PADERBORN UNIVERSITY
The University for the Information Society

W4451 – Financial Econometrics and Quantitative Risk Management, Summer term 2020

1st Applied Project in R

Group Number 38

Lecturer: Prof. Yuanhua Feng

Bastian Schäfer

Start of Project: Tuesday, 9. June 2019

End of Project: Tuesday, 14. July 2019

	Q1	Q2	Q3	Total
Points				

Submitted by (Student names + Student numbers):

- Fatima Kohne: 6822651
- Djankou Nana Sonia: 6832815
- Fotso Tenku Joel Cedric: 6810782

Paderborn, 14.07.2020

PROBLEM 1

1-1- The codes of the problem 1 contain 6 errors

Errors	*Corrections*
Error 1: p = sample(1:6, n = 1)	p = sample(1:6, size= 1)
Error 2: q = sample(1:6, n = 1)	q = sample(1:6, size= 1)
Error 3: err[(t - 1):(p - q)]	err[(t - 1):(t - q)]
Error 4: err[(t - 1):(p - q)] + Err[t]	err[(t - 1):(p - q)] + err[t]
Error 5: Y = y[(n + 1)(2*n])	Y = y[(n + 1)*(2*n])
Error 6: Y = y[(n + 1)(2*n])	Y = y[(n + 1)(2*n)]

Error's description

Error 1 and 2: Because we first defined "n" as the number of observations, we cannot use it as the size of our sample. Due, to correct the error we have used we have used size instead "n".

Error 3 and 4: on this line code the first error concern MA(q) process: *alpha %*% err[(t - 1):(p - q)]* which normally is normally is defined as *alpha %*% err[(t - 1):(p - q)]*.

Concerning the second error *Err[t]*, we should used *err[t]* because we first defined it

Error 5 and 6:

*Y = y[(n + 1)(2*n])*

Here we add the sign of multiplication because R does not recognize parenthesis as multiplication, and we also changed *"])" whit ")]"*.

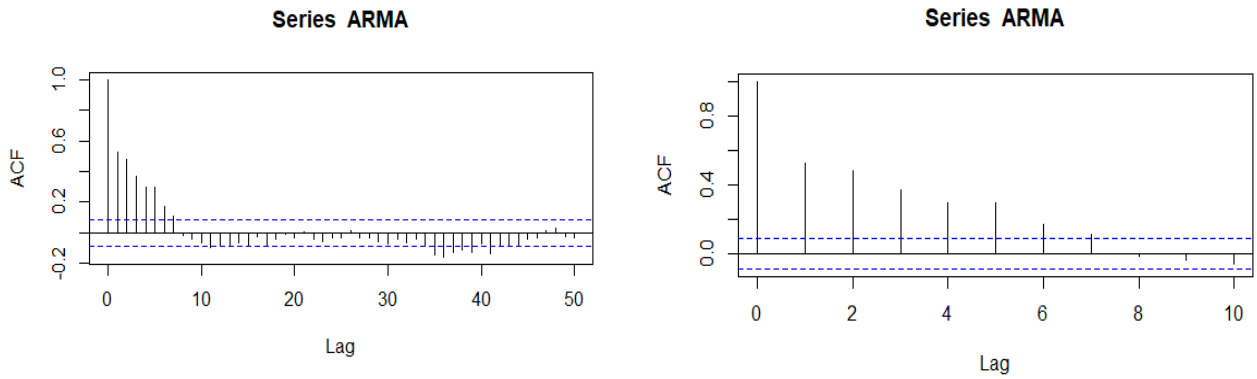
1-2- The formula of the ARMA process taken form the code

ARMA=arima.sim(n=n, list(ar=c(0.225, 0.211), ma=c(0.064, 0.151, 0.055, 0.052, 0.158, 0.039)

ARMA(2,0,6):

$$X_t = 0.225X_{t-1} + 0.211X_{t-2} + 0.064\varepsilon_{t-1} + 0.151\varepsilon_{t-2} + 0.055\varepsilon_{t-3} + 0.052\varepsilon_{t-4} + 0.158\varepsilon_{t-5} + 0.039\varepsilon_{t-6} + \varepsilon_t$$

1-3- Plot of the autocorrelation function of the time-series for 10 and 50 lags



- For lag.max = 10: The acf at 5% indicates a significant dependence but it is not strong.
- For lag.max = 50: the acf at 5% indicates a significant dependence but it is not strong.

1- 4- Fit 16 AR(p) models for p= 0,...,15 and find the best models according to the AIC and BIC

- The best models according to AIC is: **AR(2)**

To find this best model we compared all the models according to the AIC, then we chose the third model (with p = 0, …, 15) that has the smallest AIC. Considering that the first model corresponds to p = 0, thus the third model corresponds to p = 2.

P=0	P=1	P=2	P=3	P=4	P=5	P=6	P=7
1482.263	1438.437	1399.724	1401.401	1402.799	1403.906	1405.167	1406.117
P=8	P=9	P=10	P=11	P=12	P=13	P=14	P=15
1407.807	1406.857	1408.853	1410.785	1412.207	1413.625	1415.154	1417.013

Thus, the Best-Model is

arima(x = AR, order = c(2, 0, 0))			
Coefficients	ar1	ar2	Intercept
	0.2127	0.2799	0.0125
s.e.	0.0429	0.0429	0.0855
sigma^2 estimated as 0.9465: log likelihood = -695.86, aic = 1399.72			

$$Y_t = X_t - 0.0125$$
$$X_t = 0.2127X_{t-1} + 0.2799X_{t-2} + \mathcal{E}_t$$
$$V(\mathcal{E}_t) = 0.9465$$

- The best models according to BIC is: **AR(2)**

To find this best model we compared all the models according to the BIC, then we chose the third model (with p = 0, …., 15) that has the smallest BIC. Considering that the first model corresponds to p = 0, thus the third model corresponds to p = 2.

P=0	P=1	P=2	P=3	P=4	P=5	P=6	P=7
1478.263	1438.652	1404.153	1410.045	1415.657	1420.979	1426.454	1431.619
P=8	P=9	P=10	P=11	P=12	P=13	P=14	P=15
1437.524	1440.789	1447.000	1453.146	1458.783	1464.415	1470.159	1476.232

Thus, the Best-Model is

arima(x = AR, order = c(2, 0, 0))			
Coefficients	ar1	ar2	Intercept
	0.2127	0.2799	0.0125
s.e.	0.0429	0.0429	0.0855
sigma^2 estimated as 0.9465: log likelihood = -695.86, aic = 1399.72			

$$Y_t = X_t - 0.0125$$
$$X_t = 0.2127X_{t-1} + 0.2799X_{t-2} + \mathcal{E}_t$$
$$V(\mathcal{E}_t) = 0.9465$$

1- 5- Fit 36 ARMA (p, q) models for p= 0,...,5 and q= 0,...,5

- Best ARMA models according to AIC is: **ARMA(2, 0, 5)**

Considering that p = 0, … 5, and q = 0, … 5, we have the taken the intersection of the smallest AIC between P and q.

p \ q	0	1	2	3	4	5
0	1612.657	1519.352	1456.725	1439.894	1439.800	1423.434
1	1453.460	1415.036	1413.972	1415.557	1414.801	1402.567
2	1413.394	1413.553	1415.488	1417.340	1417.818	1402.148
3	1413.812	1415.471	1414.989	1416.593	1412.810	1402.570
4	1415.737	1417.430	1416.767	1414.446	1411.179	1404.570
5	1413.174	1412.311	1414.247	1406.802	1405.464	1406.409

Thus, the Best-Model is

arima(x = ARMA, order = c(2, 0, 5))								
Coefficients	ar1	ar2	ma1	ma2	ma3	ma4	ma5	intercept
	1.0591	-0.3438	-0.7190	0.3532	-0.0052	0.0586	0.1783	0.0781
s.e.	0.2390	0.1906	0.2383	0.1297	0.0720	0.0634	0.0654	0.1306
sigma^2 estimated as 0.9313: log likelihood = -692.07, aic = 1402.15								

$$Y_t = X_t - 0.0781$$
$$X_t = 1.0591X_{t-1} - 0.3438X_{t-2} - 0.7190\mathcal{E}_{t-1} + 0.3532\mathcal{E}_{t-2} - 0.0052\mathcal{E}_{t-3} + 0.0586\mathcal{E}_{t-4} + 0.1783\mathcal{E}_{t-5} + \mathcal{E}_t$$
$$V(\mathcal{E}_t) = 0.9313$$

- The best model according to BIC is**: ARMA(2, 0, 0)**

Considering that p = 0, … 5, and q = 0, … 5, we have taken the intersection of the smallest BIC between P and q.

p \ q	0	1	2	3	4	5
0	1608.657	1519.567	1461.154	1448.537	1452.659	1440.507
1	1453.675	1419.465	1422.615	1428.415	1431.874	1423.855
2	1417.823	1422.197	1428.347	1434.413	1439.105	1427.651
3	1422.456	1428.330	1432.062	1437.881	1438.313	1432.287
4	1428.595	1434.503	1438.055	1439.948	1440.896	1438.501
5	1430.247	1433.599	1439.749	1436.519	1439.396	1444.555

On the matrices of the AIC and BIC above, the first line and column correspond to the order (0, 0, 0).

Thus, the Best-Model is

arima(x = ARMA, order = c(2, 0, 0))			
	ar1	ar2	Intercept
Coefficients	0.3760	0.2839	0.0795
s.e.	0.0428	0.0428	0.1290
sigma^2 estimated as 0.9723: log likelihood = -702.7, aic = 1413.39			

$$Y_t = X_t - 0.0795$$
$$X_t = 0.3760X_{t-1} + 0.2839X_{t-2} + \mathcal{E}_t$$
$$V(\mathcal{E}_t) = 0.9723$$

PROBLEM 2

2-1- Explanation of the choice of data

The data we have used are that of Apple and an Insurance company was taken from Yahoo Finance.

- ***APPLE***

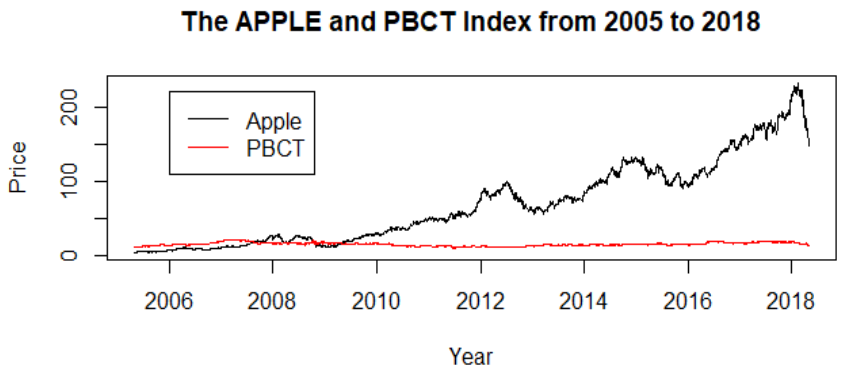
We chose Apple Inc. because it is the world richest electronic company. This company not only marketed his range of the products within his mere territories but has supplied all over the word and has earned his name at the first place of the top ten list of the richest electronic companies. However, during the crisis of 2008 Apple had set revenue record, and according

to the article “Computerworld united States”, that says I quote: “Apple had set in a single-quarter revenue record in the last three month of 2008, selling more than 2.5 million Macs and 4.3 million iPhones. It sold 1.8 million notebooks and 728,000 desktops in the first fiscal quarter, which ended Dec. 31, 2008 and increase of the former, but a drop of 25% for latter over the same quarter….” (see more by clicking on the link of the article). Overall Apple was also affected by the crisis but had been able to maintain strong products sales even in the face of a generally lousy economy.

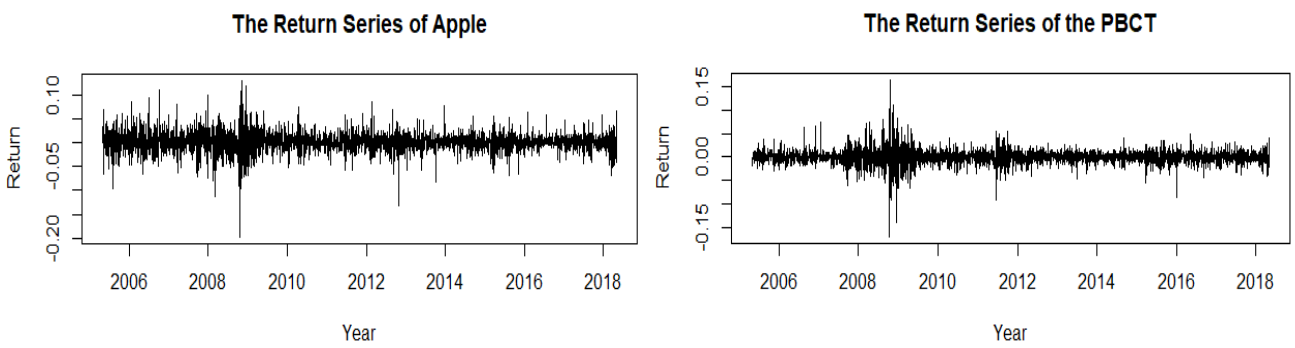
- ***PBCT (People’s United Financial Inc)***

It is an American bank holding company that owns People’s United Bank whit $36 billion in assets, which boasts more than 400 traditional branches, supermarket branches, commercial banking offices… In additional to retail and commercial banking services, the bank offers trust, wealth management, brokerage, and insurance services. Its lending activities consist mainly of commercial and industrial loans, and commercial mortgages, residential mortgages, equipment financing, and home equity loans. Concerning the crisis, the People’s United Financial Inc has been considerably raising its dividend payment for the last teen years and seemed to be low and slow-moving and never had a dividend cut even during the financial crisis. But People’s United Financials’ results were subject to fluctuations based on the crisis. In fact, the second half of 2007 has been highlighted by significant disruption and volatility. This turbulence has been attributable to variety of factors, including the fallout associated with the sub-prime mortgage market, and one aspect of this fallout has been significant deterioration in the activity of the secondary residential mortgage market. The disruptions have been exacerbated by the acceleration of the decline of the real estate and housing market.

2-2- Plot of Apple’s and PBCT’s Closes



Plot of Apple’s and PBCT’s returns



As we can see on the graphs both time series are not stationary, but their returns are stationary.

2-3- Fit the GARCH model for Apple

Error Analysis:				
	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.695e-03	2.850e-04	5.947	2.73e-09 ***
omega	9.597e-06	2.079e-06	4.615	3.93e-06 ***
alpha1	8.177e-02	1.274e-02	6.417	1.39e-10 ***
beta1	8.961e-01	1.578e-02	56.784	< 2e-16 ***

AIC **BIC**
-5.133035 -5.126030

A general GARCH(1,1) Model is given by

$$Y_t - \mu \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = \alpha_0 + \alpha_1 Y_{t-1}^2 + \beta_1 h_{t-1}$$

Here: $$Y_t - 1.695 \cdot 10^{-3} \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = 9.597 \cdot 10^{-6} + 8.177 \cdot 10^{-2} Y_{t-1}^2 + 0.8961 h_{t-1}$$

- ***Fit the GARCH model for PBCT***

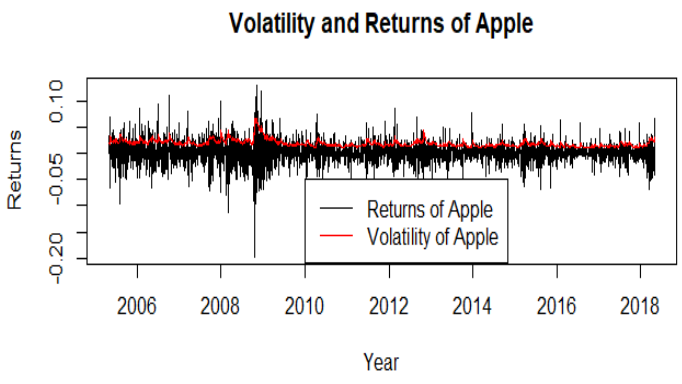
Error Analysis:				
	Estimate	Std. Error	t value	Pr(>|t|)
mu	2.747e-04	1.977e-04	1.390	0.164667
omega	6.522e-06	1.731e-06	3.768	0.000165 ***
alpha1	9.829e-02	1.654e-02	5.944	2.78e-09 ***
beta1	8.711e-01	2.317e-02	37.590	< 2e-16 ***

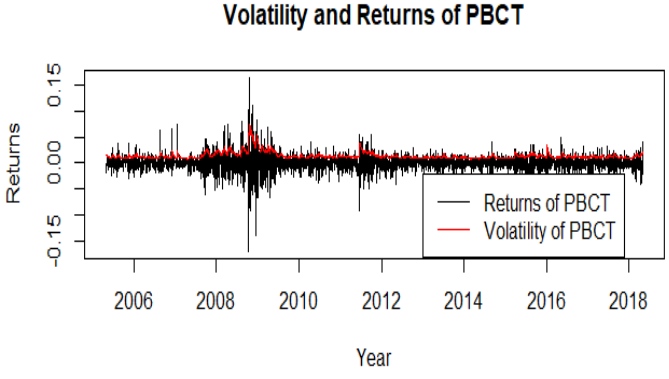
AIC **BIC**
-5.823389 -5.816384

$$Y_t - \mu \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = \alpha_0 + \alpha_1 Y_{t-1}^2 + \beta_1 h_{t-1}$$

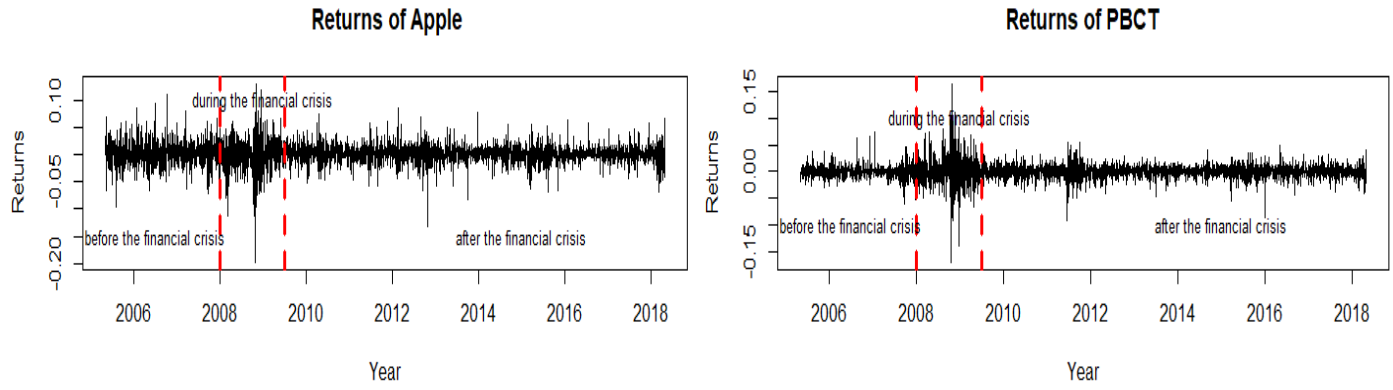
$$Y_t - 2.747 \cdot 10^{-4} \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = 6.522 \cdot 10^{-6} + 9.829 \cdot 10^{-2} Y_{t-1}^2 + 0.8711 h_{t-1}$$

Plot of the Volatility along with the Return





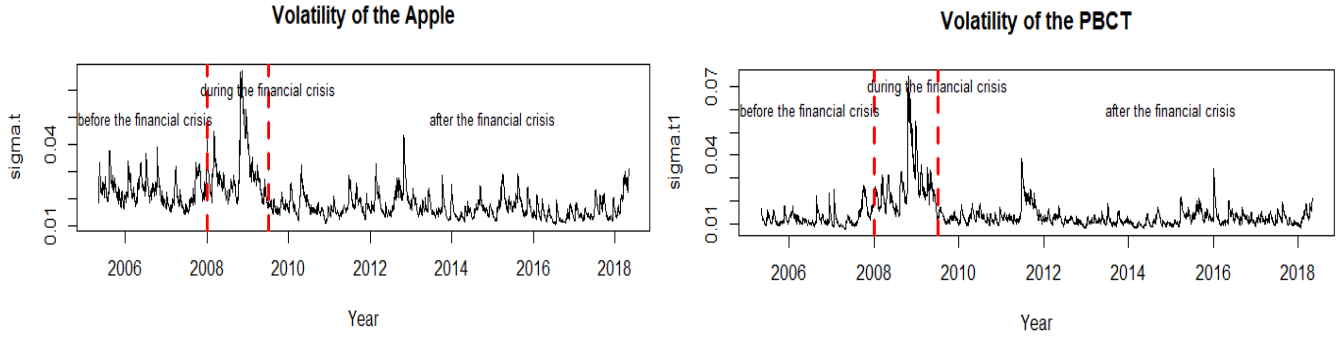
2-4- Divide both return-series in a part before, during and after the financial crisis



- The period before the financial crisis: 01.2005-12.2007
- During the financial crisis: 01.2008-06.2009
- After the financial crisis: 07.2009-12.2018

From 2005 to the end of 2007 (before the financial crisis) and from July of 2009 to December 2018 (after the financial crisis) yields do not differ too much (stationary). From 2008 to Jun 2009 (during the crisis), yields diverge very considerably (non-stationary).

Plot of the volatility



2-5 - Calculate de the correlation between the return-series of the firms for all three parts from

	Part before the crisis	Part during the crisis	Part after the crisis
Correlation between the Return times-series of AAPL and PBCT	0.2242927	0.4292943	NA
Correlation between The estimated volatility of AAPL and PBCT	0.3181464	0.8344395	NA

❖ ***Consequences of the crisis on the financial Sector***

In the year of the depression (2008), many banks and financial firms around the globe were affected by the financial crisis, which started from housing market in the US bevor spread into financial markets. The housing bubble in the US grew up the stock bubble in the mid-90s and the increasing in stock prices made unexpected wealth for people and they started to spend this extra money. This led to the consumption boom of the late 90s, with saving rate out disponible income falling form close 5% in the middle of the decade to 2% by 2000 [1]. This extra money encourages people to buy better and bigger homes. It results in exceeding demand triggered housing bubble than the supply and it led an increasing price. After that, the signs of financial crisis appear by housing bubble burst and drastic decline in house prices which were started in 2007 and become prominently in September 2008. Outcomes of the crisis are not just limited to financial and housing markets. Its consequences have spread around the world and affected almost all aspects of people's lives (increasing unemployment rate). The crisis has both inflationary and deflationary effects in the world and people have less credit to finance their purchases so by diminishing trades and decrease in demand, prices come down (deflation). On the other hand, to repel the crisis some governments inject money into society. Sometimes this decision has inflationary results as it caused increasing inflation rate in some countries [2].

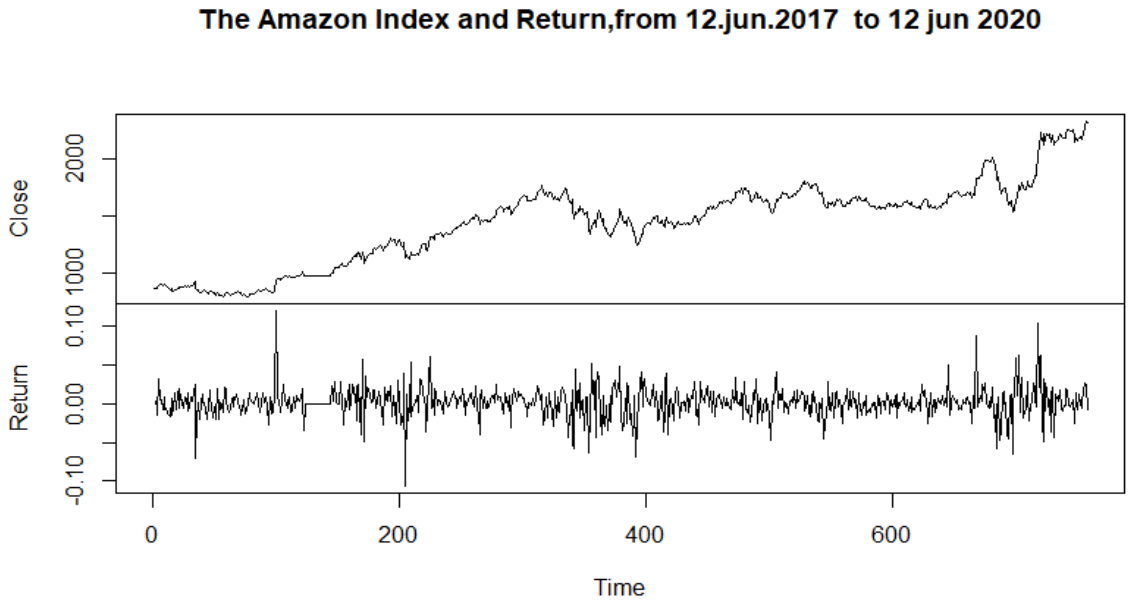
❖ ***Consequences of the crisis on the Goods and Services Markets***

According to the Author Jahan Zeb and his book called: "Impact of Current Financial Crisis on Banking Sector, Munich GRIN Verlag ", who talks about the consequences of the financial crisis on the goods and services Market, I quote: "*The banking crisis effected almost all sector of the economy especially production sectors. Their effects on the other areas, for example, rising unemployment or cut down the working hours, Consumer spending has fallen, reflecting heightened uncertainty, tight credit conditions and lower financial wealth. Business and dwellings investment have also declined, and near-term indicators point to further falls. The slowdown in activity has been significantly amplified by companies running down stocks.*
In addition to the downturn in demand for highly traded manufactured goods especially autos industry, and the falls in trade flows resulting from the disruption of globalized supply chains, a reduction in the supply of credit used to facilitate international trade may also have exacerbated the decline in trade flows. One more factor underlying the collapse in world trade flows is that, during the current downturn, the more trade-intensive elements of demand have been most affected. For example, demand for items such as capital goods, motor vehicles and other consumer durables appears to have fallen".

We can conclude that the crisis has had major negative impacts both on financial markets and on the goods and services markets.

PROBLEM 3

1-3 - For the problem 3 we have work with the Amazon Date from 12.06.2017 to 12.06.2020. Display the time-series and its log-return series in a suitable graph.



3-2- Fit 4 GARCH(p,q) models for p; q = 1; 2 to the log-returns of this sub-series under a conditional normal distribution.

- ***AMZN_1.GARCH11***

Coefficient(s):	mu	omega	alpha1	beta1
	1.6431e-03	5.3134e-05	3.0990e-01	5.9914e-01
Std. Errors: based on Hessian				
Error Analysis:	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.643e-03	7.166e-04	2.293	0.021850 *
omega	5.313e-05	1.764e-05	3.013	0.002589 **
alpha1	3.099e-01	8.043e-02	3.853	0.000117 ***
beta1	5.991e-01	8.014e-02	7.476	7.68e-14 ***

- **AMZN_1.GARCH12**

	mu	omega	alpha1	beta1	beta2
Coefficient(s):	1.3469e-03	7.0228e-05	3.7565e-01	2.4996e-01	2.4372e-01

Std. Errors: based on Hessian				
Error Analysis:	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.347e-03	7.438e-04	1.811	0.07015

omega	7.023e-05	2.277e-05	3.085	0.00204 **
alpha1	3.757e-01	9.588e-02	3.918	8.93e-05 ***
beta1	2.500e-01	1.465e-01	1.706	0.08805
beta2	2.437e-01	1.062e-01	2.295	0.02171

- ***AMZN_1.GARCH21***

	mu	omega	alpha1	alpha2	beta1
Coefficient(s):	1.6380e-03	5.3079e-05	3.0919e-01	1.0000e-08	5.9941e-01

Std. Errors: based on Hessian				
Error Analysis:	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.638e-03	7.548e-04	2.170	0.03001 *
omega	5.308e-05	1.876e-05	2.829	0.00467 **
alpha1	3.092e-01	9.942e-02	3.110	0.00187 **
alpha2	1.000e-08	1.149e-01	0.000	1.00000
beta1	5.994e-01	9.950e-02	6.024	1.7e-09 ***

- ***AMZN_1.GARCH22***

Coefficient(s):	mu	omega	alpha1	alpha2	beta1	beta2
	1.3469e-03	7.0228e-05	3.7565e-01	1.0000e-08	2.4996e-01	2.4372e-01

Std. Errors: based on Hessian				
Error Analysis:	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.347e-03	7.798e-04	1.727	0.084134
omega	7.023e-05	2.650e-05	2.650	0.008042 **
alpha1	3.757e-01	1.105e-01	3.399	0.000677 ***
alpha2	1.000e-08	1.558e-01	0.000	1.000000
beta1	2.500e-01	2.260e-01	1.106	0.268630
beta2	2.437e-01	1.192e-01	2.045	0.040834 *

BIC values for the Models

p \ q	1	2
1	-5.161501	-5.152469
2	-5.148929	-5.140163

Considering that p = 1, … 2, and q = 1, … 2, we have taken the intersection of the smallest BIC between P and q.

The best models is ***AMZN_1. GARCH11*** which corresponds to **GARCH (1,1)**

The GARCH Best Model.

Coefficient(s):	mu	omega	alpha1	beta1
	1.6431e-03	5.3134e-05	3.0990e-01	5.9914e-01
Std. Errors: based on Hessian				
Error Analysis:	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.643e-03	7.166e-04	2.293	0.021850 *
omega	5.313e-05	1.764e-05	3.013	0.002589 **
alpha1	3.099e-01	8.043e-02	3.853	0.000117 ***
beta1	5.991e-01	8.014e-02	7.476	7.68e-14 ***

A general GARCH(1,1) Model is given by

$$Y_t - \mu \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = \alpha_0 + \alpha_1 Y_{t-1}^2 + \beta_1 h_{t-1}$$

Here

$$Y_t - 1.643 \cdot 10^{-3} \backslash \mathcal{F}_t \sim \mathcal{N}(0, h_t) h_t = 5.313 \cdot 10^{-5} + 0.3099 Y_{t-1}^2 + 0.5991 h_{t-1}$$

3.3- Prediction of the conditional volatility of year 3 of the time series by using your model from 3.2.

The six first Values of the volatility's prediction (Volatility=Standard Deviation)

N°	Date	meanForecast	meanError	standardDeviation
1	2019-06-13	0.001643119	0.02324966	0.02324966
2	2019-06-14	0.001643119	0.02333477	0.02333477
3	2019-06-17	0.001643119	0.02341188	0.02341188
4	2019-06-18	0.001643119	0.02348175	0.02348175
5	2019-06-19	0.001643119	0.02354508	0.02354508
6	2019-06-20	0.001643119	0.02360251	0.02360251

The six last Values of the volatility's prediction (Volatility=Standard Deviation)

N°	Date	meanForecast	meanError	standardDeviation
246	2020-06-04	0.001643119	0.0241689	0.0241689
247	2020-06-05	0.001643119	0.0241689	0.0241689
248	2020-06-08	0.001643119	0.0241689	0.0241689
249	2020-06-09	0.001643119	0.0241689	0.0241689
250	2020-06-10	0.001643119	0.0241689	0.0241689
251	2020-06-11	0.001643119	0.0241689	0.0241689

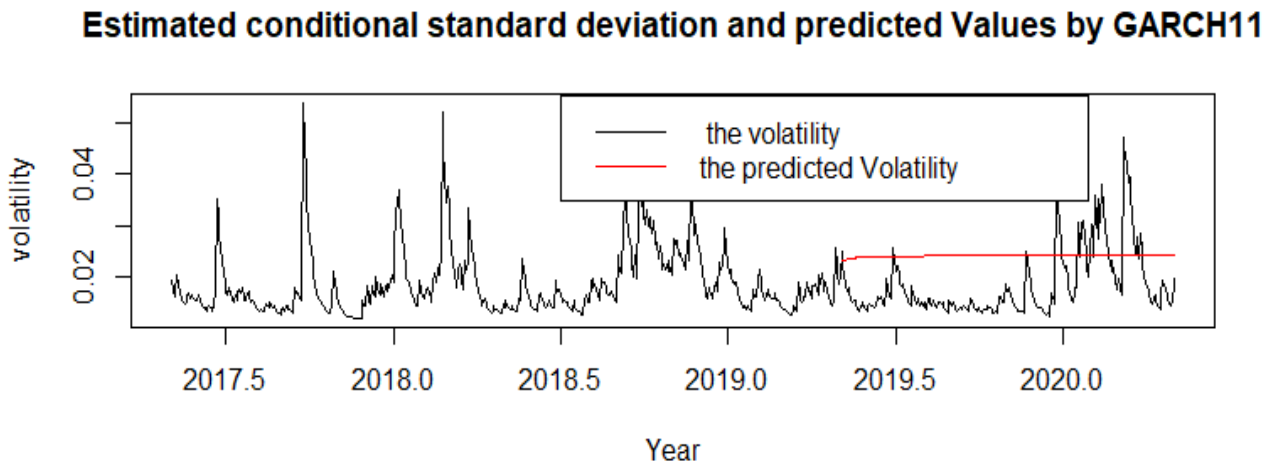
3.4- Estimation of the new GARCH model

Std. Errors:based on Hessian				
Error Analysis:				
	Estimate	Std. Error	t value	Pr(>|t|)
mu	1.531e-03	5.973e-04	2.563	0.010381 *
omega	4.053e-05	1.145e-05	3.539	0.000402 ***
alpha1	1.892e-01	4.755e-02	3.978	6.95e-05 ***
beta1	7.217e-01	5.626e-02	12.828	< 2e-16 ***

Information Criterion Statistics:

AIC	BIC	SIC	HQIC
-5.191781	-5.167319	-5.191836	-5.182359

Plot of the volatility and the predicted values from 3.3 at the right spot



We notice that volatility is non-stationary while its prediction is stationary.

SOURCES

https://www.computerworld.com/article/2530595/apple-sets-revenue-record-during-recession.html

https://www.sec.gov/Archives/edgar/data/1378946/000119312508043707/d10k.htm

United States Securities and Exchange Commission Washington, D.C. 20549, ANNUAL REPORT Pursuant to Section 13 or 15 (d) of the Securities Exchange Act of 1934 For the fiscal year ended December 31, 2007. Pages: 17-20

https://www.researchgate.net/publication/247919063_The_Impact_of_Financial_Crisis_on_B2C_e-Commerce

[1] D. Baker, "The Housing Bubble and the Financial Crisis," Journal of Real-World Economics Review, 2008.
[2] CNBC.com, "Financial Crisis Has Inflationary and Deflationary Potential," Consumer News and Business Channel, 2008, www.cnbc.com

Jahan Zeb (Author), 2009, Impact of Current Financial Crisis On Banking Sector, Munich, GRIN Verlag, https://www.grin.com/document/142224