Central Banks Balance Sheet Policies Without Rational Expectations

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Central Banks Balance Sheet Policies

Examples:

- QE (long-term public and private assets purchases)
- FX interventions

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"The problem with QE is that it works in practice,
but it does not work in theory."

Ben Bernanke (2014)

Empirics

QE

- Gagnon-Raskin-Remache-Sack (2011), Krishnamurthy-Vissing-Jorgensen (2011), Hancock-Passmore (2011), Di Maggio-Kermani-Palmer (2016), Chakraborty-Goldstein-MacKinlay (2016), Fieldhouse-Mertens-Ravn (2018)

FX interventions

- Dominguez-Frankel (1990, 1993), Dominguez (1990, 2006), Catte-Galli-Rebecchini (1994), Kearns-Rigobon (2005), Blanchard-Adler-de Carvalho (2014), Fratzscher-Gloede-Menkhoff-Sarno-Stohr (2015)

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The irrelevance result

Theory

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1. people can freely trade targeted assets
2. symmetric info between policy maker and markets
3. people correctly predict future effects of policies

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1. Portfolio balance channel (segmented markets)
2. Signaling channel (asymmetric info or limited commitment)

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This paper: bounded rationality channel

- Beliefs about future deviate from rational expectations
- Agents do not fully understand future effects of the policies

Deviations from Rational Expectations

Eduction ($\neq$ Induction/Learning)

- **Idea**: agents understand the model and use it to form expectations about the future through a process of reflection

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Level-k thinking

- Stahl-Wilson (1994,1995); Nagel (1995); Crawford (2013)

General conclusion:

- Level-k thinking is a better approximation of experimental results in strategic games (more so in new games)

Simple Model

Infinitely-lived households solve

$$\max_{\{x_{t+1}, b_{t+1}, c_t\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} e^{-\rho t} u(c_t) \right], \quad u(c) = -e^{-\gamma c}/\gamma$$

$$\text{s.t.:} \quad c_t + b_{t+1} + \widetilde{q}_t x_{t+1} \leq W_t - \widetilde{T}_t + (1+r) b_t + (D_t + \widetilde{q}_t) x_t$$

$$D_t = \overline{D} + \epsilon_t^x, \ \epsilon_t^x \sim \mathcal{N}(0, \sigma_x^2)$$

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Focus on linear beliefs about future endogenous variables

$$\widetilde{q}_{t+1} = \alpha_{q,t} + \beta_{q,t} \epsilon_{t+1}^x, \quad \widetilde{T}_{t+1} = \alpha_{T,t} + \beta_{T,t} \epsilon_{t+1}^x$$

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Risky-asset demand

$$x(q_t; \{\widetilde{q}_{t+s}, \widetilde{T}_{t+s}\}) = \frac{\overline{D} + \mathbb{E}_t\widetilde{q}_{t+1} - (1+r)q_t}{\gamma\frac{r}{1+r}\sigma_x^2} + \beta_{T,t}$$

Central Bank

- announces path of asset purchases $\Rightarrow \{X_{t+1}\}$
- finances purchases by issuing reserves $\Rightarrow \{R_{t+1}\}$
- transfers profits/losses to the Treasury:

$$Tr_t = (D_t + q_t)X_t - (1 + r)R_t$$

Government

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Treasury

- issues bonds and levies taxes to satisfy BC:

$$(1+r)B_t = \sum_{s=0}^{\infty} \frac{1}{(1+r)^s} \left(T_{t+s} + Tr_{t+s}\right)$$

Temporary Equilibrium (TE)

Idea: TE takes as given a sequence of beliefs and imposes that markets clear in every period (Hicks; Lindahl; Grandmont)

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Definition

For $\{\widetilde{T}_t, \widetilde{q}_t\}$, a TE is $\{X_{t+1}, B_{t+1}, R_{t+1}, T_t, Tr_t; q_t; b_{t+1}, x_{t+1}, c_t\}$ s.t. $\{x_{t+1}, b_{t+1}, c_t\}$ are optimal, risky-asset market clears

$$\frac{\overline{D} + \mathbb{E}_t \widetilde{q}_{t+1} - (1+r) q_t}{\gamma \frac{r}{1+r} \sigma_x^2} + \beta_{T,t} = \overline{X} - X_{t+1},$$

transfers are given by

$$Tr_t = (D_t + q_t) X_t - (1+r) R_t,$$

and taxes and bonds satisfy Treasury's BC.

REE

Level-k thinking Belief Formation

Status quo $\{\widetilde{q}_{t+s}, \widetilde{T}_{t+s}\} = \{q^*, 0\}$ (REE before intervention)

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Level-1 Thinking

$$\left.\begin{aligned} x(q_t^1; \{q^*, 0\}) &= \overline{X} - X_{t+1} \\ Tr_t^1 &= \left(D_t + q_t^1\right) X_t - (1+r) R_t \end{aligned}\right\} \Rightarrow \{T_t^1, q_t^1\}$$

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Level-2 Thinking

$$\left.\begin{aligned} x\left(q_t^2; \{q_{t+s}^1, T_{t+s}^1\}\right) &= \overline{X} - X_{t+1} \\ Tr_t^2 &= \left(D_t + q_t^2\right) X_t - (1+r) R_t \end{aligned}\right\} \Rightarrow \{T_t^2, q_t^2\}$$

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Level-k Thinking

$$\{q_t^k, T_t^k\} = \Psi(\{q_{t+s}^{k-1}, T_{t+s}^{k-1}\}; \{X_{t+1}\})$$

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REE

$$\{q^*, T_t^*\} = \Psi(\{q^*, T_{t+s}^*\}; \{X_{t+1}\})$$

Level-k thinking Belief Formation

$$q_t^k = \begin{cases} \dfrac{\overline{D} + q^* - \gamma\sigma_x^2 \frac{r}{1+r}\left(\overline{X} - X_{t+1}\right)}{1+r}, & k = 1 \\ \dfrac{\overline{D} + q_{t+1}^{k-1} - \gamma\sigma_x^2 \frac{r}{1+r}\overline{X}}{1+r}, & k > 1 \end{cases}$$

Diagonal Iteration

$$q_t^k = \frac{\overline{D} + q_{t+1}^{k-1} - \gamma \sigma_x^2 \frac{r}{1+r} \overline{X}}{1+r}, \;\; q_{t+k-1}^1 = \frac{\overline{D} + q^* - \gamma \sigma_x^2 \frac{r}{1+r} \left(\overline{X} - X_{t+k} \right)}{1+r}$$

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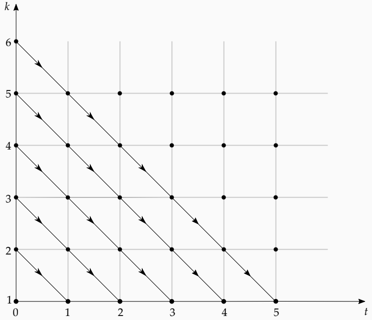

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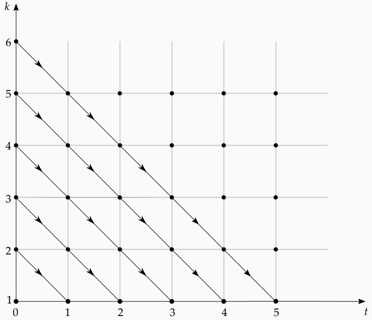

Endogenous discounting

Reflective Equilibrium

Idea: agents form beliefs according to level-k thinking, the economy is populated by agents with different k with pdf $f(k)$

When $f(k)$ is exponential with average $\bar{k}$

$$q_t = q^* + \gamma \sigma_x^2 \frac{r}{1+r} \cdot \frac{\sum_{k=1}^{\infty} \left(\frac{\bar{k}-1}{\bar{k}}\right)^{k-1} \frac{X_{t+k}}{(1+r)^k}}{\bar{k}}$$

A higher $\bar{k}$

1. reduces the direct effect of interventions
2. makes the price react more to expected future interventions

Does QE affect output?

So far: **endowment economy**

$\Rightarrow$ Balance sheet policies affect prices and taxes only

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A New-Keynesian model with aggregate risk

- Output is "demand determined" (rigid prices)
- Risky assets are claims on part of output
- Shocks to discount factor
- General preferences and asset characteristics
- Study "small" interventions ($X_{t+1} = \mu^t \overline{X}$ with $\overline{X} \to 0$)

Details

Does QE affect output?

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Proposition 1 (the role of preferences)

Consider a small and temporary intervention ($\mu = 0$) and suppose dividends are *pro-cyclical*. In the Temporary Equilibrium, QE has a positive (negative) effect on output if preferences exhibit DARA (IARA).

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Intuition:

$\Rightarrow$ CB intervention lowers both *risk* and *return* of HH portfolios

$\Rightarrow$ Overall effect depends on how risk aversion varies with wealth

Does QE affect output?

Proposition 2 (the role of assets)

Consider a small intervention and suppose preferences are CRRA. In the Temporary Equilibrium, the overall effect of QE on output is proportional to $\mathcal{R}_t + \mathcal{M}_t$, where

(i) $\mathcal{R}_t \equiv cov_t(V^*_{aa,t+1}, ER^*_{t+1})$ measures asset risk and

(ii) $\mathcal{M}_t \equiv \mathbb{E}_t[V^*_{aa,t+1}]\mathbb{E}_t[ER^*_{t+1}]$ measures asset average return.

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CB intervention raises output:

$\Rightarrow$ the higher the *risk* of the targeted asset

$\Rightarrow$ the lower the *average return* of the targeted asset

Extensions and Empirics

Extensions

- ✓ Long-term public bonds purchases (+ nominal variables)
- ✓ FX interventions (+ nominal variables)
- ✓ Learning
- ✓ Presence of rational-expectations agents

Empirics

- Asset prices forecast errors are predictable
- BCFF data + GSE purchases: 86% are level-1 Details

Conclusion

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    - interventions have a first-order effect on prices

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3. Testable predictions
    - forecast errors respond to interventions
    - evidence from mortgage rate forecast errors

Rational Expectations Equilibrium

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$$\widetilde{T}_t = T_t, \ \widetilde{q}_t = q_t$$

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Specifically

$$\underbrace{\alpha_{T,t} + \beta_{T,t}\epsilon_t^x}_{\text{tax beliefs } \widetilde{T}_t} \overset{\text{REE}}{=} \underbrace{q_t X_{t+1} - B_{t+1} + RB_t - X_t(\overline{D} + q_t) - X_t\epsilon_t^x}_{\text{realized taxes } T_t}$$

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Risky assets market in t

$$\frac{r^x + \mathbb{E}_t q_{t+1} - q_t R}{\gamma \frac{R-1}{R}\sigma_x^2} + \beta_{T,t+1} = \overline{X} - X_{t+1}$$

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$\Rightarrow$ Balance sheet policy does not affect price q_t in REE!

Back

A Model with Endogenous Output

Households

$$\max_{\{x_{t+1}, b_{t+1}, c_t\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} e^{\sum_{s=0}^{t} \epsilon_{s-1} - \epsilon_{-1} - \rho t} u(c_t) \right]$$

$$\text{s.t.:} \quad c_t + b_{t+1} + \widetilde{q}_t x_{t+1} \leq \widetilde{W}_t - \widetilde{T}_t + (1+r) b_t + (\widetilde{D}_t + \widetilde{q}_t) x_t$$

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Total Income/Output Y_t distributed as

- $\widetilde{W}_t = (1-\delta)\widetilde{Y}_t$ – labor (non-traded) income
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What determines output? goods market clearing (in TE)

$$Y_t = C\left(W_t(Y_t) - T_t(Y_t), D_t(Y_t), q_t(Y_t), \{\widetilde{W}_{t+s} - \widetilde{T}_{t+s}, \widetilde{D}_{t+s}, \widetilde{q}_{t+s}\} \right)$$

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Testable Predictions

Forecast errors

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Forecast errors in the model

Individual: $u^k_{t+s} \equiv q_{t+s} - q^k_{t+s}$

$$\text{Average: } \bar{u}_{t+s} \equiv \sum_{k=1}^{\infty} f(k) u^k_{t+s} = \mu^s \frac{\gamma \sigma_x^2 \frac{r}{1+r} X_{t+1}}{\overline{k}[(1+r-\mu)\overline{k} + \mu]}$$

Back

Empirics

Fieldhouse-Mertens-Ravn (2018, QJE)

- Monthly data on GSEs mortgage purchases: 1967-2006
- “Unexpected exogenous” purchases narrative identification
- Result: mortgage yield reacts significantly to interventions

Forecast errors

- Blue Chip conventional mortgage rate forecasts: 1982-2006
- Project median forecast errors on “exogenous” purchases

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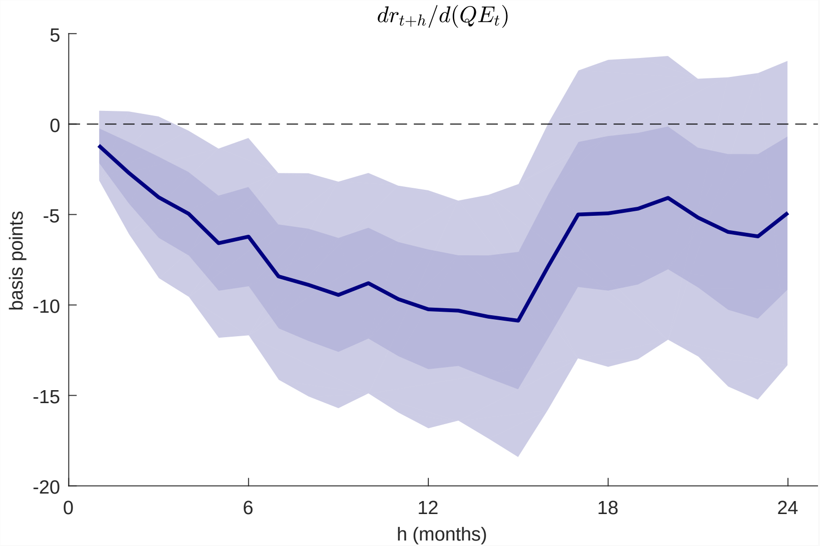

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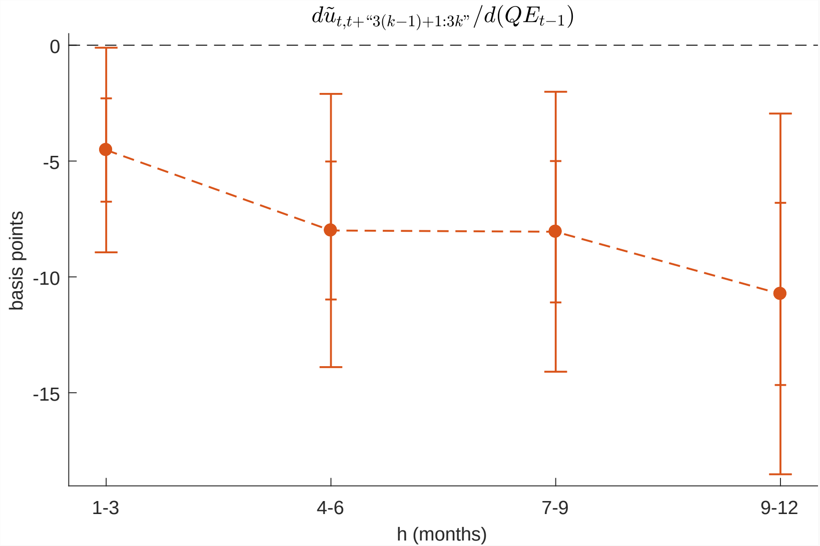

$d\tilde{u}_{t,t+``3(k-1)+1:3k"}/d(QE_{t-1})$
0
-5
-10
-15
basis points
1-3
4-6
7-9
9-12
h (months)

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