Written Exam Economics Summer 2018

Econometrics II

18 May 10 am - 25 May 10 am

This exam question consists of 10 pages in total

Answers only in English.

The paper must be uploaded as one PDF document. The PDF document must be named with exam number only (e.g. '1234.pdf') and uploaded to Digital Exam.

Introduction and Formal Requirements

The exam is a portfolio exam consisting of four separate parts. The first three parts are based on the assignments you have worked with during the semester. The last part is a theoretical part.

Each of the four parts is weighted by approximately 25 percent in the overall assessment.

Formal Requirements:

(1) You are allowed to work in groups of up to three students. The formal requirements and the assessment criteria are the same for individuals, groups of two, and groups of three students.

(2) You are only assessed based on what you hand in for the final exam, so the assignments you have handed in during the semester are not included in the assessment.

(3) Your answers to each of Parts 1 and 3 must be maximum 12,000 characters including spaces, math, and formulas (corresponding to 5 normal pages), plus a maximum of two pages with figures and tables.

(4) Your answer to Part 2 must be maximum 14,400 characters including spaces, math, and formulas (corresponding to 6 normal pages), plus a maximum of two pages with figures and tables.

(5) For Part 4, there is no limit on the maximum number of characters.

(6) You must hand in the exam in one pdf-document, which includes a frontpage and your answer to each of the four parts of the exam.

(7) On the frontpage, you must provide a count of the characters (including spaces, math, and formulas, but excluding tables and figures) for each of Part 1, 2, and 3.

(8) If you hand in as a group, you must specify on the frontpage who is responsible for the individual parts of the exam.

(9) The exam must be handed in at the Digital Exam platform (`http://eksamen.ku.dk`).

(10) **The deadline is at 10:00 (in the morning) on Friday, May 25.**

Part 1
Forecasting the Price of Owner-Occupied Apartments

The Case: House prices are a hotly debated topic. Their tendency to undergo booms and busts is well-described in the news with frequent stories about recent developments, regional differences, etc.. The price of housing inherently depends on expectations of the future price. As buying a house or an apartment is typically the most important economic decision for individuals and families, forming reasonable expectations about their future developments is crucial. Moreover, house prices are important for the overall economic activity, and thereby employment, as booms and busts can have a major impact on aggregate private consumption and savings.

An important use of econometric time series models is to make out-of-sample forecasts of future economic developments upon which economic decisions can be made. While univariate dynamic time series models, such as an autoregressive model, have limitations, they are easy to estimate, serve as a good benchmark, and they have shown to be hard to beat in practice.

Based on a sample of quarterly data covering the period 1992:1–2017:3, the aim of this assignment is to estimate a univariate autoregressive (AR) model and use the model to forecast out-of-sample (log) changes in a price index for owner-occupied apartments in Denmark.

The Data: The file Assignment2.in7 contains the following variable from Statistics Denmark:

PRICE Price index (2006=100) for owner-occupied apartments in Denmark.

Consider the following transformations:

$$p_t = \log(\mathsf{PRICE}_t) \qquad\qquad \Delta p_t = p_t - p_{t-1}.$$

The Assignment: Construct a univariate autoregressive model for the (log) growth rate of the price index for owner-occupied apartments and use the model to forecast the (log) growth rate over the period 2017:4–2025:4.

Hints:

(1) You are only required to assess stationarity of the variables based on the graphs of the data.

(2) For the graphical analysis, use any transformations of the variables you find are relevant (among the transformations proposed above, or any other ones), and explain your choices.

(3) When using the OLS or ML estimator, carefully discuss which assumptions are required and explain if they are fulfilled or not. If not, what are the consequences on your estimation results? Can you improve on this?

(4) If you come up with several model specifications, select the one that seems the most relevant to you, and justify your decision. Remember that in most cases, the simpler the better.

(5) If you perform some statistical tests, be precise about the hypotheses you test, why you test them, and what your conclusions are.

(6) Consider whether the model used for out-of-sample forecasts should be estimated based on the entire sample period.

Formal Requirements:

(1) You must hand in a report that (*i*) presents your graphical analysis, (*ii*) describes the econometric model, (*iii*) outlines the modeling progress (e.g., the approach you have taken, the alternative models you have estimated, etc.), (*iv*) presents your preferred model including interpretation and statements on economic and statistical significance, and (*v*) discusses the potential weaknesses of the model.

Limitations:

(1) You are not required to perform formal unit root tests, such as the Dickey-Fuller unit root test.

Part 2
Interest Rate Pass-Through

The Case: Danmarks Nationalbank (the central bank) sets its interest rates in accordance with the fixed exchange rate policy against the euro. Changes in the monetary policy rate are fully passed through to money market rates, which determine the exchange rate of the krone.

In response to changes in Danmarks Nationalbank's interest rates, banks normally adjust their interest rates on loans to corperations and households. However, the degree and speed of the pass-through of monetary policy interest rates to the banks' interest rates depend on several factors. These include the degree of products with variable interest rates and the degree of competition. Overall, empirical studies for Denmark have found a high degree of interest rate pass-through to banks' deposit and lending rates reflecting an effective transmission of the monetary policy interest rate, though only part of the adjustment takes place immediately.

For the post financial crisis sample period from 2006(1) to 2016(2), Mandsberg *et al.* (2016)[1] find a long-run pass-through to banks' deposit rate to non-financial corporations of 0.52 with an adjustment of 24 percent each month. That implies that a one percentage point increase in Nationalbanken's rate of interest on certificates of deposits leads to a 0.52 percentage points increase in banks' deposit rate in the long run with 24 percent of the correction taking place each month. They also find a short-term pass-through of 0.25.

Using monthly data covering the period 2009(4)–2016(12), the aim of this assignment is to estimate the short-run and long-run pass-through from Danmarks Nationalbank's interest rate on certificates of deposits to banks' average deposit rate on loans to non-financial corporations.

The Data: The files `Assignment3.in7` and `Assignment3.bn7` contain the following variables:

- CD — Danmarks Nationalbank's rate of interest on certificates of deposit. Annualized rate in percent, average over the month.
- DEP — Banks' deposit rate for loans (all maturities, in kroner) to non-financial corporations. Average over all loans, annualized rate in percent, average over the month.

[1] Mandsberg *et al.* (2016), Pass-Through from Danmarks Nationalbank's Interest Rates to the Banks' Interest Rate in Danmarks Nationalbank's Monetary Review, 2nd Quarter 2016. The described results are shown in Table 2, while Box 1 outlines their econometric approach.

Consider the following transformations:

$$
\begin{aligned}
r_t &= \mathsf{CD}_t, & \Delta r_t &= r_t - r_{t-1}, \\
d_t &= \mathsf{DEP}_t, & \Delta d_t &= d_t - d_{t-1}, \\
s_t &= d_t - r_t. & &
\end{aligned}
$$

The data are obtained from the Danmarks Nationalbank's Statbank.

The Assignment: Conduct an empirical analysis to estimate the short-run and long-run pass-through to banks' deposit rate. If you find a long-run relationship, investigate how the corresponding equilibrium is sustained and explain if the estimated long-run coefficients have the expected signs. Compare your empirical results to those of Mandsberg *et al.* (2016) described above and test if there is full long-run pass-through to banks' deposit rate, i.e. test if the long-run pass-through is significantly different from 1.

Hints:

(1) Conduct a graphical analysis to determine the stationarity of time series variables and to check if they seem to cointegrate.

(2) Carry out unit root tests to formally confirm or reject the conclusions from your graphical inspection.

(3) Perform a cointegration analysis based on either the Engle-Granger two-step procedure and/or a dynamic model (ADL/ECM). Comment on the signs and sizes of the estimated cointegration parameters, adjustment coefficients, and short-run parameters.

(4) Use an error-correction model to investigate the forces driving the system back to the equilibrium after a deviation from the long-run relationship.

Formal Requirements:

(1) You must hand in a report that (*i*) presents your graphical analysis, (*ii*) describes the econometric model, (*iii*) outlines the modeling progress (e.g., the approach you have taken, the alternative models you have estimated, etc.), (*iv*) presents your preferred model including interpretation and statements on economic and statistical significance, and (*v*) discusses the potential weaknesses of the model.

Part 3
Volatility of Excess Stock Returns

The Case: In an influential paper, Glosten et *al.* (1993)[2] (henceforth GJR) estimate a GARCH-in-mean model extended with a threshold effect and the risk-free interest rate entering the equation for the conditional variance of the innovations. Their Model 3 can be formulated as:

$$r_t = \delta + \phi\sigma_t^2 + \epsilon_t, \tag{3.1}$$

$$\epsilon_t = \sigma_t z_t, \qquad z_t \sim iidN(0,1), \tag{3.2}$$

$$\sigma_t^2 = \varpi + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \kappa\epsilon_{t-1}^2 I(\epsilon_{t-1} > 0) + \gamma i_t, \tag{3.3}$$

where r_t is the monthly excess return on the monthly return on the CRSP value-weighted index of equities on the New York Stock Exchange, i_t is the monthly return on Treasury bills, and $I(\epsilon_{t-1} > 0)$ is an indicator function which takes the value 1 if $\epsilon_{t-1} > 0$ and 0 otherwise. Models 1 and 2 in GJR correspond to the model in (3.1)-(3.3) with the restrictions $\kappa = \gamma = 0$ and $\gamma = 0$, respectively.

Estimating the model in (3.1)-(3.3), GJR find a significant negative GARCH-in-mean coefficient, ϕ, and a significant negative treshold effect, κ, such that positive shocks decrease the conditional variance next period while negative shocks increase it.[3] However, they find a positive, though insignificant, effect of the risk-free rate on the conditional variance.

Using daily observations covering the period January 3, 2011 to April 9, 2018, the aim of this assignment is to test if results similar to those in GJR can be found in the return series for the Standard & Poor's 500 Stock Index.

The Data: The file Assignment4.in7 contains daily observations for the US stock market and the :

SPX	Standard & Poor's 500 Index, closing prices.
RF	Compounded daily return on the 1-month Treasury bills.

The data is from the Bloomberg database.

Consider the following transformations:

$$r_t = 100 \cdot \Delta \log(\mathsf{SPX}_t) - f_t, \qquad f_t = \mathsf{RF}_t.$$

[2] Glosten et *al.* (1993), "On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks." *The Journal of Finance*, Vol. XLVIII, No. 5. The estimation results for Models 1-3 are presented in the first three columns of Table III on page 1793.

[3] Note that in Glosten et *al.* (1993), the coefficient κ measures the additional effect of positive shocks on the conditional variance. By contrast, the threshold GARCH model in OxMetrics is specified such that κ measures the additional effect of negative shocks.

The Assignment: Conduct an empirical analysis based on the extended GARCH model in (3.1)-(3.3) for the excess return on the Standard & Poor's 500 Index, r_t, and compare the results to those for Models 1-3 in GJR.

Hints:

(1) Conduct a graphical analysis to detect if there is volatility clustering in the log excess returns.

(2) You can estimate ARCH and GARCH models using the PcGive module in OxMetrics. Select the category Models for financial data and the model class GARCH Models using PcGive. Note that a GARCH(p,q) model in PcGive corresponds to a GARCH(q, p) model in the lecture notes. For example, a GARCH model with $p = 0$ and $q = 1$ in PcGive is an ARCH(1) model.
To include explanatory variables in the equation for the conditional variance, you should select them as H: X in h_t in the Formulate window.

Formal Requirements:

(1) You must hand in a report that (*i*) presents your graphical analysis, (*ii*) describes the econometric model, (*iii*) outlines the modeling progress (e.g., the approach you have taken, the alternative models you have estimated, etc.), (*iv*) presents your preferred model including interpretation and statements on economic and statistical significance, and (*v*) discusses the potential weaknesses of the model.

Part 4
Theoretical Problems

#4.1 The Asymptotic Variance of the OLS Estimator

Consider the processes for z_t:

$$z_t = \gamma + \phi z_{t-1} + \epsilon_t, \quad t = 1, 2, ..., T, \tag{4.1}$$

where $\epsilon_t \sim IID(0, \sigma^2)$, the initial value z_0 is given, and the parameter ϕ satisfies $|\phi| < 1$. Define the true parameters $\theta = (\gamma, \phi)'$.

The OLS estimator $\widehat{\theta} = (\widehat{\gamma}, \widehat{\phi})'$ is asymptotically normally distributed,

$$\sqrt{T}(\widehat{\theta} - \theta) \overset{d}{\to} N(0, V) \quad \text{for } T \to \infty, \tag{4.2}$$

where V is the asymptotic covariance matrix.

(1) Derive the asymptotic covariance matrix V as a function of the parameter values γ, ϕ, and σ^2.

(2) Explain *briefly* what the result in (4.2) can be used for.

#4.2 Forecasting

Consider the model for s_t:

$$\Delta s_t = \phi_1 \Delta s_{t-1} + \phi_2 \Delta s_{t-2} + \epsilon_t, \tag{4.3}$$

for $t = 1, 2, ..., T$, where $\epsilon_t \sim iidN(0, \sigma^2)$ and the initial values are given. Define the information set $\mathcal{I}_t = (s_t, s_{t-1}, ...)$.

(1) Derive the forecast $s_{T+2|T} = E(s_{T+2}|\mathcal{I}_T)$.

(2) Now assume that $\phi_2 = 0.5$ and that $\Delta s_T > 0$ and $\Delta s_{T-1} = -\Delta s_T$. For which values of ϕ_1 is the forecast $s_{T+2|T}$ greater than s_T?

#4.3 Moment Conditions in a Non-Linear Time Series Model

Consider the non-linear time series model:

$$r_t = \rho r_{t-1} + \left(\sqrt{\omega + \alpha r_{t-1}^2}\right) z_t, \qquad z_t \sim IID(0,1), \tag{4.4}$$

for $t = 1, 2, ..., T$ and where $-1 < \rho < 1$, $\omega > 0$, and $\alpha \geq 0$. Define the available information set $\mathcal{I}_t = (r_0, r_1, r_2, ..., r_t)$.

(1) Derive the conditional expectation $E(r_t|\mathcal{I}_{t-1})$ and the conditional variance $V(r_t|\mathcal{I}_{t-1}) = E\left((r_t - E(r_t|\mathcal{I}_{t-1}))^2|\mathcal{I}_{t-1}\right)$.

(2) Specify a set of moment conditions which can be used to estimate the parameters $\theta = (\rho, \omega, \alpha)'$ by generalized method of moments (GMM) and explain why the moment conditions are valid.

[Hint: You can use the results from Question 1 to derive such moment conditions.]