Make-Up Strategies with Incomplete Markets and Bounded Rationality

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Outline

Motivation

Make-up strategies and the ELB

Make-up strategies

- Way to address negative inflation bias arising from effective lower bound (ELB) on policy rate
  - → Adoption of average inflation targeting by the Fed in 2020

Mechanism

- Monetary policy commits to make up for past off-target inflation in the future
  - → Expansionary impulse already today when inflation is below target (even at ELB)
- But: mechanism relies on complete markets and rational expectations

How do market incompleteness and bounded rationality affect benefits of make-up strategies?

- Build HANK model with aggregate shocks, occasionally binding ELB and boundedly rational agents
  - → Bounded rationality ≡ reflective expectations (*García-Schmidt and Woodford, 2019*)
- Compare outcomes under inflation targeting (IT) and average inflation targeting (AIT) via stochastic simulations

Preview

Main results

Benefits of make-up strategies

- Better macroeconomic stabilisation under AIT relative to IT
  - → Smaller biases in inflation and output, lower macroeconomic volatility

Market incompleteness (MI)

- Does not lead to qualitatively different results and also does not matter much quantitatively.

Bounded rationality (BR)

- Benefits of AIT relative to IT increase with cognitive ability of agents . . .
  . . . and are quite small for empirically plausible cognitive ability levels.

Interaction between MI and BR

- Complementarity between MI and BR w.r.t. attenuation of forward guidance (*Farhi and Werning, 2019*)
- But no such complementarity in the context of make-up strategy benefits!

Related literature

Heterogeneous-agent New Keynesian models

- Bounded rationality *Farhi and Werning (2019)*; *Auclert et al. (2020)*; *Pfäuti and Seyrich (2022)*
- Make-up strategies *Feiveson et al. (2020)*; *Dobrew et al. (2021)*; *Djeutem et al. (2022)*
- ELB *Schaab (2020)*; *Fernández-Villaverde et al. (2021)*; *Lee (2021)*; *McKay and Wieland (2021)*

Representative-agent New Keynesian models

- Bounded rationality *Angeletos and Lian (2018)*; *Woodford (2018)*; *Farhi and Werning (2019)*; *García-Schmidt and Woodford (2019)*; *Gabaix (2020)*
- Make-up strategies *Budianto et al. (2020)*; *Honkapohja and Mitra (2020)*; *Mele et al. (2020)*; *Erceg et al. (2021)*; *Bodenstein et al. (2022)*; *Dupraz et al. (2022)*

Numerical methods

- Sequence-space approximation *Boppart et al. (2018)*; *Auclert et al. (2021)*
- Enforce ELB with news shocks *Bodenstein et al. (2013)*; *Holden (2016)*

Outline

Model

Overview

Households

- Uninsurable idiosyncratic income risk
  - Save/borrow via nominal non-contingent bond
  - Ad-hoc debt limit
- Labour supply is demand determined

Labour market

- Labour packers
  - Combine tasks to final labour
- Unions
  - Combine household labour to specific tasks
  - Set nominal wages subject to Calvo friction

Goods market

- Final good producers
  - Combine intermediate input goods
- Intermediate-good producers
  - Set prices subject to Calvo friction

Monetary policy

- Central bank sets interest rate subject to ELB

Aggregate shocks

- Demand and cost-push shocks

Model

Monetary policy

- Central bank sets the nominal interest rate subject to a lower bound:

$$R_t = \max\{\tilde{R}_t, R_{ELB}\}$$

- Interest rate rule for shadow rate $\tilde{R}_t$:

$$\frac{\tilde{R}_t}{R} = \left(\frac{\tilde{R}_{t-1}}{R}\right)^{\rho_R} \left(\left(\frac{Y_t}{Y}\right)^{\phi_Y} \left(\frac{\Pi_t^{(T)}}{\Pi}\right)^{\phi_\Pi}\right)^{1-\rho_R}$$

with
  - average inflation over T-period horizon $\Pi_t^{(T)} \equiv \left(\prod_{k=1}^{T} \Pi_{t-k+1}\right)^{1/T}$
  - output Y_t

- Interest rate rule nests two cases:
  - $T = 1 \quad \rightarrow \quad$ inflation targeting (IT) regime
  - $T > 1 \quad \rightarrow \quad$ average inflation targeting (AIT) regime

Model

Beliefs and equilibrium

Temporary equilibrium ▸ Details

- Households, firms and unions solve their individual problems in period t, ...
  ... given observable exogenous aggregate variables $\boldsymbol{S_t} \equiv \{S_{t+j}\}$
  ... given beliefs about endogenous aggregate variables $\boldsymbol{\Omega_t^e} \equiv \{\Omega_{t+j}^e\}$
- Individual decision rules + market clearing + monetary policy $\Rightarrow$ equilibrium $\boldsymbol{\Omega_t} \equiv \{\Omega_{t+j}\}$

Level-k thinking ▸ Details

- Agents observe aggregate shock but need to figure out macroeconomic implications (GE effect)
- Iterative expectation formation:
  - Level-1 agent does not adjust beliefs, $\boldsymbol{\Omega_t^{e,1}} = \boldsymbol{\Omega_{ss}} \Rightarrow \boldsymbol{\Omega_t^1}$
  - Level-2 agent thinks everyone else behaves like a level-1 agent $\boldsymbol{\Omega_t^{e,2}} = \boldsymbol{\Omega_t^1} \Rightarrow \boldsymbol{\Omega_t^2}$

    ...
  - Level-k agent thinks everyone else behaves like a level-(k-1) agent $\boldsymbol{\Omega_t^{e,k}} = \boldsymbol{\Omega_t^{k-1}} \Rightarrow \boldsymbol{\Omega_t^k}$

Reflective expectations

- Belief formation in economy with continuous cognitive ability level $n > 0$:

$$\frac{d\boldsymbol{\Omega}_t^{e,n}}{dn} = \boldsymbol{\Omega}_t^n - \boldsymbol{\Omega}_t^{e,n} \qquad \rightarrow \qquad \boldsymbol{\Omega}_t^{e,n} = dn \times \boldsymbol{\Omega}_t^{n-dn} + (1 - dn) \times \boldsymbol{\Omega}_t^{e,n-dn}$$

Outline

Calibration and solution

Calibration

- Set most parameters to standard values from the literature
- Calibrate shock volatility parameters to match statistics for average MPC, inflation and output

Solution

- Linearise model around the steady state à la *Boppart et al. (2018)*
  - Compute economy's response to small transitory MIT shock(s), taking into account belief recursion
  - Use IRFs as linear model approximation in the sequence space
- Enforce ELB constraint during Monte Carlo simulations for linearised model
  - Use anticipated monetary policy shocks (*Holden, 2016*)

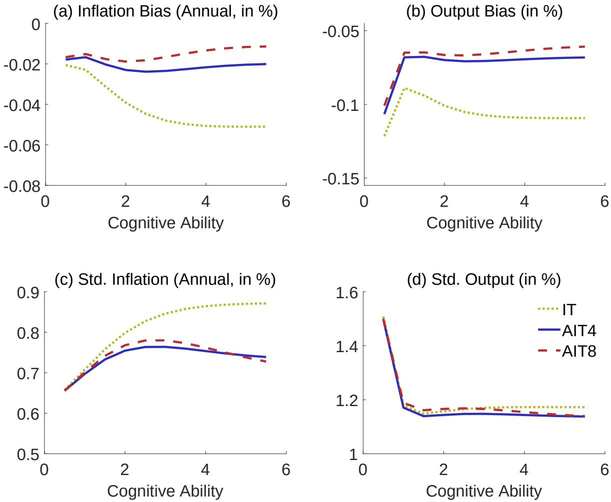
▸ Details

Simulation results

RANK case

Bounded rationality attenuates relative benefits of make-up

- Inflation bias and volatility grow with cognitive ability under IT but do not change much under AIT.
- Relative to IT, output bias under AIT declines with cognitive ability
- Output volatility hardly changes with cognitive ability for all policy rules
- Make-up has ‘decreasing returns’

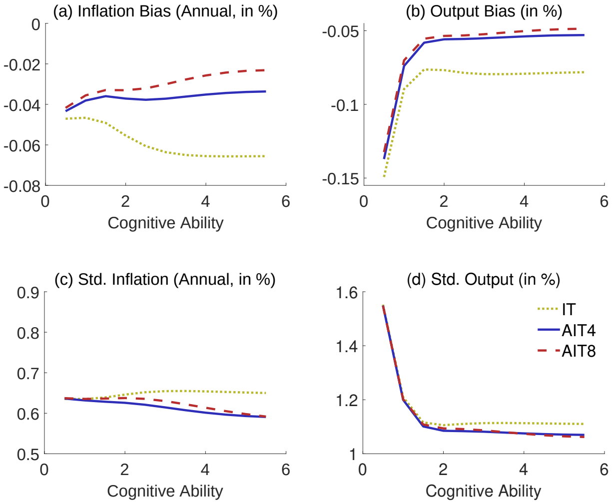


Simulation results

HANK case

Relative benefits of make-up are as in RANK case

- Make-up is not attenuated more by bounded rationality in HANK than in RANK.
- Compared to RANK
  - inflation bias is higher
  - output bias is (mostly) lower
  - macro volatility is (mostly) lower



Simulation results

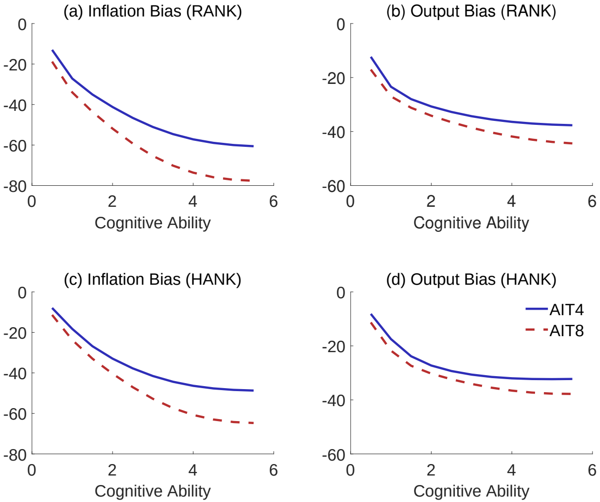
No complementarity

Values in % relative to IT

No complementarity between incomplete markets and bounded rationality

- Impact of bounded rationality on relative benefits of AIT is hardly different in RANK and HANK
- In contrast to findings for forward guidance (*Farhi and Werning, 2019*)

Details



Simulation results

Sensitivity

Results are robust with respect to various model assumptions

1. Debt denomination
   - Real bonds $\rightarrow$ no direct redistribution via inflation
2. Backward-looking price and wage indexation
   - Partial indexation to lagged inflation
3. Cyclicality of income risk
   - Variance of idiosyncratic productivity changes with output (*Auclert and Rognlie, 2020*)
4. Heterogeneous cognitive ability
   - Only one type of forward-looking agent exhibits level-*k* thinking
5. Interest rate smoothing
   - No history dependence in policy rate via lagged shadow rate

Outline

Summary

Role of incomplete markets and bounded rationality for make-up strategies

- Stochastic simulation of HANK model with
  - occasionally binding ELB
  - reflective expectations

Main findings

1. AIT outperforms IT in terms of macroeconomic stabilisation
2. Market incompleteness (MI) does not matter for relative performance of AIT
3. Benefits of AIT relative to IT are small for plausible degree of bounded rationality (BR)
4. MI and BR do not complement each other in attenuating benefits of AIT

Appendix

Optimal individual behaviour: households

- Given beliefs, optimal individual period-t consumption in the RANK case is

$$c_{i,t} = \frac{b_{i,t-1}\frac{R_{t-1}}{\Pi_t} + w_t N_t + d_t + \sum_{s=1}^{\infty}\left(\prod_{u=1}^{s}\left(\frac{R^e_{t+u-1}}{\Pi^e_{t+u}}\right)^{-1}\right)\left(w^e_{t+s}N^e_{t+s} + d^e_{t+s}\right)}{1 + \sum_{s=1}^{\infty}\prod_{u=1}^{s}\beta^{1/\sigma}_{t+u-1}\left(\frac{R^e_{t+u-1}}{\Pi^e_{t+u}}\right)^{1/\sigma-1}}$$

  and savings are

$$b_{i,t} = b_{i,t-1}R_{t-1}\Pi_t^{-1} + w_t N_t + d_t - c_{i,t}$$

- Relevant beliefs: nominal rate R^e_{t+s-1}, inflation Π^e_{t+u}, labour income $w^e_{t+s}N^e_{t+s}$, dividend income d^e_{t+s}
- Discount factor β_{t+s-1} is perfectly observable

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Appendix

Distribution of level-k agents for different n^*

- Assuming a Poisson distribution with mean n^*, the population share of level-k agents is:

$$\omega_k(n^*) = \frac{(n^*)^{k-1}\exp(-n^*)}{(k-1)!}$$

- Average beliefs in the economy:

$$\Omega_{t+s}^{e,n^*} = \sum_{k=1}^{\infty} \omega_k(n^*)\Omega_{t+s}^{e,k}$$

with $\Omega_{t+s}^{e,n^*} = \Omega_{t+s}^{k-1}$

(*García-Schmidt and Woodford, 2019*)

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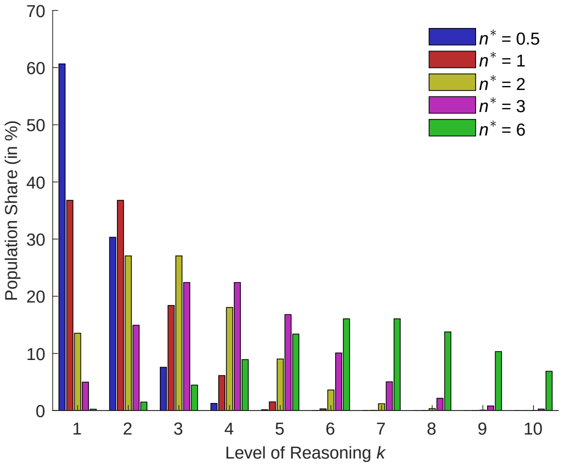

Appendix

Model parameters

	Description	Value
β	Discount factor	0.995 (RANK: 0.998)
θ_p	Price elasticity	6
θ_w	Wage elasticity	6
σ	IIES	2
χ	Weight labour disutility	1.023 (RANK: 1)
η	Inverse Frisch elasticity	2
Φ	Fixed cost of production	0.167
ξ_p	Calvo price-setting	0.85
ξ_w	Calvo wage-setting	0.85
Π_w	SS nom. wage inflation	1.005
ϕ_Π	Inflation response MP rule	1.5
ϕ_Y	Output response MP rule	1

	Description	Value
ρ_R	Interest rate smoothing	0.75
ρ_β	Persist. discount factor	0.85
ρ_μ	Persist. mark-up	0
ρ_e	Persist. idios. productivity	0.966
σ_β	Std. discount factor shock	0.006
σ_μ	Std. mark-up shock	0.118
σ_e	Std. idios. prod. shock	0.052
$\underline{b}$	Household debt limit	-1.667
r^*	SS real rate (annual)	1.010
Π^*	Inflation target (annual)	1.020
R^4_{ELB}	ELB (annual)	1.001

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Appendix

Real rate forward guidance

- One-time real rate cut for period $t + \tau$ announced today
- Bounded rationality attenuates response in HANK more than in RANK
  - → Complementarity between incomplete markets and bounded rationality
  - → Consistent with results in *Farhi and Werning (2019)*

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Values in % relative to case with $n^* = \infty$