Assignment 9

1. Perform unit root test of series y and x

```
. dfuller y, trend lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                                 ------------ Interpolated Dickey-Fuller ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)              1.000           -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 1.0000

------------------------------------------------------------------------------
D.y          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
y            |
         L1. |   .0001178   .0001179     1.00   0.318    -.0001137    .0003494
         LD. |   .6997015   .0248993    28.10   0.000     .6507799    .7486231
      _trend |   2.897751   1.159296     2.50   0.013      .619992    5.175511
       _cons |   1811.233   147.0426    12.32   0.000     1522.327    2100.139
------------------------------------------------------------------------------
```

From the result, p-value=1. So, it reject null hypothesis of unit root. It can conclude that the trend exist.

```
. dfuller x, trend lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =       498

                                 ------------ Interpolated Dickey-Fuller ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)              0.601           -3.980            -3.420           -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9970

------------------------------------------------------------------------------
D.x          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
x            |
         L1. |   .0001061   .0001764     0.60   0.548    -.0002405    .0004526
         LD. |     .46018   .0349881    13.15   0.000     .3914361    .5289239
      _trend |   4.166909    1.14105     3.65   0.000     1.924999    6.408818
       _cons |   2128.626   140.0551    15.20   0.000     1853.449    2403.803
------------------------------------------------------------------------------
```

From the result, p-value=0.997. So, it reject null hypothesis of unit root. It can conclude that the trend exist.

2. Perform cointegration test of series y and x using set up of (i) linear trend; (ii) restricted trend; (iii) unrestricted constant; (iv) restricted constant; and (v) no trend, with one lag term.

Linear trend

```
. vecrank y x, trend(t) lag(1/1) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =       499
Sample:  2 - 500                                           Lags =          1
```

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	4	-7387.4577	.	790.3357	>	18.17	Reject H_0: r=0
1	7	-6992.3441	0.79477	0.1085*	<	3.74	Fail to reject H_0: r=1
2	8	-6992.2899	0.00022				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	4	-7387.4577	.	790.2272	>	16.87	Reject H_0: r=0
1	7	-6992.3441	0.79477	0.1085	<	3.74	Fail to reject H_0: r=1
2	8	-6992.2899	0.00022				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 1.

Restricted trend

```
. vecrank y x, trend(rt) lag(1/1) max

                    Johansen tests for cointegration
Trend: rtrend                                        Number of obs =       499
Sample:  2 - 500                                           Lags =          1
```

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	2	-8050.4781	.	2116.3764	>	25.32	Reject H_0: r=0
1	6	-7075.2453	0.97993	165.9107	<	12.25	Fail to reject H_0: r=1
2	8	-6992.2899	0.28286				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	2	-8050.4781	.	1950.4657	>	18.96	Reject H_0: r=0
1	6	-7075.2453	0.97993	165.9107	<	12.52	Fail to reject H_0: r=1
2	8	-6992.2899	0.28286				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 2.

Unrestricted constant

```
. vecrank y x, trend(c) lag(1/1) max

                    Johansen tests for cointegration
Trend: constant                                      Number of obs =       499
Sample:  2 - 500                                             Lags =         1
------------------------------------------------------------------------------
                                                            5%
maximum                                          trace      critical
  rank     parms       LL       eigenvalue     statistic      value
    0        2      -8050.4781          .      2086.8946  >   15.41    Reject H0: r=0
    1        5      -7083.8611     0.97923      153.6607  >    3.76    Reject H0: r=1
    2        6      -7007.0308     0.26504
------------------------------------------------------------------------------
                                                            5%
maximum                                            max      critical
  rank     parms       LL       eigenvalue     statistic      value
    0        2      -8050.4781          .      1933.2339  >   14.07    Reject H0: r=0
    1        5      -7083.8611     0.97923      153.6607  >    3.76    Reject H0: r=1
    2        6      -7007.0308     0.26504
------------------------------------------------------------------------------
```

Both Johanson trace and Max Eigenvalues test suggest to use rank = 2.

Restricted constant

```
. vecrank y x, trend(rc) lag(1/1) max

                    Johansen tests for cointegration
Trend: rconstant                                     Number of obs =       499
Sample:  2 - 500                                             Lags =         1
------------------------------------------------------------------------------
                                                            5%
maximum                                          trace      critical
  rank     parms       LL       eigenvalue     statistic      value
    0        0      -8811.3759          .      3607.9616  >   19.96    Reject H0: r=0
    1        4      -7091.9244     0.99898      169.0586  >    9.42    Reject H0: r=1
    2        6      -7007.3951     0.28737
------------------------------------------------------------------------------
                                                            5%
maximum                                            max      critical
  rank     parms       LL       eigenvalue     statistic      value
    0        0      -8811.3759          .      3438.9030  >   15.67    Reject H0: r=0
    1        4      -7091.9244     0.99898      169.0586  >    9.24    Reject H0: r=1
    2        6      -7007.3951     0.28737
------------------------------------------------------------------------------
```

Both Johanson trace and Max Eigenvalues test suggest to use rank = 2.

No trend

```
. vecrank y x, trend(n) lag(1/1) max
```

Johansen tests for cointegration

Trend: none — Number of obs = 499
Sample: 2 - 500 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	0	-8811.3759	.	3204.1196	>	12.53	Reject H_0: r=0
1	3	-7211.7591	0.99836	4.8860	>	3.84	Reject H_0: r=1
2	4	-7209.3161	0.00974				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	0	-8811.3759	.	3199.2337	>	11.44	Reject H_0: r=0
1	3	-7211.7591	0.99836	4.8860	>	3.84	Reject H_0: r=1
2	4	-7209.3161	0.00974				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 2.

3. Perform cointegration test of series y and x using set up of linear trend with (i) one lag term; (ii) two lag terms; and (iii) three lag terms.

One lag term

```
. vecrank y x, trend(t) lag(1/1) max
```

Johansen tests for cointegration

Trend: trend — Number of obs = 499
Sample: 2 - 500 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	4	-7387.4577	.	790.3357	>	18.17	Reject H_0: r=0
1	7	-6992.3441	0.79477	0.1085*	<	3.74	Fail to reject H_0: r=1
2	8	-6992.2899	0.00022				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	4	-7387.4577	.	790.2272	>	16.87	Reject H_0: r=0
1	7	-6992.3441	0.79477	0.1085	<	3.74	Fail to reject H_0: r=1
2	8	-6992.2899	0.00022				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 1.

Two lag term

```
. vecrank y x, trend(n) lag(1/1) max
```

Johansen tests for cointegration

Trend: none — Number of obs = 499
Sample: 2 - 500 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	0	-8811.3759	.	3204.1196	>	12.53	Reject H_0: r=0
1	3	-7211.7591	0.99836	4.8860	>	3.84	Reject H_0: r=1
2	4	-7209.3161	0.00974				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	0	-8811.3759	.	3199.2337	>	11.44	Reject H_0: r=0
1	3	-7211.7591	0.99836	4.8860	>	3.84	Reject H_0: r=1
2	4	-7209.3161	0.00974				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 2.

Three lag term

```
. vecrank y x, trend(t) lag(3/3) max

                    Johansen tests for cointegration
Trend: trend                                         Number of obs =     497
Sample:  4 - 500                                             Lags =       3
```

maximum rank	parms	LL	eigenvalue	trace statistic		5% critical value	
0	12	-6756.658	.	140.0434	>	18.17	Reject H_0: r=0
1	15	-6688.113	0.24106	2.9534*	<	3.74	Fail to reject H_0: r=1
2	16	-6686.6363	0.00592				

maximum rank	parms	LL	eigenvalue	max statistic		5% critical value	
0	12	-6756.658	.	137.0900	>	16.87	Reject H_0: r=0
1	15	-6688.113	0.24106	2.9534	<	3.74	Fail to reject H_0: r=1
2	16	-6686.6363	0.00592				

Both Johanson trace and Max Eigenvalues test suggest to use rank = 1.

4. From (2) & (3), determine the most appropriated set up and make the conclusion of the test whether y and x are cointegrated series? If yes, how many cointegrating equations.

From (2) & (3), y and x are cointegrated series. There are at least one cointegrating equations.

5. Estimated VECM models of y and x using (i) one lag term; (ii) two lag terms; and (iii) three lag terms. Determine the optimal lags. Specify cointegrating equation and speed of adjustment parameters.

One lag term

```
. vec y x, lag(1/1)

Vector error-correction model

Sample:  2 - 500                                  Number of obs     =       499
                                                  AIC               =   28.41227
Log likelihood = -7083.861                        HQIC              =   28.42883
Det(Sigma_ml)  =  7.34e+09                        SBIC              =   28.45448

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
D_y                    2     331.479   0.9988   399343.6   0.0000
D_x                    2     430.726   0.9953   105050.2   0.0000
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_y						
_ce1						
L1.	-1.303404	.0095397	-136.63	0.000	-1.322102	-1.284707
_cons	-107.843	69.40373	-1.55	0.120	-243.8718	28.18583
D_x						
_ce1						
L1.	-.8364345	.0123959	-67.48	0.000	-.8607301	-.812139
_cons	168.0502	90.1839	1.86	0.062	-8.706964	344.8074

```
Cointegrating equations

Equation           Parms      chi2     P>chi2
------------------------------------------------
_ce1                   1   1.71e+10   0.0000
------------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
```

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
y	1	.	.	.	.	.
x	-1.500508	.0000115	-1.3e+05	0.000	-1.500531	-1.500486
_cons	-1678.204	.	.	.	.	.

Two lag terms

```
. vec y x, lag(2/2)

Vector error-correction model

Sample:  3 - 500                                  Number of obs     =       498
                                                  AIC               =   27.18032
Log likelihood = -6758.899                        HQIC              =   27.21018
Det(Sigma_ml)  =  2.11e+09                        SBIC              =   27.25641

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
D_y                    4     213.415   0.9995   964110.3   0.0000
D_x                    4     263.876   0.9982   280728.2   0.0000
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_y						
_ce1						
L1.	-.427199	.0483639	-8.83	0.000	-.5219905	-.3324075
y						
LD.	.4022605	.0224005	17.96	0.000	.3583563	.4461646
x						
LD.	.4814843	.0598769	8.04	0.000	.3641276	.5988409
_cons	171.4546	44.03061	3.89	0.000	85.15624	257.7531
D_x						
_ce1						
L1.	.2903827	.0597995	4.86	0.000	.1731779	.4075875
y						
LD.	.5734396	.0276971	20.70	0.000	.5191544	.6277249
x						
LD.	.3676105	.0740347	4.97	0.000	.2225051	.5127159
_cons	252.237	54.44157	4.63	0.000	145.5335	358.9405

```
Cointegrating equations

Equation           Parms      chi2     P>chi2
------------------------------------------------
_ce1                   1   8.09e+08   0.0000
------------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
```

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
y	1	.	.	.	.	.
x	-1.500176	.0000527	-2.8e+04	0.000	-1.50028	-1.500073
_cons	-577.9622	.	.	.	.	.

Cointegrating Equation : $Y_t = 577.9622+1.500176X_t$

Three lag terms

```
. vec y x, lag(3/3)

Vector error-correction model

Sample:  4 - 500                                  Number of obs     =       497
                                                  AIC               =   27.1245
Log likelihood = -6727.439                        HQIC              =  27.16771
Det(Sigma_ml)  =  1.96e+09                        SBIC              =  27.23459

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
D_y                    6   211.673   0.9995   980003.4   0.0000
D_x                    6   253.098   0.9984   305162.2   0.0000
------------------------------------------------------------------
```

Lowest SBIC
Optimal lags = 3

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_y						
_ce1						
L1.	-.3193909	.058155	-5.49	0.000	-.4333726	-.2054092
y						
LD.	.3553209	.0559202	6.35	0.000	.2457194	.4649225
L2D.	.0174858	.0312998	0.56	0.576	-.0438607	.0788323
x						
LD.	.6042668	.0763396	7.92	0.000	.4546439	.7538896
L2D.	.0521968	.0634683	0.82	0.411	-.0721988	.1765925
_cons	181.5838	45.38519	4.00	0.000	92.63049	270.5372
D_x						
_ce1						
L1.	.4434064	.0695359	6.38	0.000	.3071185	.5796943
y						
LD.	.4713427	.0668638	7.05	0.000	.3402922	.6023932
L2D.	.012763	.0374252	0.34	0.733	-.060589	.0861151
x						
LD.	.5220109	.0912792	5.72	0.000	.3431069	.700915
L2D.	.0911602	.0758891	1.20	0.230	-.0575797	.2399001
_cons	130.797	54.26707	2.41	0.016	24.43548	237.1585

Speed of adjustment = $\frac{1}{|-0.3193909|}$ = 3.13 (approximately 3 periods)

```
Cointegrating equations

Equation           Parms      chi2     P>chi2
------------------------------------------------
_ce1                   1   6.64e+08   0.0000
------------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
```

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
y	1	.	.	.	.	.
x	-1.500049	.0000582	-2.6e+04	0.000	-1.500163	-1.499935
_cons	-92.13439	.	.	.	.	.

Cointegrating Equation : $Y_t = 92.13439+1.500049X_t$