UNIVERSITY OF OSLO
DEPARTMENT OF ECONOMICS

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

Date of exam: Wednesday, November 30, 2016 **Grades are given:** December 20, 2016

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

The problem set covers 6 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.

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

Day of exam: 30 November 2016

Time of day: 09:00—12:00

This is a 3 hour school exam.

Guidelines:
In the grading, question A gets 40 %, B 30 % and C 30 %.

Question A (40 %)

We have annual observations of the two variables *pci* and *pmi* for the period 1950 to 2015. *pci* is Norwegian inflation, in percent, and *pmi* is the change (also in percent) in an import price index, so called imported inflation.

1. Explain why the evidence in Table 1 gives reason to conclude that neither *pci* nor *pmi* contain a unit-root (they are not $I(1)$ series).

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Unit-root tests

The sample is: 1950 - 2015 (68 observations and 2 variables)

pci: ADF tests (T=66, Constant; 5%=-2.91 1%=-3.53)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -3.491*      0.65840    2.505     0.5587  0.5783
  0     -3.563**     0.67909    2.492

pmi: ADF tests (T=66, Constant; 5%=-2.91 1%=-3.53)
D-lag    t-adf      beta Y_1    sigma   t-DY_lag  t-prob
  1     -4.432**     0.42707    4.821     0.5411  0.5904
  0     -4.894**     0.46361    4.795
```

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

2. Table 2 shows the result of estimation of the following ADL model for Norwegian inflation:

   (1) $pci_t = \phi_0 + \phi_1 pci_{t-1} + \beta_1 pmi_t + \beta_2 pmi_{t-1} + \epsilon_t, \quad t = 1950, ..., 2015$

Modelling pci by OLS
The estimation sample is: 1950 - 2015

	Coefficient	Std.Error	t-value	t-prob
Constant	1.39333	0.4039	3.45	0.0010
pci_1	0.367467	0.09465	3.88	0.0003
pmi	0.286378	0.04869	5.88	0.0000
pmi_1	0.133322	0.06304	2.11	0.0385

sigma	1.86419	RSS	215.461777
R^2	0.71277	F(3,62) =	51.28 [0.000]**
Adj.R^2	0.698871	log-likelihood	-132.693
no. of observations	66	no. of parameters	4
mean(pci)	4.62354	se(pci)	3.39714

AR 1-2 test:	F(2,60)	=	1.3208 [0.2746]
ARCH 1-1 test:	F(1,64)	=	0.37217 [0.5440]
Normality test:	Chi^2(2)	=	1.6559 [0.4369]

Table 2: Results for estimation of equation (1).

(a) Based on the information in the table, does the column labelled "t-probability" provide reliable statistical evidence about the significance of the individual variables? Explain briefly.

(b) Assume that *pmi* is increased permanently by one unit (one percentage point). Use the results in Table 1 to answer the following questions:

   i. What is the impact effect on Norwegian inflation?

   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?

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

(d) Re-write (1) in ECM-form.

(e) Using the coefficient estimates in Table 2, what are the coefficient estimates of the ECM equation?

(f) Show that you can use the empirical ECM equation to confirm your answer to the question about long-run effect of a permanent increase in *pmi*.

(g) Explain briefly how you could test the null hypothesis that the long-run effect of a permanent increase in pmi is one? In particular, what extra regression output would you need?

3. Assume that, for a different data set with two variables, the unit-root tests lead to the conclusion that both variables were $I(1)$.

   (a) Describe how you could test the hypothesis of no cointegration in this case.

   (b) If the outcome of your test was rejection of the hypothesis of no cointegration, how would you estimate the cointegrating parameters?

Question B (30 %)

Consider the VAR:

$$\begin{pmatrix} pci_t \\ pmi_t \end{pmatrix} = \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{pmatrix} \begin{pmatrix} pci_{t-1} \\ pmi_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix} \tag{2}$$

where the two disturbances are jointly normally distributed, with zero expectations and with covariance matrix:

$$\mathbf{\Sigma} = \begin{pmatrix} \sigma_1^2 & \sigma \\ \sigma & \sigma_2^2 \end{pmatrix}. \tag{3}$$

Assume that this VAR is the statistical system that has generated the data series pci_t and pmi_t that we used in Question A.

1. When (2) is estimated on the 1950-2015 sample, we get the estimated residual covariance matrix:

$$\hat{\mathbf{\Sigma}} = \begin{pmatrix} (2.3084)^2 & 6.6644 \\ 6.6644 & (4.8240)^2 \end{pmatrix}. \tag{4}$$

   Show that the estimate of β_1 in Table 2 can be confirmed by using the information in (4).

2. Table 3 contains more estimation results for the VAR:

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      Estimating the system by OLS
      The estimation sample is: 1950 - 2015

URF equation for: pci
                 Coefficient  Std.Error  t-value  t-prob
pci_1               0.400283     0.1170     3.42  0.0011
pmi_1               0.251545    0.07399     3.40  0.0012
Constant      U      1.87936     0.4895     3.84  0.0003

sigma = 2.30837   RSS = 335.6989835

URF equation for: pmi
                 Coefficient  Std.Error  t-value  t-prob
pci_1               0.114588     0.2445    0.469  0.6409
pmi_1               0.412824     0.1546     2.67  0.0096
Constant      U      1.69716      1.023     1.66  0.1021

sigma = 4.82403   RSS = 1466.088488

log-likelihood    -328.666187
no. of observations        66  no. of parameters       6
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Table 3: Results for estimation of the VAR in equation (2).

When we estimate an econometric model of the VAR, with (1) as the first equation, and with

$$pmi_t = \gamma_0 + \gamma_1 pmi_{t-1} + v_t \qquad (5)$$

as the second equation, the estimated log-likelihood is -328.781029. (Estimation is by OLS on each equation). How can you use this result to test the validity of the restriction(s) on the system that the model consisting of (1) and (5) implies?

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

3. Does the evidence support the hypothesis that pmi_t is strongly exogenous?

4. Are the impulse responses of the model consisting of (1) and (5) identified?

Question C (30 %)

A researcher wants to estimate a more complete simultaneous equation model (SEM) of Norwegian inflation. She wants to bring in two other domestic variables: Domestic wage inflation, wi, and the unemployment rate, UR. Both variables are measured in percent. She specifies the following theoretical model:

$$pci_t + \beta_{12} wi_t + \beta_{14} pmi_t = \beta_{10} + \phi_{11} pci_{t-1} + \epsilon_{1t} \tag{6}$$

$$\beta_{21} pci_t + wi_t + \beta_{23} UR_t = \beta_{20} + \phi_{22} wi_{t-1} + \epsilon_{2t} \tag{7}$$

$$\beta_{31} pci_t + UR_t - \beta_{31} pmi_t = \beta_{30} + \phi_{33} UR_{t-1} + \epsilon_{3t} \tag{8}$$

$$pmi_t = \beta_{40} + \phi_{44} pmi_{t-1} + \epsilon_{4t} \tag{9}$$

All the coefficients are assumed to be non-zero. There are no theoretical restrictions on the covariance matrix of the disturbances

1. In the researcher's theory, equation (6) is a price equation, and (7) is a wage equation. Discuss the identification of each of these two equations.

2. Based on your conclusions about identification, explain in words how you would estimate the identified equation(s) using single equation estimation (i.e., without estimating the complete structural model).