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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
------------------------------------------------------------------------------


. dfuller y, 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)             10.999            -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 1.0000

------------------------------------------------------------------------------
         D.y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           y |
         L1. |   .0003983   .0000362    11.00   0.000     .0003272    .0004695
         LD. |   .7218985   .0233849    30.87   0.000     .6759527    .7678444
             |
       _cons |    1773.23   147.0277    12.06   0.000     1484.355    2062.105
------------------------------------------------------------------------------
```

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

Augmented Dickey-Fuller test for unit root         Number of obs   =       497
```

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-10.554	-3.980	-3.420	-3.130

MacKinnon approximate p-value for Z(t) = 0.0000

D2.y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
D.y						
L1.	-.2787856	.0264156	-10.55	0.000	-.3306866	-.2268845
LD.	-.32127	.0373756	-8.60	0.000	-.3947051	-.2478349
_trend	3.631984	.3708318	9.79	0.000	2.903379	4.36059
_cons	1678.082	154.4788	10.86	0.000	1374.564	1981.6

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

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

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical 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

```
. dfuller x, 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)             13.875           -3.440            -2.870            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 1.0000

------------------------------------------------------------------------------
         D.x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |
         L1. |   .0007222   .0000521    13.88   0.000       .00062    .0008245
         LD. |   .5003968    .033621    14.88   0.000     .4343393    .5664543
             |
       _cons |   2103.573   141.6193    14.85   0.000     1825.324    2381.822
------------------------------------------------------------------------------
```

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

Augmented Dickey-Fuller test for unit root         Number of obs   =       497

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
                Statistic         Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -10.657           -3.980            -3.420            -3.130
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D2.x         |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         D.x |
         L1. |  -.4007114   .0376021   -10.66   0.000    -.4745915   -.3268312
         LD. |   -.414172   .0358603   -11.55   0.000    -.4846298   -.3437141
      _trend |   3.508317   .3506567    10.00   0.000     2.819351    4.197283
       _cons |   1596.429   147.0971    10.85   0.000     1307.415    1885.444
------------------------------------------------------------------------------
```

According to Unit Root Test, to check whether the dependent variable x and y are stationary or not, we set H0 : α1 = 0, p-value is 1.0000 which is > 0.05, we reject H0. Therefore, there is a unit root test. The model is nonstationary. Next, we perform the test without trend, we set H0 : γ = 0. The p-value > 0.05, we reject H0. There exists the unit root test and the model is nonstationary. After that we perform the test at integrated level 1, the MacKinnon approximate p-value for Z(t) is 0.0000 which is > 0.05. Therefore, there is no unit root test. The model is stationary at X ~ I(1) and Y ~ I(1). Therefore, there is a long run relationship between these two variables.

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.

i)

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

                       Johansen tests for cointegration
Trend: trend                                            Number of obs =     499
Sample:  2 - 500                                                 Lags =       1
-------------------------------------------------------------------------------
                                                        5%
maximum                                     trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       4    -7387.4577         .      790.3357    18.17
    1       7    -6992.3441     0.79477      0.1085*    3.74
    2       8    -6992.2899     0.00022
-------------------------------------------------------------------------------
                                                        5%
maximum                                      max     critical
  rank    parms       LL       eigenvalue  statistic    value
    0       4    -7387.4577         .      790.2272    16.87
    1       7    -6992.3441     0.79477      0.1085     3.74
    2       8    -6992.2899     0.00022
-------------------------------------------------------------------------------
```

ii)

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

                       Johansen tests for cointegration
Trend: rtrend                                           Number of obs =     499
Sample:  2 - 500                                                 Lags =       1
-------------------------------------------------------------------------------
                                                        5%
maximum                                     trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2    -8050.4781         .     2116.3764    25.32
    1       6    -7075.2453     0.97993    165.9107    12.25
    2       8    -6992.2899     0.28286
-------------------------------------------------------------------------------
                                                        5%
maximum                                      max     critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2    -8050.4781         .     1950.4657    18.96
    1       6    -7075.2453     0.97993    165.9107    12.52
    2       8    -6992.2899     0.28286
-------------------------------------------------------------------------------
```

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iii)

```
. vecrank y x, trend(c) lags(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
    1       5    -7083.8611     0.97923     153.6607     3.76
    2       6    -7007.0308     0.26504
-------------------------------------------------------------------------------
                                                         5%
maximum                                        max    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       2    -8050.4781         .      1933.2339    14.07
    1       5    -7083.8611     0.97923     153.6607     3.76
    2       6    -7007.0308     0.26504
-------------------------------------------------------------------------------
```

iv)

```
. vecrank y x, trend(rc) lags(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         .      3593.1922    19.96
    1       4    -7096.9792     0.99896     164.3988     9.42
    2       6    -7014.7798     0.28069
-------------------------------------------------------------------------------
                                                         5%
maximum                                        max    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       0    -8811.3759         .      3428.7934    15.67
    1       4    -7096.9792     0.99896     164.3988     9.24
    2       6    -7014.7798     0.28069
-------------------------------------------------------------------------------
```

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v)

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

                    Johansen tests for cointegration
Trend: none                                       Number of obs =     499
Sample:  2 - 500                                           Lags =       1
--------------------------------------------------------------------------
                                                           5%
maximum                                          trace    critical
  rank    parms      LL        eigenvalue  statistic   value
    0       0    -8811.3759         .      3204.1194   12.53
    1       3    -7211.7592     0.99836       4.8860    3.84
    2       4    -7209.3162     0.00974
--------------------------------------------------------------------------
                                                           5%
maximum                                            max    critical
  rank    parms      LL        eigenvalue  statistic   value
    0       0    -8811.3759         .      3199.2334   11.44
    1       3    -7211.7592     0.99836       4.8860    3.84
    2       4    -7209.3162     0.00974
--------------------------------------------------------------------------
```

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.

i)

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

                    Johansen tests for cointegration
Trend: trend                                      Number of obs =     499
Sample:  2 - 500                                           Lags =       1
--------------------------------------------------------------------------
                                                           5%
maximum                                          trace    critical
  rank    parms      LL        eigenvalue  statistic   value
    0       4    -7387.4577         .       790.3357   18.17
    1       7    -6992.3441     0.79477       0.1085*   3.74
    2       8    -6992.2899     0.00022
--------------------------------------------------------------------------
                                                           5%
maximum                                            max    critical
  rank    parms      LL        eigenvalue  statistic   value
    0       4    -7387.4577         .       790.2272   16.87
    1       7    -6992.3441     0.79477       0.1085    3.74
    2       8    -6992.2899     0.00022
--------------------------------------------------------------------------
```

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ii)

```
. vecrank y x,trend(t) lags(2/2) max

                    Johansen tests for cointegration
Trend: trend                                       Number of obs =     498
Sample:  3 - 500                                            Lags =       2
--------------------------------------------------------------------------
                                                           5%
maximum                                      trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       8     -6795.5337        .       187.5771    18.17
    1      11     -6703.3826     0.30932      3.2749*    3.74
    2      12     -6701.7451     0.00655
--------------------------------------------------------------------------
                                                           5%
maximum                                        max    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       8     -6795.5337        .       184.3022    16.87
    1      11     -6703.3826     0.30932      3.2749     3.74
    2      12     -6701.7451     0.00655
--------------------------------------------------------------------------
```

iii)

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

                    Johansen tests for cointegration
Trend: trend                                       Number of obs =     497
Sample:  4 - 500                                            Lags =       3
--------------------------------------------------------------------------
                                                           5%
maximum                                      trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0      12      -6756.658        .       140.0434    18.17
    1      15      -6688.113     0.24106      2.9534*    3.74
    2      16     -6686.6363     0.00592
--------------------------------------------------------------------------
                                                           5%
maximum                                        max    critical
  rank    parms       LL       eigenvalue  statistic    value
    0      12      -6756.658        .       137.0900    16.87
    1      15      -6688.113     0.24106      2.9534     3.74
    2      16     -6686.6363     0.00592
--------------------------------------------------------------------------
```

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.

According to the test, we set H0 : r = 1 and H1 : r > 2. One lag term with linear trend is statistically insignificant in 5% critical value (0.1085 < 3.74), we fail to reject H0. Therefore, one lag term with linear trend is cointegrated at rank = 1 or there is 1 cointegrating equation.

The two lag terms with linear trend is statistically insignificant in 5% critical value (3.2749 < 3.74), we fail to reject H0. Therefore, one lag term with linear trend is cointegrated at rank = 1 or there is 1 cointegrating equation.

The three lag term with linear trend is statistically insignificant in 5% critical value (2.9534 < 3.84), we fail to reject H0. Therefore, one lag term with linear trend is cointegrated at rank = 1 or there is 1 cointegrating equation.

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.

i)

```
. vec y x, lags(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	-8.706965	344.8074

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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	.	.	.	.	.

ii)

```
. vec y x, lags(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	171.4547	44.03061	3.89	0.000	85.15624	257.7531

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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	.	.	.	.	.

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iii)

```
. vec y x, lags(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
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      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

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	.	.	.	.	.

According to the estimated VECM model, cointegrating equation is statistically significant with a p-value of 0.0000 which is less than 0.05 and the optimal lag term is lag term = 3 since it has the lowest SBIC which is SBIC = 27.23459 implies that there is less error among others. The cointegrating equation is $Yt = \beta_0 + \beta_1 Xt$ or Yt = 92.13439 + 1.5Xt and has the speed of adjustment of Y = -0.3193 and X = 0.4434.