



PROJECT PORTFOLIO

/Research/Stochastic Shocks in the New-Keynesian Model

Project Summary:

This project was done as an assignment for my SFU Undergraduate Class ECON 483 (Special Topics in Economics - Topics in Macroeconomics) which was instructed by Ms. Luba Peterson.

This project simulates stochastic shocks on macro variables of the New-Keynesian DSGE model which includes Demand, Supply and Inflation. It assumes rational expectations to evaluate how the economy converges back into its steady state.

The paper also looks into how the convergence is affected when we change the degree of stochastic shock and how aggressively the government reacts to changes in macro variables for its steady state.

Technical Skills Required

DYNARE

MATLAB (Dynare)



Microsoft Word

(a) We can start by looking at the two rules for nominal interest rate

$$\text{Rule 1: } i_t = \phi_\pi \pi_t + \phi_x x_t$$

The first rule states that the central bank will set the interest rate rule depending on the level of output and rate of inflation in the current period. ϕ_π refers to the policy rule the government has set for every one-unit increase in the rate of inflation. i.e. for every one unit percent increase in inflation, the nominal interest rate will go up by ϕ_π and vice versa.

$$\text{Rule 3: } i_t = \phi_\pi E_t \pi_{t+1}$$

For the third policy rule, the government uses policy rule of inflation with the expectation of next period's inflation. In other words, for every one percent increase in the rate of expected inflation, the nominal interest rate will go up by ϕ_π .

(b) For this question, I will be doing 6 different simulations using Dynare. In the first two simulations, I will be adding a demand shock in the form of u_t . Where

$$u_t = \rho u_{t-1} + \epsilon_t$$

Hence giving me the output equation,

$$x_t = E_t x_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{t+1}) + u_t$$

I will be using the demand shock to find out how the economic factors are affected when interest rate rule 1 is in play and when interest rate rule 3 is in play.

For the next two simulations, I will be using a supply shock in the form of u_t . That is

$$\pi_t = \beta E_t \pi_{t+1} + k x_t + u_t$$

Similarly, I will be using the shock to find out how the economic factors are affected when interest rate rule 1 is in play and when interest rate rule 3 is in play.

Finally, for the last two simulations, I will be adding a shock to both the interest rate rules in the form of u_t to see how economic factors are affected. That is

$$\begin{aligned} i_{t_1} &= \phi_\pi \pi_t + \phi_x x_t + u_t \\ i_{t_2} &= \phi_\pi E_t \pi_{t+1} + u_t \end{aligned}$$

Demand Shocks

$$x_t = E_t x_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{t+1}) + u_t$$

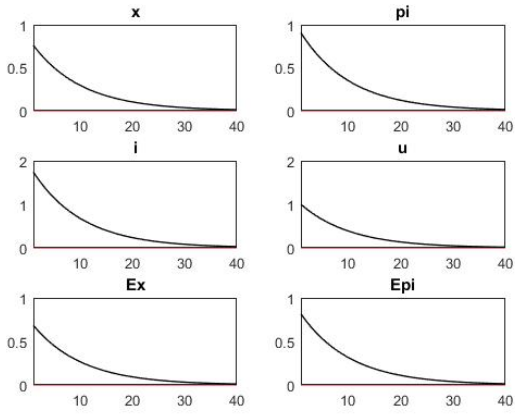


Fig1. Rule 1 Impulse Graph

$$i_t = \phi_\pi \pi_t + \phi_x x_t$$

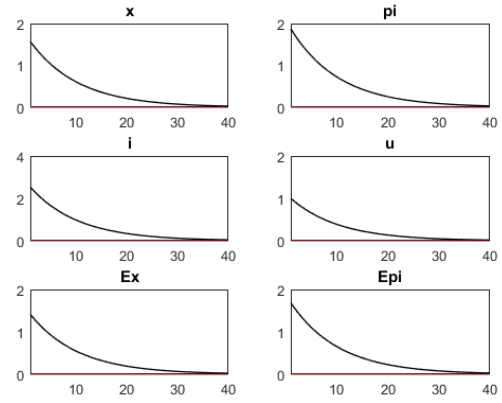


Fig 2. Rule 3 Impulse Graph

$$i_t = \phi_\pi E_t \pi_{t+1}$$

Inflation Shocks

$$\pi_t = \beta_t E_t \pi_m + k x_t + u_t$$

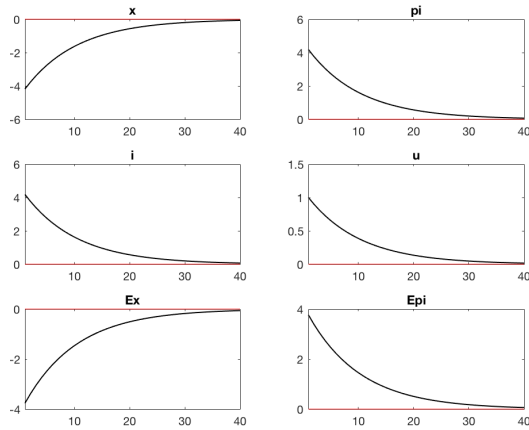


Fig 3. Rule 1 Impulse Graph

$$i_t = \phi_\pi \pi_t + \phi_x x_t$$

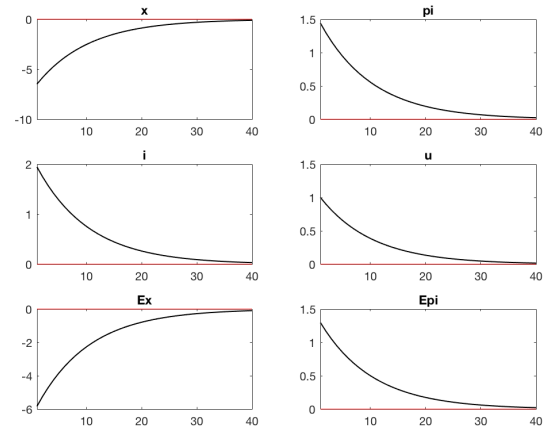


Fig 4. Rule 3 Impulse Graph

$$i_t = \phi_\pi E_t \pi_{t+1}$$

Interest Rate Shocks

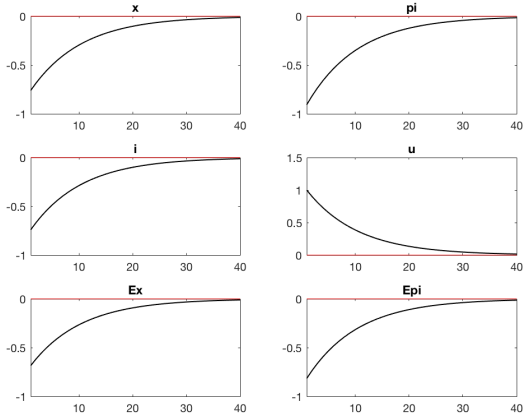


Fig 5. Rule 1 with Shock Impulse Graph

$$i_{t_1} = \phi_{\pi}\pi_t + \phi_x x_t + u_t$$

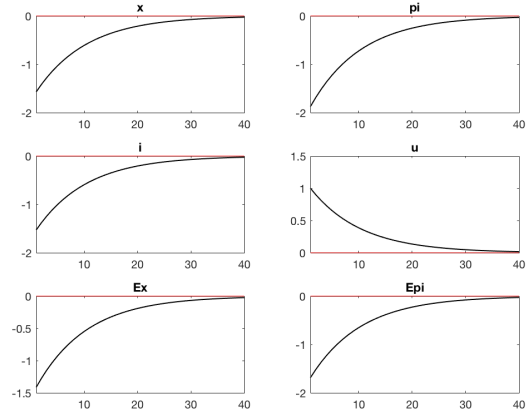


Fig 6. Rule 3 with shock Impulse Graph

$$i_{t_2} = \phi_{\pi}E_t\pi_{t+1} + u_t$$

Bi) Demand Shocks: We start at a steady state and introduce an economic shock that creates a demand shock. The shock makes ϵ_t goes up by 1 units thereby increasing the term u_t . This transmits into the IS curve thereby making the output jump as $x_t = E_t x_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1}) + u_t$ where u_t goes up in Fig1 and Fig2. As a result of this, inflation goes up as $\pi_t = \beta_t E_t \pi_{t+1} + kx_t + u_t$ and $k > 0$. Following this, the economy converges back to steady state through interest rate changes. The changes on nominal interest rate are as follows,

- Rule 1 (Fig.1 $i_t = \phi_{\pi}\pi_t + \phi_x x_t$): Both the output and the interest rate are going up on period 0. This in turn causes interest rate to shift upward depending on what the policy rule is set by the government. In this case, a 0.5% increase for every 1% increase in output and 1.5% increase for every 1% increase in the rate of inflation (see phix and phi_pi in appendix). Eventually, the rise in nominal interest rate reduces aggregate demand as cost of borrowing and benefit of saving goes up. This reduction transitions into the Phillips curve reducing the inflation. Following this, as output and inflation gradually decrease, government converges back to the steady state nominal interest rate.
- Rule 3 (Fig.2 $i_t = \phi_{\pi}E_t\pi_{t+1}$): The interest rate shocks upward because current period's inflation makes people expect a shock in the next period due to rational expectations. The interest rate goes up depending on the policy rule set by the government, which in this case is 1.5% for every 1% increase in expected future interest rate. Following this, as output goes down due to a higher nominal interest rate, the rate of inflation also goes down thereby reducing people's expectation. As expectations are revised, interest rate moves back to steady state.

Inflation Shocks: Similar to the previous simulation, we introduce an economic shock where ϵ_t goes up by 1 units thereby increasing the term u_t . However, this time around, rather than doing a demand shock, we are doing an inflation shock (i.e. $\pi_t = \beta_t E_t \pi_{t+1} + kx_t + u_t$) thereby giving us the impulse graphs Fig3 and Fig4. The transmission begins by pushing up the rate of inflation, this in turn pushes down people's expectation of output because the price level went up. Hence, transitioning into the IS Curve (i.e. $x_t = E_t x_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1}) + u_t$) where $E_t x_{t+1}$ goes down. Following this, the economy converges back to steady state through interest rate changes. The changes on nominal interest rate are as follows

- Rule 1 (Fig.3 $i_t = \phi_\pi \pi_t + \phi_x x_t$): As inflation is high, government increases interest rate to control the inflation. The increased interest rate makes people's expectation of inflation go down, thereby increasing the expected future output. As output gradually increases and inflation gradually decreases to steady state, the government gradually reduces interest rate to steady state.
- Rule 3 (Fig.4 $i_t = \phi_\pi E_t \pi_{t+1}$): As inflation goes up, people's expectation on future inflation also goes up given rational expectations. Given the policy rule, the nominal interest goes up by 1.5% for every 1% increase in expected inflation rate. This in turn causes interest rate to jump in the first period thereby causing output to increase gradually and inflation to reduce gradually. As this happens, the interest rate converges to steady state interest rate.

Interest Rate Shocks: A rise in the rate of nominal interest causes the output to fall as $x_t = E_t x_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1}) + u_t$ where i_t goes up. This in turn causes the rate of inflation to fall. After this, the economy slowly converges back to steady rate through changes in the nominal interest rate as follows,

- Rule 1 (Fig.5 $i_t = \phi_\pi \pi_t + \phi_x x_t + u_t$): As a result of this shock, both the output and inflation rate falls. The government has to reduce the interest rate by in accordance with the policy rules in order to stimulate the economy. As a result of this, the economy slowly starts having an increase in output and inflation. Following this, the interest rate gradually converges back to the steady state.
- Rule 3 (Fig.6 $i_{t_2} = \phi_\pi E_t \pi_{t+1} + u_t$): As a result of this shock, the government has to reduce the rate of interest to 1.5% for every 1% decrease on expected inflation. This in turn increase the rate of output and inflation as explained above. As people have rational expectations, the rate of interest, output and inflation rate gradually converges back into the steady state.

Bii) Changing the interest rate rule can influence the persistence of the shock. For instance, in Rule 1 where interest rate is determined by both output and rate of inflation, the policy is tighter as opposed rule 3 where interest rate is determined by expected inflation only. As a result, economic factors like output and inflation have less deviation from steady state in Rule 1 versus Rule 3. Therefore, adding more variables or increasing the value of policy rules will make the government more efficient in terms to handling economic shocks and the economy will converge to steady state faster.

Biii)

- **Demand Shock:** In Fig1. The demand shocks could come into play through a government tax cut. Cutting the tax will cause u_t to go up in $x_t = E_t x_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1}) + u_t$. As a result, the sudden spike in x_t will cause the inflation to go up. This could be because people now have

more purchasing power and they begin to demand more goods. As aggregate demand goes up, the price level shoots up to balance out the excess demand. The government finds out that the economy is no longer at a steady state and tries to control this by increasing the interest rate. Doing so will reduce investment demand and increase demand for savings. As a result, x_t begins to gradually go down as aggregate demand falls, so inflation gradually goes down as well. As this happens, government decides to slowly decrease the interest rate back to steady state. As such, the impulse graph all have a downward sloping shape.

- **Inflation Shock:** In Fig3. The inflation shock comes into play as government decides to start printing a lot of money. The increase inflation causes the price level to shoot upwards. As prices begin to rise, people's expectation of output goes down given that prices are now higher than people will demand less. This in turn reduces the output. The government intervenes by increasing the rate of interest to control the inflation. As a result, prices of goods and services begin to fall and people become more optimistic, as such expected output begins to rise.

Biv) The story will be very similar¹ to the previous answer, however, in this case, the government will be stimulating the economy by setting interest rate based on expected inflation rather than actual output and inflation gap.

- (c) We can evaluate shock persistence by changing the policy rule for nominal interest rate. Having a lower policy rule (higher ϕ_π and ϕ_x) would imply that the shock is more persistent because government will change interest rate at a more aggressive rate when the economy deviates from its steady state. Also, having a higher discounting rate (ρ) for future implies more persistence as people base their expectation of shock on the past rather than being rational. The following shows impulse graphs with different values for the parameters for ρ, ϕ_π and ϕ_x

$$\text{Demand Shock } x_t = E_t x_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{t+1}) + u_t$$

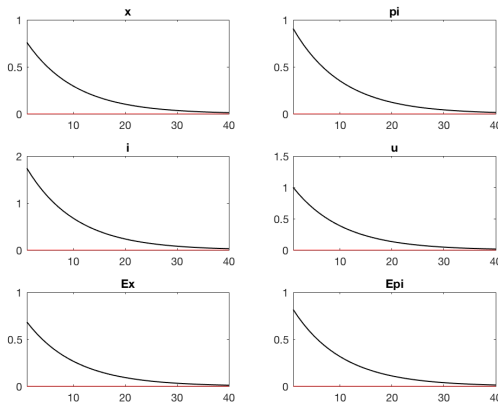


Fig 7. , $\phi_\pi = 1.5, \phi_x = 0.5, \rho = 0.9$

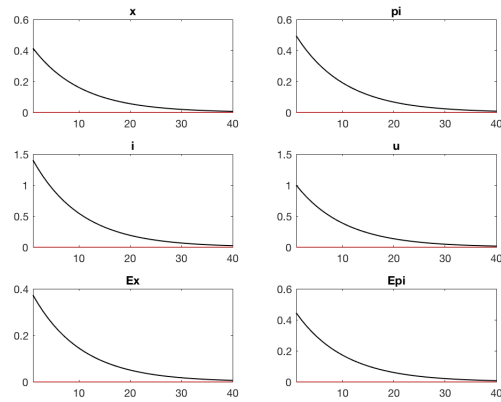


Fig 8. , $\phi_\pi = 1.5, \phi_x = 2, \rho = 1$

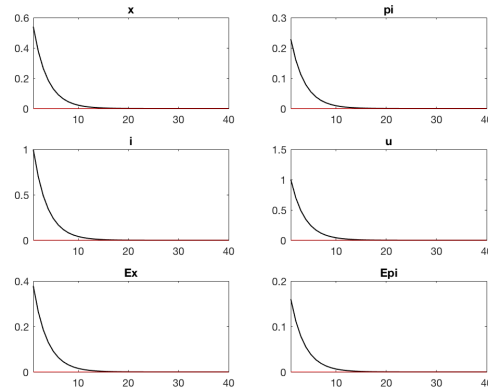


Fig 9. , $\phi_{\pi} = 2, \phi_x = 1, \rho = 0.7$

In the above impulse graphs, I made three different simulations with three different values for my parameters. When I am increasing the policy rule values, the shock is becoming less persistent, where in Fig 7. , in period 30, x_t is 0.0358 above steady state as opposed to Fig 8 where in period 30, x_t is 0.0195 above steady state. As such, reducing the policy rule parameter causes the shock to be more persistent.

In terms of changing ρ , when comparing Fig 8 with Fig 9, in Fig 8 with $\rho = 0.9$, x_t is 0.1606 percent above steady state in period 10 while in Fig 9, x_t is 0.0218 percent above steady state in period 10. In other words, for higher discount rate of shock, the persistence is more.

In the real world, if the policy rules aren't very strict or people don't have rational expectations and base their expectations on past figures, then the error will persist.

d) i) In this case, I will be using Rule 1 to stimulate the economy from a demand shock. For the case where I decrease σ to 0.75, the standard deviation for output and inflation are 1.33 and 1.59 respectively. When sigma is 0.25, the standard deviations for output and inflation are 0.46 and 0.55 respectively. This could be because when I reduce σ , the sensitivity of change in output due to change in interest rate increases, which implies that the economy should react more to changes in interest rate and hence the gap between steady state should reduce.

d) ii) For the case where I increase k to 0.2, the standard deviation for output and inflation are 1.35 and 2.47 respectively. When I increase k to 0.3, the standard deviation for output and inflation are 1.01 and 2.8 respectively. This could be because the demand shock has a larger impact on inflation when k is larger as k is the sensitivity to how much output deviation affects the inflation rate gap.

Appendix: Code used for model Simulations:

```
%Block 1

var x pi i u Ex Epi;

varexo epsilon;

parameters beta kappa sigma rhou phipi phix;

%Block 2

%Values changed in this block for part (c) and
(d)% beta=0.99;
kappa=0.3;
sigma=1;
rhou=0.9;
hipi=1.5;
phix=0.5;

%Block 3

model(linear);

Ex = x(+1);
Epi = pi(+1);
x = Ex - (1/sigma)*(i-Epi)+u;
%x = Ex - (1/sigma)*(i-Epi);->without demand shock%
pi = beta*Epi + kappa*x;
%pi = beta*Epi + kappa*x+u;-> with inflation shock%
i = phipi*pi + phix*x;
%i = phipi*pi + phix*x+u;-> Rule 1 with shock%
%i = phipi*Epi; -> Rule 3%
%i = phipi*Epi+u; -> Rule 3 with shock%

u = rhou*u(-1) + epsilon;

end;

shocks;
var epsilon;
stderr 1;
end;

steady;
stoch_simul;
```