UNIVERSITY OF OSLO
DEPARTMENT OF ECONOMICS

Postponed exam: **ECON4160 – Econometrics – Modeling and Systems Estimation**

Date of exam: Thursday, December 15, 2016

Time for exam: 09:00 a.m. – 12:00 noon

The problem set covers 7 pages (incl. cover sheet)

Resources allowed:
- All written and printed resources – as well as calculator - is allowed

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

Postponed exam in: ECON 4160: Econometrics: Modelling and Systems Estimation

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This is a 3 hour school exam.

Guidelines:
In the grading, question A gets 50 %, B 25 % and C 25 %.

Question A (50 %)

We have annual observations of the two variables wage inflation, wi, and the unemployment rate, UR. Both variables are measured in percent. The sample period is 1950 to 2015.

1. Use the information in Table 1 to explain why there is reason to conclude that neither wi nor UR contain a unit-root (they are not $I(1)$ series), if a 5 % significance level is used.

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wi: ADF tests (T=68, Constant+Trend; 5%=-3.48 1%=-4.10)
D-lag    t-adf       beta Y_1    sigma   t-DY_lag  t-prob
 2     -3.428        0.56185    2.303    -0.8921   0.3758
 1     -4.364**      0.50830    2.300      1.369   0.1759
 0     -4.176**      0.57894    2.315

UR: ADF tests (T=68, Constant+Trend; 5%=-3.48 1%=-4.10)
D-lag    t-adf       beta Y_1    sigma   t-DY_lag  t-prob
 2     -3.678*       0.79228   0.4458    -0.4617   0.6459
 1     -3.915*       0.78623   0.4431      4.949   0.0000
 0     -2.595        0.83774   0.5170
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Table 1: Augmented Dickey-Fuller (ADF) tests to determine the order of integration of wi_t and UR_t.

2. We are interested in the relationship between wage growth, wi, and the unemployment rate, UR. We condition the model on a third variable,

denoted pci, which is the rate of inflation. pci_i is also $I(0)$. Table 2 shows the results of estimation of the following wage Phillips Curve (WPCM):

$$(1) \qquad wi_t = \phi_0 + \beta_1 pci_t + \beta_2 UR_t + \epsilon_t, \qquad t = 1950, ..., 2015.$$

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EQ(1)  Modelling wi by OLS
       The estimation sample is: 1950 - 2015

                 Coefficient  Std.Error  t-value  t-prob
Constant             5.68757     0.4590     12.4  0.0000
pci                 0.618527    0.04919     12.6  0.0000
UR                 -0.770639     0.1298    -5.94  0.0000

sigma                1.23678  RSS               96.3655926
R^2                 0.826321  F(2,63) =     149.9 [0.000]**
Adj.R^2             0.820808  log-likelihood       -106.14
no. of observations       66  no. of parameters          3
mean(wi)             6.83093  se(wi)               2.92167

AR 1-2 test:      F(2,61)   =   2.6308 [0.0802]
ARCH 1-1 test:    F(1,64)   =  0.78622 [0.3786]
Normality test:   Chi^2(2)  =   1.5201 [0.4676]
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Table 2: Results for estimation of equation (1).

(a) Complete the econometric specification of (1) as a regression model with classical properties. Explain briefly how information found in Table 2 can be used to test for mis-specification of the model.

(b) Assume that both pci and UR are increased by one unit (one percentage point). What is the implied change in wi ?

(c) Calculate a 95% confidence interval for your answer in 2b. You can use that the estimated covariance between $\hat{\beta}_1$ and $\hat{\beta}_2$ is 0.0025336 .

(d) A parameter of interest in wage Phillips curve models is the natural rate of unemployment, U_n, defined for the case of zero wage and price change.

i. Show that, in the context of model (1), U_n is given as

$$U_n = \frac{\phi_0}{-\beta_2}.$$

ii. Calculate the estimated natural rate $\hat{U}_n$.

iii. An approximate standard error of $\hat{U}_n$ is 0.8. Show how this can be confirmed by using information from Table 2, and $\widehat{Cov}(\hat{\phi}_0, \hat{\beta}_2) = -0.049$ in the 'delta-method' formula.

iv. Test H_0: $\hat{U}_n = 5$ against H_1: $\hat{U}_n \neq 5$.

3. Next, consider the dynamic WPCM:

(2) $wi_t = \phi_0 + \phi_1 wi_{t-1} + \beta_1 pci_t + \beta_2 UR_t + v_t, \qquad t = 1950, ..., 2015$

and the estimation results for this model in Table 3.

```
EQ(2) Modelling wi by OLS
     The estimation sample is: 1950 - 2015

                  Coefficient  Std.Error  t-value  t-prob
Constant              4.07268     0.5980     6.81  0.0000
wi_1                 0.258779    0.06864     3.77  0.0004
pci                  0.500619    0.05458     9.17  0.0000
UR                  -0.598677     0.1265    -4.73  0.0000

sigma                 1.12447  RSS                78.3948897
R^2                   0.85871  F(3,62) =     125.6 [0.000]**
Adj.R^2              0.851873  log-likelihood       -99.3294
no. of observations        66  no. of parameters           4
mean(wi)              6.83093  se(wi)                2.92167

AR 1-2 test:      F(2,60)    =   1.3580 [0.2650]
ARCH 1-1 test:    F(1,64)    =  0.10802 [0.7435]
Normality test:   Chi^2(2)   =   2.5255 [0.2829]
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Table 3: Results for estimation of equation (2).

(a) Assume that UR_t is increased permanently by one unit (one percentage point). Use the results in Table 3 to answer the following questions about the partial effects of the change in UR_t on wage inflation:

i. What is the impact effect on wi?

ii. What is the second year effect? (To save time, you can do the algebra with two decimals.)

iii. What is the long-run effect?

(b) Is the estimated effect in b.ii) biased if UR_t is not strongly exogenous? Explain briefly.

Question B (25 %)

A researcher wants to estimate a more complete simultaneous equation model (SEM) of Norwegian inflation. She wants to include the variable pmi, the change (also in percent) in an import price index, so called imported inflation. She specifies the following theoretical model for the four stationary variables: pci_t, wi_t, UR_t (endogenous variables) and pmi_t (conditioning variable):

$$pci_t + \beta_{12} wi_t + \beta_{14} pmi_t = \beta_{10} + \phi_{11} pci_{t-1} + \epsilon_{1t} \tag{3}$$

$$\beta_{21} pci_t + wi_t + \beta_{23} UR_t = \beta_{20} + \phi_{22} wi_{t-1} + \epsilon_{2t} \tag{4}$$

$$\beta_{31} pci_t + UR_t + \beta_{34} pmi_t = \beta_{30} + \phi_{33} UR_{t-1} + \epsilon_{3t} \tag{5}$$

In the researcher's theory, equation (3) is a price equation, (4) is a wage equation and (5) is an equation for the rate of unemployment. All the coefficients of the equations of the SEM are assumed to be non-zero. There are no theoretical restrictions on the covariance matrix of the disturbances of the SEM.

1. Explain what is meant by identification of the parameters of (5), and explain why this equation is over-identified (with degree of over-identification equal to one).

2. Table 4 shows estimation results for (5) using generalized instrumental variable estimation, denoted IVE in the table.

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EQ(3) Modelling UR by IVE
      The estimation sample is: 1950 - 2015

                  Coefficient  Std.Error  t-value  t-prob
pci           Y     0.0917395    0.04597     2.00  0.0504
UR_1                 0.986613    0.06229     15.8  0.0000
Constant            -0.235038     0.2691   -0.873  0.3858
pmi                -0.0340696    0.02141    -1.59  0.1167

sigma                0.515982  RSS                16.506724
Reduced-form sigma    0.48747
no. endogenous variables    2  no. of instruments         5
no. of observations        66  no. of parameters          4
mean(UR)              2.22727  se(UR)                1.2874
Additional instruments:
[0] = wi_1
[1] = pci_1

Specification test: Chi^2(1)  =  0.87329 [0.3500]
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Table 4: Generalized instrumental variable estimation (IVE) results for equation (5).

(a) Discuss the validity and relevance of instrumental variables used in the estimation, in particular the interpretation of the "Specfication test".

(b) Explain the 2SLS interpretation of generalized instrumental variable estimation.

(c) A fellow student remarks that based on economic theory, a real variable like UR_t should depend on other real variables, and not on changes in nominal variables. To test if this theoretical principle gets empirical support, you agree to estimate the equation with $\beta_{34} = -\beta_{31}$ imposed. The restricted equation gives *Specification test: Chi^2(2) = 4.5370.*

Use this information to test statistically the hypothesis $H_0: \beta_{34} = -\beta_{31}$?

(Hint: The 5 % critical value for a $\chi^2(1)$ distribution is 3.8.)

(d) Are the degrees of identification of (3) and (4) affected if you impose $\beta_{34} = -\beta_{31}$ on the SEM ? Explain.

Question C (25 %)

Assume that the two time series X_t and Y_t are $I(1)$ variables. Assume that the system of X_t and Y_t can be written as:

$$(6) \qquad Y_t - \gamma_1 X_t = \gamma_0 + u_{1t}, \quad u_{1t} = u_{1t-1} + \varepsilon_{1t}$$

$$(7) \qquad Y_t - \beta_1 X_t = \beta_0 + u_{2t}, \quad u_{2t} = \phi_2 u_{2t-1} + \varepsilon_{2t},\ 0 < \phi_2 < 1$$

where ε_{1t} and ε_{2t} are two independent white-noise processes.

1. Why is β_1 and not γ_1 a cointegrating parameter in the system of equations given by (6) and (7)?
2. Explain why the OLS estimator of β_1 in the static regression between Y_t and X_t is not subject to simultaneity bias in this model.
3. Derive the dynamic equations that are implied by (6) and (7).
4. Is the dynamic system you derived in 3. characterized by exogeneity? Explain your answer.