Take Home Exam

- This exam consists of 2 problems. Please do them all. The grade you get for the take home counts 30% of the final grade.
- Please upload your solutions to the 'Übungsmodul' on ILIAS no later than January 13, 2023, 23.59h. Your solutions should contain **one** pdf-file and **one** zip-file containing your Python/Matlab code used for the solutions. Late submissions will not be considered!
- The pdf with your solutions should be in form of a short research report. Hand in a text with your graphs, outputs and answers. Your solutions may contain scanned versions of handwritten notes (no need to typeset). Make sure that we understand what you have done, that is, briefly explain your answers and modeling decisions and include all relevant computer output. Consistently number all tables and graphs and refer to these results accordingly. When presenting results from statistical tests, make sure to state the null hypothesis, the appropriate distribution of the test statistic (under H_0), the value of the test statistic, the critical value (or p-value) and the test decision. Be as concise as possible nonetheless. You are allowed to hand in at most 10 pages (including graphs and tables).
- Note: Submitting as solutions only Python/Matlab code with answers to questions as text comments within the code is not acceptable.
- Unless specified otherwise, for standard methods you may use functions readily available in Python/Matlab. You may, of course, reuse program code that you have written for the programming assignments.
- On your solutions and code, please give your student number not your name.
- Policy with regard to academic dishonesty: The grade for your take home exam will be a part of your overall grade for this course. Students who wish to work together on assignment material may do so. However, **each student must formulate and hand in the solutions independently**. This means that students who have worked as a group may **not** simply hand in the same solution.
- Good luck!

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1) In this problem you explore the finite sample properties of information criteria for lag selection and its implication for forecasting accuracy using a small Monte Carlo simulation.

   a) Repeat the steps 1b) to 1d) for $T = 50, 100, 200$.

   b) Generate $M = 1000$ sets of time series data of length $T + 4$ according to the VAR(1) process

$$y_t = \begin{bmatrix} a_{11} & 0 \\ 0.5 & 0.5 \end{bmatrix} y_{t-1} + u_t, \tag{1}$$

   where u_t is normally distributed white noise with covariance matrix $\Sigma_u = \begin{bmatrix} 1 & 0.5 \\ 0.5 & 1 \end{bmatrix}$. Use $a_{11} = 0.5$.

c) In each of the M replications, hold out the last 4 observations for forecasting and apply the standard information criteria for lag selection (FPE, AIC, HQ, SC) with $p_{\max} = 8$ in a VAR with an intercept and store the selected lag length. Based on the selected model, compute and store h-step ahead forecasts for $h = 1, 2, 4$. Using the results from all M replications, report the relative frequency distribution of estimated VAR lag orders and the normalized mean squared forecast errors,

$$\mathsf{MSPE}(h) = \frac{1}{M} \sum_{m=1}^{M} \left(y_{T+h,m} - \hat{y}_T(h)_m\right)' \Sigma_{y,m}(h)^{-1} \left(y_{T+h,m} - \hat{y}_T(h)_m\right), \qquad (2)$$

where $\Sigma_{y,m}(h)$ is the h-step ahead forecast error variance matrix in replication m based on the true DGP parameters.

d) In each of the M replications, also compute 95% prediction intervals[1] for the predictions in 1c) and check (for each horizon separately) whether the actual value is inside the interval or not. Report the empirical interval coverage over the M replications for each variable, VAR selection criteria and horizon $h = 1, 2, 4$.

e) Comment on and interpret your results.

f) Repeat the experiment now using $a_{11} = 0.95$. How do your results change? Explain.

2) In this problem you study the dynamic effects of monetary policy and exchange rate shocks. `usmacroex.csv` contains quarterly, seasonally adjusted US data for the period 1960Q1-2022Q3. This file includes data on a chained-weighted GDP price index (GDPCTPI), the unemployment rate (UNRATE), the federal funds rate (FEDFUNDS) and the US Dollar/UK Pound exchange rate as (DEXUSUK). Observations on the exchange rate are available from 1971Q1 only. **Only use data until 2019Q4 (unless specified differently below).**

a) Compute the annualized rate of inflation $\mathrm{INF}_t = 400 \times \Delta \log(\mathrm{GDPCTPI})_t$. Provide time series plots of INF_t, UNRATE_t, and $\mathrm{FEDFUNDS}_t$. Use 'eyeball econometrics' and comment on the likely order of integration of the series. Also conduct formal unit root tests on the three variables. Use an ADF test on the 5% significance level (lag selection by the AIC criterion and $p_{max} = 8$). Explain how you choose the deterministic terms, summarize your results. What do you conclude?

b) Estimate VAR models with an intercept for

$$y_t = (\Delta\mathrm{INF}_t, \mathrm{UNRATE}_t, \Delta\mathrm{FEDFUNDS}_t)'$$

using the lag lengths suggested by AIC and SC ($p_{\max} = 12$). Perform diagnostic checks on the models, i.e. perform Portmanteau tests for remaining residual autocorrelations and normality tests. What do you conclude with respect to the adequacy of your models? Use plots of standardized residuals of the model selected by AIC to explain your normality test results. Which model would you prefer?

c) Use your preferred VAR from 2b) and check whether the federal funds rate Granger-causes the remaining variables. Also test whether the inflation rate Granger-causes the other variables in the system. Use a significance level of 1%. Interpret your results.

d) Provide the estimated residual correlation matrix $\hat{R}_u$ of your preferred model. Given the results, explain why using forecast error impulse responses in this system may be misleading.

[1] Use intervals that neglect parameter estimation uncertainty.

e) Using the preferred model from 2b), compute and plot orthogonalized impulses responses. Make sure that you report responses of the level of inflation and the level of the federal funds rate. Use $h = 24$ and confidence intervals with a nominal coverage of 90%. Describe and interpret your results.

f) Based on your VAR model, perform a forecast error variance decomposition of the inflation, unemployment and federal funds rate. Comment on the relative importance of the monetary policy shock.

g) Explain briefly why your results obtained in 2b) to 2f) could be misleading if INF_t and $\mathrm{FEDFUNDS}_t$ were cointegrated?

h) Repeat your analysis from 2e) using all variables in levels, i.e. redo your analysis with $y_t = (\mathrm{INF}_t, \mathrm{UNRATE}_t, \mathrm{FEDFUNDS}_t)'$. Compare the results from the impulse response analysis to those in 2e).

i) Now add the exchange rate as a fourth variables to the VAR, i.e. use

$$y_t = (\Delta\mathrm{INF}_t, \mathrm{UNRATE}_t, \Delta\mathrm{FEDFUNDS}_t, \mathrm{DEXUSUK}_t)'.$$

Compute orthogonalized IRFs to innovations in the federal funds rate and the exchange rate from a VAR(m), where m is selected by AIC. Report responses for INF_t, UNRATE_t, $\mathrm{FEDFUNDS}_t$, and $\mathrm{DEXUSUK}_t$.

i. Describe and interpret the responses of the system variables to the 'exchange rate' shock. Do you find them economically plausible?

ii. Repeat the FEVD exercise on the VAR including $\mathrm{DEXUSUK}_t$. Does the relative importance of the monetary policy shock change? Describe any changes compared to 2f).

iii. Are there changes in the responses to a 'monetary policy shock' compared to your results from 2e)? Reestimate the 4 variable model over a sample ending in 2007Q4. Are there changes in the response to a monetary policy shock? What do you conclude?