- **Impulse response to one shock at a time**

When analyzing impulse responses to economic shocks, we typically isolate the effect of a single shock at t=0 to study how the system responds over time.

Here we apply one standard deviation change to these three shocks (cost-push, demand, monetary policy) at t=0 and observe how the curves change and how long it takes for the system to return to equilibrium.

We need to set all other shocks to zero in subsequent periods after t=0, because if we introduce continuous shocks in later periods, it becomes difficult to distinguish the effects of the initial shock from the new ones. By setting all subsequent shocks to zero, we ensure that the observed dynamics are due to the initial shock only.

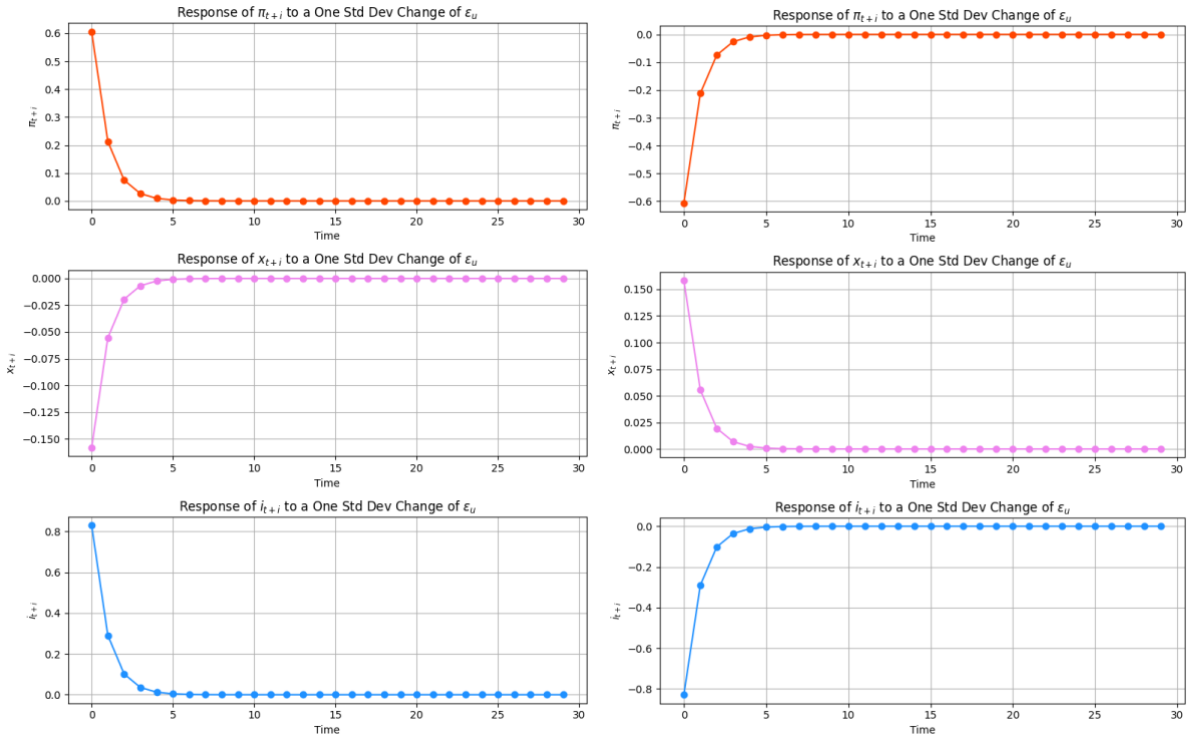
Once the initial shock is applied, the system evolves based on its own structure, including persistence parameters rho_u, rho_r, rho_nu, feedback rules, and equilibrium relationships. The persistence of the shock ensures that its effects last beyond t=0 without needing additional shocks.

1. First, we let cost-push shock change to one standard deviation.

We can see when the cost-push shock has a positive change, it leads to higher inflation pi_t , because firms face higher costs and tend to pass them on to consumers as higher prices.
For the nominal interest rate i_t, since it reflects monetary policy reaction. It responds by increasing value to counteract inflation, because the central bank reacts by raising interest rates.
The output gap x_t will be lower, because higher inflation and tendency to higher prices of goods and services reduce demand.

When the cost-push shock has a negative change, vice versa.

After the initial shock, the system evolves only through its internal mechanisms, such as the persistence parameters rho_u, rho_r, rho_nu. Since there is no new shocks interfere, so the effect of the original shock gradually decays over time. Eventually, all variables return to steady state as the shock dissipates.



(figure 1 and 2)

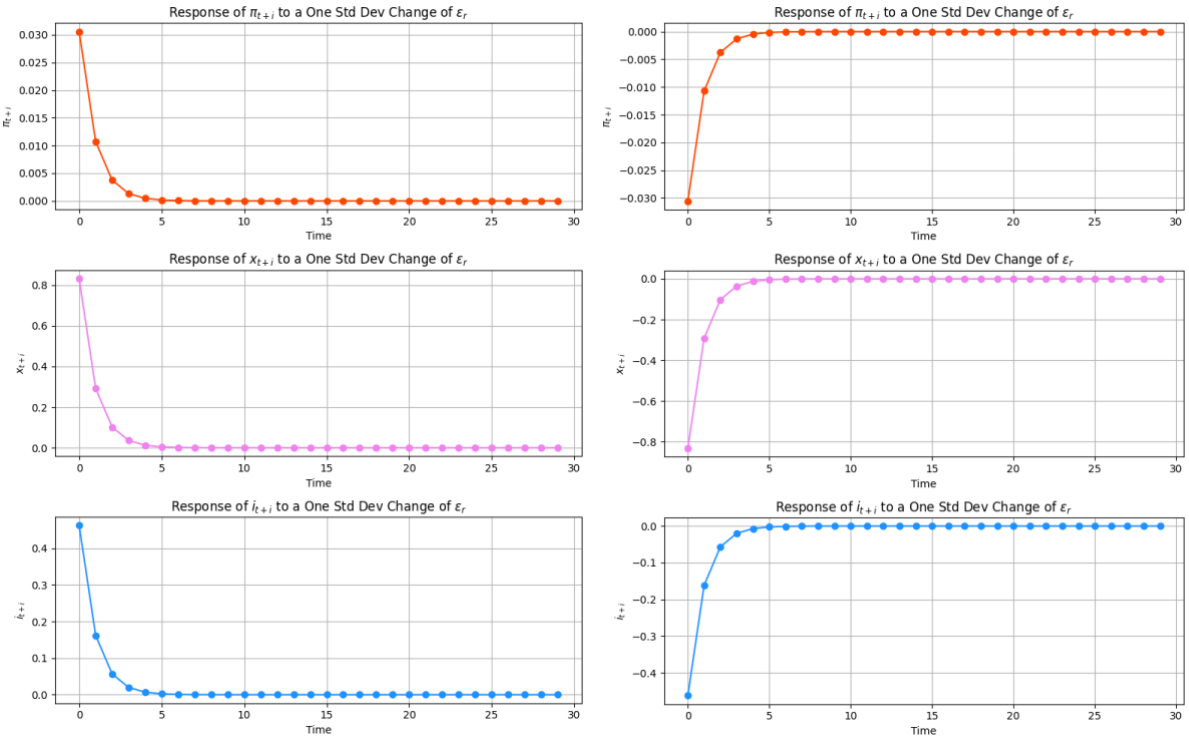
2. Second, we let demand shock change to one standard deviation.

A demand shock r_t directly affects the output gap x_t and indirectly influences inflation pi_t and nominal interest rates i_t through monetary policy responses.

We can see when the demand shock has a positive change, it leads to increasing aggregate demand and thus higher output gap. In the figure this corresponds to the immediately rising x_t.
And more demand pushes the prices of good and service up, because the demand exceeds supply, leading to higher inflation pi_t.
Therefore, the central bank reacts by raising interest rates i_t to control inflation.

When the demand shock has a negative change, vice versa.

After the initial shock, they gradually return to equilibrium as the shock fades. The system still evolves only through its internal mechanisms, such as the persistence parameters rho_u, rho_r, rho_nu and feedback relationship.



(figure 3 and 4)

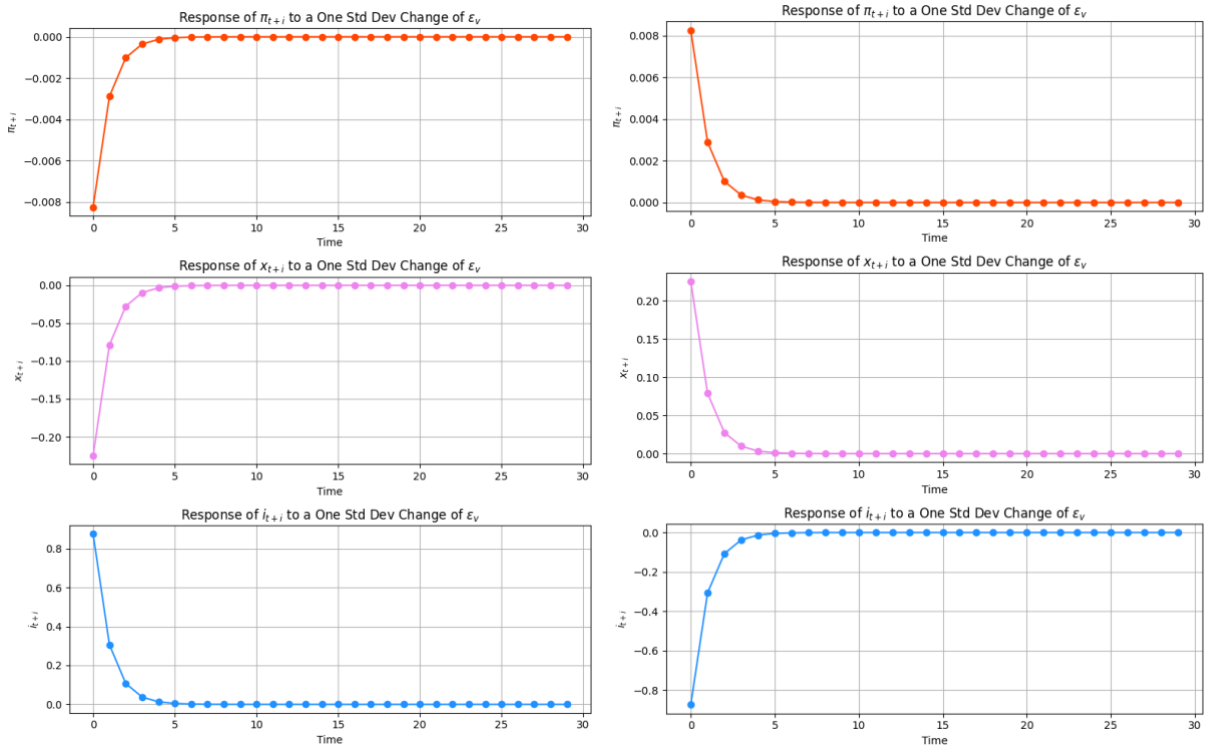
3. Third, we let monetary policy shock change to one standard deviation.

A monetary policy shock nu_t represents unexpected changes in the central bank's interest rate decision. It directly affects the nominal interest rate i_t and influences inflation pi_t and the output gap x_t through supply-demand side.

When the monetary policy shock has a positive change, it leads to unexpected increase in interest rate i_t. Firms will cut back on investments in new projects, hiring, and expansion because of higher borrowing cost, leading to a lower output gap x_t. For people, higher interest rates make loans more expensive, weakening the consumption power. Therefore, the lower demand reduces inflation pi_t over time, as firms adjust prices downward.

When the demand shock has a negative change, vice versa.

After the initial shock, they gradually return to equilibrium as the shock fades. The system still evolves only through its internal mechanisms, such as the persistence parameters rho_u, rho_r, rho_nu and feedback relationship.



(figure 5 and 6)

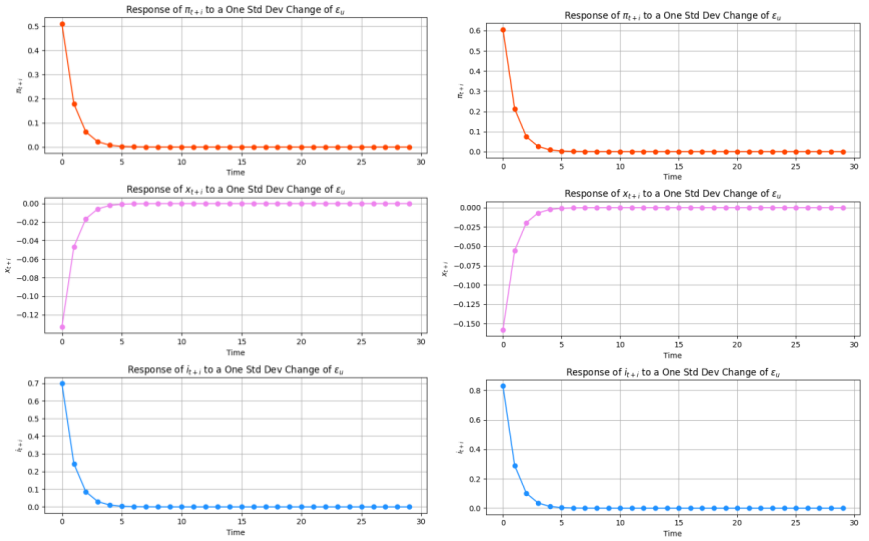
- **Five Parameters Change and Effect on Result**

The parameters kappa, rho_u, rho_r, phi_pi, phi_x influence how economic shocks impact inflation pi_t, the output gap x_t, and the interest rate i_t. We isolate the change of every parameter to see how they influence the effect of a single shock at t=0 on system.

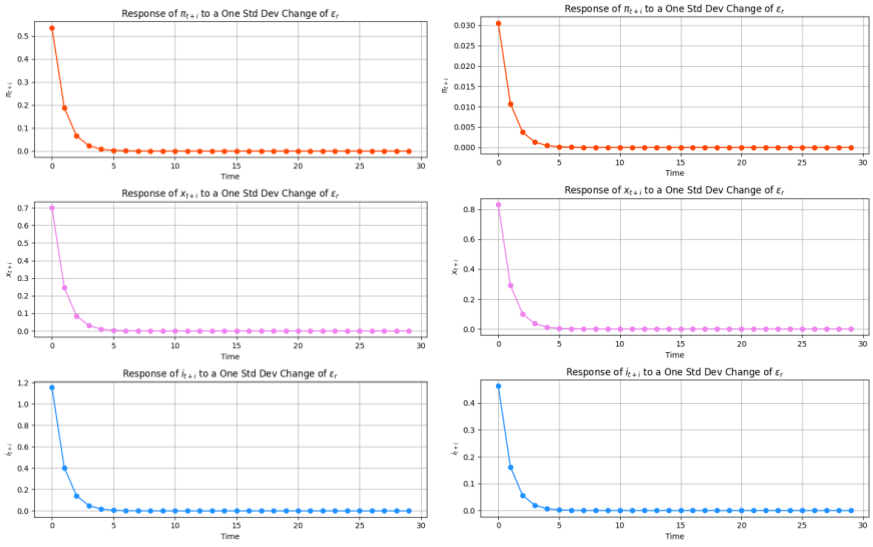
1. Change of Phillips Curve kappa

The slope of Phillips Curve kappa is related to the price stickiness, and it captures the sensitivity of inflation to the output gap in the Phillips curve equation. Now we increase the kappa from 0.024 to 0.5 to see how a weaker price stickiness affects the result in previous task. Here we set the one standard deviation change of three shocks to positive.

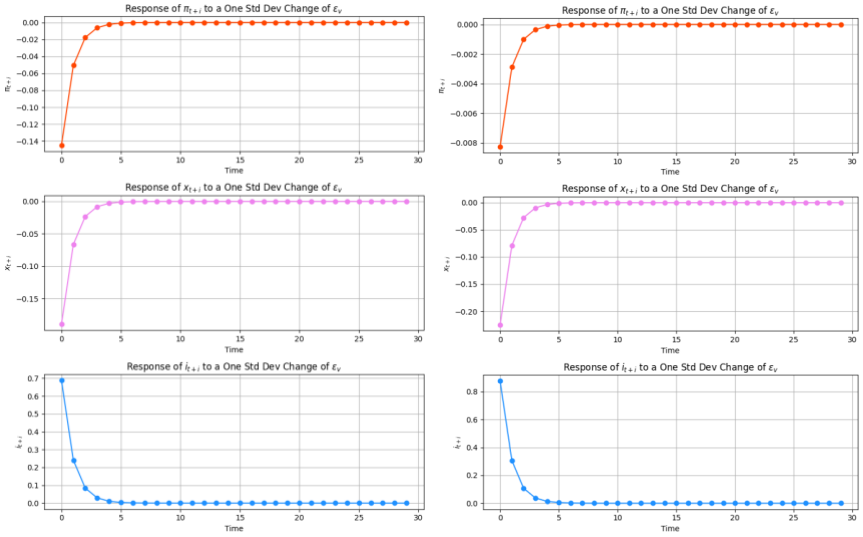
For the change of cost-push shock, increasing slope of Phillips Curve kappa has a minor impact on its effect on system.
But for the change of demand shock, a small change in demand shock will cause a bigger positive inflation response, as inflation reacts more strongly to the output gap if kappa increases.
For the change of monetary policy shock, it leads to a bigger negative inflation response, because the monetary policy must act aggressively to stabilize inflation.



cost-push shock



demand shock



policy shock

(左边一列是 kappa=0.5， 右边一列图是 kappa=0.024， 回头再修改图, figure 从左往右 7 /1/8/3/9/5)

（改完可视化，把上面的对比画进一张图，如果有多余的空间，再把 kappa 从 0.024 改成更小，可以得到 kappa 减小的情况，但是结果就是上面的反过来，相当于一种验证。此外，画进一张图，应该可以得到 persistence 更长/短的结论，但是感觉不是作用在 period 上，应该是斜率或者 delta 上。）
If kappa Decreases (Stronger Price Stickiness): Inflation adjusts more slowly, leading to more persistent inflationary pressures after a shock. Central bank actions (monetary policy shocks) have a weaker immediate effect on inflation, requiring more aggressive policy moves.

2. Effect of Changing rho_u and rho_r (Shock Persistence)

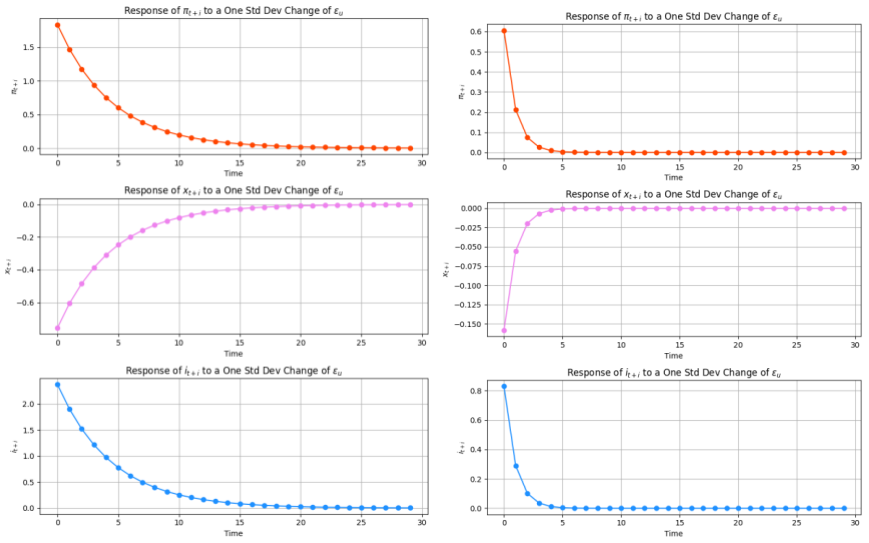
The parameters ρ_u and ρ_r serve as the autoregressive (or persistence) coefficients for the cost-push shock and demand shock respectively. Now we increase the rho_u and rho_r from 0.35 to 0.8 to see how a strong shock persistence affects the result in previous task. Here we set the one standard deviation change of three shocks to positive.

For cost-push shock, a larger ρ_u makes the cost-push shock more persistent. As a cost-push shock directly raises production costs, which firms pass on as higher prices, the cost-push disturbance lingers longer, meaning inflation remains elevated over more periods and sustained inflationary pressures. The higher interest rate means the central bank tightens policy aggressively to counteract inflation, so the output gap can turn negative (output falls below potential), leading to a stagflation-like scenario.

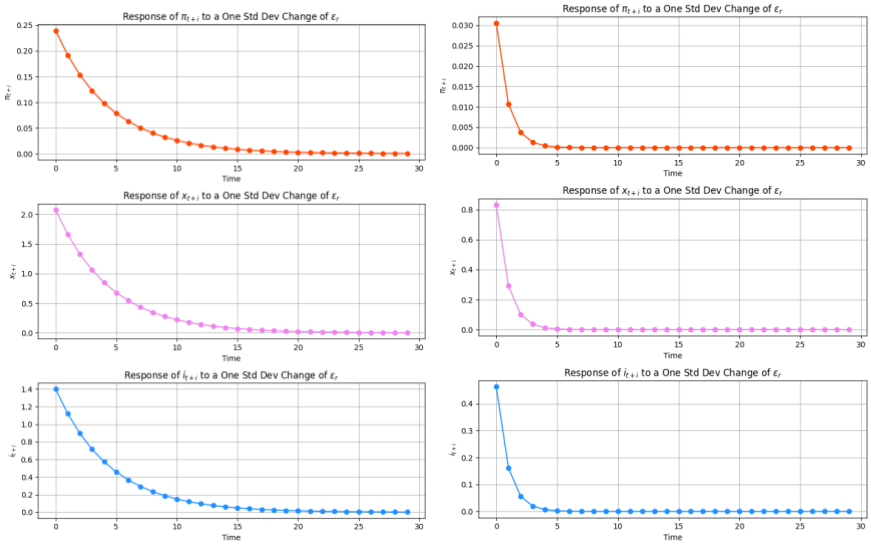
For demand shock, a higher ρ_r means that a one-time demand shock lasts longer. As a positive demand shock pushes up consumption and aggregate demand. It can lead to a more persistent increment in inflation via the Phillips curve. Besides, a positive demand shock usually drives the economy above its potential output, creating a positive output gap. Under the Taylor-rule framework, the central bank responds to higher inflation and a positive output gap by raising interest rates.

The degree of the persistence effect depends on how strongly these shocks translates into price pressures in the model. In the figure we can see the number of periods to steady state changes from five to twenty.

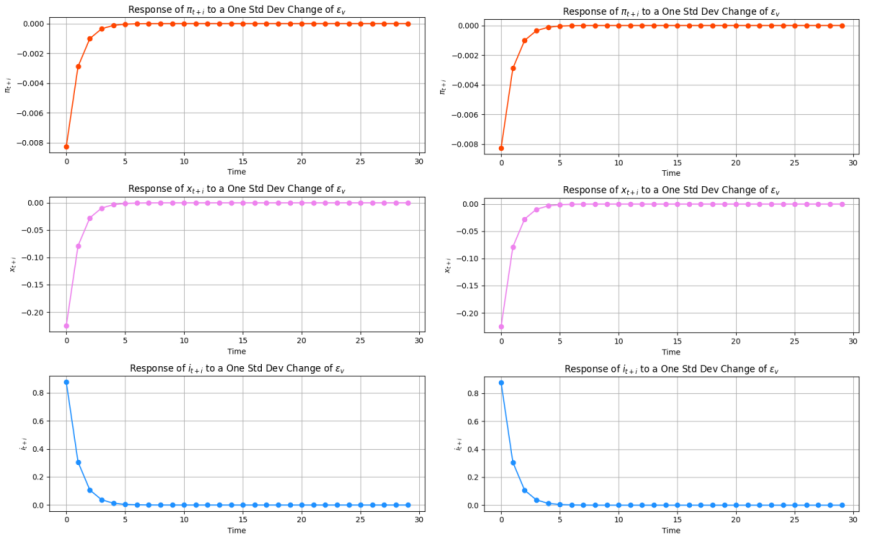
For monetary policy shock, since the persistence parameter ρv remains unchanged, the curve remains the same as before.



cost-push shock



demand shock



policy shock

(左边一列是 parameters=0.8， 右边一列图是 parameters=0.35，回头再修改图，figure 从左往右 10 /1/11/3/12/5)

3. Effect of Changing phi_pi and phi_x

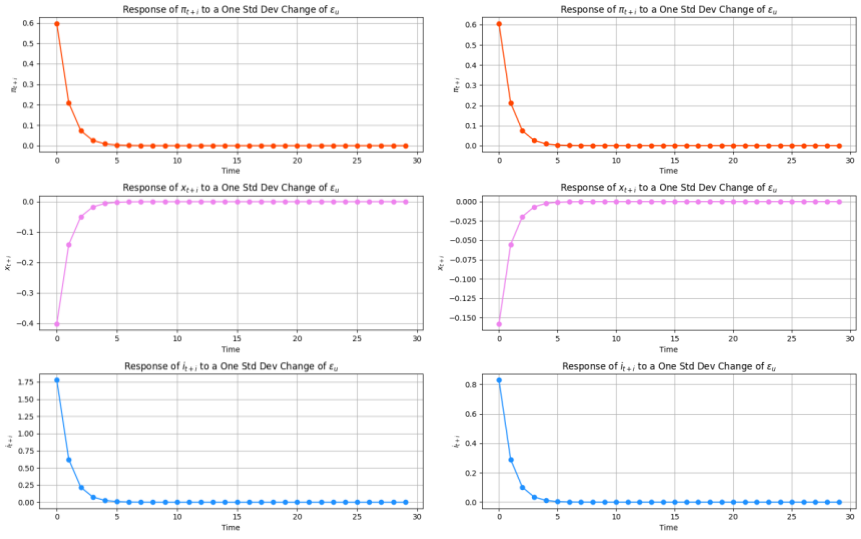
ϕ_{pi} (phi_pi) and ϕ_x (phi_x) are the key coefficients in the Taylor rule that determine how strongly monetary policy reacts to inflation and the output gap, respectively. Now we increase the phi_pi from 1.5 to 5, phi_x from 0.15 to 5 to see how a strong shock monetary policy affects the result in previous task. Here we set the one standard deviation change of three shocks to positive.

A cost-push shock raises production costs, putting upward pressure on inflation.

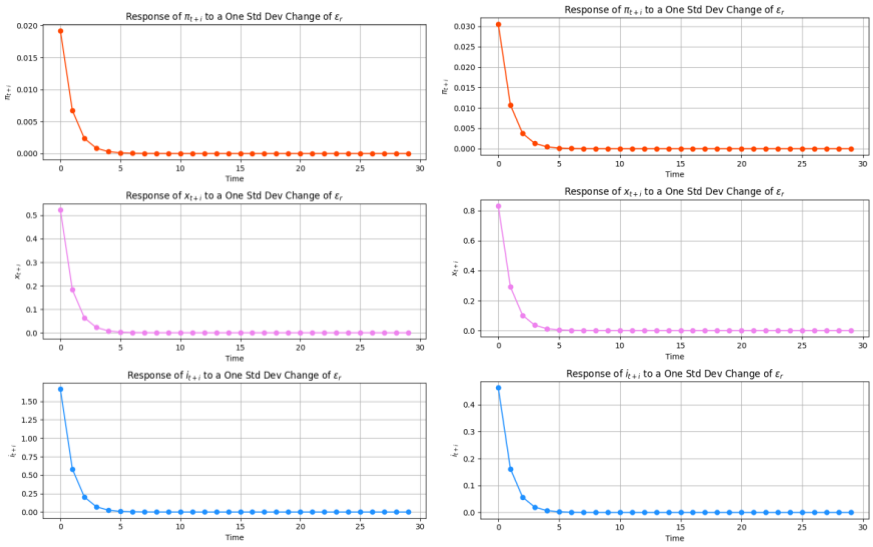
With a higher ϕ_{pi}, the central bank reacts more aggressively to rising inflation by increasing the nominal interest rate. And the tighter monetary policy can cool economic activity. This may lead to a contraction in the output gap, as higher interest rates reduce spending and investment. The inflation, however, remains unchanged under the Taylor Rule structure.

A positive demand shock directly raises aggregate demand, influencing the inflation and output gap. Since a demand shock directly affects the output gap, a higher ϕ_x leads to a quicker and more forceful adjustment. The central bank raises rates more sharply to counteract an excess demand situation, which tends to reduce the output gap faster. Then by stabilizing the output gap, the secondary effect is a moderation of inflationary pressures. With a higher ϕ_{pi}, the central bank responds more forcefully to any resulting inflation, thereby curbing the inflation rise.

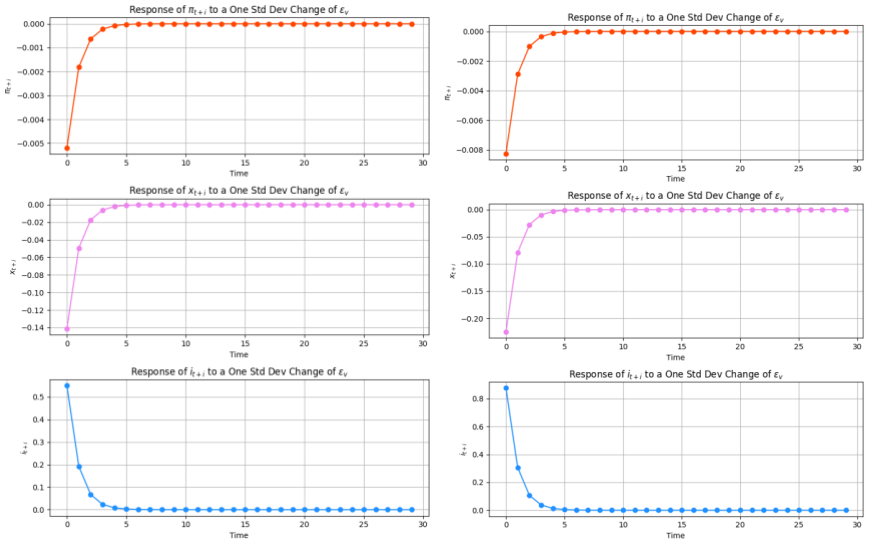
When faced with a monetary shock, a higher ϕ_{pi} and ϕ_x indicate that the monetary authority is quick to correct any deviations in both inflation and the output gap. This typically means a minor impact on the result due to the change of ϕ_{pi} and ϕ_x.



cost-push shock



demand shock



policy shock

(左边一列是 parameters=5/3， 右边一列图是 parameters=1.5/0.5，回头再修改图，figure 从左往右 13 /1/14/3/15/5)