UNIVERSITY OF OSLO
DEPARTMENT OF ECONOMICS

Exam: **ECON4160 – Econometrics – Modeling and systems estimation**

Date of exam: Wednesday, November 25, 2015 **Grades are given: December 15, 2015**

Time for exam: 09.00 a.m. – 12.00 noon

The problem set covers 8 pages (incl. cover sheet)

Resources allowed:
- Open book examination where all printed and written resources, in addition to calculator, are allowed.

The grades given: A-F, with A as the best and E as the weakest passing grade. F is fail.

Exam in: ECON 4160: Econometrics: Modelling and Systems Estimation

Day of exam: 25 November 2015

Time of day: 09:00—12:00

This is a 3 hour school exam.

Guidelines:
In the grading, question A will count 30%, and question B will count 70%.

Question A (30 %)

1. Assume that the conditional expectation of Y grows linearly with X. Consider the n variable pairs $(Y_1, X_1), \ldots, (Y_n, X_n)$, and assume that the variable pairs are mutually independent and have identical normal distributions. In this case, what are the expressions for the maximum likelihood estimators of the two parameters

$$\frac{\partial}{\partial X_i} E(Y_i \mid X_i) \text{ and } Var(\varepsilon_i \mid X_i) = \sigma^2 \text{ ?}$$

2. How can you estimate the parameter $\frac{\partial}{\partial X_i} E(Y_i \mid X_i)$ efficiently, if the assumption $Var(\varepsilon_i \mid X_i) = \sigma^2$ is changed to $Var(\varepsilon_i \mid X_i) = \sigma^2 X_i^2$?

3. Assume that the relationship

$$Y_i = \beta_1 + \beta_2 X_i + \varepsilon_{1i}, \tag{1}$$

is an equation in a model consisting of two equations. Discuss identification and estimation of the parameter β_2 in the following three cases: (We denote parameters in the second equation by γ_j in all three cases, and that the only unobservable variables are disturbances.)

   (a) The second equation is

$$Z_i = \gamma_0 + \gamma_1 X_i + \varepsilon_{2i} \tag{2}$$

   and we assume $Cov(\varepsilon_{1i}, \varepsilon_{2i}) = \omega_{12} \neq 0$, and that X_i is uncorrelated with both disturbances.

(b) The second equation is

$$X_i = \gamma_0 + \varepsilon_{2i} \tag{3}$$

and we assume $\omega_{12} = 0$.

(c) The second equation is

$$X_i = \gamma_0 + \gamma_1 Y_i + \gamma_2 Z_{1i} + \gamma_3 Z_{2i} + \varepsilon_{2i} \tag{4}$$

and we assume $\omega_{12} \neq 0$.

4. In case 3(b) and 3(c), is the second equation of the model identified?

Question B (70 %)

We have collected annual data for hourly wages in Norwegian manufacturing for the period 1970 to 2013. We also have data for the value of labour productivity in this sector. In the print-out from PcGive in Table 1, we denote the logarithms of these two variables as LW (wages) and LZ (value of labour productivity) respectively.

1. Explain why the evidence in Table 1 gives reason to conclude that both LW and LZ are integrated of order one, $I(1)$. (You can consider the degree of augmentation as a given thing).

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Unit-root tests
The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
The sample is: 1972 - 2013 (44 observations and 2 variables)

LW: ADF tests (T=42, Constant+Trend; 5%=-3.52 1%=-4.19)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -2.811       0.94888  0.01856      3.623  0.0008
  0     -4.145*      0.92148  0.02125

LZ: ADF tests (T=42, Constant+Trend; 5%=-3.52 1%=-4.19)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -1.887       0.93151  0.03735    -0.3623  0.7192
  0     -1.915       0.93131  0.03693


Unit-root tests
The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
The sample is: 1973 - 2013 (43 observations and 2 variables)

DLW: ADF tests (T=41, Constant; 5%=-2.93 1%=-3.60)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -3.079**     0.55138  0.02025      1.143  0.2603
  0     -2.864**     0.62787  0.02033

DLZ: ADF tests (T=41, Constant; 5%=-2.93 1%=-3.60)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -4.655**   -0.11150  0.03953     0.2770  0.7833
  0     -6.553**   -0.063503  0.03905
```

Table 1: Augmented Dickey-Fuller (ADF) tests to determine the order of integration of LW_t and LZ_t.

2. According to theory, the system of collective wage bargaining in Norway creates a long-run dependency between the hourly wage and the manufacturing firms' ability to pay, as measured by the value of labour productivity.

   To test this theory, we estimate the following Engle-Granger regression by OLS:

   (5) $$LW_t = \beta_0 + \beta_1 LZ_t + u_t, \qquad t = 1970, ..., 2013$$

   where u_t is the disturbance. In the print-out in Table 2, the residual from the Engle-Granger regression has been labeled EGLWresiduals.

   Use the results in Table 2 to form a conclusion about whether the theory of a long-run relationship between LW and LZ is supported or not. The critical values of the Engle-Granger test of no long-run (cointegrating) relationship are: $5\% = -3.33$, and $1\% = -3.90$. As part of your answer, explain why you use these critical values, instead of the critical values for the ADF tests given in Table 1.

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EQ( 1) Modelling LW by OLS
    The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
    The estimation sample is: 1970 - 2013

                Coefficient  Std.Error  t-value  t-prob Part.R^2
Constant          -0.172383    0.04508    -3.82  0.0004   0.2582
LZ                 0.963630   0.008637     112.  0.0000   0.9966

sigma             0.0504044  RSS            0.106705506
R^2                0.996637  F(1,42) =    1.245e+004 [0.000]**


Unit-root tests
The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
The sample is: 1973 - 2013 (43 observations and 1 variables)

EGLWresiduals: ADF tests (T=41; 5%=-1.95 1%=-2.62)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob      AIC  F-prob
1     -2.853**     0.61462  0.03731     0.5051  0.6163    -6.529
0     -2.935**     0.64303  0.03696                       -6.572  0.6163
```

Table 2: Results for an Engle-Granger regression between LW_t and LZ_t, and unit-root tests for the disturbance of that regression.

3. An alternative test for the null hypothesis of no long-run relationship can be based on a conditional equilibrium correction model (ECM). You find estimation results for such a model in Table 3. In that print-out, the variables DLW and DLZ are the differences of LW and LZ, for example DLW=LW-LW_1, where LW_1 denotes the first lag of LW.

   The ECM of LW also includes two other conditioning variables: DLKPI, which is the inflation rate, and DLNH, which is the change in the length of the normal working day. It is relevant to condition on these two variables because compensation for increases in the cost of living, and for shorter-hours is part of the bargaining between the unions and the firms. We base our analysis on the assumption that DLKPI and DLNH are $I(0)$ variables.

   (a) Based on the results in Table 3, and the information that the relevant 1% critical value for the ECM-test of no relationship is -3.29, explain why it is reasonable to conclude that LW is cointegrated with LZ.

   (b) Can you give some intuition on why the evidence in support of cointegration may be stronger when we use the ECM-test than when the Engle-Granger test is used?

(c) Use the results to find the estimated long-run elasticity of the wage level (W) with respect to the value of labour productivity (Z). The estimated standard-error of the long-run elasticity can be shown to be 0.032. Is a long-run elasticity of 1 supported empirically if you use a significance level of 5%?

(d) How could the standard-error be calculated? Explain in words.

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EQ(2) Modelling DLW by OLS
      The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
      The estimation sample is: 1972 - 2013
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	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLW_1	0.247629	0.09799	2.53	0.0163	0.1581
Constant	-0.00492564	0.03616	-0.136	0.8925	0.0005
DLZ	0.100648	0.05653	1.78	0.0839	0.0853
DLZ_1	0.00917294	0.05715	0.160	0.8734	0.0008
LW_1	-0.250837	0.04727	-5.31	0.0000	0.4530
LZ_1	0.237388	0.04547	5.22	0.0000	0.4449
DLKPI	0.567936	0.1122	5.06	0.0000	0.4297
DLNH	-0.685046	0.2384	-2.87	0.0070	0.1953

sigma	0.0124393	RSS	0.00526103907
R^2	0.911595	F(7,34) =	50.08 [0.000]**
Adj.R^2	0.893394	log-likelihood	129.092
no. of observations	42	no. of parameters	8
mean(DLW)	0.0691441	se(DLW)	0.0380983

AR 1-2 test:	F(2,32)	=	0.55526[0.5792]
ARCH 1-1 test:	F(1,40)	=	1.9135 [0.1743]
Normality test:	Chi^2(2)	=	0.33955 [0.8439]
Hetero test:	F(14,27)	=	1.3089 [0.2652]
RESET23 test:	F(2,32)	=	3.0802 [0.0598]

Table 3: Results for ECM of LW_t

4. As a way of imposing a long-run elasticity of one, we define the variable

$$ECMwage = LW - LZ,$$

which we assume to be $I(0)$ from now on, and re-estimate the ECM for wages. Table 4 shows the results. Table 5 shows the result for a marginal model of DLZ.

(a) Explain how you can test the weak exogenity of LZ with respect to the cointegration parameters with the aid of the information given. What does the evidence indicate?

(b) Assume that you are asked by the Norwegian Productivity Commission to estimate the dynamic effects on wages of a shock to average labour productivity. Could you use the results reported in Table 4 and 5 to give an answer? Explain how you would motivate your answer.

(c) A colleague suggests that to appropriately address question 4 (b), a SVAR model needs to be considered. Do you think using a SVAR is suitable to deal with this question?

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EQ( 3) Modelling DLW by OLS
      The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
      The estimation sample is: 1972 - 2013

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
DLW_1                0.333612    0.09621     3.47  0.0014   0.2557
Constant           -0.0768366    0.01971    -3.90  0.0004   0.3027
DLZ                  0.134225    0.05796     2.32  0.0265   0.1329
DLZ_1               0.0570952    0.05652     1.01  0.3193   0.0283
DLKPI                0.681517     0.1071     6.36  0.0000   0.5365
DLNH                -0.582600     0.2485    -2.34  0.0249   0.1357
ECMwage_1           -0.210894    0.04668    -4.52  0.0001   0.3683

sigma               0.0131938  RSS             0.00609264708
R^2                  0.897621  F(6,35) =     51.14 [0.000]**
Adj.R^2               0.88007  log-likelihood         126.01
no. of observations        42  no. of parameters           7
mean(DLW)           0.0691441  se(DLW)             0.0380983

AR 1-2 test:      F(2,33)   =   2.7736 [0.0770]
ARCH 1-1 test:    F(1,40)   =0.00067955 [0.9793]
Normality test:   Chi^2(2)  =   1.9124 [0.3844]
Hetero test:      F(12,29)  =  0.84777 [0.6042]
Hetero-X test:    F(27,14)  =   1.4910 [0.2185]
RESET23 test:     F(2,33)   =   3.5640 [0.0397]*
```

Table 4: Results for an ECM of LW_t with cointegration imposed in the form of the variable ECMwage.

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EQ( 4) Modelling DLZ by OLS
      The dataset is: C:\SW20\ECON4160\H2015\Exam\LoennIndogFastland.in7
      The estimation sample is: 1972 - 2013

                Coefficient  Std.Error  t-value  t-prob Part.R^2
DLZ_1              0.105475     0.1616    0.653  0.5180   0.0117
Constant           0.130999    0.05231     2.50  0.0169   0.1484
DLW_1              0.558570     0.2605     2.14  0.0389   0.1132
DLKPI             -0.144616     0.3070   -0.471  0.6404   0.0061
DLNH              0.0181977     0.7147   0.0255  0.9798   0.0000
ECMwage_1          0.284411     0.1256     2.26  0.0297   0.1247

sigma              0.037941  RSS             0.0518226244
R^2                0.452038  F(5,36) =      5.94 [0.000]**
Adj.R^2            0.375932  log-likelihood       81.0541
no. of observations      42  no. of parameters          6
mean(DLZ)         0.0693511  se(DLZ)            0.0480278

AR 1-2 test:      F(2,34)   =  0.18983 [0.8280]
ARCH 1-1 test:    F(1,40)   =  0.44294 [0.5095]
Normality test:   Chi^2(2)  =  0.31240 [0.8554]
Hetero test:      F(10,31)  =  0.60697 [0.7958]
Hetero-X test:    F(20,21)  =   1.6381 [0.1349]
RESET23 test:     F(2,34)   =   4.8045 [0.0145]*
```

Table 5: Results for a marginal model of DLZ_t .