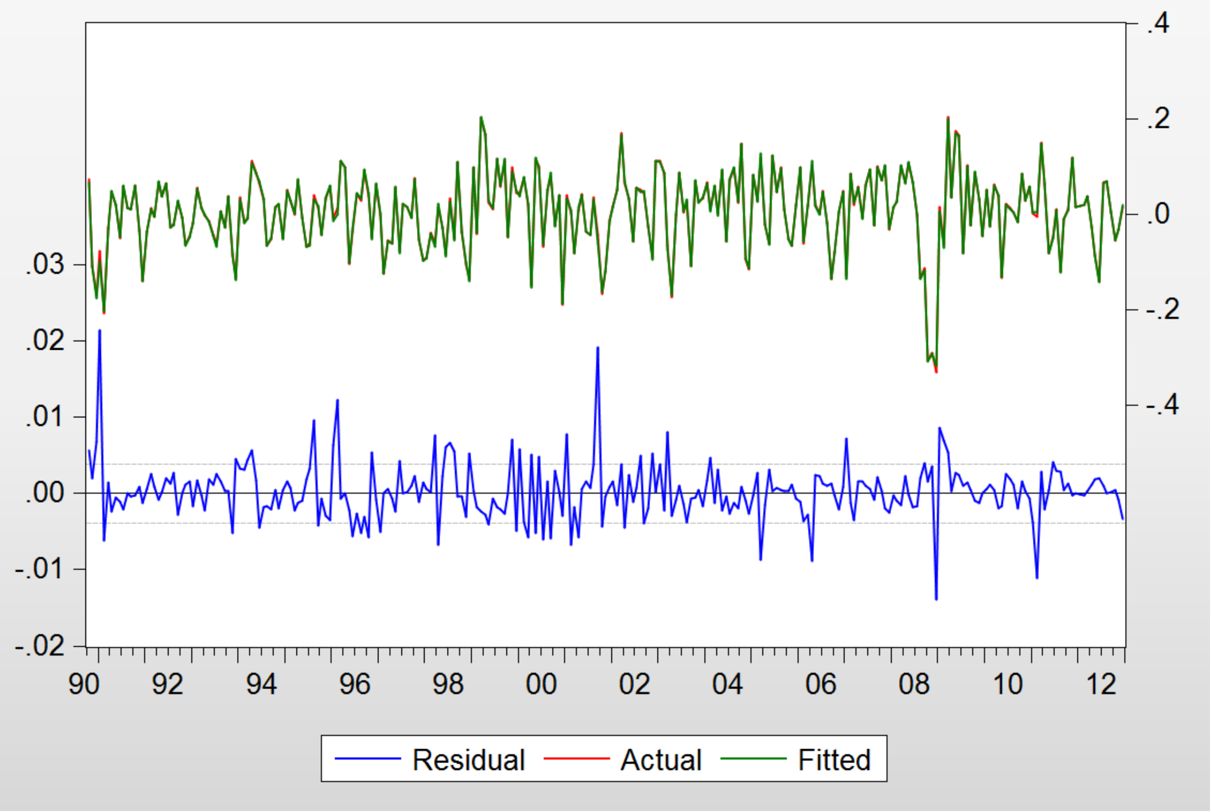
F-statistic	0.053749	Prob. F(1,264)	0.8168
Obs*R-squared	0.054145	Prob. Chi-Square(1)	0.8160

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 06/04/13 Time: 19:09
Sample (adjusted): 1990M11 2012M12
Included observations: 266 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.016702	0.140628	7.229706	0.0000
WGT_RESID^2(-1)	-0.014272	0.061559	-0.231837	0.8168

R-squared	0.000204	Mean dependent var	1.002481
Adjusted R-squared	-0.003584	S.D. dependent var	2.060178
S.E. of regression	2.063866	Akaike info criterion	4.294529
Sum squared resid	1124.519	Schwarz criterion	4.321473
Log likelihood	-569.1724	Hannan-Quinn criter.	4.305353
F-statistic	0.053749	Durbin-Watson stat	2.000796
Prob(F-statistic)	0.816844		

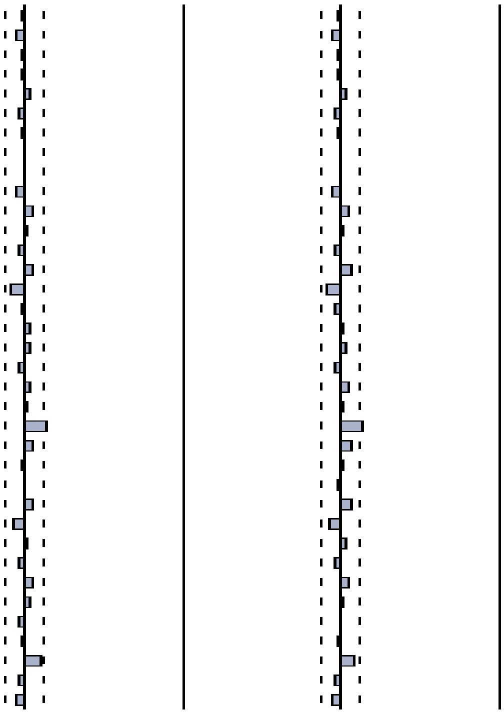
Residuals



Correlogram of Residuals Squared

Date: 06/04/13 Time: 19:13
Sample: 1990M10 2012M12
Included observations: 267
Q-statistic probabilities adjusted for 7 ARMA term(s)

Autocorrelation / Partial Correlation



	AC	PAC	Q-Stat	Prob
1	-0.014	-0.014	0.0549	
2	-0.053	-0.053	0.8048	
3	-0.021	-0.023	0.9274	
4	-0.011	-0.014	0.9581	
5	0.039	0.037	1.3805	
6	-0.043	-0.043	1.8825	
7	-0.014	-0.012	1.9345	
8	0.001	-0.002	1.9349	0.164
9	-0.005	-0.007	1.9412	0.379
10	-0.060	-0.064	2.9485	0.400
11	0.057	0.058	3.8582	0.426
12	0.023	0.017	4.0050	0.549
13	-0.041	-0.039	4.4843	0.611
14	0.064	0.067	5.6558	0.580
15	-0.092	-0.090	8.0694	0.427
16	-0.024	-0.031	8.2351	0.511
17	0.028	0.023	8.4548	0.585
18	0.030	0.031	8.7091	0.649
19	-0.029	-0.040	8.9560	0.707
20	0.041	0.055	9.4401	0.739
21	0.014	0.016	9.4958	0.798
22	0.147	0.147	15.809	0.395
23	0.064	0.066	17.018	0.384
24	-0.022	0.015	17.163	0.443
25	-0.004	-0.013	17.168	0.512
26	0.065	0.082	18.419	0.495
27	-0.071	-0.067	19.926	0.463
28	0.021	0.028	20.053	0.518
29	-0.039	-0.035	20.519	0.551
30	0.042	0.053	21.047	0.578
31	0.039	0.024	21.511	0.608
32	-0.038	-0.008	21.952	0.638
33	-0.010	-0.011	21.986	0.689
34	0.104	0.094	25.331	0.556
35	-0.034	-0.032	25.700	0.590
36	-0.058	-0.050	26.732	0.586

Test for assymetric data: TARCH (1,1,1)

Dependent Variable: DLSPOT
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/04/13 Time: 18:59
Sample (adjusted): 1990M10 2012M12
Included observations: 267 after adjustments
Convergence achieved after 289 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(15) + C(16)*RESID(-1)^2 + C(17)*RESID(-1)^2*(RESID(-1)<0)
+ C(18)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000136	9.67E-05	1.407994	0.1591
DLSPOT(-1)	-0.597756	0.097675	-6.119840	0.0000
DLFUTURE	1.002778	0.002001	501.2270	0.0000
DLFUTURE(-1)	0.593288	0.098297	6.035660	0.0000
DSTOCK	-4.40E-08	1.76E-08	-2.496335	0.0125
DBASIS	-0.003257	0.001082	-3.010927	0.0026
DBASIS(-1)	0.002435	0.001182	2.059679	0.0394
AR(1)	-0.058279	0.114341	-0.509696	0.6103
AR(2)	-0.431764	0.070751	-6.102590	0.0000
AR(3)	-0.135096	0.084582	-1.597226	0.1102
AR(4)	-0.341622	0.055842	-6.117716	0.0000
AR(5)	-0.219132	0.068323	-3.207294	0.0013
AR(6)	-0.299772	0.036137	-8.295381	0.0000
AR(7)	0.039738	0.059170	0.671593	0.5018
Variance Equation				
C	5.56E-06	1.18E-06	4.720097	0.0000
RESID(-1)^2	0.820435	0.209236	3.921101	0.0001
RESID(-1)^2*(RESID(-1)<0)	0.373393	0.337336	1.106886	0.2683
GARCH(-1)	-0.005296	0.052585	-0.100716	0.9198

R-squared	0.997751	Mean dependent var	0.003610
Adjusted R-squared	0.997636	S.D. dependent var	0.080884
S.E. of regression	0.003933	Akaike info criterion	-8.374637
Sum squared resid	0.003914	Schwarz criterion	-8.132800
Log likelihood	1136.014	Hannan-Quinn criter.	-8.277493
Durbin-Watson stat	2.060426		

Inverted AR Roots	.64-.62i	.64+.62i	.12	-.10-.83i
	-.10+.83i	-.64+.44i	-.64-.44i	