Written Exam Economics Winter 2018-19

Econometrics II

December 14 to December 21

This exam question consists of 12 pages in total

Answers only in English.

The paper must be uploaded as <u>one PDF document</u>. 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, December 21.**

Part 1
Forecasting GDP Growth

The Case: Forecasts of the future economic growth play an important role in economic policy. But like most macroeconomic time series, forecasting the growth rate in the gross domestic product (GDP) is difficult. In Denmark, major institutions, such as the Ministry of Finance, are from time to time criticized for not providing accurate forecasts for decision-makers. Recently, the media Altinget wrote that the Ministry of Finance's forecasts of the government balance have been systematically lower than the actual subsequent realizations since the financial crisis. Assistant Professor Søren Hove Ravn followed up with an op-ed, also in Altinget, explaining why economic forecasts are useful and necessary despite their lack of precision, and he briefly discussed if economists should be better at explaining the uncertainty associated with their forecasts.[1]

Using quarterly data covering the period 1991:1–2018:2, the goal of this assignment is to estimate a univariate dynamic model and use the model to forecast the future growth in GDP.

The Data: The dataset Assignment2.in7 contains the following variable from Statistics Denmark's StatBank (amounts in bill. DKK, table NKN1):

GDP Gross domestic product (GDP), 2010-prices, chained values, seasonally adjusted.

Consider the following transformations:

$$y_t = \log(\mathsf{GDP}_t) \qquad\qquad \Delta y_t = y_t - y_{t-1}.$$

The Assignment: Estimate a univariate time series model for the real growth in Danish GDP and forecast the growth rate over the period 2018:3–2028:2.

You are only required to assess stationarity of the variables based on the graphs of the data. You are allowed to consider only the class of autoregressive models, AR(p) models.

[1] You can read the two articles (in Danish only) here: K. Rosenkilde, "Finansministeriet har undervurderet dansk økonomi med over 300 milliarder siden 2010," *Altinget*, June 19, 2018, `https://www.altinget.dk/artikel/170125-finansministeriet-har-undervurderet-dansk-oekonomi-med-over-300-milliarder-siden-2010` and S. H. Ravn, "Søren Hove: Den grumsede økonomiske krystalkugle," *Altinget*, August 9, 2018, `https://www.altinget.dk/magasin/artikel/soeren-hove-den-grumsede-oekonomiske-krystalkugle`.

Hints:

(1) 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.

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

(3) 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.

(4) Be precise about the statistical tests you use for testing various hypotheses. Explain which null hypotheses you test, how you test them, and what your conclusions are.

(5) Consider whether the same model should apply to the entire 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
The Effects of Housing and Financial Wealth on Consumption

The Case: Private consumption is the largest demand component, and it is important to economic activity and employment. Macroeconomic theory suggests that private consumption is driven by disposable income and wealth. Wealth is composed mainly of housing wealth and financial wealth, which are driven by the booms and busts in house prices and stock prices over time. Consequently, the short- and long-run effects of housing and financial wealth on consumption represents an important link from the financial markets to the real economy.

Many empirical studies have estimated the wealth effects on consumption using different econometric methods for different countries and sample periods. One example is Kishor (2007)[2], who finds evidence of a cointegration relation between consumption, income, housing wealth, and financial wealth for the United States using quarterly data from 1952(1) to 2002(3). Based on the estimated cointegration vector presented in Table 1, Kishor (2007) concludes that the "long-run elasticity of consumption with respect to financial wealth is three times bigger than [the] elasticity of consumption with respect to housing wealth."

Using quarterly data covering the period 1974(2)–2011(4), the aim of this assignment is to estimate the short-run and long-run effect of income, housing wealth, and financial wealth on consumption for the United States.

[2] Kishor, N. K. (2007), "Does Consumptino Respond More to Housing Wealth Than to Financial Market Wealth? If So, Why?" *Journal of Real Estate Financial Economics*, 35, p. 427–448.

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

CONS	Households and nonprofit organizations' personal consumption expenditures of nondurable goods and service. Seasonally adjusted by annual rates. Billions of dollars.
INCOME	Households and nonprofit organizations' disposable personal income. Seasonally adjusted by annual rates. Billions of dollars.
WEALTH	Households and nonprofit organizations' total wealth (net worth), calculated as total assets minus total liabilities. Not seasonally adjusted. Billions of dollars.[3]
HOUSING	Households and nonprofit organizations' housing wealth (real estate equity), calculated as real estate assets measured at market value minus home mortgage liabilities. Not seasonally adjusted. Billions of dollars.
FIN	Households and nonprofit organizations' financial wealth, measured as total financial assets minus total liabilities excluding home mortgage liabilities. Not seasonally adjusted. Billions of dollars.[4]

Consider the following transformations:

$$\begin{aligned}
c_t &= \log(\mathsf{CONS}_t), & \Delta c_t &= c_t - c_{t-1}, \\
y_t &= \log(\mathsf{INCOME}_t), & \Delta y_t &= y_t - y_{t-1}, \\
w_t &= \log(\mathsf{WEALTH}_t), & \Delta w_t &= w_t - w_{t-1}, \\
h_t &= \log(\mathsf{HOUSING}_t), & \Delta h_t &= h_t - h_{t-1}, \\
f_t &= \log(\mathsf{FIN}_t), & \Delta f_t &= f_t - f_{t-1},
\end{aligned}$$

The consumption and income data are from the National Income and Products Account (NIPA) released by the U.S. Department of Commerce, Bureau of Economic Analysis. The wealth data are from The Flow of Funds Accounts released by the Federal Reserve Board of Governors. All series have been deflated using the price deflator for personal consumption expenditures (index 2012=100) from the NIPA.

The Assignment: Conduct an empirical analysis to estimate the short-run and long-run effects of income, housing wealth, and financial wealth on consumption. 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 the results in Table 1 and 2 in Kishor (2007).

[3] Note that total wealth does not equal the sum of housing and financial wealth as total wealth also includes other non-financial assets than real estate assets. However, real estate assets represent around 85 percent of non-financial assets, while the remaining non-financial assets include equipment, intellectual property products, and consumer durable goods.

[4] The majority of financial wealth is stock market wealth, either directly or indirectly held through pension funds, mutual funds, etc., so the financial wealth can be considered as the stock market wealth.

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.

(5) In your empirical analysis, focus on the effects of housing wealth and financial wealth on consumption. The time series for total wealth are included in the dataset only for reference and comparison, but you are not supposed to include total wealth in your empirical analysis.

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
Monetary Policy and Asset Price Volatility

The Case: At the Federal Reserve Bank of Kansas City's symposium *New Challenges for Monetary Policy* in Jackson Hole, 1999, Ben Bernanke and Mark Gertler presented a paper[5] arguing that central banks should pursue flexible inflation targeting. Their main argument was that "in the context of short-term monetary policy management, central banks should view price stability and financial stability as highly complementary and mutually consistent objectives, to be pursued within a unified policy framework."

Within the framework of the classic Taylor rule, the central bank adjusts the interest rate in response to expected inflation to achieve the goal of price stability. By contrast, the central bank should not respond to changes in asset prices, except when they signal changes in expected inflation. However, Bernanke and Gertler argue that asset price volatility becomes an independent source of economic instability that policy makers should take into account if 1) asset markets are partly driven by non-fundamental factors, such as market psychology, and, 2) if booms and busts in asset markets have important effects on the real economy, for example through the "balance sheet channel" caused by frictions in credit markets. Consequently, Bernanke and Gertler suggested an extension of the classic Taylor rule where the central bank combines its long-run goal of price stability with a short-run goal of financial stability.

After presenting a simple theoretical model to illustrate their proposed policy framework, Bernanke and Gertler present an empirical analysis where they estimate a Taylor rule with interest rate smoothing extended with asset price volatility. Specifically, they consider the extended Taylor rule with interest rate smoothing:

$$r_t = (1 - \rho_1 - \rho_2) \cdot r_t^* + \rho_1 \cdot r_{t-1} + \rho_2 \cdot r_{t-2}, \tag{3.1}$$

$$r_t^* = \bar{r} + \beta \cdot (E(\pi_{t+12}|\mathcal{I}_t) - \bar{\pi}) + \gamma \cdot E(\widetilde{y}_t|\mathcal{I}_t) + \xi' z_t, \tag{3.2}$$

where r_t is the Federal Funds rate, r_t^* is Federal Funds target rate, $\bar{r}$ is a long-run equilibrium nominal interest rate, π_t is the year-on-year inflation rate, $E(\pi_{t+12}|\mathcal{I}_t)$ is the forecast of inflation at time $t + 12$ based on the information set $\mathcal{I}_t$, $\bar{\pi}$ is an inflation target, $\widetilde{y}_t = y_t - y_t^*$ is the output gap, $E(\widetilde{y}_t|\mathcal{I}_t)$ is the forecast of the output gap at time t based on the information set $\mathcal{I}_t$, and z_t is a vector of stock market returns defined as $z_t = (s_t, s_{t-1}, s_{t-2}, s_{t-3}, s_{t-4}, s_{t-5})'$, where s_t is the log-return on the S&P 500 index. In-

[5] Bernanke, B., and M. Gertler (1999), "Monetary Policy and Asset Price Volatility", *Economic Review – Federal Reserve Bank of Kansas City*, Fourth Quarter.

flation stabilization requires that $\beta > 1$, output stabilization requires that $\gamma > 0$, while financial stabilization requires $\xi > 0$.

Bernanke and Gertler estimate the model in (3.1) and (3.2) by generalized method of moments for the United States using a sample of monthly data from 1979(10)–1997(12).[6] They get the estimates $\widehat{\beta} = 1.71$ and $\widehat{\gamma} = 0.20$, and both coefficients are significant. However, they get a negative and insignificant estimate of the sum of the coefficients in ξ of -0.082. Based on these results, Bernanke and Gertler conclude that "the Fed has focused its attention on expected inflation and the output gap and has neither sought to stabilize stock prices nor reacted to information in stock returns other than that useful for forecasting the output gap and inflation."

Using monthly data for the US economy covering the period from 1986(8) to 2007(1), the aim of this assignment is to analyze if there is empirical evidence of the Federal Reserve setting its interest rate in accordance with the extended Taylor rule with interest rate smoothing in (3.1) and (3.2) during the period where Alan Greenspan served as Chairman of the Federal Reserve (Aug. 1987 to Jan. 2006).

The Data: The file `Assignment5.in7` contains the variables:

ff	Federal Funds rate, monthly average.
inflex	Inflation rate excluding food and energy, year-on-year.
inflcomm	Inflation rate of producer prices based on the commodity price index, year-on-year.
caputil	Capacity utilization, total industry. Percent of capacity.
capgap	Measure of the output gap. Deviation of caputil from its mean.
unr	Unemployment rate, percent.
unrgap	Measure of the output gap. Deviation of unr from its mean.
spx	SP500 stock market index.
rspx	Log-returns on the SP500 stock market index.
cape	Cyclically adjusted price-earnings ratio for the SP500 stock market index.

The data is for the US economy and the data source is the FRED Database maintained by the Federal Reserve Bank of St. Louis, except from the stock market data which is downloaded from Robert Shiller's website.

The Assignment: Conduct an empirical analysis based on *generalized method of moments* estimation to analyze if there is empirical evidence of an extended Taylor rule with interest smoothing in (3.1) and (3.2). Use the estimation sample from 1987(8) to 2006(1) during which Alan Greenspan served as Chairman of the Federal Reserve of the United States.

[6] The estimation procedure and results are described in Section IV, while the main results are presented in Table 2.

Hints:

(1) You must explain how the *generalized method of moments* estimator can be derived from the equations (3.1) and (3.2). In particular, explain how the moment conditions can be derived and how you choose your instruments for GMM estimation.

(2) You must report some robustness analysis for your empirical results. Hints (3) to (7) below gives some suggestions for robustness analyses along different dimensions.

(3) You can estimate the model with and without stock market returns and with different numbers of lags of the stock market returns. For example, you can estimate the model without any stock market returns ($\xi = 0$) and compare the results to the models with only s_t included and with the full vector z_t included. You can also try to include other measures of the stock market, for example you can use indicator functions to estimate if the Fed has reacted differently to positive and negative stock market returns, or you can include the cyclically adjusted price-earnings ratio as a measure of the deviation of the level of the stock market from its long-run fundamental level.

(4) You can estimate the Taylor rule without interest rate smoothing by restricting $\rho_1 = \rho_2 = 0$, or with interest rate smoothing with one lag instead of two by restricting $\rho_2 = 0$. Does your estimated extended Taylor rule depend on whether you allow for interest rate smoothing?

(5) The data set contains two proxies for the output gap, one based on the capacity utilization and one based on the unemployment rate. You can choose which variables to work with, and you can see if your results are robust to the choice of variables.

(6) You can try different choices of instruments. Are your results robust for your choice of instruments? Argue for your preferred choice of instruments and report the Hansen test for overidentification.

(7) You can estimate your model with different weight matrices. What seems like a reasonable assumption about the moments, and what does it imply for the choice of the weight matrix? Are your results robust for different weight matrices?

(8) Conduct a graphical analysis to detect if there is evidence for a Taylor rule. You can plot the actual Federal Funds rate together with the rate predicted by the estimated reaction function if it can be interpreted as a Taylor rule.

Part 4
Theoretical Problems

#4.1 Maximum Likelihood Estimation

Consider the model for z_t given by:

$$z_t = \rho_t \cdot z_{t-1} + \epsilon_t, \tag{4.1}$$

$$\rho_t = \rho + \sqrt{\alpha} \cdot \eta_{1t}, \tag{4.2}$$

$$\epsilon_t = \sqrt{\omega} \cdot \eta_{2t}, \tag{4.3}$$

for $t = 1, 2, \dots, T$, where z_0 is given, $0 < \rho < 1$, $\alpha > 0$, and $\omega > 0$. The innovations $(\eta_{1t}, \eta_{2t})'$ follow the multivariate Gaussian process:

$$\begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \sim i.i.d.N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \right). \tag{4.4}$$

(1) Derive the conditional expectation $E(z_t|z_{t-1})$ and the conditional variance $V(z_t|z_{t-1})$. Comment briefly on the results.

(2) The conditional distribution of z_t given z_{t-1} is normal (Gaussian).

Given a sample $(z_0, z_1, \dots, z_T)$, state the log-likelihood function of the model in (4.1)–(4.4) as a function of the model parameters θ.

#4.2 Mean-Squared Forecast Errors

Consider the model for y_t given by:

$$y_t = \rho \cdot y_{t-1} + \epsilon_t, \tag{4.5}$$

$$\epsilon_t = \eta_t + \alpha \cdot \eta_{t-1}, \qquad \eta_t \sim i.i.d.N(0, \sigma_\eta^2), \tag{4.6}$$

for $t = 1, 2, \ldots, T$, where $0 < \rho < 1$, $\alpha > 0$, and the initial values y_0 and η_0 are given.

Define the information set at time t as $\mathcal{I}_t = \{y_0, \eta_0, y_1, \eta_1, \ldots, y_t, \eta_t\}$.

(1) Derive the forecast $\widehat{y}_{T+1|T} = E(y_{T+1}|\mathcal{I}_T)$ and the mean-squared error of the forecast $\widehat{y}_{T+1|T}$, given by:

$$MSE(\widehat{y}_{T+1|T}) = E\left(\left(y_{T+1} - \widehat{y}_{T+1|T}\right)^2\right). \tag{4.7}$$

(2) Derive the infinite moving average representation for y_t in terms of the innovations η_{t-i} for $i = 0, 1, 2, \ldots, \infty$. Use this moving-average representation to derive the unconditional expectations $E(y_t)$ and $E(y_t^2)$.

(3) A *naive forecast* of y_{T+1} is given by $\tilde{y}_{T+1|T} = y_T$.

Derive the mean-squared error of the naive forecast $\tilde{y}_{T+1|T}$ given by:

$$MSE(\tilde{y}_{T+1|T}) = E\left(\left(y_{T+1} - \tilde{y}_{T+1|T}\right)^2\right). \tag{4.8}$$

(4) Compare the mean-squared errors of the forecasts $\widehat{y}_{T+1|T}$ and $\tilde{y}_{T+1|T}$ in (4.7) and (4.8) for the parameter values $\rho = 0.5$ and $\alpha = 1$. Explain which of the two forecasts has the smallest mean-squared error and explain briefly the intuition behind.