Durham University

ARCH AND GARCH MODELS IN EVIEWS - PRACTICAL NOTES COMPUTER LAB 3

Financial Modelling and Business Forcecasting

2015 / 2016

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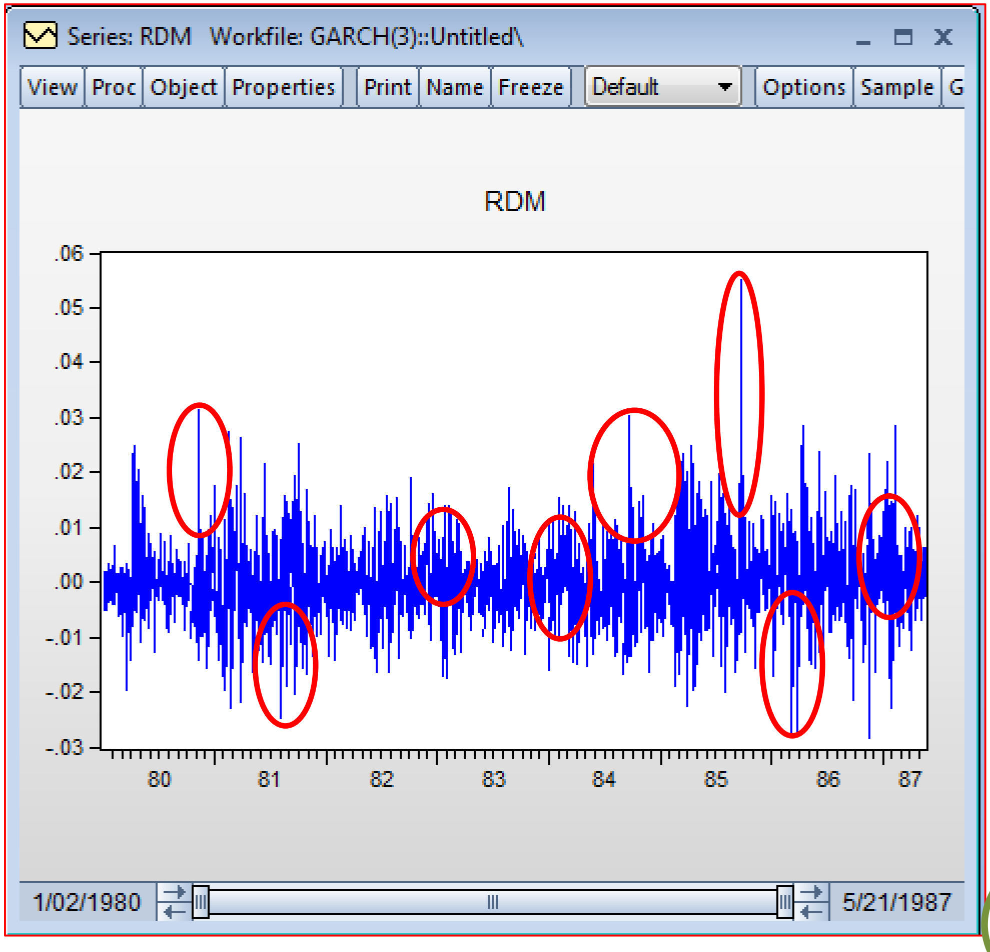
Eviews Practicals – Time Series

- **Computer Lab 1:**
  - Box-Jenkins Methodology,
  - Unit Root Tests
- **Computer Lab 2:**
  - Cointegration Tests (Engle-Granger & Johansen)
- **Computer Lab 3:**
  - *ARCH/GARCH Modelling*
  - *Forecasting from GARCH Models*
- **Computer Lab 4:**
  - Practice Review

Computer Lab 3 – ARCH/ GARCH

- To plot « rdm », double-click on the « rdm » series. Click View > Graph > Ok.



You can see few periods where the exchange rate returns seem tranquil alongside periods with large increases and decreases in the market. Such series are called conditionally heteroskedastic if the unconditional (or long run) variance is constant but there are periods in which the variance is relatively high.
(For more, see Enders (2004), Chapter 3) & Brooks (2014) Chapter 9.

Note the **volatility Clustering** in this graph: volatility tends to be positively correlated with its level during the immediately preceding periods

Computer Lab 3 – ARCH/ GARCH

Estimation of AR(1) model

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: Least Squares
Date: 03/12/16 Time: 19:21
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.97E-05	0.000169	-0.116494	0.9073
AR(1)	-0.059975	0.023125	-2.593520	0.0096

R-squared	0.003598	Mean dependent var	-1.96E-05
Adjusted R-squared	0.003063	S.D. dependent var	0.007770
S.E. of regression	0.007758	Akaike info criterion	-6.879037
Sum squared resid	0.112136	Schwarz criterion	-6.873105
Log likelihood	6416.702	Hannan-Quinn criter.	-6.876851
F-statistic	6.726345	Durbin-Watson stat	1.996127
Prob(F-statistic)	0.009574		

Inverted AR Roots	-.06

ARCH (6) model: Shows existence of ARCH effects (We are rejecting H_0 here)

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Heteroskedasticity Test: ARCH

F-statistic	13.76245	Prob. F(6,1852)	0.0000
Obs*R-squared	79.34891	Prob. Chi-Square(6)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/12/16 Time: 19:22
Sample (adjusted): 1/14/1980 5/21/1987
Included observations: 1859 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.63E-05	4.01E-06	9.043649	0.0000
RESID^2(-1)	0.072848	0.023044	3.161237	0.0016
RESID^2(-2)	0.051576	0.023058	2.236758	0.0254
RESID^2(-3)	0.038979	0.023068	1.689751	0.0912
RESID^2(-4)	0.042468	0.023068	1.840974	0.0658
RESID^2(-5)	0.064232	0.023058	2.785648	0.0054
RESID^2(-6)	0.128593	0.023043	5.580464	0.0000

R-squared	0.042684	Mean dependent var	6.03E-05
Adjusted R-squared	0.039582	S.D. dependent var	0.000126
S.E. of regression	0.000123	Akaike info criterion	-15.16421
Sum squared resid	2.80E-05	Schwarz criterion	-15.14339
Log likelihood	14102.13	Hannan-Quinn criter.	-15.15654
F-statistic	13.76245	Durbin-Watson stat	2.004508
Prob(F-statistic)	0.000000		

Computer Lab 3 – ARCH/ GARCH – Page 5

Estimation of ARCH (6) model

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 19:58
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 11 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-2)^2 + C(6)*RESID(-3)^2
+ C(7)*RESID(-4)^2 + C(8)*RESID(-5)^2 + C(9)*RESID(-6)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000109	0.000140	-0.783516	0.4333
AR(1)	-0.065058	0.024079	-2.701881	0.0069
Variance Equation				
C	2.24E-05	1.86E-06	12.01492	0.0000
RESID(-1)^2	0.095966	0.021928	4.376424	0.0000
RESID(-2)^2	0.080338	0.021396	3.754789	0.0002
RESID(-3)^2	0.124318	0.026144	4.755130	0.0000
RESID(-4)^2	0.136790	0.028370	4.821698	0.0000
RESID(-5)^2	0.124778	0.029011	4.301115	0.0000
RESID(-6)^2	0.102632	0.022601	4.540943	0.0000

R-squared	0.003421	Mean dependent var	-1.96E-05
Adjusted R-squared	0.002886	S.D. dependent var	0.007770
S.E. of regression	0.007759	Akaike info criterion	-6.976573
Sum squared resid	0.112156	Schwarz criterion	-6.949882
Log likelihood	6514.655	Hannan-Quinn criter.	-6.966738
Durbin-Watson stat	1.985341		

Inverted AR Roots	-.07

Mean Equation model output (we run ARCH on the residuals of this equation)

ARCH Equation:
Note that all of these coefficients are statistically significant

We will need to look at the IC to decide for the best fitted model among all the ones we are trying, that is ARCH, GARCH, GJR-GARCH and EGARCH (i.e the one that minimizes the AIC, SIC, HQIC)

GARCH – Page 6

Estimation of GARCH (1,1) model

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 20:28
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 10 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000222	0.000135	-1.644172	0.1001
AR(1)	-0.078108	0.025072	-3.115312	0.0018
Variance Equation				
C	1.31E-06	3.41E-07	3.857059	0.0001
RESID(-1)^2	0.101188	0.010809	9.361857	0.0000
GARCH(-1)	0.881806	0.013051	67.56476	0.0000

R-squared	0.002478	Mean dependent var	-1.96E-05
Adjusted R-squared	0.001943	S.D. dependent var	0.007770
S.E. of regression	0.007763	Akaike info criterion	-6.998451
Sum squared resid	0.112262	Schwarz criterion	-6.983622
Log likelihood	6531.055	Hannan-Quinn criter.	-6.992987
Durbin-Watson stat	1.957207		

Inverted AR Roots	-.08

The variance intercept term “c” is very small,
The ARCH parameter is 0.10
The GARCH parameter is 0.88

The coefficients on the lagged squared error (ARCH term) and the lagged conditional variance are <u>highly significant</u>

The sum of the coefficients on the lagged squared error (ARCH term) and the lagged conditional variance is **<u>very close to unity</u>** (about 0.98). This implies that <u>shocks</u> to the conditional variance will be **<u>highly persistent</u>** > Such large sums will imply that a large positive (or large negative) return will lead future forecasts of the variance to be high for an extended period. See more in Brooks (2014), Chapter 9.

GJR-GARCH – Page 7

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 21:55
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 10 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000290	0.000148	-1.963970	0.0495
AR(1)	-0.078218	0.024887	-3.142882	0.0017
Variance Equation				
C	1.05E-06	3.12E-07	3.371450	0.0007
RESID(-1)^2	0.078403	0.011342	6.912471	0.0000
RESID(-1)^2*(RESID(-1)<0)	0.034773	0.014465	2.404015	0.0162
GARCH(-1)	0.892826	0.012568	71.03789	0.0000

R-squared	0.001854	Mean dependent var	-1.96E-05
Adjusted R-squared	0.001318	S.D. dependent var	0.007770
S.E. of regression	0.007765	Akaike info criterion	-6.999506
Sum squared resid	0.112332	Schwarz criterion	-6.981712
Log likelihood	6533.039	Hannan-Quinn criter.	-6.992949
Durbin-Watson stat	1.955766		

Inverted AR Roots -.08

The GJR Specification, the asymmetry term is **positive** and **highly significant**

The estimate indicates that negative shocks imply a higher next period conditional variance than negative shocks of the same sign

EGARCH – Page 8-9

Equation: UNTITLED   Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16   Time: 22:34
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 11 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
    *RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000314	0.000145	-2.169099	0.0301
AR(1)	-0.082236	0.024145	-3.405867	0.0007
Variance Equation				
C(3)	-0.418916	0.075316	-5.562085	0.0000
C(4)	0.196645	0.019921	9.871341	0.0000
C(5)	-0.019000	0.009381	-2.025374	0.0428
C(6)	0.972646	0.006865	141.6762	0.0000

R-squared	0.001425	Mean dependent var	-1.96E-05
Adjusted R-squared	0.000889	S.D. dependent var	0.007770
S.E. of regression	0.007767	Akaike info criterion	-7.002333
Sum squared resid	0.112381	Schwarz criterion	-6.984539
Log likelihood	6535.676	Hannan-Quinn criter.	-6.995776
Durbin-Watson stat	1.946998		

Inverted AR Roots	-.08

The estimate is **significant** but has a **negative sign**: which is the opposite of our found result in GJR-GARCH (caution when interpreting results then)

The EGARCH result suggests that a strengthening dollar (weakening DM) leads to **higher next period volatility** than when the DM strengthens by the same amount (vice versa for the GJR)

Relevant questions to ask:

- Do the result for GJR and EGARCH match our expectations for the time series under study (here exchange rate returns)?
- What effects can explain the asymmetries in the context of exchange rate returns (Leverage effects, volatility feedback?)?

A positive return shock implies more Deutsche Mark per Dollar, therefore a strengthening dollar and a weakening DM.

GARCH-in-Mean, Page 10 (ARCH-M, Std Dev)

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 23:00
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 12 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
@SQRT(GARCH)	0.244695	0.087546	2.795034	0.0052
C	-0.001847	0.000595	-3.101392	0.0019
AR(1)	-0.085665	0.025174	-3.402917	0.0007
Variance Equation				
C	1.23E-06	3.19E-07	3.865632	0.0001
RESID(-1)^2	0.098935	0.010504	9.418936	0.0000
GARCH(-1)	0.885149	0.012378	71.50928	0.0000

R-squared	0.008327	Mean dependent var	-1.96E-05
Adjusted R-squared	0.007262	S.D. dependent var	0.007770
S.E. of regression	0.007742	Akaike info criterion	-7.002372
Sum squared resid	0.111604	Schwarz criterion	-6.984578
Log likelihood	6535.712	Hannan-Quinn criter.	-6.995816
Durbin-Watson stat	1.958257		

Inverted AR Roots -.09

The estimated parameter in the mean equation has a positive sign and is statistically significant: this means that there is feedback from the conditional variance to the conditional mean, which also comforts that risk and return are positively correlated

- ARCH term is statistically significant: This means that the ARCH effects (previous squared residuals) can influence the volatility of RDM,
- GARCH term is also statistically significant: this means that the volatility of the previous period affects the volatility of RDM

ARCH-M, Variance ---- ARCH-M, Log (Var)

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 23:02
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 13 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
GARCH	15.71648	5.904249	2.661892	0.0078
C	-0.000969	0.000304	-3.186633	0.0014
AR(1)	-0.086602	0.025170	-3.440729	0.0006
Variance Equation				
C	1.24E-06	3.21E-07	3.870716	0.0001
RESID(-1)^2	0.098954	0.010479	9.442854	0.0000
GARCH(-1)	0.884995	0.012385	71.45897	0.0000

R-squared	0.007702	Mean dependent var	-1.96E-05
Adjusted R-squared	0.006636	S.D. dependent var	0.007770
S.E. of regression	0.007744	Akaike info criterion	-7.002194
Sum squared resid	0.111674	Schwarz criterion	-6.984400
Log likelihood	6535.546	Hannan-Quinn criter.	-6.995638
Durbin-Watson stat	1.958761		

Inverted AR Roots -.09

Equation: UNTITLED Workfile: GARCH(3)::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: RDM
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/12/16 Time: 23:03
Sample (adjusted): 1/04/1980 5/21/1987
Included observations: 1865 after adjustments
Convergence achieved after 10 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
LOG(GARCH)	0.000821	0.000299	2.744274	0.0061
C	0.008070	0.003019	2.673102	0.0075
AR(1)	-0.085285	0.025114	-3.395921	0.0007
Variance Equation				
C	1.24E-06	3.21E-07	3.870447	0.0001
RESID(-1)^2	0.098684	0.010520	9.380760	0.0000
GARCH(-1)	0.885182	0.012436	71.17952	0.0000

R-squared	0.008179	Mean dependent var	-1.96E-05
Adjusted R-squared	0.007114	S.D. dependent var	0.007770
S.E. of regression	0.007743	Akaike info criterion	-7.002208
Sum squared resid	0.111620	Schwarz criterion	-6.984414
Log likelihood	6535.559	Hannan-Quinn criter.	-6.995652
Durbin-Watson stat	1.956490		

Inverted AR Roots -.09

About the best-fitted volatility model

Important Note:

About the "Diagnostic Checking":
You can perform a "diagnostic check" after obtaining each of these results to check again for:

- Existence/absence of serial correlation,
- Existence/absence of ARCH effects,
- Normality distribution of the residuals

These rules help decide which model is best fitted.
(You can test for these using the "View" tab in the model window > Residual Diagnostics then choose the test you want to run each time (Correlogram of squared residuals, ARCH LM Test or Normality test)

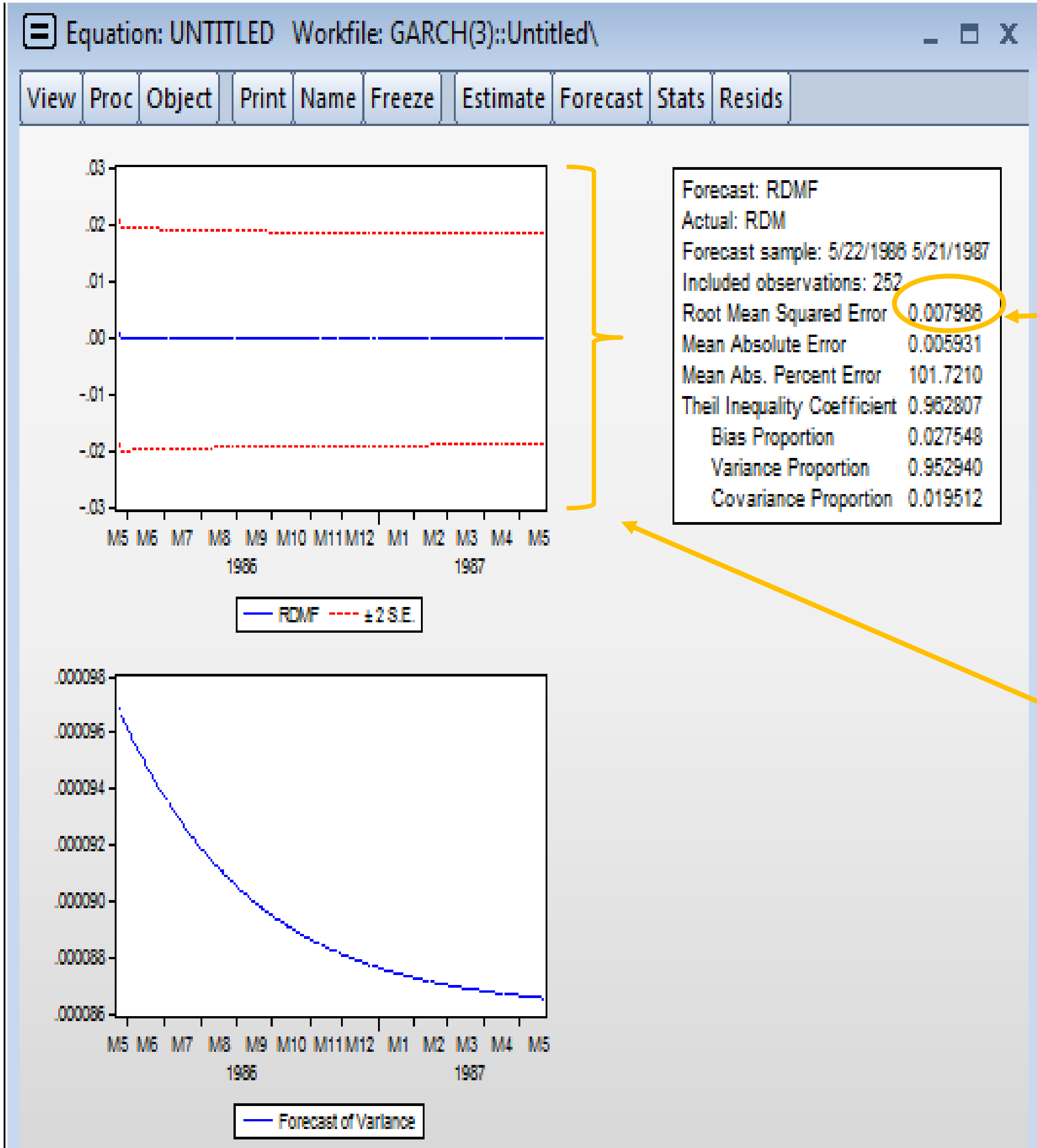
Additional Note:

GARCH-type models can be used to forecast volatility. GARCH describes movements in the conditional variance of an error term, u_t.
It can be proven that the conditional variance of "y" given its previous values is the same as the conditional variance of u given its previous values.

☺ This means that modelling σ^2_t will give models and forecasts for the variance of y_t as well.

(See Brooks 2014, Chapter 9)

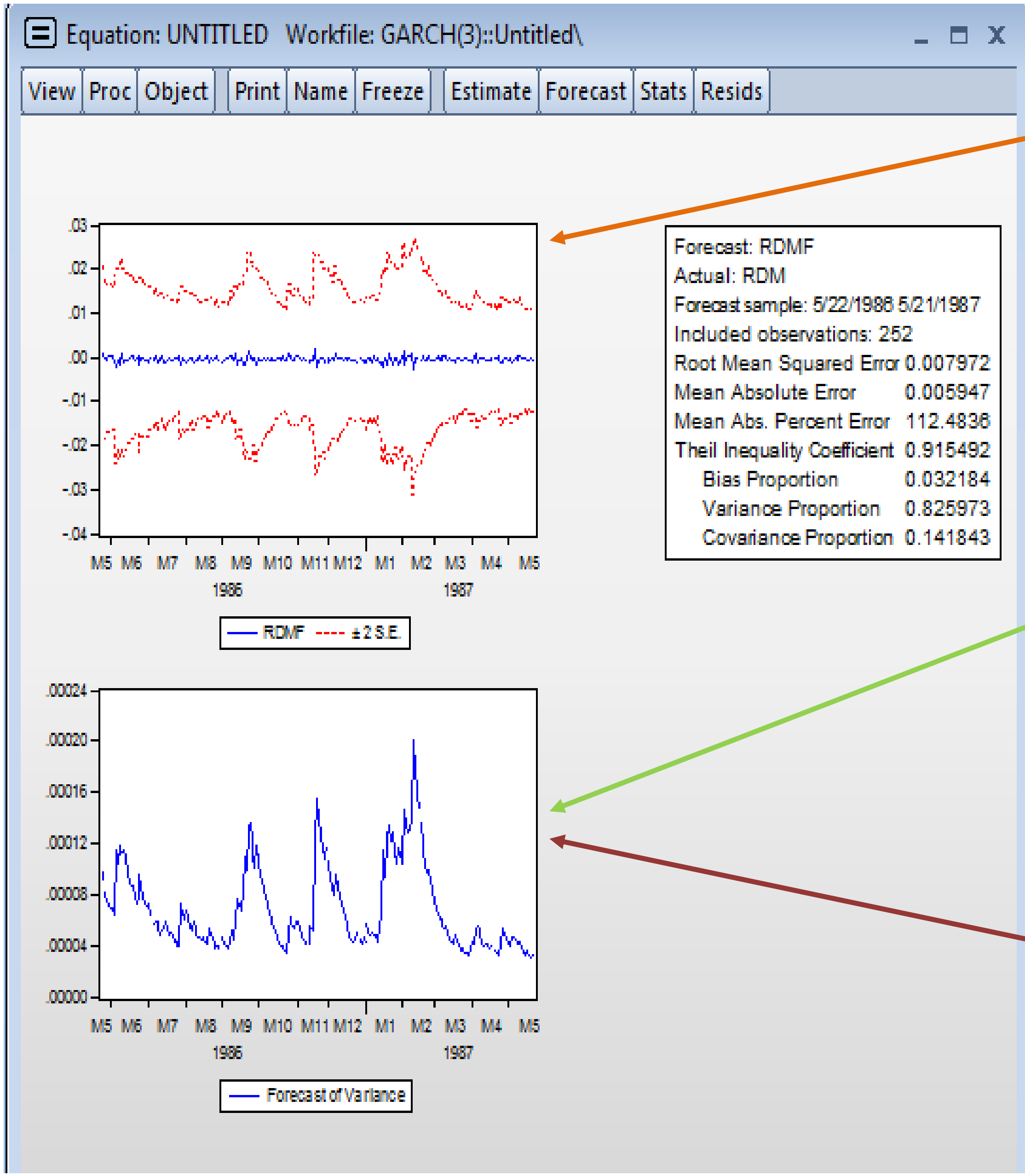
Forecasting from GARCH, Page 13



The smallest Root Mean Squared Error means that the model makes good forecast. This is because: the RMSE represents the forecasting error between the forecasted dependent variable and the actual dependent variable.

The blue line (conditional mean forecast) passes through the two red lines (standard error bands) of the 95% confidence interval

Forecasting from GARCH, Page 14



As can be seen in the Forecast Variance below, the volatility results in more variability in the standard errors bars around the conditional mean forecasts.

The variance forecasts are not really stable showing spikes in M9 and M11 during 1986 and in M1 and M2 during 1987, after these months the variance forecasts is quite low.

The static forecasts show more volatility than the dynamic forecasts since these are a series of rolling one-step ahead forecasts for the conditional variance.

Main References

- Brooks (2014), Chapter 9 “Modeling Volatility and Correlation”, 03rd Edition Cambridge
- Enders (2004), Chapter 3 “Modeling Volatility”, 02nd Edition Wiley.
- Eviews tutorials and help / forum pages online. http://blog.eviews.com/ and http://www.eviews.com/help/helpintro.html