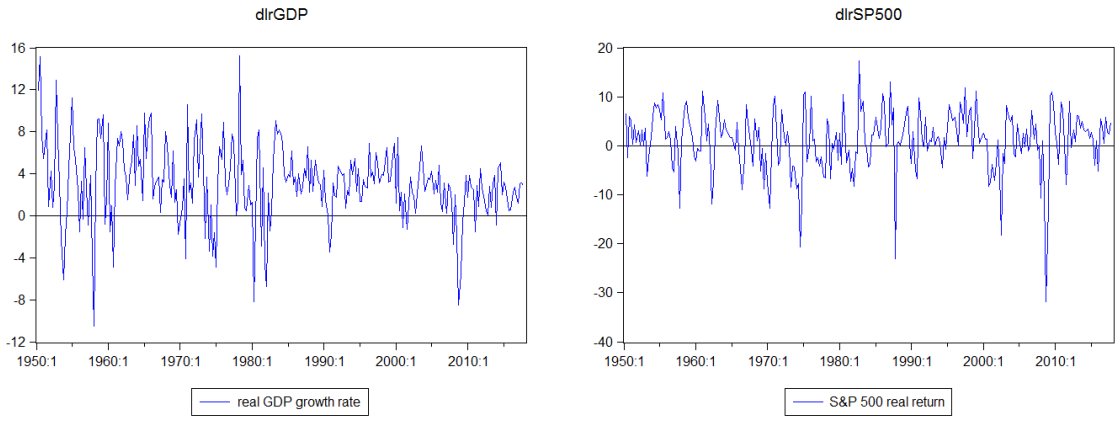
Homework 8

Eco 4306 Economic and Business Forecasting
Spring 2018
Due: Thursday, April 24, before the class

Problem 1

(a) Figure below shows the annualized growth rate of the U.S. real GDP $dlrGDP_t = 400\Delta \log GDP_t$ and the inflation adjusted return of S&P 500 $dlrSP500_t = 100(\Delta \log SP500_t - \Delta \log p_t^{GDP})$.



(b) The AIC andf SC information criteria suggests that 2 lags should be used in the bivariate VAR

VAR Lag Order Selection Criteria
Endogenous variables: DLRGDP DLRSP500
Exogenous variables: C
Date: 04/26/18 Time: 16:57
Sample: 2000Q1 2016Q4
Included observations: 68

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-369.4581	NA	190.4688	10.92524	10.99052	10.95110
1	-360.0830	17.92309	162.6346	10.76715	10.96298*	10.84474
2	-353.5682	12.07153*	151.1026*	10.69318*	11.01958	10.82251*
3	-353.2996	0.481770	168.7874	10.80293	11.25989	10.98399
4	-352.5217	1.349937	185.8737	10.89770	11.48521	11.13049
5	-351.7046	1.369815	204.6482	10.99131	11.70939	11.27584
6	-349.1817	4.081129	214.5470	11.03476	11.88339	11.37101
7	-346.2846	4.516192	222.7797	11.06719	12.04639	11.45518
8	-343.6247	3.989861	233.3418	11.10661	12.21636	11.54633

* 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

The results of the estimation of the bvivariate VAR

$$y_{1t} = c_1 + \alpha_{11} y_{1t-1} + \alpha_{12} y_{1t-2} + \beta_{11} y_{2t-1} + \beta_{12} y_{2t-2} + \varepsilon_{1t}$$
$$y_{2t} = c_2 + \alpha_{21} y_{1t-1} + \alpha_{22} y_{1t-2} + \beta_{21} y_{2t-1} + \beta_{22} y_{2t-2} + \varepsilon_{2t}$$

are shown below. Note that the coefficients $\alpha_{21}, \alpha_{22}, \beta_{21}, \beta_{22}$ in the equation for real returns of the S&P 500 are not statistically significant, which is in line with S&P 500 not being easily predictable.

Vector Autoregression Estimates
Date: 04/26/18 Time: 16:52
Sample: 2000Q1 2016Q4
Included observations: 68
Standard errors in ( ) & t-statistics in [ ]

	DLRGDP	DLRSP500
DLRGDP(-1)	0.065707	0.133711
	(0.13856)	(0.38951)
	[0.47422]	[0.34328]
DLRGDP(-2)	0.185656	-0.404508
	(0.13220)	(0.37164)
	[1.40434]	[-1.08845]
DLRSP500(-1)	0.126714	0.451046
	(0.05048)	(0.14191)
	[2.51016]	[3.17844]
DLRSP500(-2)	-0.001633	-0.101216
	(0.05241)	(0.14734)
	[-0.03115]	[-0.68698]
C	1.326002	0.647247
	(0.42193)	(1.18610)
	[3.14270]	[0.54569]
R-squared	0.228927	0.206599
Adj. R-squared	0.179969	0.156224
Sum sq. resids	313.3873	2476.547
S.E. equation	2.230337	6.269790
F-statistic	4.676069	4.101245
Log likelihood	-148.4375	-218.7217
Akaike AIC	4.512868	6.580049
Schwarz SC	4.676067	6.743248
Mean dependent	1.840825	0.194719
S.D. dependent	2.462949	6.825578

Determinant resid covariance (dof adj.)	131.1124
Determinant resid covariance	112.5401
Log likelihood	-353.5682
Akaike information criterion	10.69318
Schwarz criterion	11.01958

(c) The Granger causality tests show that

- we reject the hypothesis that real return of the S&P 500 is not Granger causing real GDP growth rate, since the p-value for the test with $H_0 : \beta_{11} = \beta_{12} = 0$ is 0.0354
- we can not reject the hypothesis that real GDP growth rate is not Granger causing real return of the S&P 500, since the p-value for the test with $H_0 : \alpha_{21} = \alpha_{22} = 0$ is 0.5484

The real returns of the S&P 500 index in the current quarter and the previous quarter are thus useful for predicting next quarter's real GDP growth rate, but real GDP growth in the current quarter and the previous quarter are not useful for predicting next quarter's real return pf the S&P 500 index.

The intuition behind this result is that the financial markets are incorporating news fast, and thus move up or down before the GDP does - they are procyclical but lead the GDP.

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 04/26/18 Time: 16:57
Sample: 2000Q1 2016Q4
Included observations: 68

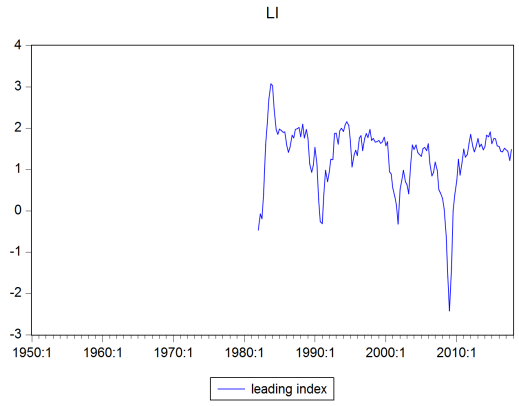
Dependent variable: DLRGDP

Excluded	Chi-sq	df	Prob.
DLRSP500	6.679366	2	0.0354
All	6.679366	2	0.0354

Dependent variable: DLRSP500

Excluded	Chi-sq	df	Prob.
DLRGDP	1.201515	2	0.5484
All	1.201515	2	0.5484

(d) Figure below shows the time series plot for U.S. Leading Index.



(e) The AIC andf SC information criteria suggests that 1 lags should be used in the VAR with, Leading Index for the United States as third variable y_{3t}

VAR Lag Order Selection Criteria
Endogenous variables: DLRGDP DLRSP500 LI
Exogenous variables: C
Date: 04/26/18 Time: 16:57
Sample: 2000Q1 2016Q4
Included observations: 68

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-435.9801	NA	81.25201	12.91118	13.00910	12.94998
1	-360.1658	142.7093*	11.39108*	10.94605*	11.33773*	11.10125*
2	-352.2663	14.17268	11.78686	10.97842	11.66386	11.25001
3	-349.4763	4.759487	14.20906	11.16107	12.14026	11.54905
4	-347.1989	3.684009	17.45190	11.35879	12.63174	11.86317
5	-341.9919	7.963595	19.76027	11.47035	13.03706	12.09113
6	-330.7852	16.15088	18.87065	11.40545	13.26592	12.14262
7	-323.1974	10.26587	20.19991	11.44698	13.60121	12.30055
8	-311.9055	14.28090	19.57509	11.37957	13.82756	12.34954

* 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

Vector Autoregression Estimates
Date: 04/26/18 Time: 16:52
Sample: 2000Q1 2016Q4
Included observations: 68
Standard errors in ( ) & t-statistics in [ ]

	DLRGDP	DLRSP500	LI
DLRGDP(-1)	-0.035401	-0.158559	6.09E-05
	(0.14987)	(0.43821)	(0.02276)
	[-0.23621]	[-0.36183]	[0.00268]
DLRSP500(-1)	0.114267	0.419174	0.032149
	(0.04814)	(0.14075)	(0.00731)
	[2.37380]	[2.97811]	[4.39834]
LI(-1)	0.891052	0.383648	0.772486
	(0.41245)	(1.20600)	(0.06263)
	[2.16039]	[0.31812]	[12.3342]
C	0.977225	0.018105	0.220571
	(0.44849)	(1.31138)	(0.06810)
	[2.17892]	[0.01381]	[3.23882]
R-squared	0.251733	0.167006	0.850376
Adj. R-squared	0.216658	0.127959	0.843362
Sum sq. resids	304.1181	2600.133	7.012292
S.E. equation	2.179873	6.373937	0.331009
F-statistic	7.176992	4.277098	121.2459
Log likelihood	-147.4167	-220.3774	-19.24516
Akaike AIC	4.453432	6.599334	0.683681
Schwarz SC	4.583992	6.729894	0.814240
Mean dependent	1.840825	0.194719	1.013824
S.D. dependent	2.462949	6.825578	0.836356

Determinant resid covariance (dof adj.)	9.596087
Determinant resid covariance	8.000320
Log likelihood	-360.1658
Akaike information criterion	10.94605
Schwarz criterion	11.33773

(f) The AC and PAC functions suggest that an AR(1) model should be adequate for $dlrGDP_t$.

Date: 05/12/18 Time: 14:17 Time Series: dlrGDP
Sample: 2000Q1 2016Q4
Included observations: 68

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.357	0.357	9.0607	0.003
		2	0.238	0.126	13.137	0.001
		3	0.085	-0.040	13.664	0.003
		4	0.065	0.022	13.976	0.007
		5	-0.037	-0.077	14.079	0.015
		6	-0.003	0.023	14.080	0.029
		7	0.014	0.036	14.095	0.050
		8	-0.026	-0.049	14.148	0.078
		9	0.052	0.083	14.369	0.110
		10	-0.015	-0.057	14.388	0.156
		11	-0.144	-0.176	16.131	0.136
		12	-0.100	0.016	16.983	0.150
		13	-0.101	-0.035	17.873	0.162
		14	-0.062	0.010	18.212	0.197
		15	-0.066	-0.015	18.605	0.232
		16	-0.057	-0.061	18.902	0.274

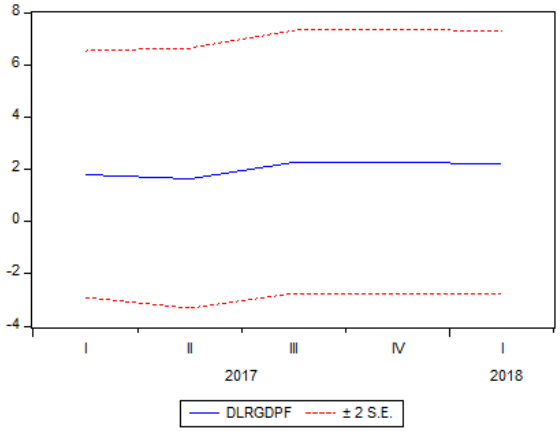
Dependent Variable: DLRGDP
Method: ARMA Maximum Likelihood (BFGS)
Date: 05/12/18 Time: 14:17
Sample: 2000Q1 2016Q4
Included observations: 68
Convergence achieved after 3 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.834685	0.473660	3.873422	0.0003
AR(1)	0.352378	0.102358	3.442603	0.0010
SIGMASQ	5.213899	0.714370	7.298595	0.0000

R-squared	0.127660	Mean dependent var	1.840825
Adjusted R-squared	0.100819	S.D. dependent var	2.462949
S.E. of regression	2.335496	Akaike info criterion	4.579390
Sum squared resid	354.5451	Schwarz criterion	4.677309
Log likelihood	-152.6993	Hannan-Quinn criter.	4.618189
F-statistic	4.756115	Durbin-Watson stat	2.076297
Prob(F-statistic)	0.011811		

Inverted AR Roots	.35

(g) Figures below show the RMSEs for univariate AR(1), bivariate VAR(2) and trivariate VAR(1) models. The RMSE for the forecast of $dlrGDP_t$ is 0.708268 and the lowest for the trivariate VAR(1) model, and is 0.9113 and the highest for the univariate AR(1) model.



Forecast: DLRGDPF	
Actual: DLRGDP	
Forecast sample: 2017Q1 2018Q1	
Included observations: 5	
Root Mean Squared Error	0.911392
Mean Absolute Error	0.847031
Mean Abs. Percent Error	35.09057
Theil Inequality Coefficient	0.195083
Bias Proportion	0.377427
Variance Proportion	0.281160
Covariance Proportion	0.341413
Theil U2 Coefficient	0.812279
Symmetric MAPE	37.99562

Forecast Evaluation
Date: 04/26/18 Time: 16:57
Sample: 2017Q1 2018Q1
Included observations: 5

Variable	Inc. obs.	RMSE	MAE	MAPE	Theil
DLRGDP	4	0.734972	0.703944	32.32103	0.149761
DLRSP500	4	3.748164	2.887295	616.7781	0.661163

RMSE: Root Mean Square Error
MAE: Mean Absolute Error
MAPE: Mean Absolute Percentage Error
Theil: Theil inequality coefficient

Forecast Evaluation
Date: 04/26/18 Time: 16:57
Sample: 2017Q1 2018Q1
Included observations: 5

Variable	Inc. obs.	RMSE	MAE	MAPE	Theil
DLRGDP	4	0.708268	0.613947	26.04605	0.137210
DLRSP500	4	3.272321	2.523393	354.6254	0.563865
LI	4	0.172922	0.156729	11.50939	0.061201

RMSE: Root Mean Square Error
MAE: Mean Absolute Error
MAPE: Mean Absolute Percentage Error
Theil: Theil inequality coefficient

(h) The Federal Bank of New York Nowcast was 2.9%, GDPNow Federal Bank of Atlanta forecast 2.0%, the minimum, the average, and the maximum forecasts in the Wall Street Journal Economic Forecasting Survey 1.0%, 2.1%, and 3.1% respectively.

The forecasts for the real GDP growth rate in 2018Q1 are as follows: using AR(1) from part(f) roughly 2.2%, using bivariate VAR(2) from part(b) roughly 2.7%, and using trivariate VAR(1) from part(e) roughly 2.8%. They are thus in line with the forecasts from these institutions.