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Statement on class recording

ECON3206/ECON5206 Financial Econometrics

Sample Answers/Hints to Tutorial 2

1. Linear regression models are linear in parameters. With a log transformation, (1) becomes $\ln(y_t) = \alpha + \beta \ln(x_t) + u_t$, a linear regression model. Hence both (1) and (3) are linear regression and can be estimated by OLS. However, (2) is not linear in parameters and OLS is not applicable. Its parameters cannot be properly estimated at all because the parameters are not identified in the sense that β and γ are observationally equivalent to βc and γ / c for any non-zero constant c. In this case, we can only use OLS to estimate the product $\beta\gamma$ but cannot estimate β and γ separately.

2. Population (true) model $Y_t = \alpha + u_t$, assume $E(u_t) = 0$

   Regression $Y_t = \hat{\alpha} + e_t$, $t = 1 \ldots T$

   $$SSE = \sum e_t^2 = \sum (Y_t - \hat{\alpha})^2$$

   By definition ordinary least squares estimator is defined as

   $\hat{\alpha} = \arg\min SSE$

   FOC:

   $$\frac{\partial SSE}{\partial \hat{\alpha}} = -2\sum (Y_t - \hat{\alpha}) = -2\sum Y_t + 2T\hat{\alpha} \equiv 0$$

   $\hat{\alpha} = \frac{1}{T}\sum Y_t$, which is just (not surprisingly) a sample mean estimator

   SOC: (just to make sure)

   $$\frac{\partial^2 SSE}{\partial \hat{\alpha}^2} = 2T > 0 \rightarrow \text{true minimum}$$

   We can check if $\hat{\alpha}$ is unbiased:

   $$E(\hat{\alpha}) = \frac{1}{T}\sum E(Y_t) = \frac{1}{T}\sum E(\alpha + u_t) = \frac{T\alpha}{T} + 0 = \alpha \rightarrow unbiased$$

3. The OLS estimator for the assumed (omitted variable) regression is $\mathbf{b} = (\mathbf{X'X})^{-1}\mathbf{X'Y}$. To find the bias compute

$$E(\mathbf{b}) = E_{\mathbf{X}}(E[(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y} \mid \mathbf{X}]) = E_{\mathbf{X}}(E[(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{X}\boldsymbol{\beta} + (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Z}\boldsymbol{\gamma} + (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{u} \mid \mathbf{X}])$$

using $\mathbf{E}[\mathbf{u} \mid \mathbf{X}, \mathbf{Z}] = 0$

$$= \boldsymbol{\beta} + \boldsymbol{\gamma} E_{\mathbf{X}}(E[(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Z} \mid \mathbf{X}) = \boldsymbol{\beta} + \boldsymbol{\gamma}\underbrace{E[(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Z})}_{\textbf{bias}}$$

Hence, omitted variable estimator is typically biased, unless $E(\mathbf{Z} \mid \mathbf{X}) = 0$, the omitted variable $\mathbf{Z}$ is independent of the included variable $\mathbf{X}$.

4. The yield (to maturity) is the rate of return on a bond (expressed as an annual rate) if purchased at the current market price and held until the Maturity Date. The annualised yield will vary through time with changes in the price and remaining term to maturity of the bond. In turn, the Coupon Interest Rate is set when the bond is first issued and remains fixed for the life of the bond. If the price of bond increases the (implied) yield goes down because you pay more for the same Coupon Interest Rate and terminal (face) value of the bond. The time to maturity is reported on the horizontal axes. The corresponding yields on the vertical axes form a yield curve. Different colours indicate the evolution of the yield curve comparing the current yield curve (almost current: 1 July 2015) with the curve one month ago, and one year ago. From the figure we see the yield curve is flattening. This indicates that the investors expect that the long term interest rates will be lower relatively to what they expected a month or a year ago. However, the expectation is still the rate will rise in the future. Using the Fisher model the expectation about the future interest rates depend on the expectations about the future inflation. The RBA as the other central banks targets (regulates) inflation setting the rates. Higher inflation in the future typically signals economic growth. Flattening of the yield curve indicates that the investors expect the growths will be weaker than expected. This was confirmed by Glenn Stevens, the governor of the RBA.
http://www.afr.com/news/economy/monetary-policy/rbas-glenn-stevens-says-growth-below-3pc-is-new-normal-20150722-gihuut
He is a powerful man. As he speaks the yields, the exchange rates, the shares move.

5. Durbin-Watson statistics is given by as

$$DW = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^{\,2}} = \frac{\sum_{t=2}^{T} e_t^{\,2}}{\sum_{t=1}^{T} e_t^{\,2}} + \frac{\sum_{t=2}^{T} e_{t-1}^{\,2}}{\sum_{t=1}^{T} e_t^{\,2}} - \frac{2\sum_{t=2}^{T} e_t e_{t-1}}{\sum_{t=1}^{T} e_t^{\,2}} \approx 1 + 1 - 2\hat{\rho}$$
$$= 2(1 - \hat{\rho})$$

As $-1 \le \hat{\rho} \le 1,\ 0 \le DW \le 4$, when $\hat{\rho}$ is small DW is close to 2.

6. Show that in the linear regression sum of squares total $\text{SST} = \sum_{t=1}^{T}[Y_t - \bar{Y}]^2$ can be decomposed into sum of squares explained $\text{SSE} = \sum_{t=1}^{T}[\hat{Y}_t - \bar{Y}]^2$ and sum of squared residuals $\text{SSR} = \sum_{t=1}^{T}[Y_t - \hat{Y}_t]^2$.

$$\text{SST} = \sum_{t=1}^{T}[Y_t - \bar{Y}]^2 = \sum_{t=1}^{T}[Y_t - \hat{Y}_t + \hat{Y}_t - \bar{Y}]^2 = \sum_{t=1}^{T}[Y_t - \hat{Y}_t]^2 + \sum_{t=1}^{T}[\hat{Y}_t - \bar{Y}]^2 + \sum_{t=1}^{T}2[\hat{Y}_t - \bar{Y}][Y_t - \hat{Y}]$$

Next look at the last term and show that this term equals zero in the least squares regression.

$$\sum_{t=1}^{T} 2[\hat{Y}_t - \bar{Y}][Y_t - \hat{Y}] = 2\sum_{t=1}^{T} [\hat{Y}_t - \bar{Y}]e_t = 2\sum_{t=1}^{T} \hat{Y}_t e_t + 2\bar{Y}\sum_{t=1}^{T} e_t$$

$$\sum_{t=1}^{T} \hat{Y}_t e_t = \sum_{t=1}^{T} (\hat{\beta}_1 X_{1t} + \hat{\beta}_2 X_{2t} + \ldots + \hat{\beta}_K X_{Kt})e_t = \hat{\beta}_1 \sum_{t=1}^{T} X_{1t}e_t + \hat{\beta}_2 \sum_{t=1}^{T} X_{2t}e_t + \ldots \hat{\beta}_K \sum_{t=1}^{T} X_{Kt}e_t$$

The first order condition of the least squares minimization problem implies that $\mathbf{X'e} = 0$. Recall that the first column of $\mathbf{X}$ is a vector of 1. Using the rules of matrix-vector multiplication on $\mathbf{X'e} = 0$ it is apparent that $\sum_{t=1}^{T} e_t = 0$ and $\sum_{t=1}^{T} X_{kt}e_t = 0$ for all $k = 1 \ldots K$

7. Show how F statistics, $F = \dfrac{(\mathrm{SSR_r} - \mathrm{SSR_u})/j}{\mathrm{SSR_u}/(T-K-1)}$ can be expressed in terms of R^2. This follows trivially from the definition of R^2: $R^2 = \dfrac{\mathrm{SSE}}{\mathrm{SST}} = 1 - \dfrac{\mathrm{SSR}}{\mathrm{SST}}$.

For the restricted model $R_{\mathrm{r}}^2 = 1 - \dfrac{\mathrm{SSR_r}}{\mathrm{SST}}$, so that, $\mathrm{SSR_r} = (1 - R_{\mathrm{r}}^2)\mathrm{SST}$, so and for the unrestricted model $R_{\mathrm{u}}^2 = 1 - \dfrac{\mathrm{SSR_u}}{\mathrm{SST}}$, so that $\mathrm{SSR_u} = (1 - R_{\mathrm{u}}^2)\mathrm{SST}$. Note that SST is the same for both models (we use the same data). Finally substitute in F

$$F = \frac{(\mathrm{SSR_r} - \mathrm{SSR_u})/j}{\mathrm{SSR_u}/(T-K-1)} = \frac{((1-R_{\mathrm{r}}^2)\mathrm{SST} - (1-R_{\mathrm{u}}^2)\mathrm{SST})/j}{(1-R_{\mathrm{u}}^2)\mathrm{SST}/(T-K-1)} = \frac{(R_{\mathrm{u}}^2 - R_{\mathrm{r}}^2)/j}{(1-R_{\mathrm{u}}^2)/(T-K-1)}.$$

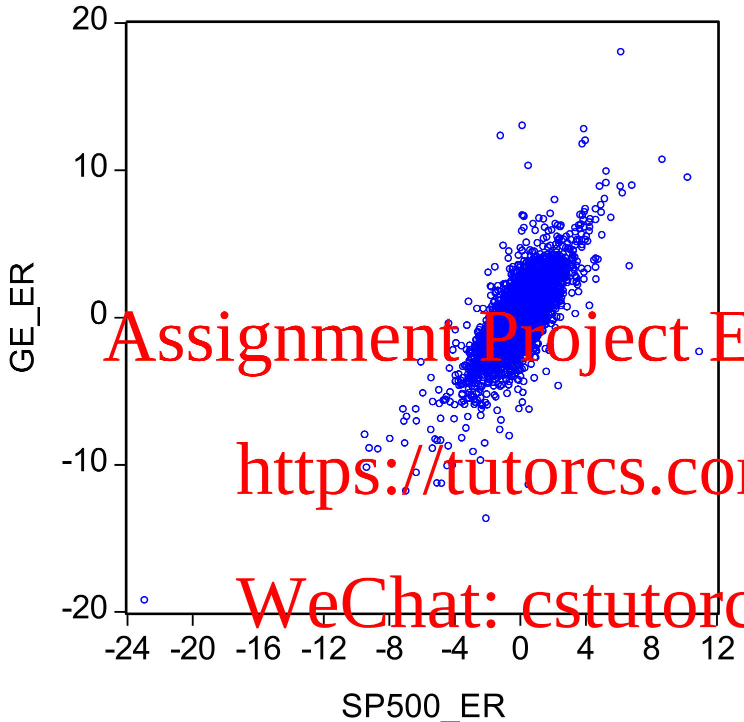
Intuitively if the restrictions are true the fit of the restricted model (measured by R^2) is close to the fit of the unrestricted model and F is small. Also because $R_{\mathrm{u}}^2 > R_{\mathrm{r}}^2$ F is always positive.

Computing Exercises

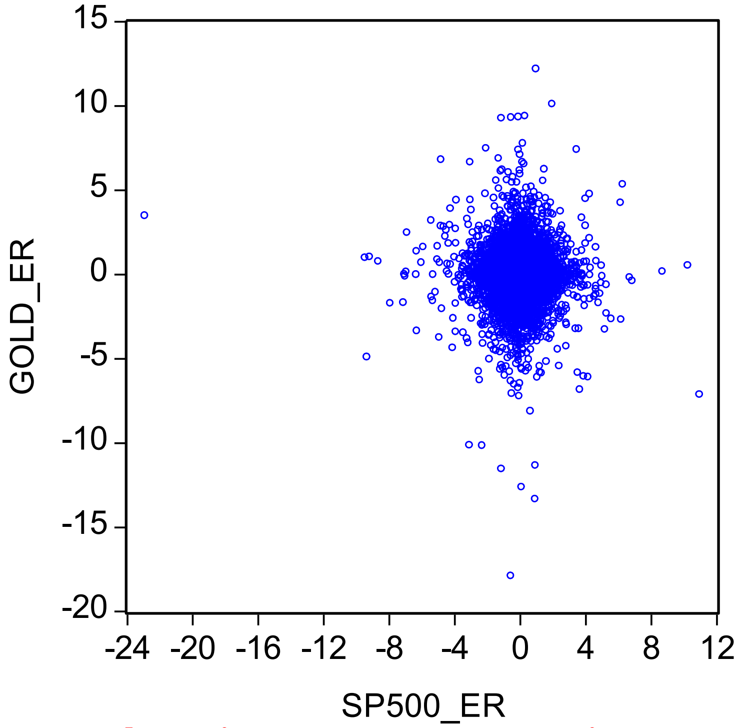
1. Estimating the CAPM

(a)-(c) See the **capm.wf1** file to check if your output is correct.

(d) The plot indicates an upward-sloping relationship between GE_ER (excess return of GE) and SP500_ER (excess return of the market). Note the outlier (more than -20% fall in one day). This is Black Monday, October 19, 1987, when stock markets around the world crashed, shedding a huge value in a very short time.



(e) The plot indicates no specific slope between GOLD_ER (excess return of GOLD) and SP500_ER (excess return of the market). Note that GOLD appreciated during the Black Friday when S&P500 fell more than -20% in one day.



While GOLD is considered a safe asset, the range of fluctuations of its returns is not particularly narrow. The remarkable drop in price is recorded on the 22nd of January, 1980 (outlier of about -20%). This is after the prices of GOLD soared the previous several days. Here is what news around this time says

Business/Economy news – January 21, 1980

Consumer prices for 1979 soar to 13.3% - the largest gain in 33 years. The gain in the previous year (1978) was a mere 9%. Inflation jumped to its highest in 1946 - when the government lifted WWII price controls and prices soared 18.2% for the year.

On inflation fears - gold continues to rise - reaching $845 an ounce this week - rising $100 in a single day. Profit takers drove the price down to $808. The price of gold has soared more than $640 an ounce from a year ago.

(f)-(g) The estimation output using GE indicates that the CAPM is supported by data ($\alpha = 0$ cannot be rejected). The beta coefficient is the % increase in the expected excess return of GE associated with 1% increase in the expected excess return of “market”. The estimate of beta is more than 1 (at 1.156882) and highly significant indicating that the GE may is a bit more risky than the market). The adjusted R-squared is 0.564154, indicating that the explanatory power of the model is relatively good (In time series setting we rarely see high R-squared). The Durbin-Watson statistic is 1.995, very close to 2. Hence there is no strong evidence for autocorrelation in the error term.

Dependent Variable: GE_ER
Method: Least Squares
Date: 08/15/15 Time: 17:23
Sample (adjusted): 8/13/1975 8/12/2015
Included observations: 10436 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001219	0.010646	-0.114470	0.9089
SP500_ER	1.156882	0.009954	116.2238	0.0000

R-squared	0.564196	Mean dependent var	0.018960
Adjusted R-squared	0.564154	S.D. dependent var	1.647184
S.E. of regression	1.087447	Akaike info criterion	3.005735
Sum squared resid	12338.64	Schwarz criterion	3.007125
Log likelihood	-15681.93	F-statistic	13507.97
Durbin-Watson stat	1.994580	Prob(F-statistic)	0.000000

The estimation output using GOLD also indicates that the CAPM is supported by data ($\alpha = 0$ cannot be rejected). The estimate of beta is less than 0 (at -0.02) and marginally significant at 7.5% significance level indicating that the GOLD has small negative correlation with the market. Note that the assets with negative beta are rather rare. They are useful for portfolio diversification as the move against the market. The adjusted R-squared is very small, indicating that the explanatory power of the model is relatively poor. The Durbin-Watson statistic is 2.07, very close to 2. Hence there is no strong evidence for autocorrelation in the error term.

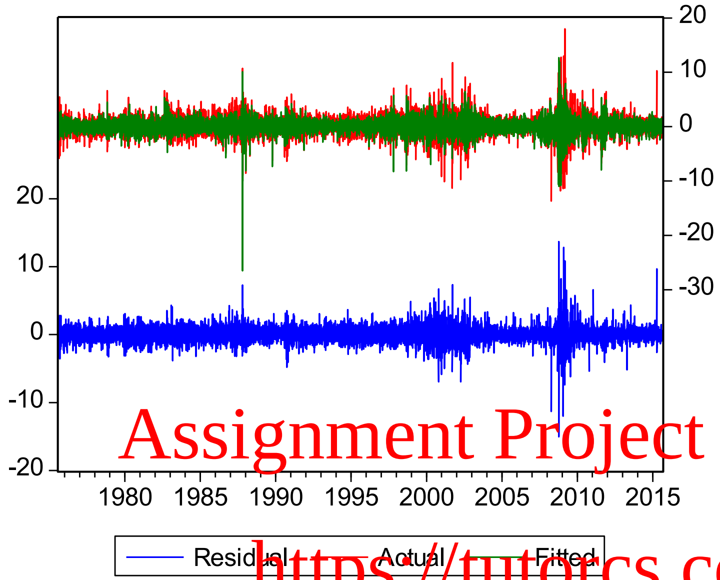
Dependent Variable: GOLD_ER
Method: Least Squares
Date: 08/15/15 Time: 17:31
Sample (adjusted): 8/13/1975 8/12/2015
Included observations: 10436 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005685	0.012033	0.472438	0.6366
SP500_ER	-0.020065	0.011250	-1.783554	0.0745

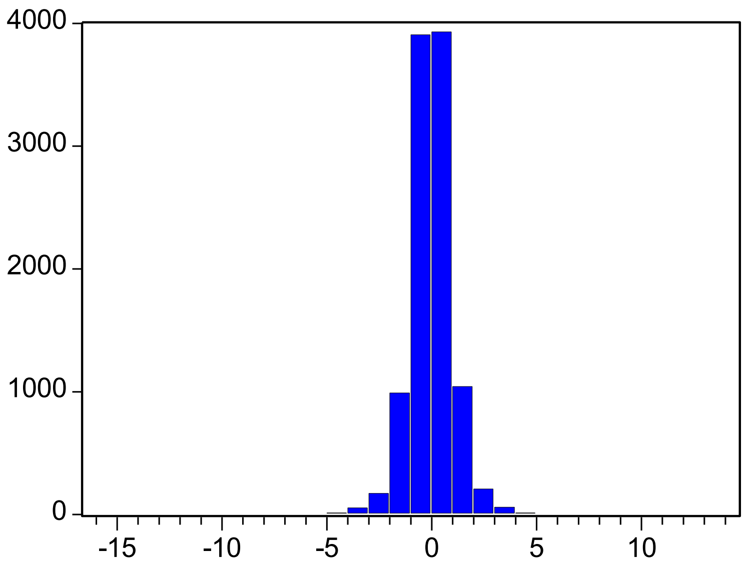
R-squared	0.000305	Mean dependent var	0.005335
Adjusted R-squared	0.000209	S.D. dependent var	1.229190
S.E. of regression	1.229062	Akaike info criterion	3.250570

Sum squared resid	15761.52	Schwarz criterion	3.251960
Log likelihood	-16959.48	F-statistic	3.181064
Durbin-Watson stat	2.071244	Prob(F-statistic)	0.074525

(h) Actual-Fitted-Residuals plot for GE.



The fit quality of the fit (range of residuals) is relatively stable except for volatile periods of early 2000s recession (dot-com bubble burst) and the recent periods of the GFC.

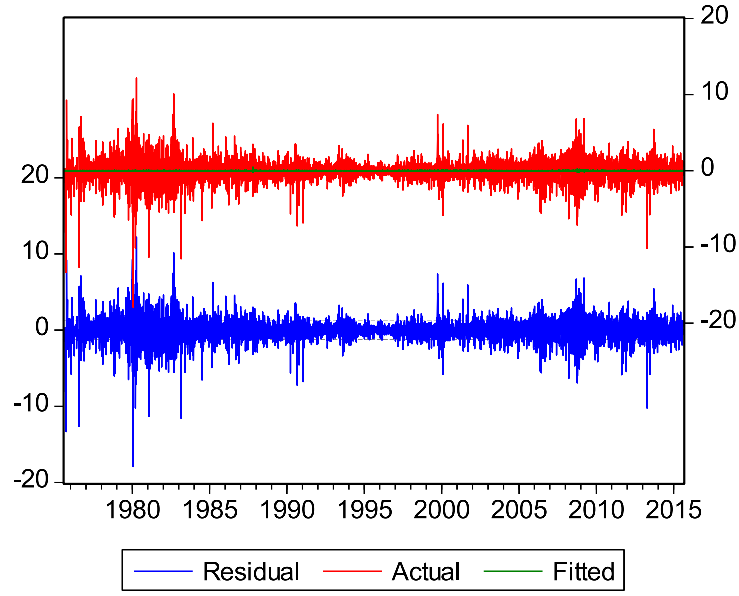


Series: Residuals
Sample 8/13/1975 8/12/2015
Observations 10436

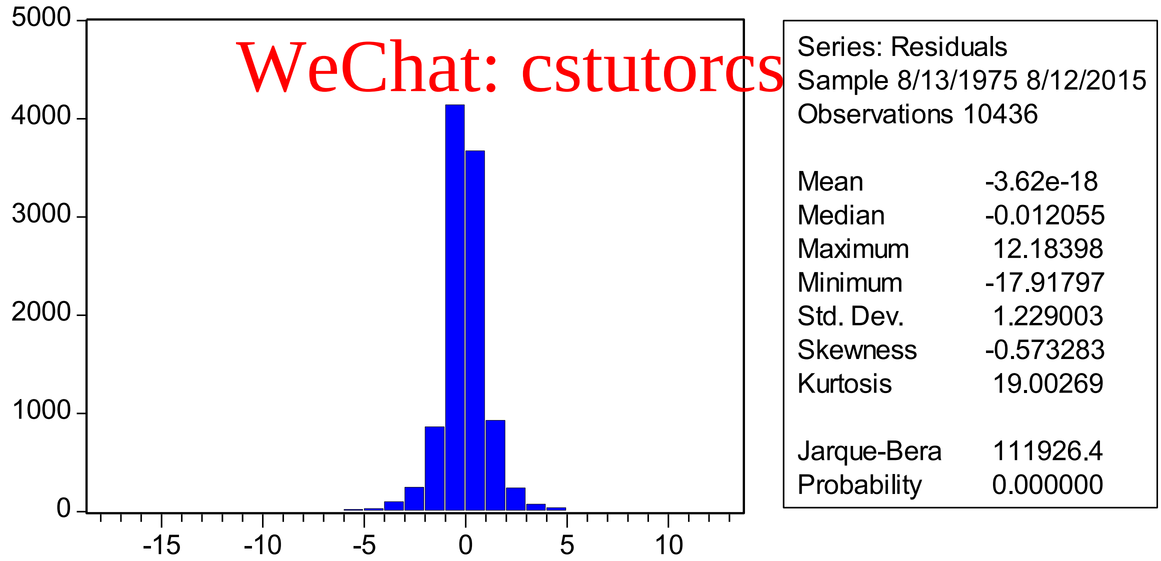
Mean	3.95e-17
Median	0.001280
Maximum	13.67857
Minimum	-15.02791
Std. Dev.	1.087395
Skewness	0.109246
Kurtosis	18.84809
Jarque-Bera	109234.3
Probability	0.000000

The normality is overwhelmingly rejected.

Actual-Fitted-Residuals plot for GOLD.



The residuals plot for GOLD shows relatively poor fit in the 1980, the periods of high inflations and high fluctuations of gold prices. The high fluctuations may be explained by abandoning of the gold standard (in October 1976 US dollar was no longer tight to Gold) and subsequent deregulation of the gold market.



The normality is also rejected.

(i)

For GE:

White Heteroskedasticity Test:

F-statistic	318.6093	Probability	0.000000
Obs*R-squared	600.7120	Probability	0.000000

The homoskedasticity is rejected and hence standard errors need to be corrected (using White or HAC standard errors).

For GOLD:

White Heteroskedasticity Test:

F-statistic	18.49337	Probability	0.000000
Obs*R-squared	36.86668	Probability	0.000000

Similarly for GOLD CAPM, the homoskedasticity is rejected and hence standard errors need to be corrected (using White or HAC standard errors).

(j)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.587708	Probability	0.075240
Obs*R-squared	5.174834	Probability	0.075214

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/15/15 Time: 18:00
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.97E-06	0.010645	-0.000561	0.9996
SP500_ER	0.000405	0.009959	0.040645	0.9676
RESID(-1)	0.002741	0.009793	0.279895	0.7796
RESID(-2)	-0.022111	0.009791	-2.258246	0.0240

R-squared	0.000496	Mean dependent var	3.95E-17
Adjusted R-squared	0.000208	S.D. dependent var	1.087395
S.E. of regression	1.087282	Akaike info criterion	3.005622

Sum squared resid	12332.53	Schwarz criterion	3.008402
Log likelihood	-15679.34	F-statistic	1.725139
Durbin-Watson stat	2.001699	Prob(F-statistic)	0.159464

There is no strong evidence for autocorrelation in the residual as the p-value is large.

For GOLD

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	7.036154	Probability	0.000884
Obs*R-squared	14.05874	Probability	0.000885

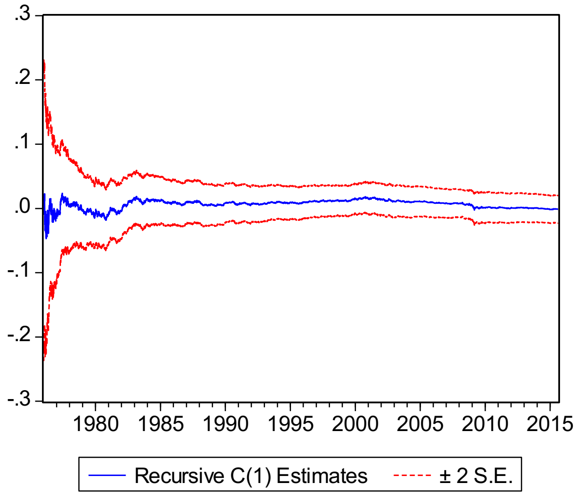
Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/15/15 Time: 18:09
Presample missing value lagged residuals set to zero.

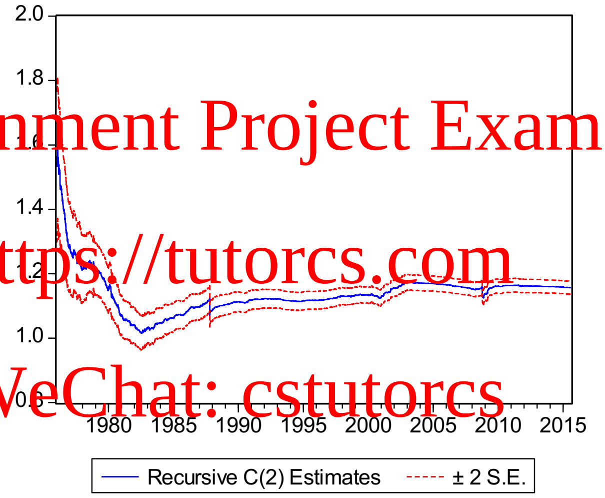
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.45E-06	0.012026	-0.000370	0.9997
SP500_ER	9.12E-05	0.011245	0.008110	0.9935
RESID(-1)	-0.035461	0.009791	-3.621760	0.0003
RESID(-2)	0.008292	0.009792	0.846781	0.3971

R-squared	0.001347	Mean dependent var	-3.62E-18
Adjusted R-squared	0.001060	S.D. dependent var	1.229003
S.E. of regression	1.228351	Akaike info criterion	3.249606
Sum squared resid	15740.29	Schwarz criterion	3.252386
Log likelihood	-16952.44	F-statistic	4.690769
Durbin-Watson stat	1.999985	Prob(F-statistic)	0.002820

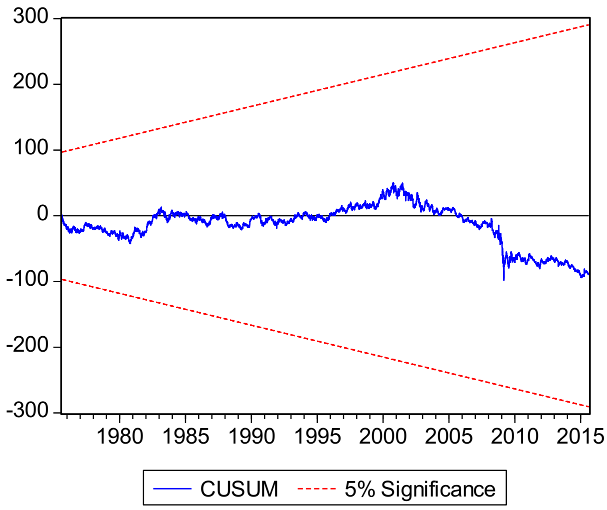
There is some evidence for autocorrelation in the residual as the p-value is small. Note that the conclusions are different from Durbin-Watson test commented on earlier. The reason for difference is that DW test looks only on lag 1, while Breusch-Godfrey Serial Correlation LM Test includes lags of higher order and it more general. HAC standard errors should be in this case.

(k) Stability for GE



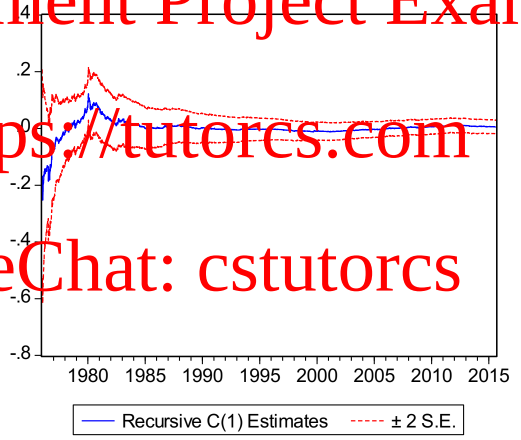


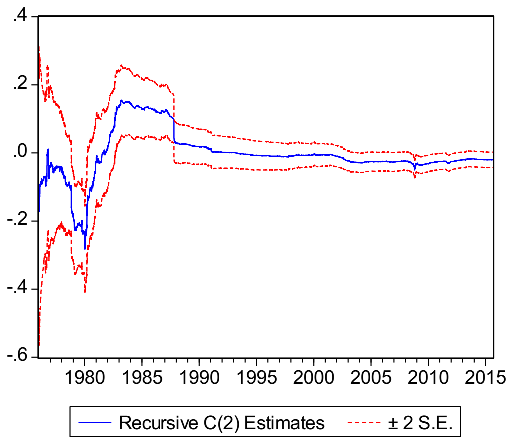
The recursive coefficients show that generally the coefficients are stable (especially after 90es). The coefficients are somewhat noisy in the beginning as relatively small samples are used. It is reasonable to assume higher beta in the beginning of the sample.



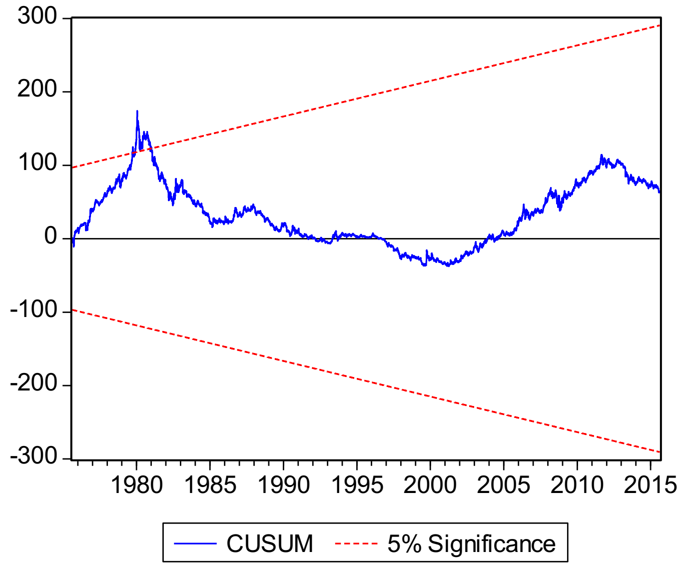
The model stability is formally tested via the CUSUM test. As the CUSUM does not go outside the 95% probability bands, there is no evidence for instability.

For GOLD:



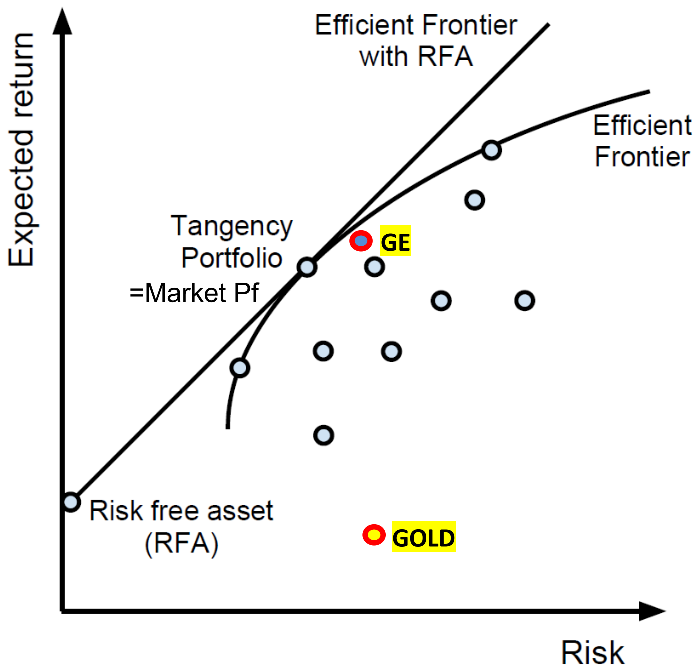


We observe relatively high parameter instability around 80ies. Before 80is GOLD seem to have relatively large negative beta. After 80is the beta increase and become positive and there was a structural jump around 1987 a sharp reduction in Gold's beta.



CUSUM test also signals some instability. Hence it may be useful to separate different periods using the dummy variables.

(l)-(o)



The expected return of GE can be replicated by combining market portfolio with the risk-free asset.

Generally this portfolio will be β fraction of market portfolio and (1- β) risk-free asset. We discussed in class why this it optimal. Because β is greater than one (1- β) is negative indicating that we need to short sell Tbill (borrow money at risk-free rate) and buy S&P500 (market) index.

The portfolio combination: 1.156882*S&P500 - 0.156882*Tbill

To replicate Gold return we will do something rather bizarre: short-sell a small fraction of the market portfolio and buy secure Tbills.

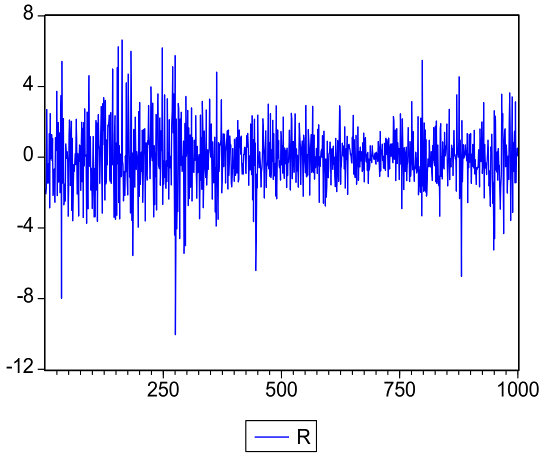
The portfolio combination: -0.02*S&P500 + 1.02*Tbill

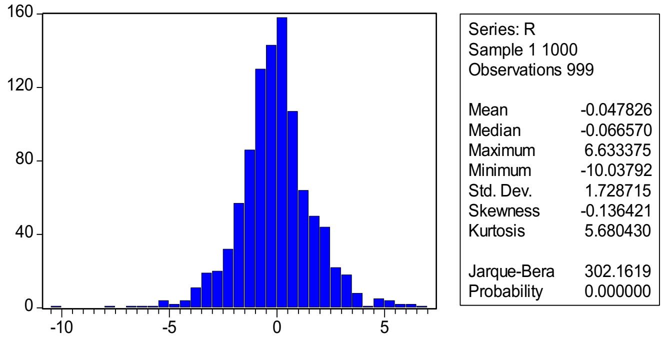
	GE_R	GE_EQUIV_P	GOLD_R	GOLD_EUIV_P	SP500_R
Mean	0.031948	0.033167	0.018323	0.012900	0.030431
Std. Dev.	1.647229	1.237171	1.229045	0.023489	1.069396

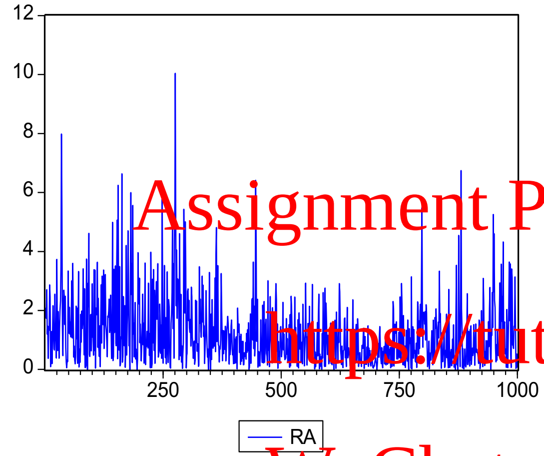
The replicated expected returns are close the expected returns of the underlying assets. The risk the replicated portfolio is smaller than of the underlying asset (especially in the case of gold).

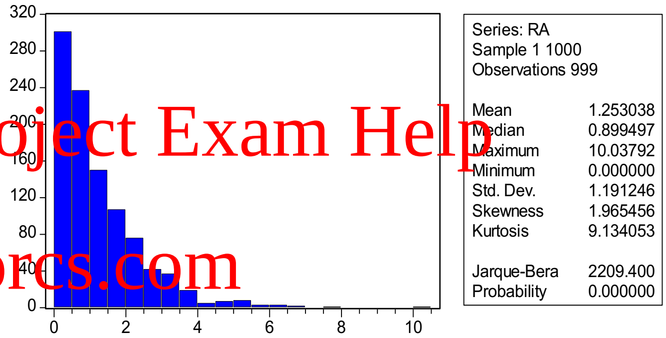
The market is willing to reward only with the expected return only the systematic risk. In the case of Gold the risk premium is negative (as the gold can be used as a hedge, you have to pay to hedge the risk). Difference between the risk (st.dev.) of the underlying asset and the corresponding portfolio can be viewed as the idiosyncratic risk (which is not rewarded by expected return): about 0.31 for GE and 1.2 for Gold.

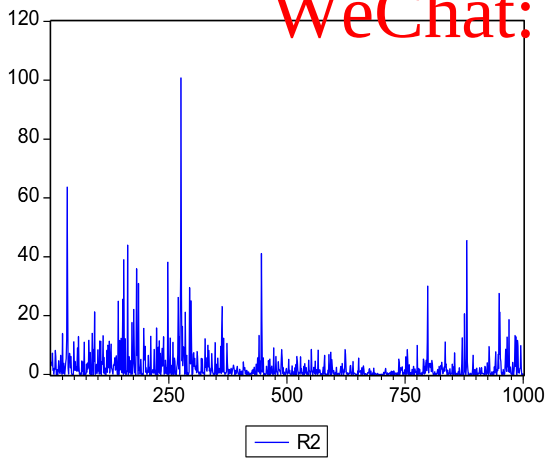
2. **The** following results are useful as a benchmark for your computation.

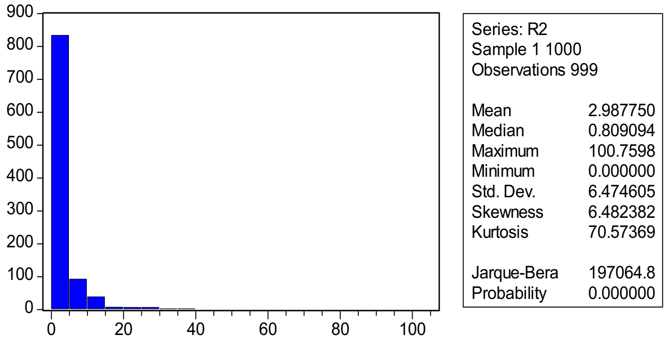












Sample: 1 1000

	R	R2	RA
Mean	-0.047826	2.987750	1.253038
Median	-0.066570	0.809094	0.899497
Maximum	6.633375	100.7598	10.03792
Minimum	-10.03792	0.000000	0.000000
Std. Dev.	1.728715	6.474605	1.191246
Skewness	-0.136421	6.482382	1.965456
Kurtosis	5.680430	70.57369	9.134053
Jarque-Bera	302.1619	197064.8	2209.400
Probability	0.000000	0.000000	0.000000
Sum	-47.77822	2984.762	1251.785
Sum Sq. Dev.	2982.477	41836.67	1416.228
Observations	999	999	999

(a) , (b), (c): You should obtain results that are the same as the above. The "Histogram" from Eviews delivers the required empirical distribution and statistics. Clearly, rc2 and rca are non-negative variables and are nowhere near a "bell-shaped" distribution (see their histograms). Their time-series plots illustrate the variability in rc to some extent (as the average of rc2 is approximately the variance of rc). For rc, its JB statistic convincingly reject the normality hypothesis since it is negatively skewed and with a kurtosis as large as 5.68 (comparing to 3 in a normal distribution).

Correlogram of R

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.169	-0.169	28.713	0.000
		2	0.013	-0.016	28.893	0.000
		3	-0.035	-0.036	30.109	0.000
		4	-0.043	-0.056	31.948	0.000
		5	0.041	0.024	33.600	0.000
		6	-0.027	-0.019	34.353	0.000
		7	-0.054	-0.067	37.260	0.000
		8	0.011	-0.010	37.391	0.000
		9	0.021	0.023	37.832	0.000
		10	0.001	0.001	37.835	0.000
		11	0.029	0.026	38.667	0.000
		12	-0.020	-0.006	39.087	0.000

Correlogram of RA

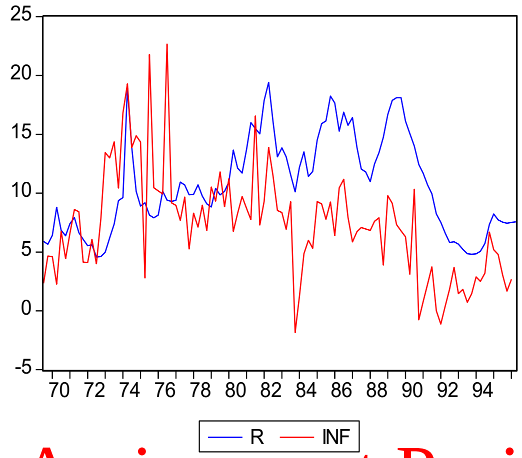
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.250	0.250	62.726	0.000
		2	0.151	0.094	85.569	0.000
		3	0.155	0.104	109.55	0.000
		4	0.129	0.064	126.26	0.000
		5	0.152	0.098	149.57	0.000
		6	0.138	0.062	168.66	0.000
		7	0.105	0.028	179.86	0.000
		8	0.100	0.030	189.97	0.000
		9	0.105	0.039	201.19	0.000
		10	0.118	0.050	215.21	0.000
		11	0.068	-0.011	219.91	0.000
		12	0.057	-0.002	223.24	0.000

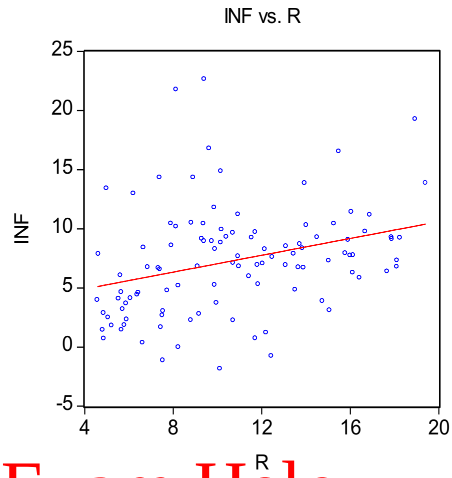
Correlogram of R2

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.267	0.267	71.470	0.000
		2	0.136	0.070	90.112	0.000
		3	0.112	0.064	102.62	0.000
		4	0.100	0.053	112.68	0.000
		5	0.121	0.076	127.38	0.000
		6	0.124	0.066	142.74	0.000
		7	0.065	-0.003	147.01	0.000
		8	0.056	0.013	150.18	0.000
		9	0.103	0.068	160.84	0.000
		10	0.091	0.032	169.20	0.000
		11	0.034	-0.028	170.34	0.000
		12	0.031	-0.001	171.31	0.000

(d) According to the above correlograms, there is a statistically significant first order autocorrelation in rc, which (-0.169) is outside the Bartlett bands (dashed lines). Because of this, the log price of Copper does not behave like a random walk and hence the efficient market hypothesis is statistically rejected. For rc2 and rca, the autocorrelations are much stronger than for rc, indicating the predictability of volatility.

3. The sample answers are based on the following computation results.





Dependent Variable: R
Method: Least Squares
|
Sample (adjusted): 1969Q3 1996Q1
Included observations: 107 after adjustments
Newey-West HAC Standard Errors & Covariance (lag truncation=4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.705765	1.130294	7.702214	0.0000
INF	0.273318	0.129300	2.113833	0.0369

R-squared	0.097315	Mean dependent var	10.70084
Adjusted R-squared	0.088718	S.D. dependent var	4.006681
S.E. of regression	3.824823	Akaike info criterion	5.539416
Sum squared resid	1536.073	Schwarz criterion	5.589375
Log likelihood	-294.3588	F-statistic	11.31960
Durbin-Watson stat	0.264260	Prob(F-statistic)	0.001072

Wald Test:
Equation: EQN1

Test Statistic	Value	df	Probability
F-statistic	31.58605	(1, 105)	0.0000
Chi-square	31.58605	1	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-1 + C(2)	-0.726682	0.129300

Correlogram of Residuals

Sample: 1969Q3 1996Q1
Included observations: 107

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.863	0.863	81.906	0.000
		2	0.793	0.191	151.81	0.000
		3	0.719	0.002	209.78	0.000
		4	0.676	0.090	261.52	0.000
		5	0.524	-0.412	292.97	0.000
		6	0.492	0.275	320.94	0.000
		7	0.441	0.017	343.59	0.000
		8	0.410	0.020	363.39	0.000

Correlogram of R

Sample: 1969Q3 1996Q2
Included observations: 108

	AC	PAC	Q-Stat	Prob
1	0.898	0.898	89.629	0.000
2	0.791	-0.086	159.70	0.000
3	0.708	0.073	216.43	0.000
4	0.621	-0.083	260.46	0.000
5	0.489	-0.274	287.98	0.000
6	0.382	0.064	304.97	0.000
7	0.326	0.146	317.44	0.000
8	0.284	0.054	327.06	0.000

Correlogram of INF

Sample: 1969Q3 1996Q2
Included observations: 107

	AC	PAC	Q-Stat	Prob
1	0.539	0.539	31.926	0.000
2	0.538	0.349	64.047	0.000
3	0.510	0.214	93.224	0.000
4	0.499	0.161	121.41	0.000
5	0.295	-0.208	131.37	0.000
6	0.353	0.050	145.78	0.000
7	0.217	-0.128	151.26	0.000
8	0.276	0.132	160.25	0.000

(a) and (b) are straightforward.

(c) When $\beta_1 = 1$, the intercept is in fact the *real* interest rate. The hypothesis $\beta_1 = 1$ is rejected, see the p-value for F-test or z = (0.273318 – 1)/0.1293 = -5.62, which is far too negative in comparison to the critical value -1.96 at the 5% level of significance.

(d) From the correlograms, both R and INF have strong autocorrelations (both AC and PAC are outside the bands). The autocorrelation in R is mainly caused by the first-order PAC, although a smallish fifth-order PAC is also statistically significant. In this case, R_{t-2} is not directly correlated with R_t but affects R_t via R_{t-1}. Further, we note that the residual from the regression model is autocorrelated. This is a violation of the basic assumption that error term is uncorrelated with one another.