

Animal Spirit in the New Keynesian Model: How Does Cognitive Bias Affect Monetary and Fiscal Policies?

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- New Keynesian models are widely applied and are used to explore policy issues.
- However, several limitations has been noted, such as forward guidance puzzle, stability at ZLB, effectiveness of fiscal policy.
- Modifications such as incomplete market, heterogeneous responses of different agents, or HANK has be proposed in order to resolve the issues.
- Gabaix (2020) proposes a behavioral model to solve all the issues, but the several inconsistencies between his results and empirical findings, in particular the asymmetric effects of different states.
- This papers extends the behavioral model Gabaix (2020- Cognitive Discounting) to account for asymmetric effects of monetary and fiscal policies by incorporating the Reference Dependence model proposed by Santoro et al. (2014).

Behavioral New Keynesian Model, Gabaix (2020)

- Gabaix (2020) develops a framework of Behavioral New Keynesian Model to solve several puzzles in macroeconomics.
- IS Curve: $y_t = mE_t y_{t+1} + \sigma(i_t - E_t \pi_{t+1})$
- NK Phillips Curve: $\pi_t = \beta m^f E_t \pi_{t+1} + \kappa y_t$
- m is the myopia parameter and if $m=1$ the model converges back to the basic NK model.
- Puzzles: (1) forward guidance puzzle, (2) stability at ZLB, (3) fiscal policy is effective.

- Santoro et al. (2014) use the reference model from Köszegi and Rabin (2006) to explain why there exists asymmetric effect of monetary policy in different cycle.
- Gain and loss depend on the reference point of consumption.
- Household suffers from loss aversion and thus the impact of the monetary policy is larger in the contraction period.

Why we need a bridge between two models?

- Empirical findings clearly demonstrates the asymmetric effectiveness of monetary and fiscal policies, but it cannot be explained by the exiting NK model at once.
- Santoro et al. (2014) cannot analyze the impact of the fiscal policy and the traditional macroeconomics puzzles still remain (forward guidance puzzle, stability in the ZLB...).
- Gabaix (2020) cannot show asymmetric effect in different business cycle and several arguments contradict with previous empirical literature.
- We build a model to analyze the monetary policy and fiscal policy in different stage that is simple and solvable.

Setup: Households

- A household has demand for leisure, $1 - N$ and the total consumption, C and he would like to maximise his value function such that:

$$E_t \sum_{s=0}^{\infty} \beta^s \left[U(C_{t+s}) - \frac{(N_{t+s})^{1+\phi}}{1+\phi} \right], \quad (1)$$

subject to the budget constraint:

$$k_{t+1} = (1 + r_t)(k_t - c_t + y_t) \quad (2)$$

$$y_t = \omega_t N_t + y_t^f, \quad (3)$$

where β is the time discounting factor, ϕ is the inverse of the Frisch elasticity of the labor supply.

- Each firm i produces differentiated goods:

$$Y_t(i) = A_t N_t(i), \quad (4)$$

where A_t is the technology shock follows AR(1) process such that:

$$A_t = \rho_A A_{t-1} + \epsilon_A, \quad (5)$$

where ϵ_A is the technology shock and $\epsilon_A \sim N(0, \sigma_A)$.

- A final goods firm minimizes its cost by choosing the amount of the intermediate goods:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} \quad (6)$$

where $\epsilon > 1$ is the elasticity of substitution between intermediate goods.

Setup: Firms

- We assume the standard Calvo's pricing setup with monopolistic competition such that each firm has $1-\mu$ probability to reset its price, and we further assume the government pays a constant subsidy rate, τ_s .
- With the wage be the marginal cost, we can generate the profit function J_t such that:

$$J_t(i) = (1 + \tau_s) \left(\frac{P_t(i)}{P_t} \right) Y_t(i) - A_t N_t(i), \quad (7)$$

where P_t is the aggregated price index such that:

$$P_t = \left[\int_0^1 P_t(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}} \quad (8)$$

Cognitive Bias Setup

- *Cognitive Discounting*.- Following Gabaix (2020), we assume household pays attention to any macro variables with myopia parameter m . Then, any macro variable $z(X)$ in rational expectation model $E_t(z(X_{t+k}))$ will become

$$m^k E_t(z(X_{t+k})). \quad (9)$$

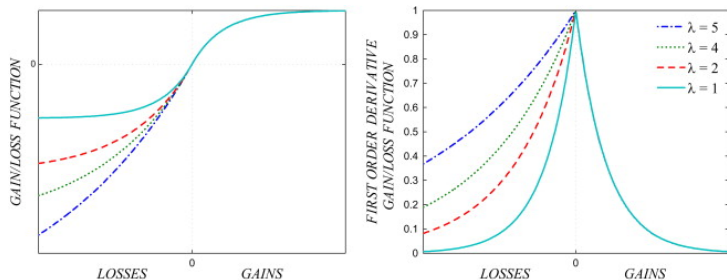
- *Reference Dependence*.- Following Santoro et al. (2014), we assume Utility function contains CRRA utility function and loss aversion utility function such that

$$U(C_{t+s}) = V(C_{t+s}) + [G(C_{t+s}, X)], \quad V(C_{t+s}) = \frac{C_{t+s}^{1-\gamma} - 1}{1-\gamma} \quad (10)$$

$$G(X, C_{t+s}) = \begin{cases} \frac{1 - \exp(-\theta \delta_{t+s})}{\theta}, & \text{iff } \delta_{t+s} \equiv \ln(C_{t+s}) - \ln(X) > 0 \\ -\lambda \frac{1 - \exp(\frac{\theta}{\lambda} \delta_{t+s})}{\theta}, & \text{otherwise,} \end{cases}$$

where θ is the sensitivity of the loss-aversion, λ is the degree of loss-aversion, γ is the degree of risk-aversion.

Cognitive Bias Setup



This graph is adopted from figure 3 in Santoro et al(2014) for illustration. The left panel is the gain-loss utility and the right panel is the marginal utility of the gain-loss utility with $\theta = 1$

- We assume the simple Taylor's Rule in the log-linearization term such that:

$$i_t = \phi_\pi \pi_t + \epsilon_t^{mp}, \quad (11)$$

where ϵ_t^{mp} is the monetary policy shock follows an AR(1) process.

Model Solution - IS Curve

- After log linearization, and we use the lower case letter to represent the log deviation from steady state, we can obtain the non-linear IS Curve as following:

$$y_t = \begin{cases} mE_t y_{t+1} - \sigma_e(i_t - E_t \pi_{t+1}), & \text{if } C_t > X \ \& \ C_{t+1} > X \\ mE_t y_{t+1} - \sigma_r(i_t - E_t \pi_{t+1}), & \text{if } C_t < X \ \& \ C_{t+1} < X, \end{cases} \quad (12)$$

where $\sigma_e = \frac{1}{\gamma + \theta}$ and $\sigma_r = \frac{1}{\gamma - \frac{\theta}{\lambda}}$.

- $\theta = 0$ and $m = 1$ converge back to the basic IS curve. $\theta > 0$ and $m = 1$ converge back to the IS curve of Santoro et al. (2014). $\theta = 0$ and $m < 1$ converge back to the IS curve of Gabaix (2020).
- $\sigma_e < \sigma_r$: the power of the monetary policy is larger in the contraction than in the expansion.

- We can also obtain the piece-wise NK Phillips Curve such that:

$$\pi_t = \begin{cases} \beta m^f E_t \pi_{t+1} + \kappa_e y_t, & \text{if } C_t > X \text{ \& } C_{t+1} > X \\ \beta m^f E_t \pi_{t+1} + \kappa_r y_t, & \text{if } C_t < X \text{ \& } C_{t+1} < X, \end{cases} \quad (13)$$

where

$$m^f = m(\mu + \frac{1 - \beta\mu}{1 - \beta\mu m}(1 - \mu)), \quad \kappa = (\frac{1}{\theta} - 1)(1 - \beta\mu)(\gamma + \phi),$$
$$\kappa_e = \frac{\kappa}{\gamma + \phi}(\phi + \gamma + \theta), \quad \kappa_r = \frac{\kappa}{\gamma + \phi}(\phi + \gamma - \frac{\theta}{\lambda}).$$

- $\kappa_e > \kappa_r$:the slope of the NK Phillips Curve is flatter in the contraction.
- Empirical Evidence:Daly, M. C. and Hobijn, B. (2014)

Results (1): Forward Guidance Puzzle

- The forward guidance puzzle is that the power of forward guidance is more powerful if the horizon of the interest rate is longer in the standard NK model.
- Following Gabaix (2020), we can rewrite Eq (12) and let $i_t - \pi_{t+1} = r_t$ with $r_T = -\delta = -1\%$ and $r_t = 0$ with $t \neq T$ to generate the following equation:

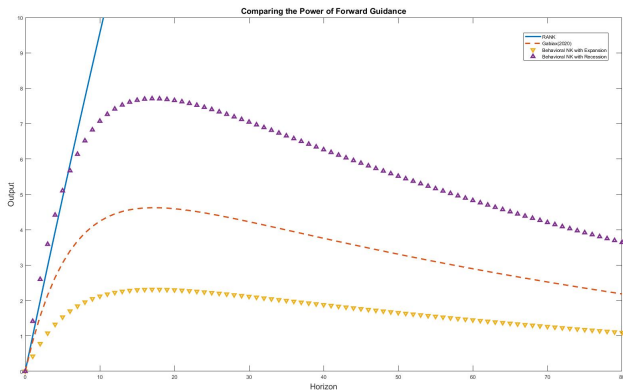
$$\pi_0 = \begin{cases} \sigma_e \kappa_e \frac{m^{T+1} - (\beta m^f)^T}{m - (\beta m^f)} \delta, & \text{if } C_t > X \text{ \& } C_{t+1} > X \\ \sigma_r \kappa_r \frac{m^{T+1} - (\beta m^f)^T}{m - (\beta m^f)} \delta, & \text{if } C_t < X \text{ \& } C_{t+1} < X, \end{cases}$$

with $r_T = -\delta = -1\%$.

- However, in Gabaix (2020) with $\sigma_e \kappa_e = \sigma_r \kappa_r$, this cannot explain the empirical evidence from Campbell, J. R., Evans, C. L., Fisher, J. D., Justiniano, A., Calomiris, C. W., and Woodford, M. (2012).

Results (1): Forward Guidance Puzzle

- $\sigma_e \kappa_e < \sigma_r \kappa_r$: The power of forward guidance is smaller in the expansion than in the contraction.



Results (2): Interest Rate Peg Stability

- Cochrane (2016) points out Gabaix (2020)'s findings are inconsistent with Clarida et al. (2000).
- Clarida et al. (2000) show that the the main reason for the volatile output in 1970s is due to passive interest rate, but the output is stable in the ZLB in the US and Japan, why?
- Gabaix (2020) uses the behavioral model to explain why interest rate is stable during the ZLB but how about the passive interest rate in 1970s?
- From the IS curve in Eq (12) and the standard NKPC in Eq (13), the condition for the stable dynamic system is the following:

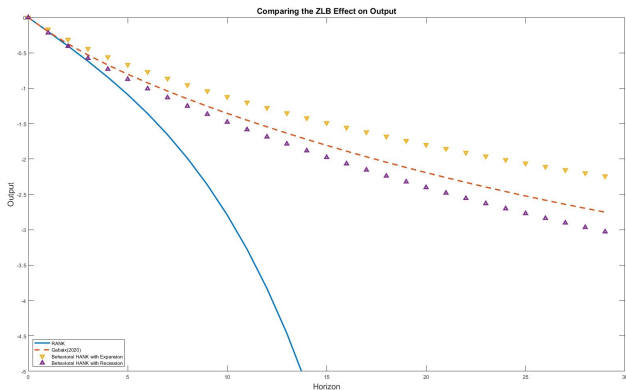
$$\phi_\pi + \frac{(1-m)(1-\beta m^f)}{\sigma_s \kappa_s} > 1,$$

where $s \in \{e, r\}$

- Since $\sigma_e \kappa_e < \sigma_r \kappa_r$, it is harder to achieve the condition in contraction than in expansion.

Results (2): Interest Rate Peg Stability

- Even if the ZLB is stable, output will become less stable in the contraction than in the expansion: both Gabaix (2020) and Clarida et al. (2000) could be right within our model.



- The government spending is financed by the debt in the future, which we denote as $B_{t+1} = B_t + Rd_t$.
- Let d_t be the deficit and G be the government spending, we can rewrite $d_t = G_t + \frac{r}{R}B_{t-1}$ with fiscal rule $d_t = -\delta_y y_t + \epsilon_t^g$
- Solving the problem, we can obtain the IS curve with debt such that:

$$\begin{cases} y_t = mE_t y_{t+1} + b_e d_t - \sigma_z (i_t - E_{t+1} \pi_{t+1}), & \text{if } C_t > X \ \& \ C_{t+1} > X \\ y_t = mE_t y_{t+1} + b_r d_t - \sigma_z (i_t - E_{t+1} \pi_{t+1}), & \text{if } C_t < X \ \& \ C_{t+1} < X \end{cases} \quad (14)$$

where $b_e = \frac{\phi r R(1-m)}{(\phi + \frac{1}{\sigma_e})(R-m)}$ and $b_r = \frac{\phi r R(1-m)}{(\phi + \frac{1}{\sigma_r})(R-m)}$ are the sensitivity of the consumption toward the deficit during the expansion and recession.

- Agent is non-Ricardian if $m < 1$ and Ricardian if $m = 1$.

Results (3): Asymmetric Effects of Fiscal Policy

- Some empirical literature shows the fiscal policy is powerful (i.e. Johnson et al. (2006), Parker et al. (2013)), while some works find little evidence on the power of fiscal policy (i.e. Taylor (2009), Fama (2021)).
- This result cannot be explained by Gabiax (2020).
- In our model with $b_e < b_r$, fiscal policy is more powerful in the contraction than in the expansion in line with empirical evidence from Berge et al(2021).

Results (3): Asymmetric Effects of Fiscal Policy

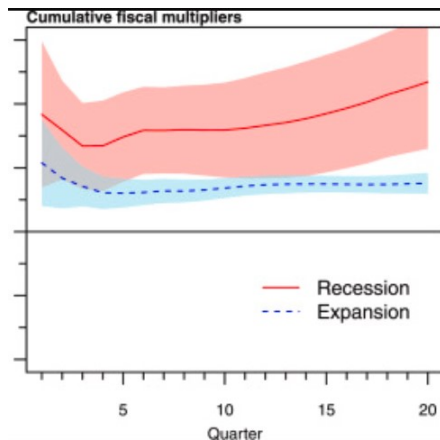
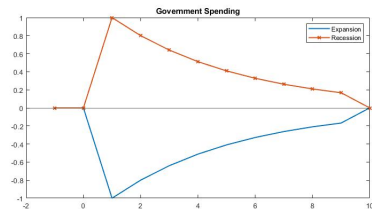
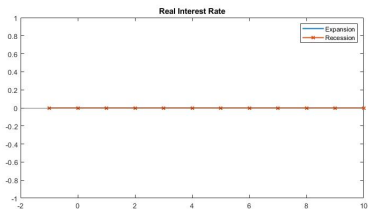
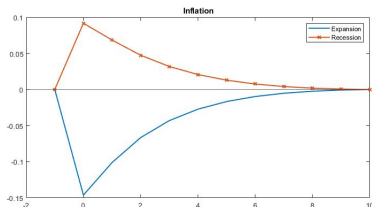
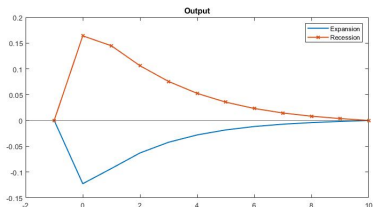


Figure: This graph is adopted from Figure 6 from Berge et al(2021)

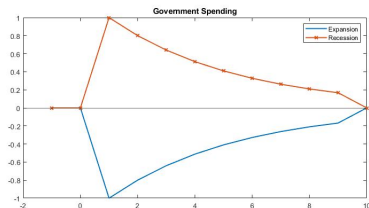
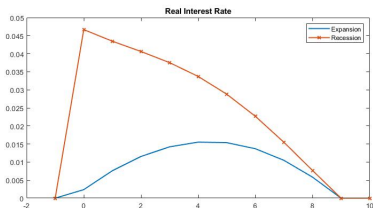
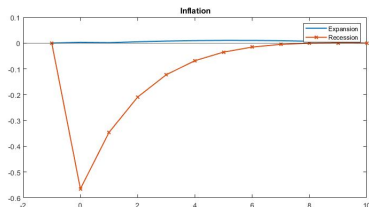
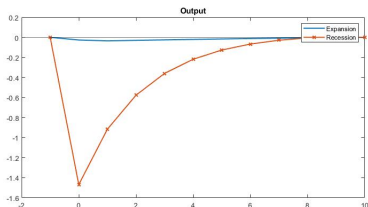
Results (3): Asymmetric Effects of Fiscal Policy

Response of the Government Spending with Interest Rate Peg



Results (3): Asymmetric Effects of Fiscal Policy

Response of the Government Spending with Taylor Rule



Results (3): Asymmetric Effects of Fiscal Policy

- If we let Taylor's rule passive, we can show that the fiscal policy is indeed powerful.
- If we let Taylor's rule active, we will see that the fiscal policy is deteriorated significantly especially during recession.
- So what is the relationship between the fiscal policy and monetary policy rule?

Results (4): Fiscal Policy helps stabilize the ZLB: Impulse Response

- Stable condition becomes:

$$\phi_{\pi} + \frac{(1-m)(1-\beta m^f)}{\kappa_s \sigma_s} + (1-\beta m^f) \frac{b_s \delta_y}{\sigma_s \kappa_s} > 1.$$

where $s \in \{e, r\}$

- With fiscal policy, it is easier to stabilize the economy under the ZLB.
- This show that there is a trade-off between fiscal and monetary rule to stabilize the economy, if $m < 1$.
- $(1-m)(1-\beta m^f) > (\sigma_s \kappa_s - 1) + \beta m^f b_s \delta_y$ and since $b_e < b_r$ and $\sigma_e \kappa_e < \sigma_r \kappa_r$ the δ_y could be smaller in the contraction to avoid explosion.
- Even in the active rule, it can be shown that the condition to avoid the explosion in output for Taylor's rule is more restricted in the contraction (ie ϕ_{π} could be larger in the contraction to avoid explosion).

Results (4): Fiscal Policy helps stabilize the ZLB

US economy stability in interest rate hike				
Year	Interest Rate(bps)	Debt(%)	Output Volatility	Output Drop
1965/09-1966/11	175	2.5	39.96	
1967/07-1969/08	540	7.3	138.76	-0.6
1972/02-1974/07	960	12	128.5	-2.7
1977/01-1980/04	1300	31.1	257.9	-2.2
1980/07-1981/01	1000	6.2	129.2	-2.1
1983/02-1984/08	315	19.1	247.02	
1988/03-1989/04	325	9.9	138.9	1.4
1993/12-1995/04	310	8.2	148.34	
1999/01-2000/07	190	0.3	303.75	-0.1
2004/06-2006/06	425	14.1	290.41	-3.8
2015/10-2019/01	225	16.4	470.26	-10.1
2021/03-2022/04	26	7.1	192.53	

The interest rate and output are adopted from Blinder(2022), and the debt and volatility

Results (4): Fiscal Policy helps stabilize the ZLB

- Why output is twice more volatile in the 1977/01-1980/04(with 1300 bps hike) than in 1980/07-1981/01(with 1000 bps hike)—Debt Change(31.1% vs 6.2%)
- Same for 1983/02-1984/08(with 315 bps hike) and 1993/12-1995/04(with 310 bps hike)—Debt Change(19.1% vs 8.2%)

- Using a parsimonious model, we explain the asymmetric effect in the monetary and fiscal policies (monetary policy, forward guidance, ZLB, fiscal policy)
- We show different stages have different policy coordination implication.
- For future work, we will focus on policy implication such as welfare analysis in different stages.

Thanks!