JÖNKÖPING UNIVERSITY
Jönköping International Business School

AMEFA 2022 – Assignment 2

COURSE: *FSSS23 - Analytical Methods for Economic and Financial Analysis*

PROGRAMME: *International Financial Analysis*

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All calculations were made with EViews Version 12 LITE

Q.2.1. – Vector Autoregressive Models – Granger Causality Tests

Q.2.1.1

For this exercise we test at 10% significance level.

Notice: We included the following command in the exercise:

Genr dx1 = d(x1)

Genr dy = d(y)

We also calculated this exercise without this command, since the variables were already given, and received different results (which are not included in this assignment due to space), but those did not change the conclusions.

1. Determine the optimal lag-length for the bivariate VAR model

VAR Lag Order Selection Criteria
Endogenous variables: DX1 DY
Exogenous variables: C
Date: 02/27/22 Time: 11:13
Sample: 1971 2006
Included observations: 30

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-155.8823	NA	127.7124	10.52549	10.61890	10.55537
1	-128.5174	49.25681*	26.93464*	8.967826*	9.248066*	9.057477*
2	-127.2650	2.087326	32.50921	9.151000	9.618065	9.300418
3	-124.4351	4.339098	35.54395	9.229010	9.882902	9.438196
4	-123.4306	1.406321	44.30215	9.428709	10.26943	9.697662
5	-121.3521	2.632831	52.07322	9.556805	10.58435	9.885526

* 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

As can be seen from the output above, 1 lag seems to be the optimal lag length, since that is the lag at which e.g., the AIC is the lowest.

2. Estimating the bivariate VAR (1) model

Vector Autoregression Estimates
Date: 02/27/22 Time: 11:20
Sample (adjusted): 1973 2006
Included observations: 34 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DX1	DY
DX1(-1)	0.938717	526010.8
	(0.08975)	(262627.)
	[10.4594]	[2.00288]
DY(-1)	-6.19E-08	0.399910
	(5.6E-08)	(0.16456)
	[-1.10075]	[2.43014]
C	0.000547	807.9827
	(0.00037)	(1075.26)
	[1.48751]	[0.75143]
R-squared	0.796414	0.348918
Adj. R-squared	0.783279	0.306913
Sum sq. resids	4.78E-05	4.09E+08
S.E. equation	0.001241	3632.937
F-statistic	60.63479	8.306536
Log likelihood	180.8354	-325.3987
Akaike AIC	-10.46091	19.31757
Schwarz SC	-10.32623	19.45225
Mean dependent	0.003534	4218.773
S.D. dependent	0.002667	4363.791
Determinant resid covariance (dof adj.)		20.11609
Determinant resid covariance		16.72280
Log likelihood		-144.3730
Akaike information criterion		8.845468
Schwarz criterion		9.114826
Number of coefficients		6

This is the same as estimating two OLS regressions separately.

ls dx1 c dy(-1) dx1(-1)

Dependent Variable: DX1
Method: Least Squares
Date: 02/27/22 Time: 11:25
Sample (adjusted): 1973 2006
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000547	0.000367	1.487506	0.1470
DY(-1)	-6.19E-08	5.62E-08	-1.100747	0.2795
DX1(-1)	0.938717	0.089748	10.45944	0.0000
R-squared	0.796414	Mean dependent var		0.003534

ls dy c dy(-1) dx1(-1)

Dependent Variable: DY
Method: Least Squares
Date: 02/27/22 Time: 11:26
Sample (adjusted): 1973 2006
Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	807.9827	1075.256	0.751433	0.4581
DY(-1)	0.399910	0.164562	2.430144	0.0211
DX1(-1)	526010.8	262627.0	2.002882	0.0540
R-squared	0.348918	Mean dependent var		4218.773

3. Autocorrelation test - checking if the residuals are white noise for the VAR model

VAR Residual Serial Correlation LM Tests
Date: 02/27/22 Time: 11:32
Sample: 1971 2006
Included observations: 34

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	2.432982	4	0.6567	0.610511	(4, 56.0)	0.6568
2	3.765263	4	0.4387	0.956030	(4, 56.0)	0.4388
3	4.020541	4	0.4032	1.023162	(4, 56.0)	0.4034
4	3.706774	4	0.4471	0.940691	(4, 56.0)	0.4473
5	4.068222	4	0.3969	1.035734	(4, 56.0)	0.3970
6	1.437500	4	0.8377	0.357560	(4, 56.0)	0.8377
7	5.223774	4	0.2651	1.343662	(4, 56.0)	0.2652
8	0.444972	4	0.9786	0.109719	(4, 56.0)	0.9786
9	4.372678	4	0.3579	1.116260	(4, 56.0)	0.3581
10	5.341517	4	0.2540	1.375390	(4, 56.0)	0.2542

H_0: No autocorrelation up to the specified lag

H_1: Autocorrelation up to the specified lag

As can be seen in the output above, all p-values (corresponding to F-statistic) are higher than 10% (> 0.10), which indicates that we cannot reject H_0.

Therefore, it can be concluded that there is no autocorrelation in the residuals.

4. Jarque-Bera normality test

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 02/27/22 Time: 11:40
Sample: 1971 2006
Included observations: 34

Component	Skewness	Chi-sq	df	Prob.*
1	0.310127	0.545011	1	0.4604
2	-0.333312	0.629547	1	0.4275
Joint		1.174559	2	0.5558

Component	Kurtosis	Chi-sq	df	Prob.
1	2.460556	0.412249	1	0.5208
2	2.439400	0.445218	1	0.5046
Joint		0.857468	2	0.6513

Component	Jarque-B...	df	Prob.
1	0.957261	2	0.6196
2	1.074766	2	0.5843
Joint	2.032026	4	0.7299

*Approximate p-values do not account for coefficient estimation

H0: Normally distributed residuals

H1: Non normally distributed residuals

The third section shows the Jarque-Bera statistic with 0.957261 for the first component and a p-value of 0.6196 > 0.10 and a Jarque-Bera statistic of 1.074766 and a p-value of 0.5843 > 0.10 for the second component.

The joint test also shows a p-value of 0.7299 > 0.10 (Jarque-Bera 2.032026).

Therefore, we cannot reject H0 and can conclude normal distribution of the residuals.

5. Estimating a Granger causality test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 02/27/22 Time: 11:50
Sample: 1971 2006
Included observations: 34

Dependent variable: DX1

Excluded	Chi-sq	df	Prob.
DY	1.211644	1	0.2710
All	1.211644	1	0.2710

Dependent variable: DY

Excluded	Chi-sq	df	Prob.
DX1	4.011536	1	0.0452
All	4.011536	1	0.0452

First test hypothesis for the upper section: Dependent variable: **dx1**

H_0: **dy** does not Granger cause **dx1**

H_1: **dy** does Granger cause **dx1**

We have a chi-squared statistic of 1.211644 and a p-value of 0.2710 which is greater than 0.10 (10% significance level).

Therefore, we cannot reject H_0, which indicates that **dy** does not Granger cause **dx1**.

Second test hypothesis for the lower section: Dependent variable: **dy**

H_0: **dx1** does not Granger cause **dy**

H_1: **dx1** does Granger cause **dy**

We have a chi-squared statistic of 4.011536 and a p-value of 0.0452, which is less than 0.10.

Therefore, we reject H_0 and conclude that **dx1** does Granger cause **dy**.

Conclusion: geographic concentration (dx1) drives economic growth (dy), while there is no significant support for a relationship in the opposite direction.

Q.2.1.2

Now the significance level is 5%

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 02/27/22 Time: 11:50
Sample: 1971 2006
Included observations: 34

Dependent variable: DX1

Excluded	Chi-sq	df	Prob.
DY	1.211644	1	0.2710
All	1.211644	1	0.2710

Dependent variable: DY

Excluded	Chi-sq	df	Prob.
DX1	4.011536	1	0.0452
All	4.011536	1	0.0452

First test hypothesis for the upper section: Dependent variable: **dx1**

H_0: **dy** does not Granger cause **dx1**

H_1: **dy** does Granger cause **dx1**

We have a chi-squared statistic of 1.211644 and a p-value of 0.2710 which is greater than 0.05 (5% significance level).

Therefore, we cannot reject H_0, which indicates that **dy** does not Granger cause **dx1**.

Second test hypothesis for the lower section: Dependent variable: **dy**

H_0: **dx1** does not Granger cause **dy**

H_1: **dx1** does Granger cause **dy**

We have a chi-squared statistic of 4.011536 and a p-value of 0.0452, which is less than 0.05.

Therefore, we reject H_0 and conclude that **dx1** does Granger cause **dy**.

Conclusion: geographic concentration (dx1) drives economic growth (dy), while there is no significant support for a relationship in the opposite direction. So applying the 5% significance level yields the same conclusion as above.

Q.2.1.3

Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: HAWAII_HILO HAWAII_MANOA
Exogenous variables: C
Date: 02/27/22 Time: 12:25
Sample: 1971 2008
Included observations: 19

Lag	LogL	LR	FPE	AIC	SC	HQ
0	59.22779	NA	8.30e-06	-6.023978	-5.924563	-6.007153
1	73.01263	23.21657*	2.98e-06*	-7.053961*	-6.755717*	-7.003486*
2	74.30561	1.905453	4.04e-06	-6.769012	-6.271939	-6.684887
3	78.77473	5.645199	4.03e-06	-6.818392	-6.122490	-6.700618

* 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

According to the AIC, SC and HQ 1 lag is the optimal lag length, since the value is the lowest one for all the criterion (negative number).

Since the variable Manoa ~ I(1), that is first differenced, and we conclude that m=1, we add 1 extra lag due to Toda and Yamamoto.

This means we estimate the entire VAR with 2 lags (due to p+m=2)

Vector Autoregression Estimates
Date: 02/27/22 Time: 12:36
Sample (adjusted): 1988 2007
Included observations: 20 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	HAWAII_HILO	HAWAII_MANOA
HAWAII_HILO(-1)	-0.094356	-0.031490
	(0.25971)	(0.09239)
	[-0.36331]	[-0.34084]
HAWAII_MANOA(-1)	1.293265	0.717118
	(0.69086)	(0.24577)
	[1.87196]	[2.91783]
C	-1.570207	0.551688
	(1.10799)	(0.39416)
	[-1.41717]	[1.39964]
HAWAII_HILO(-2)	-0.208884	0.044457
	(0.22189)	(0.07894)
	[-0.94140]	[0.56320]
HAWAII_MANOA(-2)	0.494515	0.087778
	(0.81651)	(0.29047)
	[0.60564]	[0.30219]
R-squared	0.558493	0.793501
Adj. R-squared	0.440758	0.738435
Sum sq. resids	0.064484	0.008161
S.E. equation	0.065566	0.023325
F-statistic	4.743643	14.40991
Log likelihood	28.99189	49.66264
Akaike AIC	-2.399189	-4.466264
Schwarz SC	-2.150256	-4.217331
Mean dependent	2.861500	2.972000
S.D. dependent	0.087676	0.045607
Determinant resid covariance (dof adj.)		2.32E-06
Determinant resid covariance		1.31E-06
Log likelihood		78.72774
Akaike information criterion		-6.872774
Schwarz criterion		-6.374907
Number of coefficients		10

Causality tests:

First test:

H_0: Manoa GPA does not Granger cause Hilo GPA

H_1: Manoa GPA does Granger cause Hilo GPA

Wald Test:
Equation: EQ1

Test Statistic	Value	df	Probability
t-statistic	1.871961	15	0.0808
F-statistic	3.504238	(1, 15)	0.0808
Chi-square	3.504238	1	0.0612

Null Hypothesis: C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	1.293265	0.690861

Restrictions are linear in coefficients.

As seen above, the chi-squared statistic is 3.504238; d.o.f. = 1; p-value of 0.0612 > 0.05 and therefore, we accept H_0.

This indicates that, at the 5% significance level, Manoa GPA does not Granger cause Hilo GPA.

Second test:

H_0: Hilo GPA does not Granger cause Manoa GPA

H_1: Hilo GPA does Granger cause Manoa GPA

Wald Test:
Equation: EQ2

Test Statistic	Value	df	Probability
t-statistic	-0.340838	15	0.7380
F-statistic	0.116170	(1, 15)	0.7380
Chi-square	0.116170	1	0.7332

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.031490	0.092391

Restrictions are linear in coefficients.

As seen above the chi-squared statistic is 0.116170; d.o.f. =1; p-value of 0.7332 > 0.05 and therefore, we accept H_0.

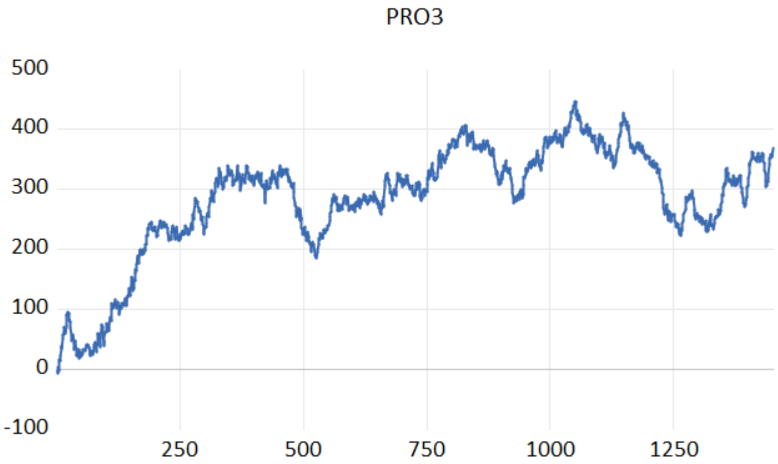
Accordingly, Hilo GPA does not granger cause Manoa GPA, at the 5% significance level.

Conclusion: Over the period of 1971 to 2008, neither the grade inflation in Manoa nor the grade inflation in Hilo caused the opposite to start inflating their grades too.

Q.2.2

Q.2.2 Pro3

For this data set we assume that we are dealing with the GDP of an industrialized country



This means that we can assume that y_t is growing, which can also be assumed when looking at the plot.

1.1 Augmented Dicked Fuller Test

h_0:ρ=1 $Unit\ root\ (non-stationary)$

h_1:ρ<1 $No\ unit\ root\ (stationary)$

Null Hypothesis: PRO3 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.696645	0.2381
Test critical values:	1% level	-3.964390	
	5% level	-3.412914	
	10% level	-3.128449	

Since the p-value is 0.2381 > 0.05 we cannot reject h_0, meaning that we assume at least one unit root.

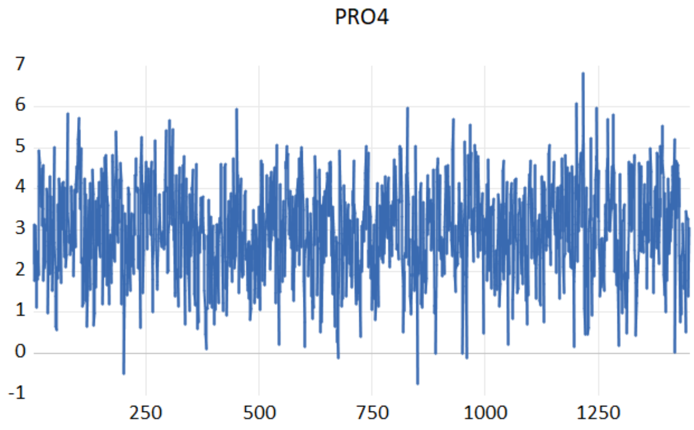
This also implies that β=0. We can assume a stochastic trend which is created where α≠0, because we know that y_t grows over time and only α can induce this drift.

Conclusion: ρ=1 (unit root), αnot equal 0 (drift, stochastic trend since ρ=1), β = 0

⇨ Process 3

Q.2.2 Pro4

For this data set we assume that we are dealing with a "rate-variable".



This means that we can assume that y_t is not growing

1.2 Augmented Dicked Fuller Test

h_0:ρ=1 $Unit\ root\ (non-stationary)$

h_1:ρ<1 $No\ unit\ root\ (stationary)$

Null Hypothesis: PRO4 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-22.54065	0.0000
Test critical values:	1% level	-3.964390	
	5% level	-3.412914	
	10% level	-3.128449	

Since the p-value is 0 < 0.05 we must reject h_0 and must assume that there is no unit root.

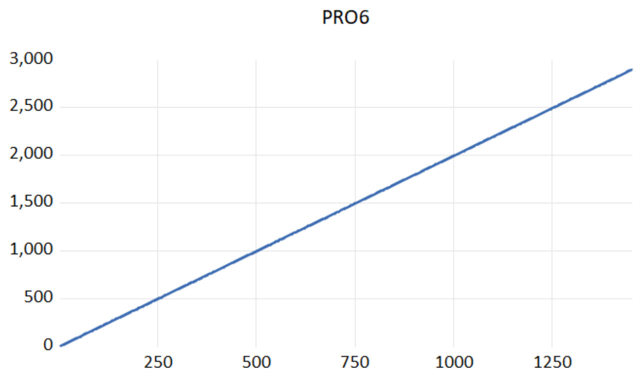
This means that we believe in stationarity (ρ<1). This also means that we can assume that $\alpha \neq 0$.

Conclusion: ρ<1 (no unit root) $\alpha \neq 0$ (just a constant, no drift since ρ<1), and β=0 (no deterministic trend)

⇨ Process 4

Q.2.2 Pro4

For this data set we assume that we are dealing with consumption of an industrialized country.



This means that we can assume that y_t is growing.

1.3 Augmented Dicked Fuller Test

h_0:ρ=1 $Unit\ root\ (non-stationary)$

h_1:ρ<1 $No\ unit\ root\ (stationary)$

Null Hypothesis: PRO6 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-22.21218	0.0000
Test critical values:	1% level	-3.964390	
	5% level	-3.412914	
	10% level	-3.128449	

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

Since the p-value is 0< 0.05 we must reject h_0 and must assume that there is no unit root.

This means that we believe in stationarity (ρ<1). This also implies that β≠0.

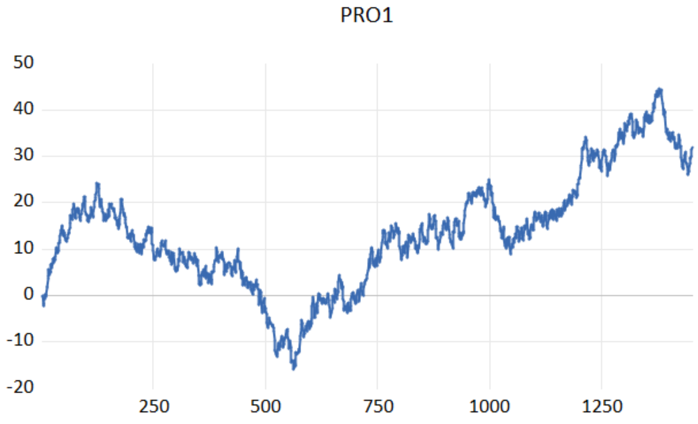
Conclusion: ρ<1 (no unit root) and α≠0 (just a constant, no drift since ρ<1) and & β≠0 (deterministic trend).

⇨ Process 6

This also makes sense when looking at the plot, which looks like it has a deterministic trend.

Q.2.2 Pro1

For this data set we have no prior knowledge.



Since the growth status is unknown, we use "Case 3" in the Elder & Kennedy approach.

1.4 Augmented Dicked Fuller Test

h_0:ρ=1 *Unit root (non − stationary)*

h_1:ρ<1 *No unit root (stationary)*

Null Hypothesis: PRO1 has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.909046	0.6492
Test critical values:	1% level	-3.964390	
	5% level	-3.412914	
	10% level	-3.128449	

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

Since the p-value is 0.6492 > 0.05 we cannot reject h_0, which means that we must assume at least one unit root.

We still cannot conclude whether we have a stochastic or deterministic trend since we have no prior knowledge. To come to a conclusion, we regress Δ(pro1) on only an intercept. A significant trend would mean that there is a trend that is causing a constant increase, which would manifest itself in a statistically significant intercept.

$\Delta yt = \alpha + \varepsilon t$

Dependent Variable: D(PRO1)
Method: Least Squares
Date: 03/06/22 Time: 13:21
Sample: 2 1450
Included observations: 1449

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.022021	0.026579	0.828523	0.4075

R-squared	0.000000	Mean dependent var	0.022021
Adjusted R-squared	0.000000	S.D. dependent var	1.011745
S.E. of regression	1.011745	Akaike info criterion	2.861919
Sum squared resid	1482.212	Schwarz criterion	2.865562
Log likelihood	-2072.460	Hannan-Quinn criter.	2.863279
Durbin-Watson stat	2.053751		

Since the p-value of the intercept is 0.4075>0.05 we must assume no drift and no stochastic trend.

Conclusion2: $\rho=1$ (unit root), $\alpha=0$ (no drift, no stochastic trend since $\rho=1$), $\beta = 0$

- ➔ Pure random walk
- ⇨ Process 1

Q.2.3

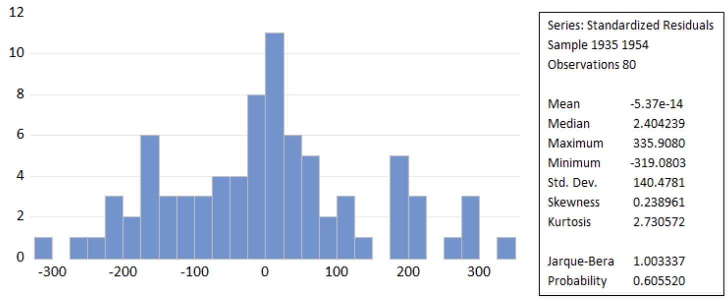
1. All Coefficients are constant across Time and Individuals

Dependent Variable: Y
Method: Panel Least Squares
Date: 03/06/22 Time: 11:46
Sample: 1935 1954
Periods included: 20
Cross-sections included: 4
Total panel (balanced) observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-63.36773	29.58691	-2.141749	0.0354
X2	0.110168	0.013724	8.027358	0.0000
X3	0.303384	0.049282	6.156023	0.0000

R-squared	0.756938	Mean dependent var	290.8871
Adjusted R-squared	0.750624	S.D. dependent var	284.9375
S.E. of regression	142.2908	Akaike info criterion	12.79040
Sum squared resid	1558993.	Schwarz criterion	12.87973
Log likelihood	-508.6160	Hannan-Quinn criter.	12.82621
F-statistic	119.8956	Durbin-Watson stat	0.218229
Prob(F-statistic)	0.000000		

1.1 Test the residuals for normality



$h_0: Normaly\ distributed\ residuals$

$h_1: Not\ normaly\ distributed\ residuals$

Since the p-value is 0.61 > 0.10 we cannot reject h_0 and must assume a normal distribution.

2. Slope coefficients are constant, but the intercept varies across individuals

$Y_{it} = \beta_{1i} + \beta_2 * X_{2it} + \beta_3 * X_{3it} + u_{it}$

The i after the intercept indicates that each firm has a specific intercept now.

We can also calculate this regression by adding dummy terms:

$Y_{it} = \alpha_1 + \alpha_2 * D_{2i} + \alpha_3 * D_{3i} + \alpha_4 * D_{4i} + \beta_{1i} + \beta_2 * X_{2it} + \beta_3 * X_{3it} + u_{it}$

We only add 3 dummy terms because we use the intercept of the fourth company as a base, so that the terms show the "distance" to the base intercept.

Either way, the results of the regression are the same, that's why we skipped the normality test in this step and conducted it in the next step (3.).

Dependent Variable: Y
Method: Panel Least Squares
Date: 03/06/22 Time: 11:57
Sample: 1935 1954
Periods included: 20
Cross-sections included: 4
Total panel (balanced) observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-73.91292	37.51846	-1.970041	0.0526
X2	0.108013	0.017518	6.165864	0.0000
X3	0.346202	0.026656	12.98764	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.934703	Mean dependent var	290.8871
Adjusted R-squared	0.930291	S.D. dependent var	284.9375
S.E. of regression	75.23044	Akaike info criterion	11.55103
Sum squared resid	418811.8	Schwarz criterion	11.72968
Log likelihood	-456.0411	Hannan-Quinn criter.	11.62265
F-statistic	211.8570	Durbin-Watson stat	0.805529
Prob(F-statistic)	0.000000		

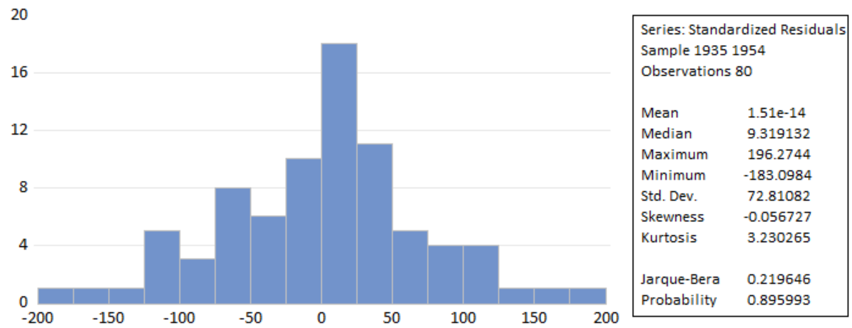
3. Slope coefficients are constant, but the intercept varies across individuals by Least-Squares Dummy Variable

Dependent Variable: Y
Method: Panel Least Squares
Date: 03/06/22 Time: 12:05
Sample: 1935 1954
Periods included: 20
Cross-sections included: 4
Total panel (balanced) observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-245.6495	35.76948	-6.867573	0.0000
DUMGM	161.1416	46.50371	3.465135	0.0009
DUMUS	339.4758	23.97041	14.16229	0.0000
DUMWEST	186.3290	31.47026	5.920796	0.0000
X2	0.108013	0.017518	6.165864	0.0000
X3	0.346202	0.026656	12.98764	0.0000

R-squared	0.934703	Mean dependent var	290.8871
Adjusted R-squared	0.930291	S.D. dependent var	284.9375
S.E. of regression	75.23044	Akaike info criterion	11.55103
Sum squared resid	418811.8	Schwarz criterion	11.72968
Log likelihood	-456.0411	Hannan-Quinn criter.	11.62265
F-statistic	211.8570	Durbin-Watson stat	0.805529
Prob(F-statistic)	0.000000		

1.2 Test the residuals for normality



h_0: *Normaly distributed residuals*

h_1: *Not normaly distributed residuals*

Since the p-value is 0.896 > 0.10 we cannot reject h_0 and must assume a normal distribution.

(This is our best result yet)

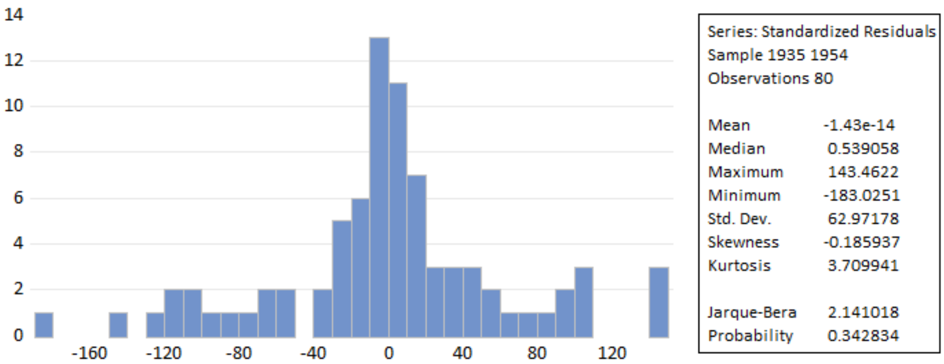
4. All coefficient vary across individuals

Dependent Variable: Y
Method: Panel Least Squares
Date: 03/06/22 Time: 12:07
Sample: 1935 1954
Periods included: 20
Cross-sections included: 4
Total panel (balanced) observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.38605	76.55446	-0.148731	0.8822
DUMGM	-137.8927	109.4570	-1.259789	0.2121
DUMUS	-37.45806	129.3168	-0.289661	0.7730
DUMWEST	10.59789	93.19637	0.113716	0.9098
X2	0.027157	0.038115	0.712506	0.4786
X3	0.152308	0.062678	2.429999	0.0177
DUMGM*X2	0.092010	0.042630	2.158347	0.0344
DUMGM*X3	0.219237	0.068408	3.204848	0.0021
DUMUS*X2	0.143672	0.064779	2.217875	0.0299
DUMUS*X3	0.256727	0.120609	2.128592	0.0369
DUMWEST*X2	0.026320	0.110931	0.237265	0.8132
DUMWEST*X3	-0.062574	0.378093	-0.165499	0.8690

R-squared	0.951158	Mean dependent var	290.8871
Adjusted R-squared	0.943257	S.D. dependent var	284.9375
S.E. of regression	67.87425	Akaike info criterion	11.41067
Sum squared resid	313270.2	Schwarz criterion	11.76798
Log likelihood	-444.4269	Hannan-Quinn criter.	11.55393
F-statistic	120.3861	Durbin-Watson stat	0.973063
Prob(F-statistic)	0.000000		

1.3 Test the residuals for normality



$h_0: Normaly\ distributed\ residuals$

$h_1: Not\ normaly\ distributed\ residuals$

Since the p-value is 0.343 > 0.10 we cannot reject h_0 and must assume a normal distribution.

(Worse than in the case before)

5. Random effects model

Dependent Variable: Y
Method: Panel EGLS (Cross-section random effects)
Date: 03/06/22 Time: 12:10
Sample: 1935 1954
Periods included: 20
Cross-sections included: 4
Total panel (balanced) observations: 80
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-73.09669	84.15441	-0.868602	0.3878
X2	0.107720	0.016881	6.381075	0.0000
X3	0.345750	0.026628	12.98470	0.0000

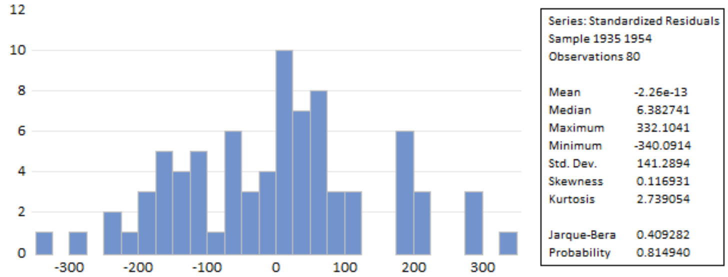
Effects Specification		S.D.	Rho
Cross-section random		151.9823	0.8032
Idiosyncratic random		75.23044	0.1968

Weighted Statistics			
R-squared	0.805271	Mean dependent var	32.00117
Adjusted R-squared	0.800213	S.D. dependent var	167.7384
S.E. of regression	74.97487	Sum squared resid	432834.8
F-statistic	159.2110	Durbin-Watson stat	0.778772
Prob(F-statistic)	0.000000		

Unweighted Statistics			
R-squared	0.754122	Mean dependent var	290.8871
Sum squared resid	1577053.	Durbin-Watson stat	0.213740

(Almost the same result as in 2.)

1.5 Test the residuals for normality



$h_0: Normaly\ distributed\ residuals$

$h_1: Not\ normaly\ distributed\ residuals$

Since the p-value is 0.815 > 0.10 we cannot reject h_0 and must assume a normal distribution.

2. Conduct the Hausmann-test

This is done to see whether the random effects or the fixed effects model is the best approximation.

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1.477716	2	0.4777

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
X2	0.108013	0.107720	0.000022	0.9500
X3	0.346202	0.345750	0.000002	0.7152

$$h_0: Choose\ a\ random\ effects\ model$$
$$h_1: Choose\ a\ fixed\ effetcs\ model$$

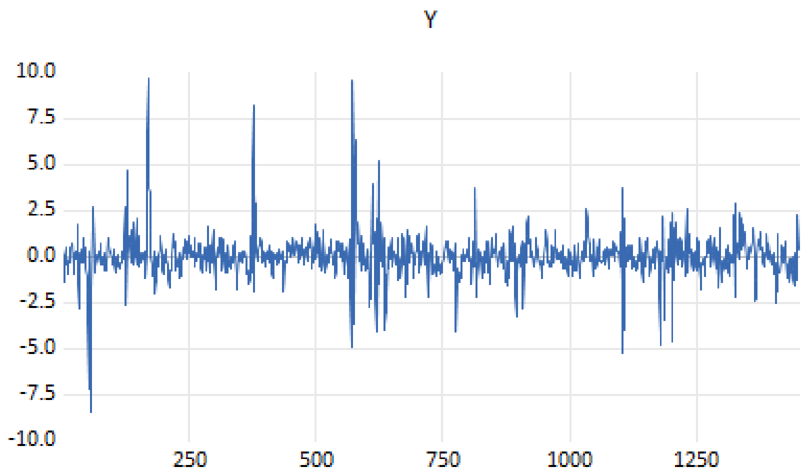
Since the p-value 0.4777 >0.05 we cannot reject the h_0 hypothesis, meaning the is little evidence against the connotation that we have specified the model correctly. Therefore, we should use a random effects model.

Q.2.4. Conditional Heteroscedasticity

Replication of: ar1-garch11 - lite.wf1 (from Part 12)

<u>THE ARCH-MODEL</u>

The plotted data takes on the following form:



We will follow the Box-Jenkins approach. We can obviously see from the plot, that the data exhibits no growth and looks like its mean reverting. Therefor, we can assume "Case 2" in the Box-Jenkins approach.

1. **First, we check for unit roots using the augmented Dickey-Fuller test**

h_0: ρ=1 $Unit\ root\ (non - stationary)$

h_1: ρ=1 $No\ unit\ root\ (stationary)$

Null Hypothesis: Y has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-20.86038	0.0000
Test critical values:	1% level	-3.434655	
	5% level	-2.863328	
	10% level	-2.567771	

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

Since the p-value is 0 < 0.05 we must reject h_0 and have to assume that there is no unit root. (This is in line with our expectations after looking at the plot.)

Since h_0 is rejected, we can assume a stationary process. Which implies that $\alpha \neq 0$ & $\beta = 0$.

This leads us to the conclusion that we are dealing with a stationary process and a non-zero equilibrium. → Process 4

Know that we know that the underlying data generating process has no unit roots we can rule out all ARIMA models. What is left to do now is to choose between the ARMA-models.

2. Run a correlogram

We do this, to determine which process is best by looking at the SAC and SPAC.

Date: 03/06/22 Time: 13:53
Sample: 1 1450
Included observations: 1450

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.538	0.538	419.80	0.000
		2	0.262	-0.038	519.58	0.000
		3	0.132	0.009	544.88	0.000
		4	0.117	0.070	564.69	0.000
		5	0.100	0.015	579.27	0.000
		6	0.083	0.016	589.28	0.000
		7	0.035	-0.031	591.12	0.000
		8	-0.006	-0.028	591.17	0.000
		9	-0.040	-0.035	593.45	0.000
		10	-0.025	0.015	594.40	0.000
		11	0.003	0.023	594.41	0.000
		12	-0.010	-0.030	594.56	0.000
		13	-0.018	0.002	595.02	0.000
		14	-0.017	0.003	595.43	0.000
		15	-0.007	0.005	595.50	0.000
		16	-0.010	-0.011	595.64	0.000
		17	0.011	0.026	595.81	0.000
		18	0.011	-0.005	595.99	0.000
		19	0.019	0.016	596.50	0.000
		20	0.019	0.007	597.03	0.000
		21	0.017	-0.001	597.45	0.000
		22	0.021	0.012	598.12	0.000
		23	-0.006	-0.036	598.17	0.000

One spike in the SPAC and a decay in the SAC indicates an AR(1) process.

3. Creating the AR(1) model

Dependent Variable: Y
Method: ARMA Maximum Likelihood (BFGS)
Date: 03/06/22 Time: 13:55
Sample: 1 1450
Included observations: 1450
Convergence achieved after 3 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018541	0.058064	-0.319321	0.7495
AR(1)	0.537186	0.008163	65.81026	0.0000
SIGMASQ	1.021622	0.014852	68.78892	0.0000

R-squared	0.288942	Mean dependent var	-0.018894
Adjusted R-squared	0.287959	S.D. dependent var	1.199064
S.E. of regression	1.011800	Akaike info criterion	2.863641
Sum squared resid	1481.352	Schwarz criterion	2.874564
Log likelihood	-2073.140	Hannan-Quinn criter.	2.867717
F-statistic	293.9973	Durbin-Watson stat	1.958463
Prob(F-statistic)	0.000000		

Inverted AR Roots	.54

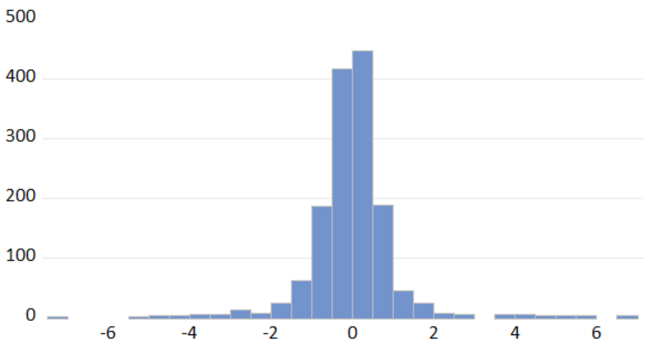
The formula would be: $y_t = -0.018541 + 0.537186 * y_{t-1}$

4. Testing the AR(1) model

We test the model by looking at the distribution of the residuals and testing whether they are normally distributed or not, with the Jarque-Bera test.

H_0: *Normal distribution*

H_1: *Non-normal distribution*



Series: Residuals	
Sample 1 1450	
Observations 1450	
Mean	-8.87e-06
Median	0.004976
Maximum	6.938373
Minimum	-7.209229
Std. Dev.	1.011102
Skewness	0.569263
Kurtosis	14.38404
Jarque-Bera	7908.092
Probability	0.000000

Since the p-value is 0 < 0.05 we must reject h_0 and assume non-normality within the residuals.

5. Testing the residuals for autocorrelation

Date: 03/06/22 Time: 15:18
Sample: 1 1450
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.021	0.021	0.6149	
		2	-0.031	-0.031	1.9910	0.158
		3	-0.047	-0.045	5.1639	0.076
		4	0.036	0.037	7.0455	0.070
		5	0.031	0.026	8.4169	0.077
		6	0.048	0.047	11.735	0.039
		7	0.006	0.009	11.789	0.067
		8	-0.008	-0.004	11.875	0.105
		9	-0.048	-0.046	15.254	0.054
		10	-0.019	-0.021	15.779	0.072
		11	0.033	0.028	17.369	0.067
		12	-0.007	-0.016	17.449	0.095
		13	-0.012	-0.008	17.656	0.127
		14	-0.012	-0.005	17.856	0.163
		15	0.007	0.009	17.930	0.210
		16	-0.020	-0.020	18.520	0.236
		17	0.018	0.017	19.002	0.269
		18	-0.002	-0.004	19.009	0.328
		19	0.011	0.010	19.193	0.380
		20	0.007	0.013	19.274	0.439
		21	0.000	-0.001	19.274	0.504

No patterns can be seen in the test for autocorrelation since the p-values are < 0.05. Therefore, we accept h_0 and conclude that there is no autocorrelation.

6. Testing to see if there are ARCH-effects in the residuals

We use the ARCH-LM test. This test is conducted with one lag.

h_0: *No arch effects*

h_1: *ARCH effects*

Heteroskedasticity Test: ARCH

F-statistic	774.5819	Prob. F(1,1447)	0.0000
Obs*R-squared	505.2117	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/06/22 Time: 15:28
Sample (adjusted): 2 1450
Included observations: 1449 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.418918	0.082231	5.094390	0.0000
RESID^2(-1)	0.590464	0.021216	27.83131	0.0000

R-squared	0.348662	Mean dependent var	1.022327
Adjusted R-squared	0.348212	S.D. dependent var	3.740003
S.E. of regression	3.019431	Akaike info criterion	5.049393
Sum squared resid	13192.25	Schwarz criterion	5.056679
Log likelihood	-3656.285	Hannan-Quinn criter.	5.052112
F-statistic	774.5819	Durbin-Watson stat	1.959351
Prob(F-statistic)	0.000000		

Since the p-value $0 < 0.05$ we reject h_0 and conclude that there are significant ARCH effects.

7. Estimating a GARCH(1,1) model

A GARCH(1,1) model is estimated, because it is a remedy against ARCH-effects in the residuals.

Dependent Variable: Y
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/06/22 Time: 15:35
Sample (adjusted): 2 1450
Included observations: 1449 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
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	-0.028529	0.028852	-0.988801	0.3228
AR(1)	0.571291	0.022817	25.03786	0.0000
	Variance Equation			
C	0.091314	0.009626	9.485688	0.0000
RESID(-1)^2	0.718299	0.062493	11.49417	0.0000
GARCH(-1)	0.228043	0.031686	7.196912	0.0000

R-squared	0.287791	Mean dependent var	-0.018907
Adjusted R-squared	0.287299	S.D. dependent var	1.199478
S.E. of regression	1.012619	Akaike info criterion	1.949388
Sum squared resid	1483.749	Schwarz criterion	1.967603
Log likelihood	-1407.332	Hannan-Quinn criter.	1.956186
Durbin-Watson stat	2.020934		
Inverted AR Roots	.57		

This leads to the following equations:

Mean: $y_t = -0.028529 + 0.571291 * x_{t-1}$

Variance: $h_t = 0.091314 + 0.718299 * \varepsilon_{2t-1} + 0.228043 * h_{t-1} + u_t$

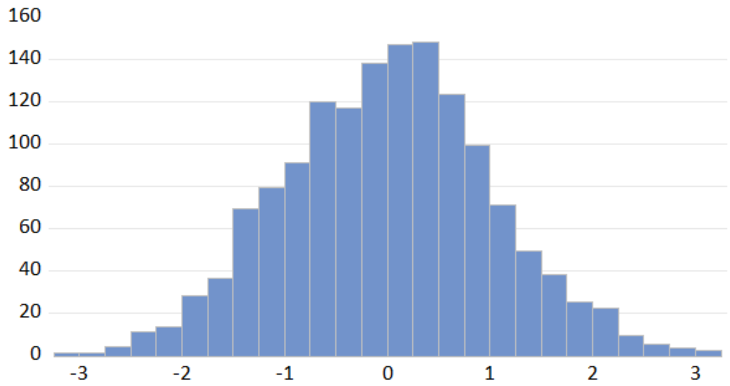
What is now left to do is to check the residuals in the same manner that we checked them for the AR(1) process. Meaning we must check whether the residuals are normally distributed, whether there is autocorrelation and lastly check whether there are any ARCH-effects in the residuals.

8. Are the residuals normally distributed?

This is done using the Jarque-Bera test for normality.

H_0: *Normal distribution*

H_1: *Non-normal distribution*



Series: Standardized Residuals	
Sample 2 1450	
Observations 1449	
Mean	0.005481
Median	0.019340
Maximum	3.108189
Minimum	-3.036555
Std. Dev.	1.000418
Skewness	0.053427
Kurtosis	2.893273
Jarque-Bera	1.377072
Probability	0.502311

Since the p-value 0.502311 > 0.05 we cannot reject H_0 and must assume normality.

9. Check the residuals for autocorrelation

Date: 03/06/22 Time: 15:50
Sample (adjusted): 2 1450
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.003	0.003	0.0122	
		2	-0.032	-0.032	1.5142	0.218
		3	-0.026	-0.025	2.4667	0.291
		4	0.016	0.015	2.8560	0.414
		5	0.001	-0.001	2.8568	0.582
		6	0.047	0.048	6.0904	0.298
		7	-0.046	-0.046	9.2210	0.162
		8	-0.026	-0.023	10.212	0.177
		9	-0.026	-0.027	11.219	0.190
		10	-0.039	-0.045	13.496	0.141
		11	0.027	0.026	14.547	0.149
		12	-0.006	-0.012	14.607	0.201
		13	0.020	0.025	15.164	0.233
		14	0.003	0.005	15.178	0.296
		15	0.022	0.022	15.886	0.320
		16	-0.010	-0.008	16.046	0.379
		17	0.026	0.019	17.030	0.384
		18	0.041	0.042	19.503	0.300
		19	-0.025	-0.030	20.436	0.309
		20	0.012	0.017	20.635	0.357

We cannot see any pattern here. So we just assume that there is no autocorrelation whithin the residuals.

10. Are there ARCH-effects in the residuals?

This test is, in accordance with the lab slides, conducted with one lag. Meaning that a more accurate specification of the optimal lag length using Schwarz information criterion is skipped.

$$h_0: \textit{No arch effects}$$

$$h_1: \textit{ARCH effects}$$

Heteroskedasticity Test: ARCH

F-statistic	0.170619	Prob. F(1,1446)	0.6796
Obs*R-squared	0.170835	Prob. Chi-Square(1)	0.6794

Test Equation:
Dependent Variable: WGT_RESID^2
Method: Least Squares
Date: 03/06/22 Time: 15:53
Sample (adjusted): 3 1450
Included observations: 1448 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.988404	0.044750	22.08702	0.0000
WGT_RESID^2(-1)	0.010859	0.026290	0.413061	0.6796

R-squared	0.000118	Mean dependent var	0.999270
Adjusted R-squared	-0.000574	S.D. dependent var	1.377152
S.E. of regression	1.377547	Akaike info criterion	3.479866
Sum squared resid	2743.980	Schwarz criterion	3.487156
Log likelihood	-2517.423	Hannan-Quinn criter.	3.482586
F-statistic	0.170619	Durbin-Watson stat	1.998864
Prob(F-statistic)	0.679623		

Since the p-value 0.6796 > 0.05 we cannot reject h_0 and must assume that there are no ARCH-effects.

11. Specification of the model

After completion of all these steps we can conclude that the GARCH(1,1) model is indeed correctly specified.

Dependent Variable: Y
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/06/22 Time: 15:57
Sample (adjusted): 2 1450
Included observations: 1449 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
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	-0.028529	0.028852	-0.988801	0.3228
AR(1)	0.571291	0.022817	25.03786	0.0000
		Variance Equation		
C	0.091314	0.009626	9.485688	0.0000
RESID(-1)^2	0.718299	0.062493	11.49417	0.0000
GARCH(-1)	0.228043	0.031686	7.196912	0.0000

R-squared	0.287791	Mean dependent var	-0.018907
Adjusted R-squared	0.287299	S.D. dependent var	1.199478
S.E. of regression	1.012619	Akaike info criterion	1.949388
Sum squared resid	1483.749	Schwarz criterion	1.967603
Log likelihood	-1407.332	Hannan-Quinn criter.	1.956186
Durbin-Watson stat	2.020934		
Inverted AR Roots	.57		

This output can be interpreted in the following way:

Mean: $y_t = -0.028529 + 0.571291 * x_{t-1}$

Variance: $h_t = 0.091314 + 0.718299 * \varepsilon_{2t-1} + 0.228043 * h_{t-1} + u_t$

12. Check the stationarity constraints

1) ω>0

As can be seen from the output: ω=0.091314 > 0

2) 0≤α<1

As can be seen from the output: 0 < α=0.718299 < 1

3) (α+β)<1

$0.091314 + 0.718299 = 0.809613 < 0$

This implies that the unconditional variance is positive:

$$Var(u) = \frac{\omega}{(1-\alpha-\beta)} = \frac{0.091314}{(1-0.718299-0.091314)} = \frac{0.091314}{0.190387} \approx 0.479623 > 0$$

Where ω is the mean variance, α is the autoregressive ARCH term (ε^2_{t-q}) and β is the GARCH term (h_{t-1})

Replication of: tarch.wf1 (from Part 12)

THE GJR OR TARCH-MODEL

The TARCH or GJR model is a model where positive news and negative news are treated asymmetrically.

The conditional variance is defined the following way:

$$h_t = \delta + \alpha_1 * \varepsilon_{t-1}^2 + \gamma * d_{t-1} * \varepsilon_{t-1}^2 + \beta_1 * h_{t-1}$$

Where d_t is a dummy variable taking on 1 for bad and 0 for good news. γ is the asymmetry term. If we would plug in 0 for γ that the model would just collapse into a GARCH model.

The output of estimating this regression is as follows:

Dependent Variable: R
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/06/22 Time: 16:25
Sample: 1 500
Included observations: 500
Convergence achieved after 24 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*RESID(-1)^2*(RESID(-1)<0) +
C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.994247	0.042924	23.16281	0.0000
		Variance Equation		
C	0.355671	0.090153	3.945179	0.0001
RESID(-1)^2	0.263027	0.080567	3.264712	0.0011
RESID(-1)^2*(RESID(-1)<0)	0.491803	0.204753	2.401926	0.0163
GARCH(-1)	0.287622	0.115607	2.487926	0.0128

R-squared	-0.005040	Mean dependent var	1.078294
Adjusted R-squared	-0.005040	S.D. dependent var	1.185025
S.E. of regression	1.188007	Akaike info criterion	2.942235
Sum squared resid	704.2692	Schwarz criterion	2.984381
Log likelihood	-730.5586	Hannan-Quinn criter.	2.958773
Durbin-Watson stat	1.909350		

It can be seen (highlighted) that the term describing the asymmetry between good and bad news (0.491803) is statistically significant at the 5% level. We can conclude that positive and negative shocks have different effects.

If we assume a positive shock, we can set $d_t = 0$ which collapses the formula to:

$$h_t = \delta + \alpha_1 * \varepsilon_{t-1}^2 + \beta_1 * h_{t-1} = 0.355671 + 0.263027 * \varepsilon_{t-1}^2 + 0.287622 * h_{t-1}$$

If we assume a negative shock, $d_t = 1$. The formula will take on the following form:

$$h_t = \delta + \alpha_1 * \varepsilon_{t-1}^2 + \gamma * d_{t-1} * \varepsilon_{t-1}^2 + \beta_1 * h_{t-1} = \delta + (\alpha_1 + \gamma) * \varepsilon_{t-1}^2 + \beta_1 * h_{t-1}$$

$$= 0.355671 + (0.263027 + 0.491803) * \varepsilon_{t-1}^2 + 0.287622 * h_{t-1}$$

Replication of: garch-m.wf1 (from Part 12)

THE GARCH-in mean (GARCH-M) model

As we understand is the GARCH-M model is used when the risk of a security effects its return.

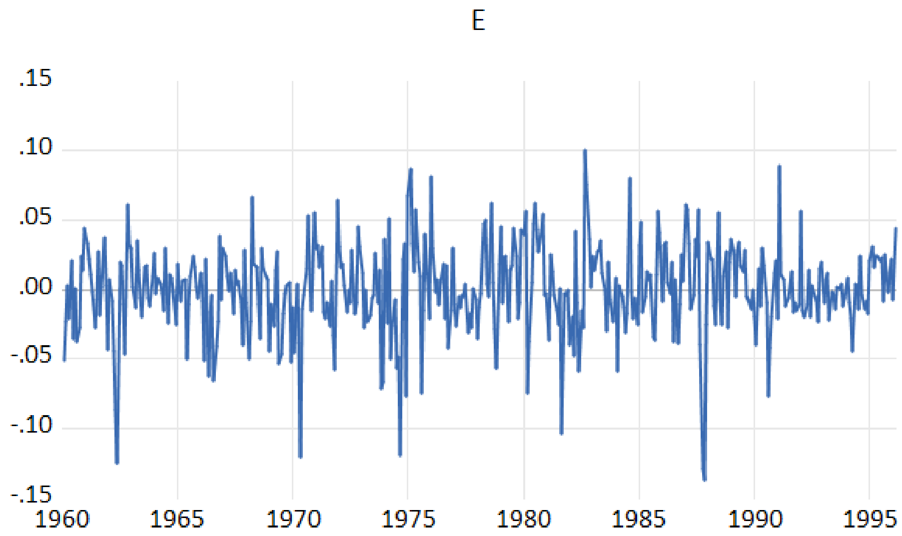
When using a normal OLS regression in cases like this we get:

Dependent Variable: RETURNSP
Method: Least Squares
Date: 03/06/22   Time: 16:38
Sample (adjusted): 1960M02 1996M02
Included observations: 433 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.012028	0.001755	6.855222	0.0000
D(R3)	-0.829997	0.306072	-2.711773	0.0070
GPW	-0.854717	0.234959	-3.637724	0.0003

R-squared	0.055120	Mean dependent var	0.009266
Adjusted R-squared	0.050725	S.D. dependent var	0.033816
S.E. of regression	0.032947	Akaike info criterion	-3.980928
Sum squared resid	0.466767	Schwarz criterion	-3.952724
Log likelihood	864.8710	Hannan-Quinn criter.	-3.969795
F-statistic	12.54203	Durbin-Watson stat	1.520157
Prob(F-statistic)	0.000005		

We can see that the R^2 is very low.



When plotting the residuals one can see that the timeseries has some “spikes” in it. This indicates that the use of a GARCH-model may be appropriate.

Dependent Variable: RETURNSP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/06/22 Time: 16:46
Sample (adjusted): 1960M02 1996M02
Included observations: 433 after adjustments
Convergence achieved after 19 iterations
Coefficient covariance computed using outer product of gradients
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.
C	0.012726	0.001556	8.180735	0.0000
D(R3)	-1.091747	0.299550	-3.644621	0.0003
GPW	-0.801557	0.183055	-4.378779	0.0000
Variance Equation				
C	0.000187	7.80E-05	2.394358	0.0166
RESID(-1)^2	0.186137	0.046329	4.017690	0.0001
GARCH(-1)	0.647594	0.101450	6.383390	0.0000

R-squared	0.052844	Mean dependent var	0.009266
Adjusted R-squared	0.048439	S.D. dependent var	0.033816
S.E. of regression	0.032987	Akaike info criterion	-4.047044
Sum squared resid	0.467891	Schwarz criterion	-3.990637
Log likelihood	882.1851	Hannan-Quinn criter.	-4.024777
Durbin-Watson stat	1.516407		

It can be seen that both the ARCH and GRACH coefficients are statistically significant.

If we assume that the riskiness of a stock effects the return of the stock itself, we should use a GARCH-M model. In this step the variance or variable of the errors are added into the regression.

Dependent Variable: RETURNSP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/06/22 Time: 16:51
Sample (adjusted): 1960M02 1996M02
Included observations: 433 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
@SQRT(GARCH)	0.471168	0.254244	1.853211	0.0639
C	-0.001256	0.007569	-0.165966	0.8682
D(R3)	-0.999345	0.307024	-3.254944	0.0011
GPW	-0.876038	0.176873	-4.952911	0.0000
Variance Equation				
C	0.000148	6.44E-05	2.297423	0.0216
RESID(-1)^2	0.185032	0.043024	4.300661	0.0000
GARCH(-1)	0.687511	0.087118	7.891750	0.0000

R-squared	0.050541	Mean dependent var	0.009266
Adjusted R-squared	0.043902	S.D. dependent var	0.033816
S.E. of regression	0.033065	Akaike info criterion	-4.052584
Sum squared resid	0.469029	Schwarz criterion	-3.986776
Log likelihood	884.3845	Hannan-Quinn criter.	-4.026606
Durbin-Watson stat	1.487998		

This is the regression output for the GARCH(1,1) model. However, the standard deviation σ_t (the measure of risk that we have chosen in this chase) is not relevant at the 5% level of significance, but it is relevant at the 10% level.