Econ 724: Financial Econometrics, Spring 2023 **Name:** *Hsiu-Yu, Tu*
Problem Set #5
02/26/2023

1. Take the daily stock prices series for New York Times Company (sticker 'NYT') for 1985-2021 and transform it to log returns.

   (a) GARCH(1,1)

   GARCH(1,1) Conditional Variance Model with Offset (Gaussian Distribution):

	Value	StandardError	TStatistic	PValue
Constant	0.03892	0.0034052	11.429	2.9827e-30
GARCH{1}	0.94616	0.0021333	443.52	0
ARCH{1}	0.046014	0.0016679	27.589	1.5113e-167
Offset	0.018	0.016313	1.1034	0.26986

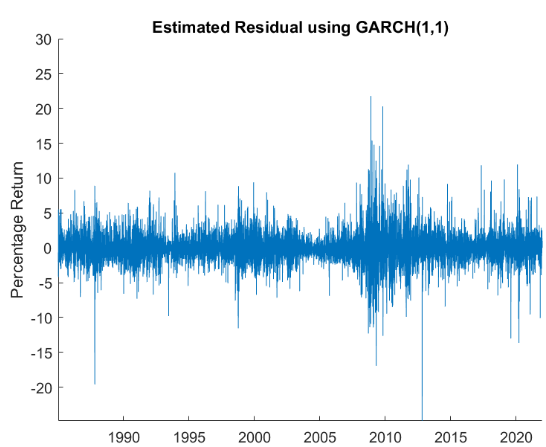
   (b) The report of GARCH(2,3) model shows that the coefficient of garch(1) and arch(3) are not significant.

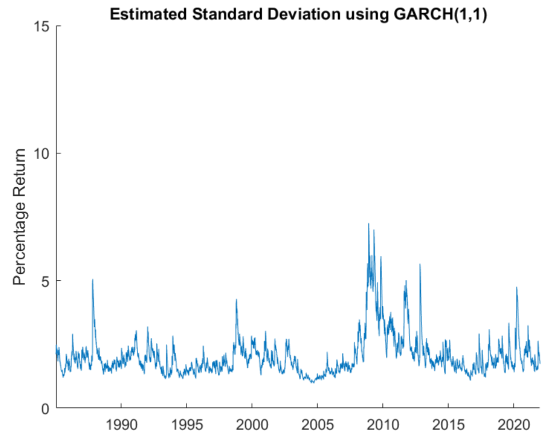
   GARCH(2,3) Conditional Variance Model with Offset (Gaussian Distribution):

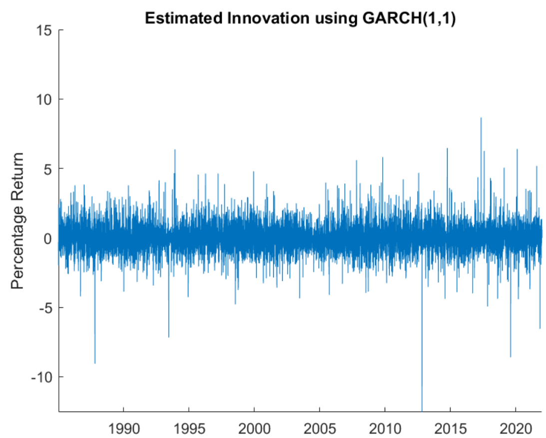
	Value	StandardError	TStatistic	PValue
Constant	0.083048	0.0076531	10.852	1.9603e-27
GARCH{1}	0.012686	0.032473	0.39065	0.69605
GARCH{2}	0.8771	0.031217	28.097	1.0567e-173
ARCH{1}	0.040971	0.0066703	6.1422	8.1374e-10
ARCH{2}	0.052393	0.0023817	21.998	2.9776e-107
ARCH{3}	2e-12	0.0071002	2.8168e-10	1
Offset	0.020399	0.01698	1.2014	0.22961

   (c) I choose GARCH(1,1) to be my model, since GARCH(1,1) has lower AIC.

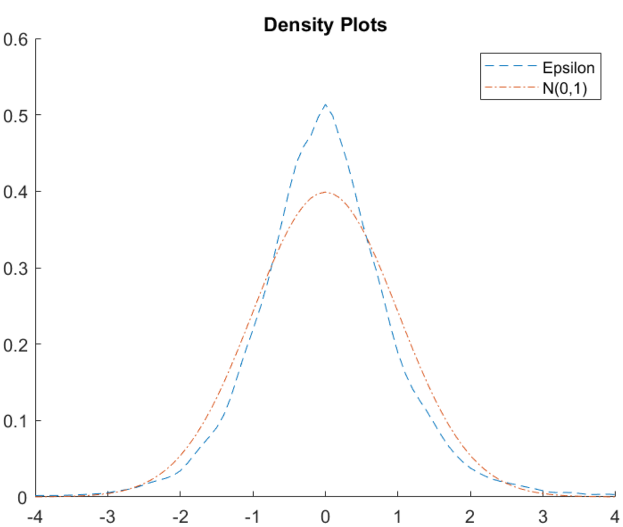
   (d) The calculated results are shown below.







(e) Plot the density of the de-volatilized residual.



2. Using the student t error distribution to estimate the same model.

   (a) The coefficients are all significant and almost consistent with the GARCH(1,1) with the normal distribution of error term.

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GARCH(1,1) Conditional Variance Model with Offset (t Distribution):
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	Value	**StandardError**	**TStatistic**	**PValue**
Constant	0.023009	0.0052764	4.3608	1.296e-05
GARCH{1}	0.9472	0.0042554	222.59	0
ARCH{1}	0.050151	0.0043998	11.398	4.2651e-30
DoF	4.597	0.21198	21.686	2.7619e-104
Offset	-0.017953	0.015531	-1.1559	0.24772

   (b) The estimated degree of freedom parameter is approximately equal to 4.6, which implies that the error distribution is not gaussian and has fat-tailed.

   (c) Result of chosen model is shown in 2(a).

3. Augment the model with a GJR leverage effect.

   (a) Report the model

GJR(1,1) Conditional Variance Model with Offset (t Distribution)

```
Effective Sample Size: 9325
Number of Estimated Parameters: 6
LogLikelihood: -18711
AIC: 37433.9
BIC: 37476.7
```

	Value	**StandardError**	**TStatistic**	**PValue**
Constant	0.024155	0.0054932	4.3972	1.0966e-05
GARCH{1}	0.94535	0.0043505	217.3	0
ARCH{1}	0.036719	0.0048109	7.6323	2.3052e-14
Leverage{1}	0.033072	0.0074789	4.422	9.7773e-06
DoF	4.6131	0.21206	21.754	6.3566e-105
Offset	-0.023877	0.0156	-1.5306	0.12586

   (b) All the coefficients except for offset(mean return) are statistically significant. First, the constant coefficient is positive and precisely estimated. Secondly, The Garch(1) coefficient is close to zero, which implies that conditional variances are persistent. Lastly, the Arch(1) coefficient presents the Arch effect for positive shock, and it turns out to be positive and statistically significant.

(c) The leverage coefficient is positive and statistically significant, which implies negative shocks have a greater effect on conditional variance than positive shocks, thus it is consistent with the leverage effect.

(d) Numerically, if there is a negative shock then the Arch coefficient will be $ARCH(1) + Leverage(1) \approx 0.07$. If there is a positive shock then the Arch coefficient will be $ARCH(1) \approx 0.04$. We can see that negative shocks have a greater effect on conditional variance.

(e) Since the leverage coefficient is greater than zero, it is consistent with the Leverage Effect.

4. To forecast the future price, we need to have precise speculation based on the information we owned. In order to be precise, we have to take volatility into consideration since the risk of an asset is measured by its conditional volatility. By observation, We can find that volatility is serially correlated, which is different from the simplified assumption that the error term is homoskedastic. Hence, we build up the ARCH model to capture the conditional variance. Subsequently, we develop advanced models based on the ARCH model to improve the goodness of fit for volatility.

Matlab Code

```
clear all;

% Question 1 %
NewYork = getMarketDataViaYahoo('NYT','1-Jan-1985','31-Dec-2021',
    '1d');
P = NewYork.Close;
dates = NewYork.Date;
dates2 = dates(2:end,:);
r = 100*(log(P(2:end)) - log(P(1:end-1)));

% GARCH(1,1) %
GARCH1 = garch('GARCHLags',1,'ARCHLags',1,'Offset',NaN);
estGARCH1 = estimate(GARCH1,r);
v1 = sqrt(infer(estGARCH1,r));
garch_1_1=summarize(estGARCH1);

% GARCH(2,3) %
GARCH2 = garch('GARCHLags',1:2,'ARCHLags',1:3,'Offset',NaN);
estGARCH2 = estimate(GARCH2,r);
v2 = sqrt(infer(estGARCH2,r));
```

```
garch_2_3=summarize(estGARCH2);

% estimating volatility and more GARCH(1,1)%
v1 = sqrt(infer(estGARCH1,r));
e=r-estGARCH1.Offset;
eps=e./v1;

figure(1);
plot(dates2,e);
ylim([0 30]);
ylabel('Percentage Return');
title('Estimated Residual using GARCH(1,1)');
box off

figure(2);
plot(dates2,v1);
ylim([0 15]);
ylabel('Percentage Return');
title('Estimated Standard Deviation using GARCH(1,1)');
box off

figure(3);
plot(dates2,eps);
ylim([0 15]);
ylabel('Percentage Return');
title('Estimated Innovation using GARCH(1,1)');
box off

% density of eps %
figure(4);
[f,x] = ksdensity(eps,(-4:.1:4));
g = normpdf(x);
plot(x,f,'--',x,g,'-.');
title('Density Plots');
legend('Epsilon','N(0,1)','Location','northeast');
box off

% Question 2 %
GARCH1_t = garch('GARCHLags',1,'ARCHLags',1,'Offset',NaN,'Distribution','t');
estGARCH1_t = estimate(GARCH1_t,r);
```

```
% Question 3 %
mdl = gjr('GARCHLags',1,'LeverageLags',1,'ARCHLags',1,'Offset',NaN,'Distribution','t');
est_mdl = estimate(mdl,r,'display','off');
summarize(est_mdl);


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
function data=getMarketDataViaYahoo(symbol, startdate, enddate, interval)
    if(nargin() == 1)
        startdate = posixtime(datetime('1-Jan-2018'));
        enddate = posixtime(datetime()); % now
        interval = '1d';
    elseif (nargin() == 2)
        startdate = posixtime(datetime(startdate));
        enddate = posixtime(datetime()); % now
        interval = '1d';
    elseif (nargin() == 3)
        startdate = posixtime(datetime(startdate));
        enddate = posixtime(datetime(enddate));
        interval = '1d';
    elseif(nargin() == 4)
        startdate = posixtime(datetime(startdate));
        enddate = posixtime(datetime(enddate));
    else
        error('At least one parameter is required. Specify ticker symbol.');
        data = [];
        return;
    end

    %% Send a request for data
    % Construct an URL for the specific data
    uri = matlab.net.URI(['https://query1.finance.yahoo.com/v7/finance/download/', upper(symbol)],...
        'period1',  num2str(int64(startdate), '%.10g'),...
        'period2',  num2str(int64(enddate), '%.10g'),...
        'interval', interval,...
```

```
            'events',    'history',...
            'frequency', interval,...
            'guccounter', 1,...
            'includeAdjustedClose', 'true');

    options = weboptions('ContentType','table', 'UserAgent', '
        Mozilla/5.0');
    try
        data = rmmissing(webread(uri.EncodedURI, options));
    catch ME
        data = [];
        warning(['Identifier: ', ME.identifier, 'Message: ', ME.
            message])
    end
end
```