# Master Economics and Public Policy
# Interprating Macroeconomic Time Series
# Final Exam

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**Rules of the game** This 2 hours exam proposes 7 exercises, each of which is valued 4 points. Hence, doing everything grants you up to 28 points. The maximum grade is however 20 which means you can get the max grade if you answer properly to 5 of the 7 exercises.

The exam grade will account for 50% of your final note, the other 50 % will be the average of the three HA grades.

## 1 Filtering

1. Why does one filter an economic time series? (1 sentence)
2. Comment on figure 1 (see end of exercises sheet) from Baxter and King : what are the pros and cons of first difference filtering? In what sense is the Baxter and King filter superior to the HP filter ?
3. Comment on the charts from Agresti Mojon (figure 2) : how does the spectral density of US GDP changes when the sample includes additional years 1996 to 1999? What does it mean ?
4. Among graphs from figure 3, say which one is EA GDP, the business cycle frequency component of EA GDP, EA inflation, EA interest rate ?
5. Why could an economist be reluctant to filter out the trend of inflation and the nominal interest rate before modeling them ? (1 sentence)

## 2 Times series analysis

1. Give the equation for $X_t$ when it follows :
   a an AR(1), an MA(2), an ARMA(1,2), an ARMA(2,1)
   b a random walk, a random walk with drift,a random walk in first difference
   (note $\varepsilon_t$ a white noise)
2. Write the state space representation of the MA(2), ARMA(1,2), ARMA(2,1) with an observation equation and an equation describing the evolution of the unobservable of each model.
3. Among the graphs of figure 4, which one is a stationary autocorrelated process, a white noise and an integrated process ?

4. For each example says if they are *a priori* stationnary time series or not :
   a Mexican log GDP
   b German inflation (since 1995)
   c HP filtered US GDP
   d French price index for beer
   e Inflation of the European Harmonized Consumption Price Index HCPI
   f Euro area real interest rate (Euribor) since the foundation of the ECB

# 3 VAR

1. Which one is the formula to estimate $\beta$ with OLS the equation $Y = \beta X + \varepsilon$ ?
   a $(X'Y)(X'X)^{-1}$
   b $(X'X)^{-1}Y$
   c $(X'X)^{-1}X'Y$
   d $(XX')^{-1}XY'$
2. Write the cannonical form (one lag) of the following VAR

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} e & f \\ g & h \end{bmatrix} \begin{bmatrix} y_{t-3} \\ z_{t-3} \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ \epsilon_t \end{bmatrix}$$

3. Use the MA form of a the following VAR of quarterly interest rate and monetary aggregate growth rate to write the variance decomposition of each variable into each shock (the share of the variance of each variable explained by each shock) ? Why is this variance decomposition easier to performe and more meaningful if the shocks are orthogonalized ?

$$\begin{aligned} Y_t &= AY_t + \varepsilon_t, \text{with } \varepsilon_t \sim N(0, \Omega) \\ \begin{bmatrix} r_t \\ \Delta m_t \end{bmatrix} &= \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} r_{t-1} \\ \Delta m_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{rt} \\ \varepsilon_{mt} \end{bmatrix} \\ P \begin{bmatrix} \varepsilon_{rt} \\ \varepsilon_{mt} \end{bmatrix} &= \begin{bmatrix} u_t^{MS} \\ u_t^{MD} \end{bmatrix} \text{with } u_t \sim N(0, D),\ D \text{ diagonal} \end{aligned}$$

4. What is an impulse response function ? Using intuitive matrix notation, express the effect of $u_t^{MS}$
   a on $r_t$ after one year,
   b on $\Delta m_t$ after 2 quarters,
   c on $m_t$ after 2 quarters.
5. What pattern of this VAR impulse responses would comfort you in interpreting this $P$ identification matrix as defining money supply and money demand shocks ?
6. Explain the idea of Blanchard and Quah to disentangle productivity from demand shocks ? (3 sentences max).

# 4 DSGE modeling

1. What is the difference between an RBC model and a neo-Keynesian model ? (1 sentence)
2. What does TFP stands for ? How can you construct a TFP time series from $y_t, n_t, i_t$ quarterly time series of GDP, labor and investment, assuming that the depreciation rate of capital is $\delta$ and a Cobb-Douglas technology with a labor share of 66 %.
3. Name 2 ways to introduce price stickiness in a business cycle model. Why does price stickiness implies the non neutrality of money ? Why would one introduce habit formations in a business cycle model ?
4. Define the steady state of a business cycle model. Write the Taylor rule equation.

# 5 DSGE estimation

1. Give an interval for the value of your priors on
   a the habit formation parameter
   b the reaction to inflation of the Central Banker
   c the discount factor
2. Define each dynare command in a sentence
   a model(linear) ;
   b estimation(...) ;
   c stoch-simul(...) ;
   d mode_check
3. How do you check the robustness of a maximum likelihood estimation ? (1 check) What test do you add if your estimation is Bayesian ? (2 checks) What is the interest of Bayesian estimation instead of maximum-likelihood ? (2 sentences max)
4. Why does one run a metropolis-Hastings after the first round estimation ? (1 sentence)

# 6 Applications of the class material

1. You work at Bercy. The cabinet asks you for normative elements to prepare a European summit about a new status for the ECB. Which model do you simulate, an RBC model or neo-Keneysian model ?
2. You work for Natixis. Patrick Artus asks you to forecast one year ahead Indonesian quaterly growth rate. You have tested two models.
   An ARMA(3,2) gives you an out-of-sample RMSE of 0.32 and in sample 0.12.
   An ARMA(5,1) model gives you an RMSE of 0.21 out-of-sample and 0.39 in-sample.
   Which one do you choose ?
3. Your PhD advisor gives you the three following time series : HICP inflation $\pi_t$, the unemployment rate $u_t$, survey based inflation expectations $S_{t+1|t}$. You assume that the true inflation expectations $E_t[\pi_{t+1}]$ that enter the following hybrid Philips curve, though not observed, are correlated with $S_{t+1|t}$.

$$\begin{aligned} \pi_t &= \alpha E_t[\pi_{t+1}] + (1-\alpha)\pi_{t-1} + \gamma u_t + \varepsilon_t \\ E_t[\pi_{t+1}] &= \beta S_{t+1|t} + \delta \pi_t + \epsilon_t \end{aligned}$$

   a Write the state space representation of this model.
   b Use the Kalman filter to define the likelihood of this model

# 7 Habit formation utility function *à la* Fuhrer 2000 AER

In a paper in 2000, Jeffrey Fuhrer introduces habit formations in the utility function of households with the following form

$$U(C_t, Z_{t-1}) = \frac{1}{1-\sigma}\left(\frac{C_t}{Z_{t-1}^{\gamma}}\right)^{1-\sigma} \tag{1}$$

with $Z_t$ an *external* reference.

**Q. 1** *Write the objective function of an infinitely lived household with discount factor $\beta$ and this utility function.*

We denote $w_t$ the total wages received by the household, $A_t$ its total asset at the end of period $t$, $r_t$ the return on $A_t$ and $P_t$ the price of consumption (and $\Pi_t$ the corresponding inflation rate).

**Q. 2** *Write the budget constraint of the household.*

**Q. 3** *Maximize the program of the household and find following Euler equation.*

$$\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{Z_{t-1}}{Z_t}\right)^{\gamma(1-\sigma)}\frac{1+r_t}{\Pi_{t+1}} = 1 \tag{2}$$

**Q. 4** *Characterize the steady state of equation* (2)

**Q. 5** *Log-linearize equation* (2)

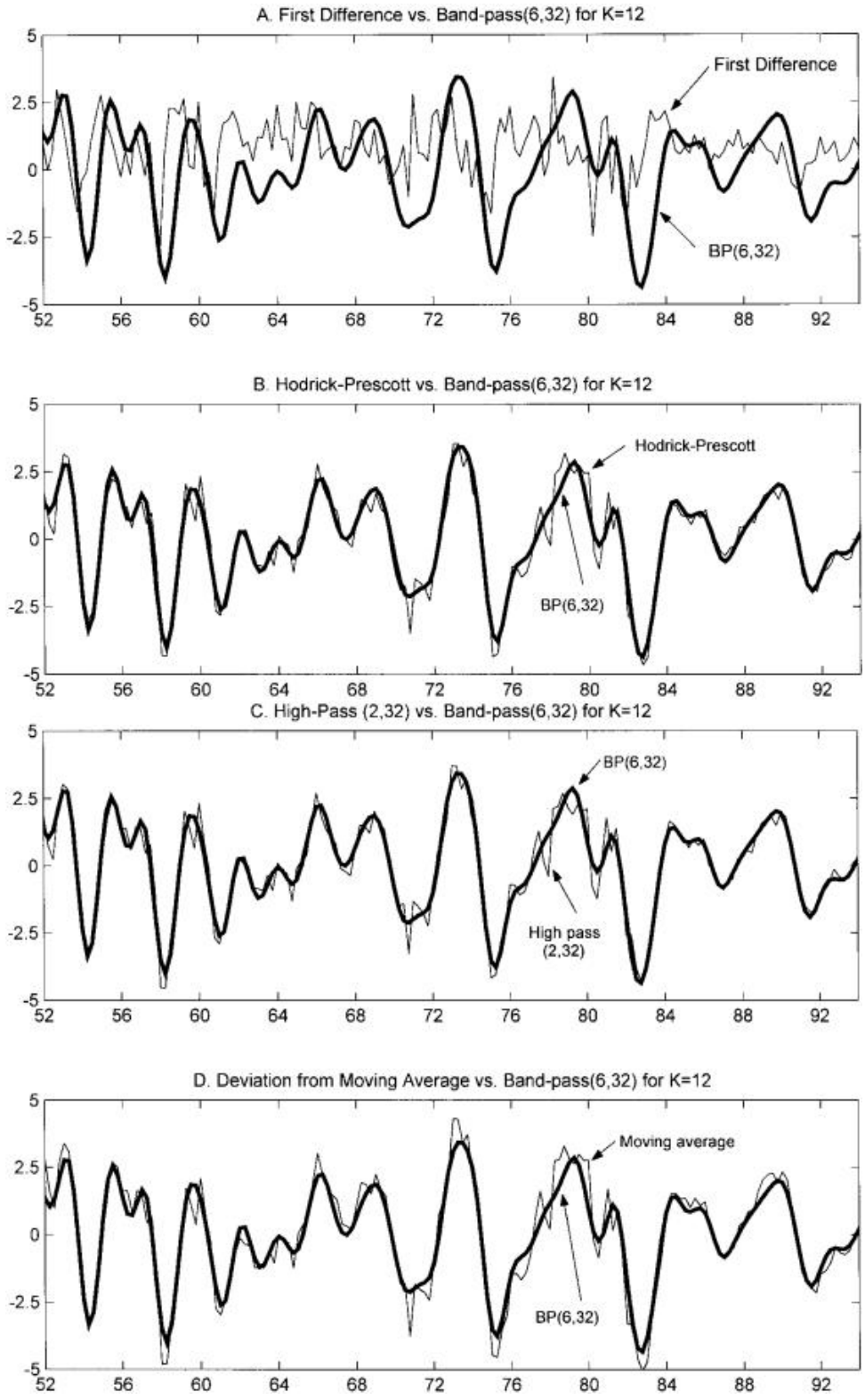


FIGURE 1 – The effect of alternative filters on GDP (from Baxter and King)

Chart 1: Spectral densities of GDP growth for the period 1970-1999 in the euro area and the US

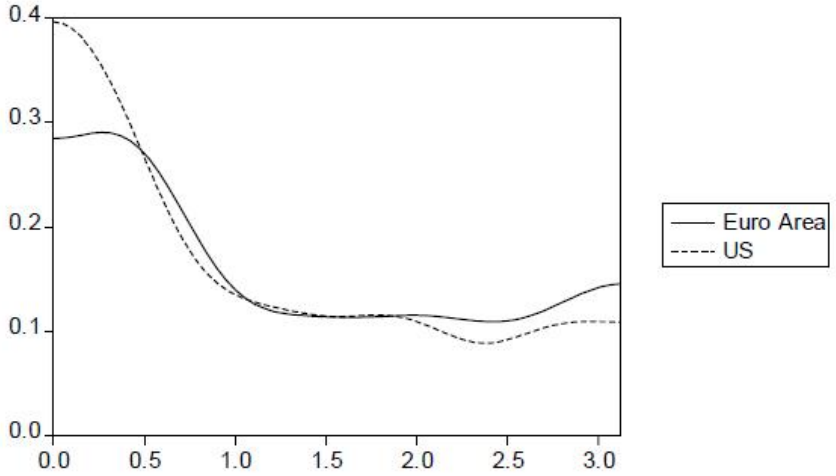


Chart 2: Spectral densities of GDP growth for the period 1970-1995 in the euro area and the US

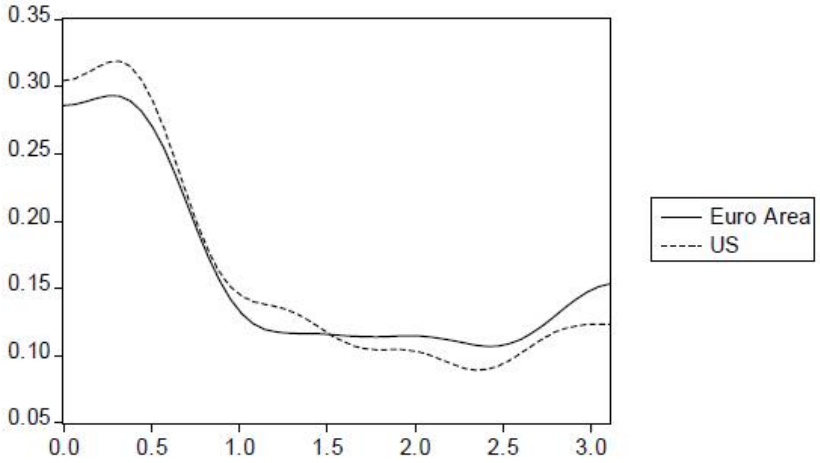


FIGURE 2 – Spectral density of GDP from Agresti Mojon

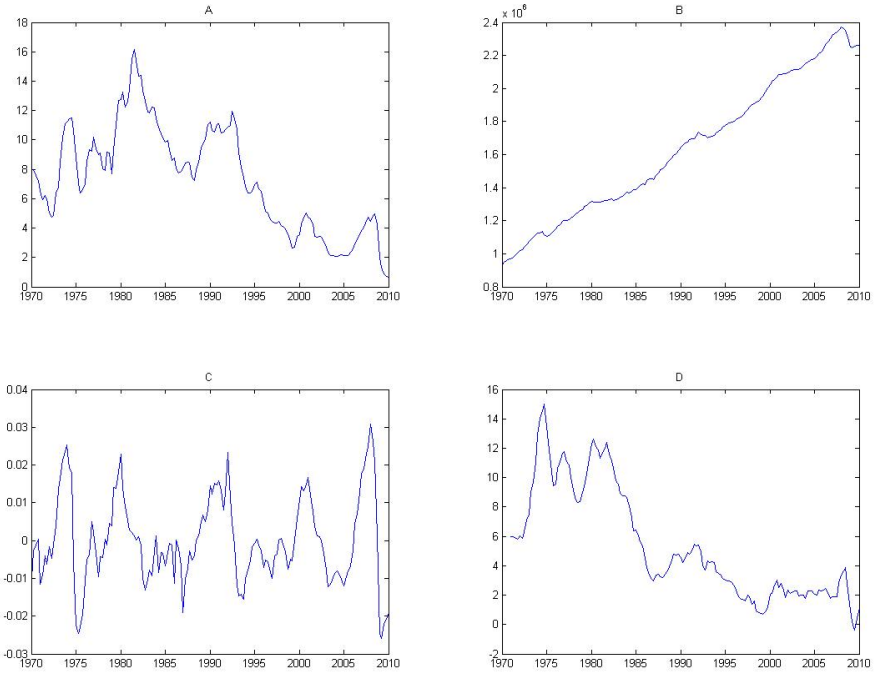


FIGURE 3 – Graphs of Euro Area times series

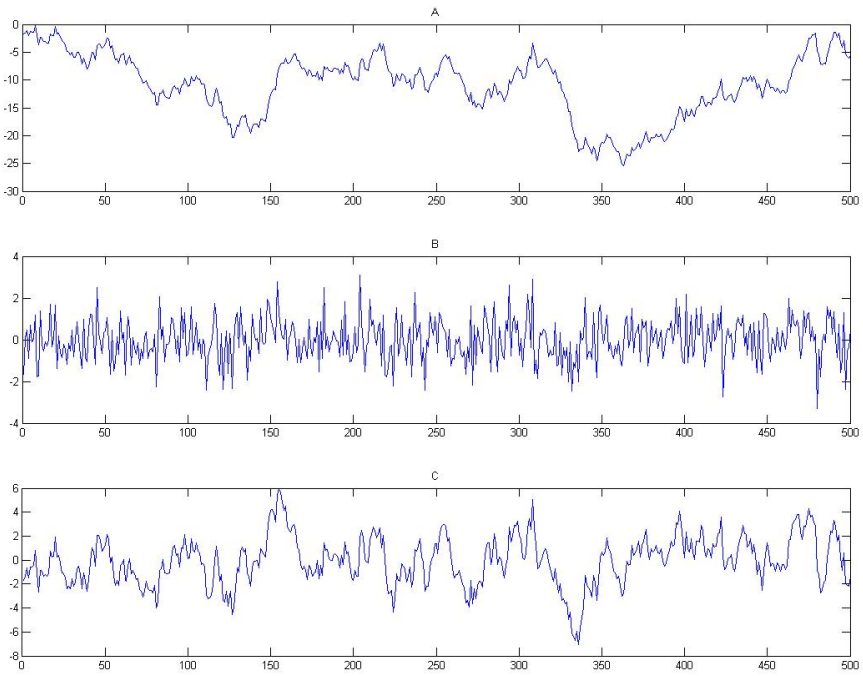


FIGURE 4 – Graphs of simulated time series