Pre-recording:
Response to shocks
Gali Ch. 3 model

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Spring, 2024

Disclaimer

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Response to Shocks

We have solved for the equilibrium of the model...

- All endogenous variables have been expressed as functions of the state
- Here, the state comprises the shocks (a_t, z_t and v_t)
    - a_t is the 'productivity shock' in the production function
    - z_t is the 'time preference shock' in the utility function
    - v_t is the 'policy shock' in the Taylor rule
- We know how these evolve (as AR(1) processes) so we can simulate the economy

Response to Shocks

Modern macroeconomists are taught (brainwashed?) to think about economies as if they are in (general) equilibrium

- There are problematic aspects to this approach
- But (in my and many people's opinion) it is a powerful starting point for how to think about the world

They **like** thinking about what will happen after a certain shock

- What happens to y_t if there is a contractionary policy shock ($v_t > 0$)

They **dislike** thinking about what will happen after a certain *endogenous variable* has experienced some change

- What happens to y_t when r_t falls by 25 basis points?
- 'Non-economists' frequently ask such questions

Response to Shocks

What happens to y_t when r_t falls by 25 basis points?

Why is this problematic to answer?

- Because it depends on the shocks - i.e. **why** r_t falls
- One shock might move r_t and y_t in the same direction, and another might move them in opposite directions, for example

From another perspective, it presumes causality from r_t to y_t

- But both of these are functions of the shocks
- The shocks are the only 'causal' factors
- r_t and y_t are *co-determined* or *simultaneously determined*

In **general** equilibrium (GE) all else is **not** equal

- A change in r_t may be due to something that is also influencing (possibly) everything else

Response to Shocks

Thinking of variables as being functions of shocks in equilibrium leads us to ask

- What is the impact of shocks on the economy?
- How important are the various shocks in explaining the movement of variables in the economy?

We will focus on the former

- Traditional to use ‘impulse response functions’ to answer this question

Impulse responses

Our equilibrium implies variables, say y_t, can be expressed in terms of three shocks

$$y_t = \psi_y + \psi_{y,a} a_t + \psi_{y,z} z_t + \psi_{y,v} v_t$$

Suppose we are asked: What is the effect of $\varepsilon_{a,t}$ being δ higher than expected in $t = 1$

- We are being asked to consider the path of the economy with a particular value of $\varepsilon_{a,t}$ in the first period, relative to the path if $\varepsilon_{a,t}$ were to take its default value
- In general models, we haven't been given enough information (e.g. what is the 'default' value of $\varepsilon_{a,t}$, what happens to other shocks in the future,...), but in linear models we have

Impulse responses

Suppose the baseline path of the economy entails

$$\varepsilon_{a,t} = \varepsilon_{z,t} = \varepsilon_{v,t} = 0 \ \forall t$$

Suppose the shocked path of the economy entails

$$\begin{aligned}
\varepsilon_{a,1} &= \delta_a \\
\varepsilon_{a,t} &= 0 \ \forall t > 1 \\
\varepsilon_{z,t} = \varepsilon_{v,t} &= 0 \ \forall t
\end{aligned}$$

We are going to *define* the impulse response as being the difference in y_t in each period under these two paths

Impulse responses

Given the AR(1) structure of the shocks we have

- Under the baseline case (for all shocks $s \in \{a, z, v\}$ and $\forall t$)

$$s_t = \rho_s^t s_0$$

- Under the shocked case (for shocks $s \in \{z, v\}$ and $\forall t$)

$$s_t = \rho_s^t s_0$$

- Under the shocked case (for the technology shock)

$$\begin{aligned} a_1 &= \rho_a a_0 + \delta_a \\ a_t &= \rho_a^{t-1} a_1 \ \forall t > 1 \end{aligned}$$

Impulse responses

Given the AR(1) structure of the shocks we have

- Under the baseline case (for all shocks $s \in \{a, z, v\}$ and $\forall t$)

$$s_t = \rho_s^t s_0$$

- Under the shocked case (for shocks $s \in \{z, v\}$ and $\forall t$)

$$s_t = \rho_s^t s_0$$

- Under the shocked case (for the technology shock)

$$a_t = \rho_a^t a_0 + \rho_a^{t-1} \delta_a \ \forall t$$

Impulse responses

Under the baseline case

$$y_t^B = \psi_y + \psi_{y,a}\rho_a^t a_0 + \psi_{y,z}\rho_z^t z_0 + \psi_{y,v}\rho_v^t v_0$$

Under the shocked case

$$y_t^S = \psi_y + \psi_{y,a}\rho_a^t a_0 + \psi_{y,z}\rho_z^t z_0 + \psi_{y,v}\rho_v^t v_0 + \psi_{y,a}\rho_a^{t-1}\delta_a$$

Defining the impulse response in t as $\Delta_{y,a}(t) \equiv y_t^S - y_t^B$

$$\Delta_{y,a}(t) = \psi_{y,a}\rho_a^{t-1}\delta_a$$

Impulse responses - NK Application

Galí constructs composite shock u_t and imagines the impact on variable var_t of shocking each of its component in turn

$$
\begin{aligned}
var_t &= \psi_{var} + \psi_{var,u} u_t \\
u_t &= -\psi_{yn,a} \left(\phi_y + \sigma(1-\rho_a)\right) a_t + (1-\rho_z) z_t - v_t
\end{aligned}
$$

Since only one component (a_t, z_t or v_t) are shocked in turn it will be like u_t is an AR(1)

- We still talk about an innovation to ε_s for $s \in \{a, z, v\}$
- Each one will correspond to an appropriately scaled innovation to u_t
- I still don't know why Galí made the u_t thing...

Impulse responses - NK Application

Parameter	Value	Interpretation/Justification
β	0.99	Steady state (annualized) $r = 4\%$
σ	1	Log utility
φ	5	Frisch L^s elasticity $= 0.2$
α	0.2	Hmmm...
ε	9	12.5% markup
θ	0.75	Expected price duration of 4 quarters
ϕ_π	1.5	$\approx$ Original Taylor rule
ϕ_y	0.125	$\approx$ Original Taylor rule
ρ_a	0.9	Technology shock persistence
ρ_z	0.5	Preference shock persistence
ρ_v	0.5	Policy shock persistence

Impulse responses - Monetary policy shock

Let us consider a monetary policy shock of $\varepsilon_{v,1} = 0.25$

- All else equal i_t will be higher
- But (we will see) $\pi_t \downarrow$ and $\hat{y}_t \downarrow$
- Puts downward pressure on i_t (via assumed rule)
- $\implies$ i_t rises by 'less' (but under our parameterization still rises)
- r_t rises unambiguously

This reflects a monetary 'tightening' or a 'contractionary shock'

- $\varepsilon_{v,1} < 0$ would be a 'loosening' or 'expansionary shock'

Impulse responses - Monetary policy shock

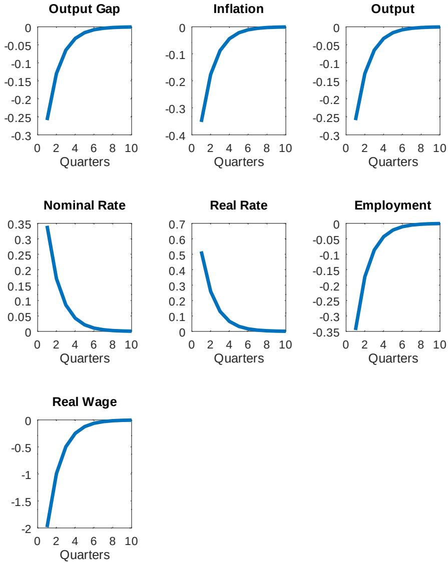
After impact the impulse response dies off smoothly and monotonically at rate ρ_v so we can just talk about the impact effect of our policy shock for the following variables

Variable	Impact Effect
Output Gap	$-$
Output	$-$
Employment	$-$
Real Wage	$-$
Real Rate	$+$
Nominal Rate	$+$
Inflation	$-$

IRFs $\rightarrow 0$ for the variables above, the LR impact on the price level is < 0

- Recall, the impact on inflation is < 0 and then remains ≤ 0
- Effect on the price level is sum of these negative numbers

Impulse responses - Monetary policy shock



Impulse responses - Monetary policy shock

- The (persistent) increase in r_t due to $i_t \uparrow$ (and $\pi_t \downarrow$) deters current expenditure
- Demand for final goods is reduced, and thus output and employment
- Recall that y_t^n does not depend on v_t so output gap declines too
- Reflecting this reduction in scale (and in marginal cost), firms who can initially reset prices set them lower, which underpins the initial $\pi_t \downarrow$ as $P_t \downarrow$
- Reduced labor demand puts downward pressure on real wage (and thus marginal cost) and this lower wage is consistent with household optimality since $-U_{n,t}/U_{c,t}$ declines due to the lower C_t and N_t that results from the shock
- Note that since $P_t \downarrow$ the real wage decline means W_t must also $\downarrow\downarrow$
- Lower wage income also contributes to lower consumption demand

Impulse responses - Time preference shock

Set δ_z to induce a 25bp decline in r_t^n

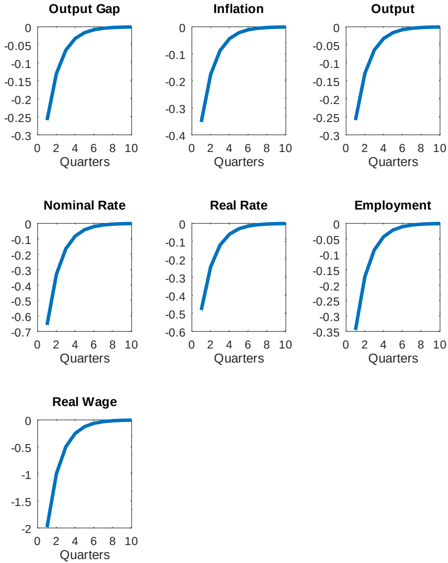
- Implies $z_t \downarrow$ on impact - as if households become more 'patient'
- Recall: In SDF Z_{t+1}/Z_t enters like β
- Like a contractionary 'demand' shock - but here not induced by policy

Variable	**Impact Effect**
Output Gap	—
Output	—
Employment	—
Real Wage	—
Real Rate	—
Nominal Rate	—
Inflation	—

Similar effects as policy shock - except in the interest rate variables

- Can set δ_z to replicate effects on non-interest rate variables *exactly*

Impulse responses - Time preference shock



Impulse responses - Time preference shock

Why do policy and preference shocks have (after appropriate scaling) the 'same effect' on economy?

- Intuitive connection between extra patience induced by preferences ≈ extra patience induced by prices
  - Both act through the Euler equation
  - If the z_t part moves, it can be offset with an appropriate 'shock' to monetary policy in the 'opposite' direction
  - Demand shocks are 'easy' to handle for policymakers - they can stabilize both real activity and inflation in the short tun

- Why can't we say the same about a_t (next slide)?
  - v_t and z_t leave y_t^n unchanged so knowing movement in $\tilde{y}_t(\equiv y_t - y_t^n)$ is sufficient to know movement of y_t (and thus n_t, w_t^r etc.)
  - But a_t affects y_t^n and this will break the equivalence
  - Policymaker can't stabilize both real activity and inflation in the short run, in response to supply shocks

Impulse responses - Technology shock

Consider a positive technology shock ($\delta_a > 0$)

Variable	**Impact Effect**
Output Gap	$-$
Output	$+$
Employment	$-$
Real Wage	$-$
Real Rate	$-$
Nominal Rate	$-$
Inflation	$-$

Note: some of these signs depend on our choice of parameterization

- $\sigma \geq 1$ and ψ_y sufficiently large $\Rightarrow$ a positive shock induces $n_t \downarrow$
- Accords with empirical evidence on effects of technology shocks

How can we reconcile this with procyclicality of n_t in data?

- Suggests shocks *other than technology* may be driving business cycle

Impulse responses - Technology shock