Exercise Session 3: Monetary Policy

Natural Interest Rate, Estimating Unobservable Variables, and Inflation in the Long Run

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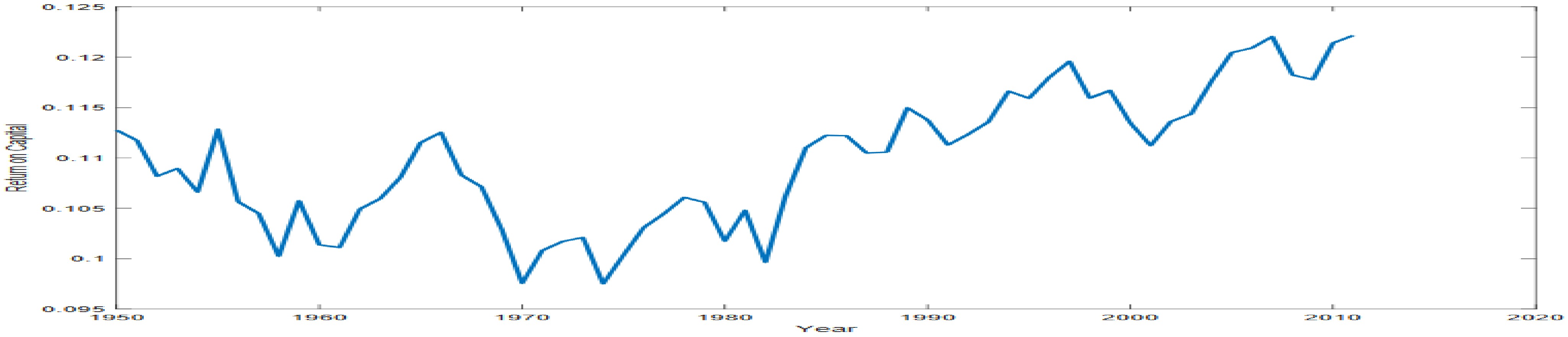
TASK 1: Repetition. Recall the solution for the long run interest rate derived from the Solow Growth model. How is each parameter driving r^*? Provide economic intuition.



Source: Garín et al. (2020), p. 65.

$$r^* = \alpha\left(\frac{\delta + z + n}{s}\right)$$

TASK 1: Repetition. Recall the solution for the long run interest rate derived from the Solow Growth model. How is each parameter driving r^*? Provide economic intuition.

$$r^* = \alpha \left(\frac{\delta + z + n}{s} \right)$$

- Capital intensity α; population growth rate n, technology growth rate z, depreciation rate δ, savings rate s

r^*: increases with factors that increase the demand for investment: technology growth z, depreciation δ, population growth n, and capital intensity α.

It decreases with an increase in the savings rate as this would increase the supply of capital/investment. For advanced economies, decreasing n also relevant.

TASK 2: Argue with the help of the Fisher equation why a persistent decrease in r^* yields the zero lower bound to bind more often.

Fisher equation: $i_t \approx r_t + \pi_t^e$

In the long run: $i^* \approx r^* + \pi^*$

If r^* decreases persistently and π^* is small, the zero lower bound on nominal interest rates binds more frequently, implying less room to maneuver for central banks

So, whether or not and if so by how much r^* delined is one of the most important discussion in monetary policy at the moment

TASK 3: Summarize the possible reasons of a decline in r^* discussed in class concisely.

1. **Slowdown in long-run growth** decreases investment profitability so that investment demand decreases

- Not clear which argument dominates: is productivity growth slowing down due to stagnation in human capital quality, pressures from globalization, and environmental issues or does the digital revolution impact productivity growth positively?

2. **Savings glut** (Bernanke 2005): increasing supply of savings not only from aging economies, but also from export-based emerging market economies, reducing their export-dependency

- If not matched by (increasing) volume of investment opportunities: excess supply of savings yielding marginal return on capital to decline

TASK 3: Summarize the possible reasons of a decline in r^* discussed in class concisely.

3. **Demographic factors** tend to increase supply of savings, first and foremost in aging advanced economies

4. **Increase in inequality** might increase supply of savings: with wealth being concentrated in wealthy households that have higher (than average) propensity to save → increase in supply of savings, decreasing marginal return on capital

TASK 4: Discuss the following questions concisely based on the article by Jordà and Taylor (2019) [required reading]:

a) What drives a country's rate of interest?

A country's rate of interest can be thought of as being determined by the sum of three components:

1) **long-run global neutral rate of interest**, determined by global demographic factors, international productivity growth, increasing financial integration among economies, and several other economic and geopolitical factors.
2) **medium-run gap** between the domestic neutral rate and the global neutral rate of interest - "local" neutral rate; same factors as before, but on a country-specific rather than international level.
3) **short-run measure of monetary policy stance →** difference between the current policy rate and the domestic neutral rate. Importantly, the central bank can influence only this component.

TASK 4: Discuss the following questions concisely based on the article by Jordà and Taylor (2019) [required reading]:

b) What explains the variation in interest rates?

- interest rates vary differently across 3 subsamples: 1955–1974, 1975–1994, and 1994–2015, and for all years.
- most of the interest rate movements are monetary policy driven during the high inflation period of 1975–1994
- during other times, variation driven by underlying trends in the global and domestic neutral rate of interest
- average monetary policy stance explains only about half of the variation in interest rates. The other half of the time, interest rates move for reasons other than a central bank's response to the economic outlook.

TASK 4: Discuss the following questions concisely based on the article by Jordà and Taylor (2019) [required reading]:

c) Discuss the insights from the Solow Model in context of the article. Which aspects are reflected in the model, which are not?

- Solow model reflects long-run developments: long-run trends in e.g. demographics (n), technological progress (A), technology growth (z)
- Abstracts from short-run developments and therewith doesn’t reflect influence of short-run monetary policy stance of the central bank
- Limiting the analysis to describe either long- or short-run developments dismisses, on average, half of the variation in interest rates

TASK 5: Explain how the HP filter and the bandpass filter decompose a time series into trend and cycle in context of GDP.

Both approximate the so-called ideal bandpass filter, aiming to extract a specific frequency (band) in the underlying series

- Problem: computation of ideal filter would require infinite data; however, our samples are finite (and often short)

- HP filter: fits a line through the data series, solving the trade-off between fitting a smooth line (trend is often perceived as a smooth line, reflecting slow-changing developments) and fitting the data closely
- Trade-off governed by smoothing parameter λ (how much weight is attributed to generate a smooth series)

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$$\min_{\{g_t\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1})(g_{t-1} - g_{t-2})]^2 \right\}$$

- **What does the first term reflect, what the second?**

TASK 5: Explain how the HP filter and the bandpass filter decompose a time series into trend and cycle in context of GDP.

- Bandpass filter: transforms GDP into the so-call frequency domain
- Frequencies within a certain range pass through to the output gap and other (longer and shorter fluctuations) are rejected
- Filter splits up log real GDP into trend, cycle and irregular component
- Common setting to extract business cycles: 6-32 quarters
- Everything longer falls into the trend component
- Everything shorter falls within the noise/irregular component

TASK 6: Estimating Trends/Cycles (Potential output/output gaps) in EXCEL

(a) Deterministic detrending: Subtract a linear time trend from real GDP. Write down the algebraic expression.

$$Y_t = (1+g)^t Y_0$$
$$\ln(Y_t) \approx \alpha + gt$$
$$\ln(Y_t) = \alpha + gt + \varepsilon_t$$

TASK 6: Estimating Trends/Cycles (Potential output/output gaps) in EXCEL

(b) Regress real GDP on a linear, quadratic, and cubic time trend. Write down the OLS regression equation in matrix notation and show how one can obtain an output gap estimate from this regression.

$$y = \ln(real\ GDP)$$
$$y = \alpha + \beta t + \gamma \mathrm{t}^2 + \delta t^3 + \varepsilon_t$$
$$\varepsilon_t = output\ gap$$

OLS estimation in matrix notation: $X = (1\ t\ t^2\ t^3), Y = y, Y = X\beta + \varepsilon$

$$\hat{\beta} = (X'X)^{-1}X'Y$$

Trend: $\hat{Y} = X\hat{\beta}$

Output gap: $\hat{\varepsilon} = Y - \hat{Y} = Y - X\hat{\beta}$

TASK 7: Compare the approaches used to estimate the natural interest rate in contexts of their characteristics, but also their limitations.

1. Unobserved Components Model

- Model, incl. observable variables (output, inflation, nom. interest rate)
- Long-run values estimated together with parameters of exogenous shocks
- If model implied values for y_t, π_t, i_t deviate from observed data, estimation algorithm would adjust equilibrium values y^*, r^* so that both align again
- Limitations:

1. High estimation uncertainty as many parameters and unobservable components are estimates on a few observables
2. Underlying assumption for assumed time series process on the observables can have large impact; small changes can substantially change the estimates for r_t^*

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2. VARs

- Can capture dynamic correlations among many variables without imposing restrictions
- Advantage: time-varying VARs can capture secular change over time
- Empirical approach: so equilibrium values need to be inferred, for example, as deviations from medium-term values (forecasted values)
- Limitation: Identification problem

Determining driving forces of r^* cannot be investigated without imposing structural identifying assumptions

TASK 7: Compare the approaches used to estimate the natural interest rate in contexts of their characteristics, but also their limitations.

3. DSGE models

- Basically large UCMs where equations are derived from microeconomic optimization problems of agents and expectations play a key role
- Estimated on a limited set of observable variables, time series for unobservable estimated together with model parameters
- Advantage: driving forces of r^* are clearly defined via structural shocks
- Limitations: $r^*$is, however, not time-varying in these models; given the specific question at hand, this is limiting; solutions: either use forecasting approach or estimate based on (rolling) subsamples

Task 8: Use the Quantity Theory to show how long run inflation is controlled by the central bank.

$$V \times M = Y \times P$$
$$\Leftrightarrow \frac{\bar{V}M}{\bar{Y}} = P$$

In growth rates:

$$\pi = g_m + g_v - g_y = g_m - g_y$$

- g_m: money growth rate controlled by central bank in the long run
- g_y: driven by real factors in the long run
- If $g_y > 0$, more transactions require more money
- Inflation occurs if $g_m > g_y$

Task 8: Use the Quantity Theory to explain why inflation is currently not increasing, despite massive monetary stimulus.

$$V \times M = Y \times P$$

Assuming that Y is constant for the moment yields:

$$\text{M} \uparrow \Rightarrow V \times M \uparrow = \bar{Y} \times P$$

Monetary stimulus would increase P, if V were constant. However, if $V \downarrow$ in consequence of precautionary savings (to cope with excess exposure to risk), deleveraging, or low investment dynamics in the aftermath of a financial crisis, P remains constant since:

$$V \downarrow \times M \uparrow = \bar{Y} \times \bar{P}$$

If $V \downarrow\downarrow$ while $M \uparrow$, P would even decrease.

Recall that decrease in velocity can be observed in the data: