Optimal monetary policy under bounded rationality

Research Department Seminar

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Motivation

- Optimal monetary policy is widely analyzed in the literature through New Keynesian models (Clarida *et al.*, 1999 and Woodford, 2003).
- Agents are supposed rational in these models, meaning that agents' expectations about the future are also rational and somehow perfect.
- Yet
- Optimal monetary policy should be revisited in the light of a behavioral model relaxing the rational expectations hypothesis.

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- Yet
  - The economy is **inconsistent** with any model of rationality (Stiglitz, 2011).
  - Agents' expectations are **exaggerated** in New Keynesian models (Blanchard, 2009).
- Optimal monetary policy should be revisited in the light of a behavioral model relaxing the rational expectations hypothesis.

Optimal policy

- We examine **inflation** targeting, **price level** targeting, and **nominal GDP** (growth and level) targeting under different forms of bounded rationality.
- Optimal monetary policy is assessed under different policy designs : **discretion**, **commitment** and **optimal simple rules**.
- For each design, **flexible** and **strict** monetary policy targeting regimes are considered (Svensson, 1999).

Model

- Behavioral new Keynesian model à la Gabaix (2018) with substantial improvements :

- 3 representative agents : boundedly rational **households** and **firms**, and a **central bank**.
- The model highlights different types of bounded rationality: interest rate, output-gap, inflation, general and full myopia.

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  - decreasing return to scale $\longrightarrow$ new Phillips curve.
  - a flexible-price economy $\longrightarrow$ microfounded output-gap.
  - welfare-relevant variables $\longrightarrow$ optimal monetary policy.
- 3 representative agents : boundedly rational **households** and **firms**, and a **central bank**.
- The model highlights different types of bounded rationality: interest rate, output-gap, inflation, general and full myopia.

Intuition

- Agents' perceptions of the economy are central to monetary policy analysis (King *et al.*, 2008).
- Each type of bounded rationality has particular properties with respect to monetary policy reactions and households' welfare.
- Bounded rationality does not impact the choice of the monetary policy targeting **regime**.
- Boundedly rational agents behave intuitively.
  - People do not take guidance from the policy targeting regimes in place...

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- Bounded rationality does not impact the choice of the monetary policy targeting **regime**.
- Boundedly rational agents behave intuitively.
  - People do not take guidance from the policy targeting regimes in place...
  - ...but instead, they act on the basis of what they perceive at the moment (Kahneman, 2003).

Findings

- Bounded rationality has important implications for the conduct of monetary policy.
- Welfare evaluation indicates the optimality of:
  - **Flexible price level targeting** under discretion.

- The optimal targeting regime, among all monetary policy designs, is **independent** of the myopia's form characterizing agents.
- Myopia does not necessarily affect **negatively** agents' welfare.

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- The optimal targeting regime, among all monetary policy designs, is **independent** of the myopia's form characterizing agents.
- Myopia does not necessarily affect **negatively** agents' welfare.
  - *Ignoring some aspects of the future...*
  - *...may be welfare increasing*.

Environment

- Boundedly rational households maximize their life-time utility subject to their budget constraint and a non-Ponzi condition. **Households**' myopic perception is reflected by

$\bar{m}$	General myopia
m_r	Interest rate myopia
m_y	Real income myopia

- Boundedly rational **firms** maximize their perceived profit subject to the production technology.

$\bar{m}$	General myopia
m^f_π	Inflation myopia
m^f_x	Output-gap myopia

- In the sticky-price economy, firms follow a Calvo pricing mechanism.

Households

Infinitely-lived household maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, N_t\right) \tag{1}$$

subject to

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

$$S_{t+1} = \bar{m} f\left(S_t, \epsilon_{t+1}\right) \tag{3}$$

where it is assumed that

$$\mathbb{E}_t^{BR}[X_{t+k}] = m_X \overline{m}^k \mathbb{E}_t[X_{t+k}] \tag{4}$$

IS Curve

- This optimization yields the **behavioral IS curve**

$$\widetilde{y}_t = M\mathbb{E}_t\left[\widetilde{y}_{t+1}\right] - \sigma\left(i_t - \mathbb{E}_t\left[\pi_{t+1}\right] - r_t^n\right) \tag{5}$$

where $M = \bar{m}/\left(R - m_y\bar{r}\right)$, $\sigma = m_r\left(\gamma R\left(R - m_y\bar{r}\right)\right)$, and $R = 1 + \bar{r} = 1/\beta$.

- The **rational IS curve**[3] is

$$\widetilde{y}_t = \mathbb{E}_t\left[\widetilde{y}_{t+1}\right] - \sigma_{re}\left(i_t - \mathbb{E}_t\left[\pi_{t+1}\right] - r_t^n\right) \tag{6}$$

where $\sigma_{re} = 1/\left(\gamma R\right)$.

[3] Obtained as a particular case when $m_r = m_y = \bar{m} = 1$.

Firms

A continuum of firms produces differentiated goods using the technology

$$Y_t = A_t N_t^{1-\alpha} \tag{7}$$

The problem of the behavioral firm is to maximize

$$\sum_{k=0}^{\infty} \theta_p^k \mathbb{E}_t^{BR} \left[\Lambda_{t,t+k} \left(P_t^* Y_{t+k/t} - \Psi_{t+k} \left(Y_{t+k/t} \right) \right) \right] \tag{8}$$

subject to the sequence of demand constraints where $\Lambda_{t,t+k}$ is the stochastic discount factor in nominal terms, $\Psi_{t+k}(.)$ is the cost function, and $Y_{t+k/t}$ is the output in period $t+k$ for a firm that last reset its price in period t, and, again, the behavioral expectation assumption

$$\mathbb{E}_t^{BR}[X_{t+k}] = m_X \overline{m}^k \mathbb{E}_t[X_{t+k}] \tag{9}$$

Phillips curve

- This yields to the following **behavioral Phillips curve**

$$\begin{aligned}\pi_t &= \beta M^f \mathbb{E}_t\left[\pi_{t+1}\right] + \kappa \widetilde{y}_t \\ &\quad + (1-\theta)\left[(1-\beta\theta)\, m_\pi^f p_t + \beta\theta \overline{m} p_t - p_{t-1}\right] \quad (10)\end{aligned}$$

where $M^f = \theta\overline{m}$ and $\kappa = m_x^f (1-\theta)(1-\beta\theta)\Theta\left(\gamma + \frac{\phi+\alpha}{1-\alpha}\right)$.

- The **rational Phillips curve**[4] is

$$\pi_t = \beta \mathbb{E}_t\left[\pi_{t+1}\right] + \kappa_{re} \widetilde{y}_t \quad (11)$$

where $\kappa_{re} = \frac{(1-\theta)(1-\beta\theta)}{\theta}\Theta\left(\gamma + \frac{\phi+\alpha}{1-\alpha}\right)$.

[4] Obtained as a particular case when $m_x^f = m_\pi^f = \overline{m} = 1$.

Summary

- The behavioral IS curve

$$\widetilde{y}_t = M\mathbb{E}_t\left[\widetilde{y}_{t+1}\right] - \sigma\left(i_t - \mathbb{E}_t\left[\pi_{t+1}\right] - r_t^n\right) \tag{12}$$

- The behavioral Phillips curve

$$\begin{aligned}\pi_t = \beta M^f \mathbb{E}_t\left[\pi_{t+1}\right] + \kappa\widetilde{y}_t \\ + (1-\theta)\left[(1-\beta\theta)\, m_\pi^f p_t + \beta\theta\overline{m}p_t - p_{t-1}\right]\end{aligned} \tag{13}$$

- Expectations in both equations are augmented by M and M^f, respectively, reducing the exaggerated weight given to expectations (Blanchard, 2009).
- The (microfounded) Phillips curve reflects the importance of, both, (inflation) **expectations** and (prices) **inertia** in the determination of current inflation.

Central bank's loss function

Name	**Targeting regime**	**Loss function**
F1	Flexible inflation	$L_t = \frac{1}{2}\left(\pi_t^2 + \alpha_x x_t^2\right)$
F2	Flexible price level	$L_t = \frac{1}{2}\left(p_t^2 + \alpha_x x_t^2\right)$
F3	Flexible nominal GDP growth	$L_t = \frac{1}{2}\left[\left(\pi_t + \Delta y_t\right)^2 + \alpha_x x_t^2\right]$
F4	Flexible nominal GDP level	$L_t = \frac{1}{2}\left[\left(p_t + y_t\right)^2 + \alpha_x x_t^2\right]$
S1	Strict inflation	$L_t = \frac{1}{2}\pi_t^2$
S2	Strict price level	$L_t = \frac{1}{2}p_t^2$
S3	Strict nominal GDP growth	$L_t = \frac{1}{2}\left(\pi_t + \Delta y_t\right)^2$
S4	Strict nominal GDP level	$L_t = \frac{1}{2}\left(p_t + y_t\right)^2$

Optimal monetary policy

- Under **discretion**, each targeting regime is assessed by minimizing L_t s.t. the behavioral Phillips curve.
- Under **commitment**, we minimize $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t L_t$ s.t. a sequence of the same constraint.
- For **optimal simple rules**,[5] we solve numerically the model in order to find the optimal parameter values.

[5] Rules reported below.

Optimal simple rule

Targeting regime	**Instrument-rule**
Flexible inflation	$i_t = \phi_\pi \pi_t + \phi_y \widetilde{y}_t$
Flexible price level	$i_t = \phi_p p_t + \phi_y \widetilde{y}_t$
Flexible nominal GDP growth	$i_t = \phi_g (\pi_t + \Delta y_t) + \phi_y \widetilde{y}_t$
Flexible nominal GDP level	$i_t = \phi_n (p_t + y_t) + \phi_y \widetilde{y}_t$
Strict inflation	$i_t = \phi_\pi \pi_t$
Strict price level	$i_t = \phi_p p_t$
Strict nominal GDP growth	$i_t = \phi_g (\pi_t + \widetilde{y}_t)$
Strict nominal GDP level	$i_t = \phi_n (p_t + y_t)$

Welfare evaluation

- To compare the performance of all targeting regimes, we compare their implications for household welfare.
- Following Garin *et al.* (2016), we calculate the compensating variation in terms of household consumption

$$CEV = 100 \left[\exp \left(\mathbb{E} W^{flexible} - \mathbb{E} W \right) - 1 \right] \tag{14}$$

- Household welfare W is the second-order approximation of household utility (Gali, 2015)

$$W = -\frac{1}{2} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \alpha x_t^2 \right) \tag{15}$$

Targeting rules (1)

Solving the central bank problem, minimizing L_t subject to the behavioral Phillips curve, yields

$$
\begin{aligned}
\text{F1D}: &\quad x_t = -\psi(\kappa, \alpha_x, \theta, m_\pi^f, m_x^f, \overline{m})\pi_t \\
\text{F2D}: &\quad x_t = -\psi(\kappa, \alpha_x, \theta, m_\pi^f, m_x^f, \overline{m})p_t \\
\text{F3D}: &\quad g_t = -\chi(\kappa, \alpha_x, \theta, m_\pi^f, m_x^f, \overline{m})x_t \\
\text{F4D}: &\quad n_t = -\chi(\kappa, \alpha_x, \theta, m_\pi^f, m_x^f, \overline{m})x_t \\
\text{S1D}: &\quad \pi_t = 0 \\
\text{S2D}: &\quad p_t = 0 \\
\text{S3D}: &\quad \pi_t = -\Delta y_t \\
\text{S4D}: &\quad y_t = -p_t
\end{aligned}
$$

where $\psi(.)$ and $\chi(.)$ are detailed in the paper, n_t is the nominal GDP level, and g_t is nominal GDP growth.

Targeting rules (2)

- Two categories of targeting rules
  1. Targeting rules (F1D) to (F4D) include myopia.
     i.e. to achieve its target, the policymaker is required to have a complete knowledge of agents' beliefs.
  2. Targeting rules (S1D) to (S4D) do not include myopia.
     i.e. the central bank's targeting rule is not impacted by bounded rationality and consists of simple rules regarding prices, inflation or output.

Welfare loss under discretion

Myopia	**F1D**	**F2D**	**F3D**	**F4D**	**S1D**	**S2D**	**S3D**	**S4D**
Rational	1.64	**1.21**	2.30	2.29	2.55	2.55	2.28	2.28
Interest rate	1.64	**1.21**	2.30	2.29	2.55	2.55	2.28	2.28
Output gap	1.82	**1.32**	2.43	2.42	3.00	3.00	2.41	2.41
Inflation	1.59	**1.19**	2.14	2.13	2.55	2.55	2.12	2.12
General	1.50	**1.23**	2.16	2.15	2.55	2.55	2.14	2.14
Full	1.55	**1.31**	2.11	2.10	3.00	3.00	2.10	2.10

- Flexible price level targeting (F2D) delivers the lowest losses.
- A performance attributed to its stabilizing properties.
- Bounded rationality does not :
  - impact the hierarchy of monetary policy targeting regimes.
  - necessarily negatively impact welfare.

Targeting rules

- The central bank:
  - adjusts the actual and future output-gap until the target is reached.
  - has to fulfill past promises (i.e. to keep track of past output-gap).
- This result overcomes shortcomings of the traditional New Keynesian model with respect to the persistence of the impact of monetary policy on the targeted variables (Fuhrer and Moore, 1995; Walsh, 2010).
- The central bank weights its preferences over sooner or later adjustments taking into account agents' beliefs (i.e. myopia is present in the CB's targeting rules).

Welfare loss under commitment

Myopia	**F1C**	**F2C**	**F3C**	**F4C**	**S1C**	**S2C**	**S3C**	**S4C**
Rational	**1.21**	1.29	2.31	2.29	2.55	2.55	2.28	2.28
Interest rate	**1.21**	1.29	2.31	2.29	2.55	2.55	2.28	2.28
Output gap	**1.32**	1.41	2.43	2.42	3.00	3.00	2.41	2.41
Inflation	**1.19**	1.27	2.14	2.13	2.55	2.55	2.12	2.12
General	**1.23**	1.34	2.16	2.15	2.55	2.55	2.14	2.14
Full	**1.31**	1.42	2.11	2.10	3.00	3.00	2.10	2.10

- Flexible inflation targeting appears to perform better than flexible price level targeting for all forms of myopia.
- However, IRFs show that under flexible inflation targeting, the central bank acts like a price level targeter.

Optimal simple rules (remainder)

Targeting regime	**Instrument-rule**
Flexible inflation	$i_t = \phi_\pi \pi_t + \phi_y \widetilde{y}_t$
Flexible price level	$i_t = \phi_p p_t + \phi_y \widetilde{y}_t$
Flexible nominal GDP growth	$i_t = \phi_g (\pi_t + \Delta y_t) + \phi_y \widetilde{y}_t$
Flexible nominal GDP level	$i_t = \phi_n (p_t + y_t) + \phi_y \widetilde{y}_t$
Strict inflation	$i_t = \phi_\pi \pi_t$
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Optimal parameter values

Myopia	**F1O**		**F2O**		**F3O**		**F4O**		**S1O**	**S2O**	**S3O**	**S4O**
	ϕ_π	ϕ_y	ϕ_p	ϕ_y	ϕ_g	ϕ_y	ϕ_n	ϕ_y	ϕ_π	ϕ_p	ϕ_g	ϕ_n
Rational	3.7	0.87	3.9	0	1	2.5	0.68	0	5	3.7	5	0.68
Interest rate	3.9	1.10	4.7	0	1	2.5	0.82	0	5	4.8	5	0.82
Output gap	3.4	0.78	3.8	0	1	2.2	0.60	0	5	3.7	5	0.60
Inflation	1	0.92	3.8	0	1	1.7	0.63	0	*	3.7	*	0.63
General	1	0.88	3.6	0.1	1	1.5	0.69	0	5	4.4	5	0.69
Full	1	0.80	3.7	0.2	1	1.3	0.67	0	5	4.8	5	0.67

- Coefficients are in line with the literature in the rational case (Gali, 2015; Rudebusch, 2002).
- Each myopia type calls for a particular calibration of the simple rule.

Welfare under optimal simple rules

Myopia	**F1O**	**F2O**	**F3O**	**F4O**	**S1O**	**S2O**	**S3O**	**S4O**
Rational	20.73	12.61	33.51	13.69	2.40	**1.84**	5.21	2.0
Interest rate	20.73	12.61	30.98	13.82	2.41	**1.86**	5.44	2.0
Output gap	25.94	15.44	47.07	16.74	2.59	**1.98**	6.25	2.1
Inflation	15.97	11.92	29.25	12.63	*	**1.79**	*	1.93
General	14.81	12.55	27.21	12.93	2.28	**1.88**	4.92	1.96
Full	15.96	14.17	32.91	14.40	2.37	**1.93**	5.82	1.99

- Results demonstrate the superiority of the strict simple rules over flexible rules (Schmitt-Grohé and Uribe, 2007).
- Particularly, strict price level targeting (S2O) is the more desirable in terms of household welfare.

Summary

- The specific model derived here highlights agents' inattentiveness to macroeconomic environment.
- This is reflected in the NKPC by a **direct link between inflation and its past and future price dynamics**, in addition to the output gap.
- (NK)PCs developed earlier lack such features (Ball, Mankiw and Reis, 2005).
- It provides valuable background for studying optimal monetary policy.

Discretionary policy

- Flexible PL targeting is optimal for all myopia types, even for the rational case (in line with Guender and Tam, 2004; Vestin, 2000; Svensson, 1999).
- This is due to the lower macroeconomic volatility implied by such a monetary policy regime.
  - The presence of myopia reduces inflation volatility more than in the rational case...
  - ...and thus, flexible price level targeting suites better inflation-averse households.

Discretionary policy

- Under another framework with sticky information, Ball *et al.* (2005) find the same result.
- A real experiment led by Amano *et al.* (2011) finds PL targeting better suited to (real) agents' beliefs.
- However, the 'representative' agent paradigm does not allow for the study of the impact of heterogeneous myopia (Elbittar *et al.*, forthcoming).
- Our full myopia case is a mix of different types of myopia that may be seen as heterogeneous agents' beliefs.

Commitment policy

- Our results are in line with Woodford (2010), assuming near-rational agents.
- Flexible IT appears to perform slightly better than flexible PL targeting for all forms of myopia.
- IRFs show that under flexible IT, the central bank acts like a PL targeter.
- Bounded rationality distorts private expectations, and consequently, monetary policy might be less effective if people's myopia are ignored.

Simple rules

- Instrument rules indicate the desirability of strict PL targeting (in line with Hatcher and Minford, 2016).
- Interest rate rules featuring a positive reaction to output implies significant welfare losses (Schmitt-Grohe and Uribe, 2007).

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- Bounded rationality is inherent to human functioning and should motivate CBs to act using the correct tools and interpretation of myopia for welfare-increasing purposes.

What does it imply for policymakers ?

- Type of bounded rationality in practice, and its amplitude, necessitate close attention from the CB.
- PL targeting appears to be a good candidate to solve the actual IT limits.
- Bounded rationality is inherent to human functioning and should motivate CBs to act using the correct tools and interpretation of myopia for welfare-increasing purposes.
- CBs should study the degree to which *Homo sapiens* are myopic, and act consistently, rather than educate people in an attempt to transform them into *Homo economicus*.

Thank you for your attention

Special thanks to Guy Segal for our very constructive discussions.

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