Intermediary Leverage, Macroeconomic Dynamics, Macroprudential Policy

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Introduction

- The recent financial crisis highlights the pitfalls of *micro*prudential approach in financial regulation.
- Trying to prevent failures of individual financial institutions may not be sufficient.
- *Individually* sound strategies may result in *socially* inefficient outcomes. cf. Fire-sale or pecuniary externality.
- Macroprudential approach identifies market failures and directly addresses the problem *at a general equilibrium level.*
- Such policies should be evaluated in terms of its ability to safeguard the financial system and the economy *as a whole*.

What We Do and Find

- Develop a dynamic general equilibrium model with financial intermediation playing an essential role in allocating resources.
- Show how equilibrium allocation can deviate from the first best when the intermediaries face financial frictions.
- Study Ramsey allocation problem to learn what a social planner would do to fix the problem.
- Propose a leverage tax in the spirit of Pigovian taxation that can replicate Ramsey allocation, evaluate its stabilization effects.
- Study if the tax policy can be implemented through a reserve requirement, show *near-equivalence* of the two policies.
  - cf. Stein [2011], Hanson, Kashyap and Stein [2011].
- Find that adjusting the tax rate (or reserve requirement rate) to lean against credit spreads achieves the most desirable outcomes.

Model Economy: Big Picture

- Key player: A continuum of risk-neutral financial intermediaries
  - owned by risk-averse households,
  - Invest funds on behalf of households,
  - In risky projects, subject to aggregate and idiosyncratic risks.
- The intermediaries optimize capital structure,
  - Raise debt and equity in frictional capital markets,
  - Trade off between the tax benefits and distress costs of debts.
- Intermediary funding suffers from financial market friction that limits the ability to arbitrage away profit opportunities.
- which then makes asset returns and real allocation in the model economy deviate from the first best.

Assumption 1-3

- Assumption 1: Limited liability of the financial intermediaries
- Assumption 2: Bankruptcy (liquidation) cost, a fraction

  $\eta \in (0, 1)$ of liquidated capital assets.

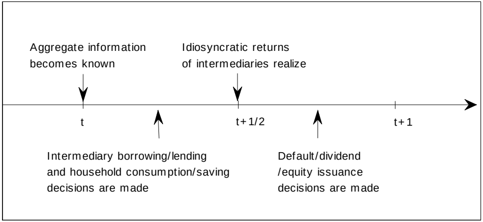
- Assumption 3: Raising outside equity is costly.
  - New shares are sold at a discount, $\varphi \in [0, 1]$ owing to informational friction. cf. Myers and Majluf [1984].
  - From a dollar issuance of equity, actual cash inflow is $1 - \varphi$. cf. Bolton and Fraixas [1990].
  - The equity related net cash-flow :

$$-D_t + \varphi \min\{0, D_t\} = \begin{cases} -D_t & \text{if } D_t \geq 0 \\ -(1-\varphi)D_t & \text{if } D_t < 0 \end{cases}$$

Assumption 4

- Assumption 4: Commitment in investment/borrowing decision.
  - Liquidity risk/maturity mismatch.
  - To replicate the liquidity risk, split one period into two
  - In the 1st half, investment/borrowing decisions should be made based on aggregate information only
  - In the 2nd half, the net-worth position becomes known as the idiosyncratic return realizes. Investment cannot be reversed.
  - Any funding gap should be closed by new outside capital

Figure: Sequence of Events



Debt, Default and Renegotiation

- Intermediary return:

$$\begin{aligned} R^F_{t+1} &= \epsilon_{t+1} \cdot R^A_{t+1} \\ \log \epsilon_{t+1} &\sim N(-0.5\sigma^2_{t+1}, \sigma^2_{t+1}) \\ R^A_{t+1} &= \frac{(1-\tau_c) r^K_{t+1} + [1 - \delta(1-\tau_c)] Q_{t+1}}{Q_t} \end{aligned}$$

- Intermediary borrows $1 - m_t$ for each dollar of investment.
- Default occurs when the total return falls short of debt obligation.
- Net return bounded below by zero: $\max\{\epsilon_{t+1} - \epsilon^D_{t+1}, 0\} R^A_{t+1}$

$$\epsilon^D_{t+1} \equiv (1 - m_t) \frac{R^B_{t+1}}{R^A_{t+1}}$$

- Upon default, the debt burden renegotiated with creditors, making the intermediary indifferent between default and non-default.

Costly Equity and Value of Internal Funds

- Intermediary raises m_t dollars of equity for each dollar investment.
- Flow of funds constraint for intermediary investing $Q_t S_t$:

$$
\begin{aligned}
Q_t S_t &= \underbrace{(1-m_t)Q_t S_t}_{\text{Debt}} + \underbrace{N_t - D_t + \varphi \min\{0, D_t\}}_{\text{Equity}} \\
N_t &= \max\{\epsilon_t - \epsilon_t^D, 0\} R_t^A Q_{t-1} S_{t-1}
\end{aligned}
$$

- λ_t : the value of internal funds, Lagrangian multiplier for FOF.
- Commitment implies investment based on $\mathbb{E}_t^{\epsilon}[\lambda_t]$, not λ_t

$$
\begin{aligned}
\mathbb{E}_t^{\epsilon}[\lambda_t] &\equiv \int \lambda_t dF_t(\epsilon) = 1 + \frac{\varphi}{1-\varphi} F_t(\epsilon_t^E) > 1 \\
\epsilon_t^E &\equiv \epsilon_{t+1}^D + m_t \frac{Q_t S_t}{R_t^A Q_{t-1} S_{t-1}}
\end{aligned}
$$

- cf. Brunnermeier and Pedersen [2009], funding liquidity.

Two-Stages Value Maximization

- Before the realization of idiosyncratic shock, the intermediary solves

$$J_t = \max_{S_t, m_t, \epsilon^D_{t+1}} \left\{ \mathbb{E}^{\epsilon}_t [D_t] + \mathbb{E}_t [M_{t,t+1} \cdot V_{t+1}(N_{t+1})] \right\}$$

  s.t. (i) expected FOF and (ii) participation const. for the creditor

- After the resolution of idiosyncratic uncertainty, intermediary solves

$$V_t(N_t) = \max_{D_t} \left\{ D_t + \mathbb{E}_t [M_{t,t+1} \cdot J_{t+1}] \right\}$$

  s.t. realized FOF constraint.

- Sym. equilibrium: J_t, S_t, m_t, ϵ^D_{t+1} and $\mathbb{E}^{\epsilon}_t[\lambda_t]$ are the same for all $i \in [0, 1]$. However, the dist of D_t and λ_t are non-degenerate.

Implication for Asset Pricing

- A few non-standard features:
  1. Levered asset pricing:

$$1 = \mathbb{E}_t \left\{ M^B_{t,t+1} \cdot \frac{1}{m_t} \left[\frac{\mathcal{R}^A_{t+1}}{\Pi_{t+1}} - (1 - m_t) \frac{R^B_{t+1}}{\Pi_{t+1}} \right] \right\}$$

  2. Pricing wedge: $M^B_{t,t+1} \equiv M_{t,t+1} \frac{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}]}{\mathbb{E}^{\epsilon}_t[\lambda_t]}$.

     cf. He and Krishnamurthy [2012], Holmstrom and Tirole [2001].
  3. Return wedge:

$$\mathcal{R}^A_{t+1} \equiv R^A_{t+1} \left[\frac{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}\epsilon_{t+1}]}{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}]} + \frac{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1} \max\{0, \epsilon^D_{t+1} - \epsilon_{t+1}\}]}{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}]} \right]$$

  4. De facto risk aversion: $\frac{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}\epsilon_{t+1}]}{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}]} \leq 1$.
  5. Value of default option: $\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1} \max\{0, \epsilon^D_{t+1} - \epsilon_{t+1}\}] > 0$.

Rest of the Economy

- Standard setting of Smets and Wouters [2007]
- Household:
  - $\sum_{j=0}^{\infty} \beta^j \left[\frac{1}{1-\gamma} [(C_{t+j} - hC_{t+j-1})^{1-\gamma} - 1] - \frac{\zeta}{1+\nu} H_{t+j}^{1+\nu} \right]$
  - Invest in bonds and shares of financial intermediaries.
- Production:
  - Competitive intermediate goods
  - Monopolistic competition of retailers with nominal rigidity
  - Competitive investment firms with investment adj. cost, Q
- Government: Balanced budget
  - $T_t = \tau_c r_t^K K_t - \tau_c [\delta + (1 - m_{t-1})] Q_{t-1} K_t$
- Monetary Policy: Taylor [1993] with inertia
  - Production based output gap

Calibration I: Non-Financial Parameters

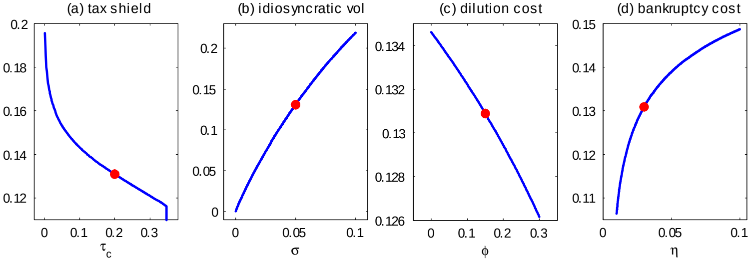
Table: Baseline Calibration of Non-financial Parameters

Description	Calibration
Preferences and production	
Time discounting factor	$\beta = 0.985$
Constant relative risk aversion	$\gamma = 2$
Habit persistence	$h = 0.75$
Elasticity of labor supply	$1/\nu = 0.25$
Value added share of labor	$\alpha = 0.6$
Depreciation rate	$\delta = 0.025$
Real/nominal rigidity and monetary policy	
Investment adjustment cost	$\chi = 5$
Price adjustment cost	$\chi^p = 125$
Monetary policy inertia	$\rho^r = 0.75$
Taylor rule coefficient for output gap	$\kappa^y = 0.125$
Taylor rule coefficient for inflation gap	$\kappa^{\Delta p} = 1.5$

Calibration II: Capital Structure

- Key determinants of long run capital structure
  - corporate tax rate: $\Delta\tau \equiv \tau_c - \tau_i$, $\tau_c = 0.20$, $\tau_i = 0.0$.
  - Idiosyncratic vol.: $\bar{\sigma} = 0.05$. cf. Std. of ROAs top 100 commercial banks in U.S. since 1986 $= 0.035$, *Call report*.
  - Issuance cost: $\varphi = 0.15$, about in the middle range in literature
  - Bankruptcy: $\eta = 0.03$, cf. Bernanke, Gertler and Gilchrist [1998]

Figure: Determination of Steady State Capital Structure (Leverage)



Impact of Financial Shocks

- We consider (i) Smets and Wouters [2007]'s risk premium shock, (ii) dilution cost shock, and (iii) time-varying volatility shock.

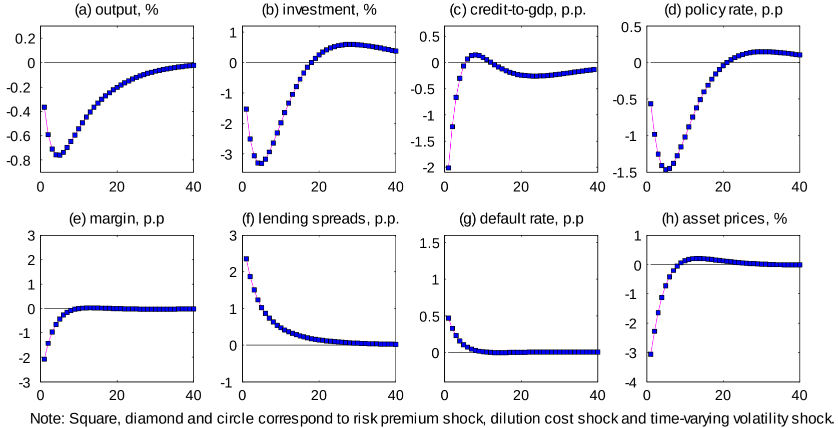


Figure: Financial Shocks: Risk Premium, Dilution Cost and Vol. Shocks

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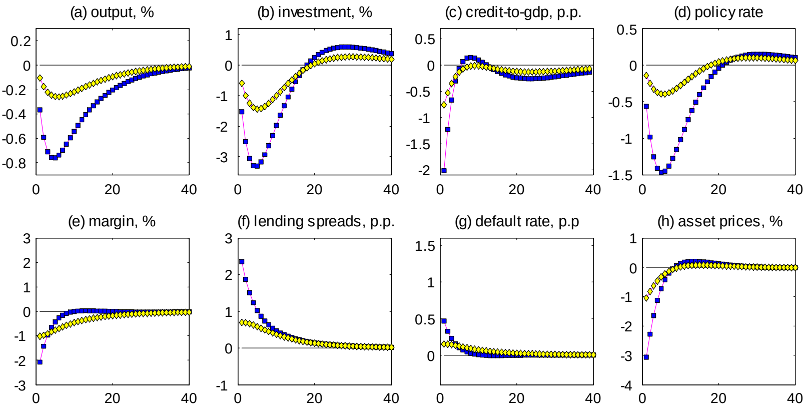

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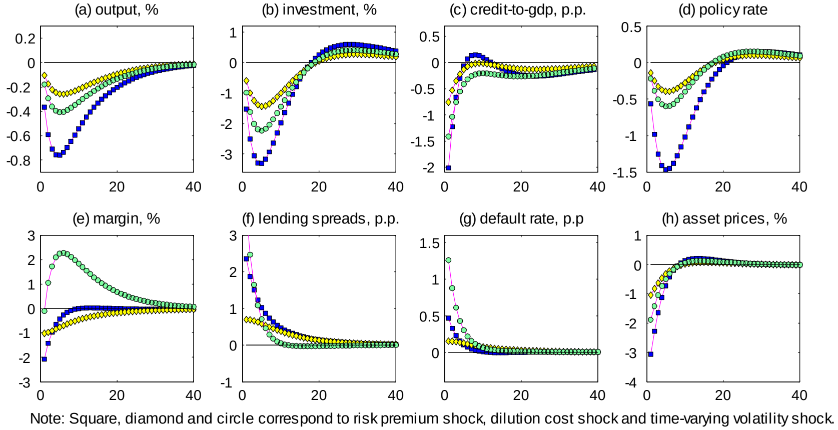

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Ramsey Allocation

- Ramsey allocation essentially gets rid of financial cycle, leading the economy close to the first best allocation (RBC).

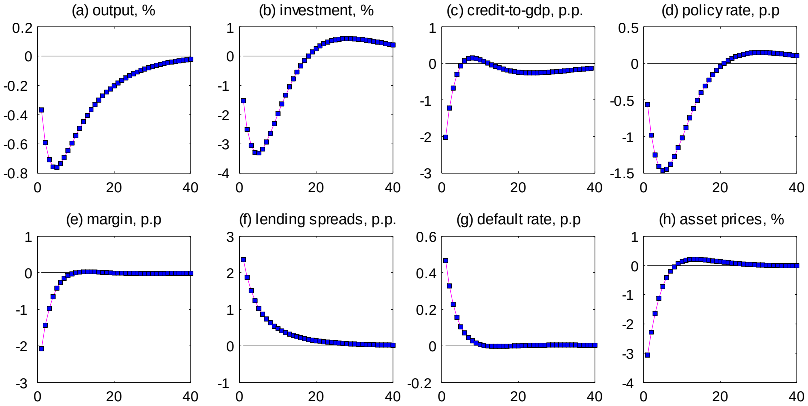

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Figure: Private vs RBC benchmark vs Ramsey Allocation

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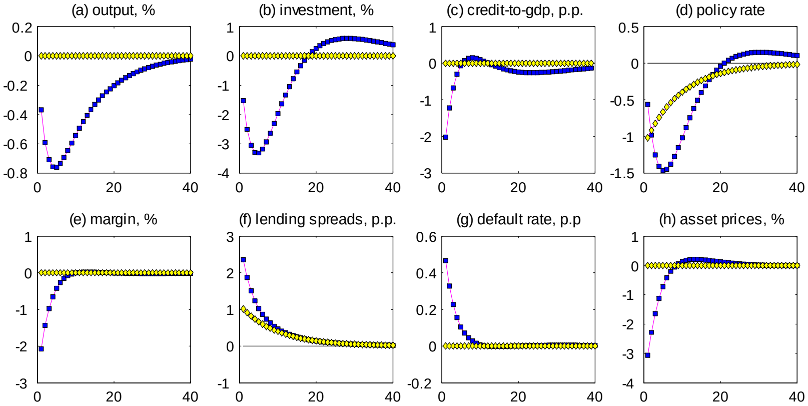

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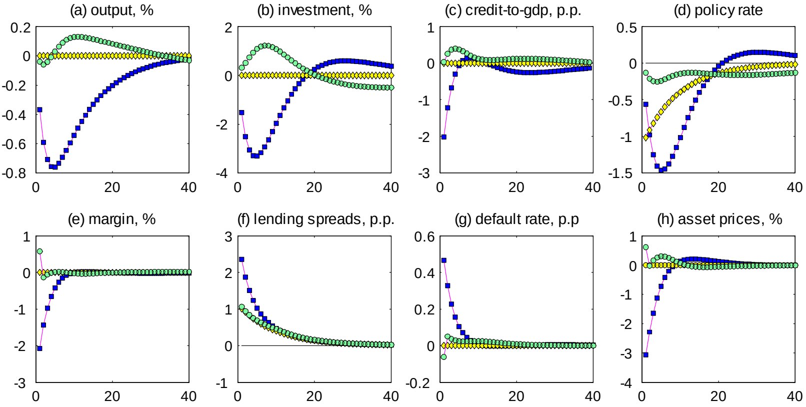

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Leverage Tax

- Constrained optimum may not be feasible. We look for a *simple* rule.
- Discrepancy: accounting (m_t) vs economic costs of inv. ($m_t \mathbb{E}_t^{\epsilon}[\lambda_t]$)
- A Pigovian tax on financial leverage, τ_t^m transforms the cost into

$$\mathbb{E}_t^{\epsilon}[\lambda_t][m_t + \tau_t^m(1 - m_t)] \gtreqless \mathbb{E}_t^{\epsilon}[\lambda_t]m_t \quad \text{if } \tau_t^m \gtreqless 0.$$

- A crucial question: how to adjust τ_t^m ?
- In a way that it offsets the changes in funding liquidity, i.e., $\mathbb{E}_t^{\epsilon}[\lambda_t]$.

$$\tau_t^m = \begin{cases} \alpha^m \times \ln(Q_t S_t / \bar{Q}\bar{S}) & \text{: asset value rule} \\ \alpha^m \times [\ln(Q_t S_t / \bar{Q}\bar{S}) - \ln(Y_t / \bar{Y})] & \text{: credit-to-gdp rule} \\ \alpha^m \times [4(R_t^L - R_t) - 4(\bar{R}^L - \bar{R})] & \text{: lending spread rule} \end{cases}$$

- Start with $\alpha^m = 0.25$ for all policies, then optimize for each policy.

Efficacy of Macroprudential Policies

- Stabilization of Financial Shock

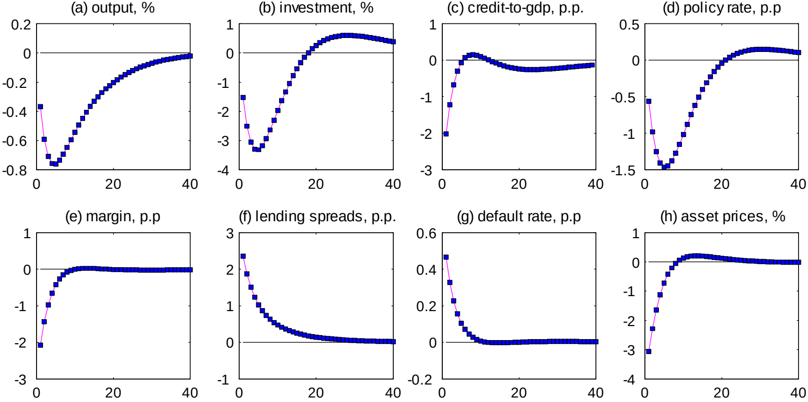

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Figure: CY (yellow) vs QK (green) vs SPR (red) Policies

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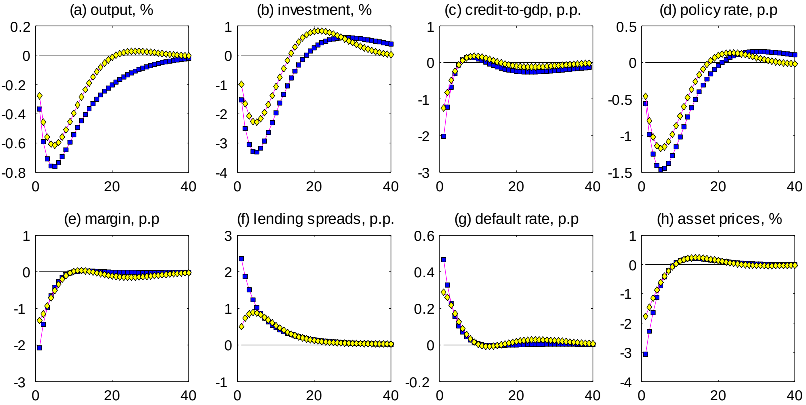

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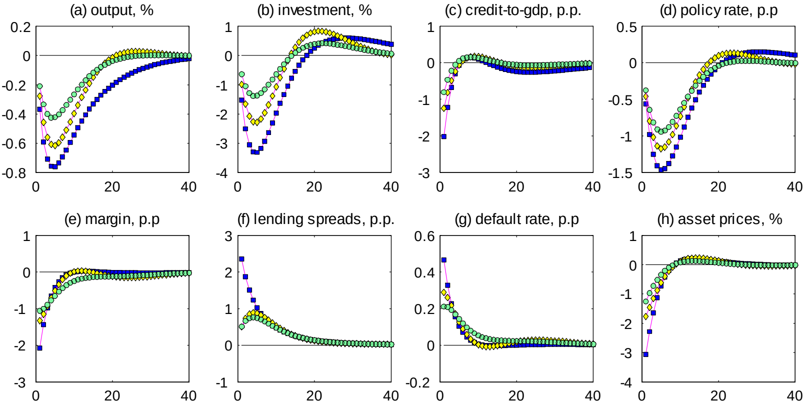

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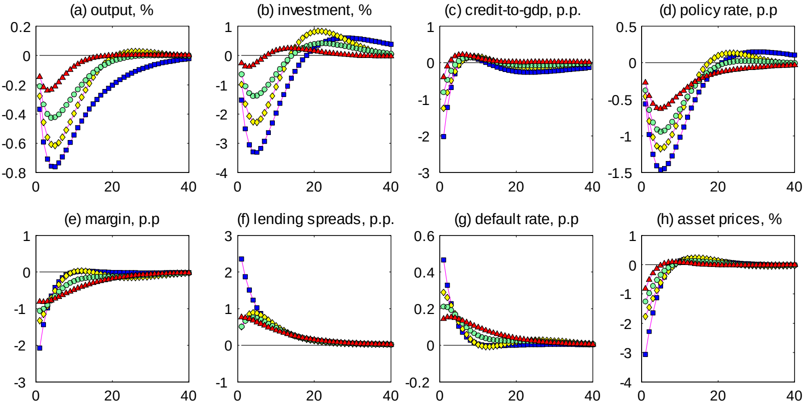

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Quantifying the Stabilization Effects

- The coefficient of each policy is optimized such that

$$\alpha_i^* = \arg\min_{\alpha_i^m} \left\{ \mathrm{var}\left[\log\left(y_t / y_t^*\right)\right] \right\}$$

Table: Stabilization Effects of Macroprudential Policies

	Rule	Standard Deviations of		
	Coeff	Output	Gap	Infl (a.r.)
No Policy	0.00	2.50	2.40	2.49
Optimal CY policy	0.39	2.74	1.91	2.01
Calibrated CY policy	0.25	2.59	1.94	2.03
Optimal QS policy	152	1.34	2.01	1.95
Calibrated QS policy	0.25	1.68	2.11	2.08
Optimal SPR policy	0.33	1.89	1.57	1.44
Calibrated SPR policy	0.25	1.89	1.61	1.60

Note: Tech and financial shocks account for 50% of y_t vol. each.

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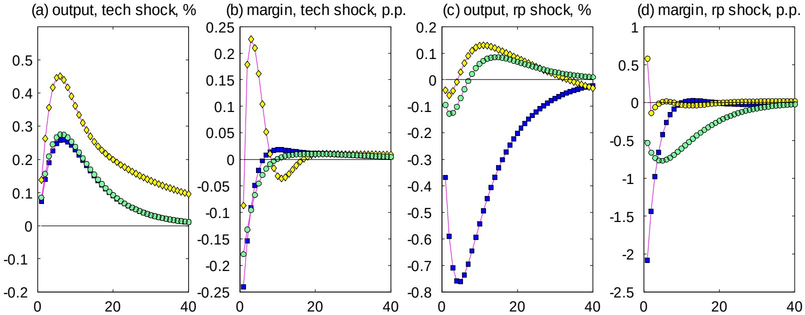
Optimal Spread Rule vs Ramsey Policy

- The optimized SPR rule is nearly neutral against tech shock
- Obtains socially optimal allocation in response to fin shock



Note: Square, diamond and circle correspond to Private, Ramsey Policy and Optimal Spread policy.

Figure: Optimal Spread Rule vs Ramsey Policy

Some Work Better Others. Why?

- The heart of the problem: the delegation of investment function to agents that are potentially subject to the *limits of arbitrage*:

$$M^B_{t,t+1} = M_{t,t+1} \cdot \frac{\mathbb{E}^{\epsilon}_{t+1}[\lambda_{t+1}]}{\mathbb{E}^{\epsilon}_{t}[\lambda_{t}]}$$

- The dynamic funding liquidity becomes a factor pricing assets.
- Policies work to the extent that they can offset the pricing wedge.
- The SPR policy works on $R^L_{t+1} - R_{t+1}$. What is the lending spread?

$$\begin{aligned} 1 &= \mathbb{E}_t[M_{t,t+1} \cdot R_{t+1}] \\ &\text{vs} \\ 1 &= \mathbb{E}_t[M^B_{t,t+1} \cdot R^L_{t+1}] \end{aligned}$$

- So called *lending standards* (SLOOS) may convey more information on lenders' fundamental than borrowers'.

Reserve Requirement

- The *fractional reserve requirement system* of the U.S. can achieve nearly identical allocation as Pigovian taxation.
  - cf. Stein [2011], Hanson, Kashyap and Stein [2011].
- With exogenously imposed reserve requirement X_{t+1},

$$Q_t S_t + X_{t+1} = (1 - m_t) Q_t S_t + X_t + N_t - D_t + \varphi \min\{0, D_t\}.$$

- By requiring $X_{t+1} = r_t^m (1 - m_t) Q_t S_t$,

$$Q_t S_t = (1 - m_t)(1 - r_t^m) Q_t S_t + X_t + N_t - D_t + \varphi \min\{0, D_t\},$$

nearly identical to the FOF constraint under the Pigovian tax,

$$Q_t S_t = (1 - m_t)(1 - \tau_t^m) Q_t S_t + T_t + N_t - D_t + \varphi \min\{0, D_t\}.$$

Pigovian Tax vs Reserve Requirement

- Despite the similarity, they are not *identical* policies.
- Lump sum transfer T_t is taken as given, but reserve requirement X_t is dynamically internalized by the intermediaries.
  - Under the leverage tax policy,

$$1 = \mathbb{E}_t \left[M^B_{t,t+1} \cdot \left(\frac{\tilde{R}^A_{t+1} - (1 - m_t)\tilde{R}^B_{t+1}}{m_t + \tau^m_t (1 - m_t)} \right) \right]$$

  - Under the reserve requirement policy,

$$1 = \mathbb{E}_t \left[M^B_{t,t+1} \cdot \left(\frac{\tilde{R}^A_{t+1} - (1 - m_t)(\tilde{R}^B_{t+1} - r^m_t)}{m_t + r^m_t (1 - m_t)} \right) \right]$$

- Only actual computation can tell how big a difference this is.

Near-Equivalence of Tax and Reserve Policies

- With $r_t^m = \tau_t^m = 0.25 \times [4(R_t^L - R_t) - 4(\bar{R}^L - \bar{R})]$,

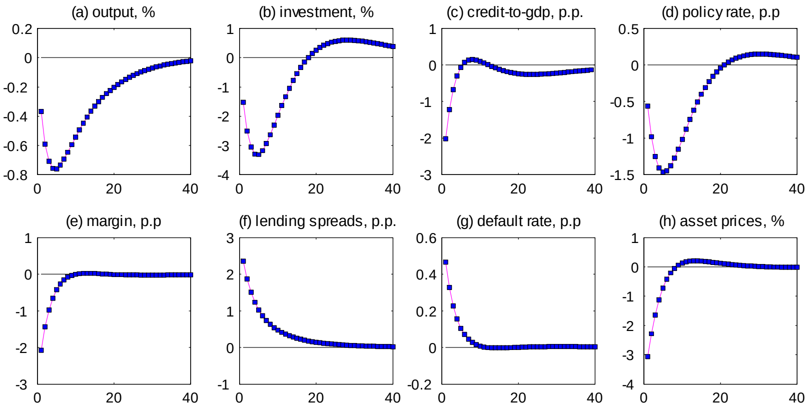


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Figure: Leverage Tax vs Reserve Requirement

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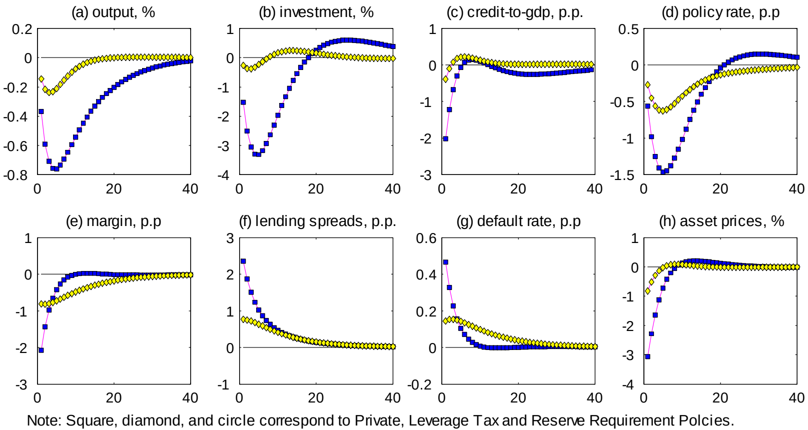

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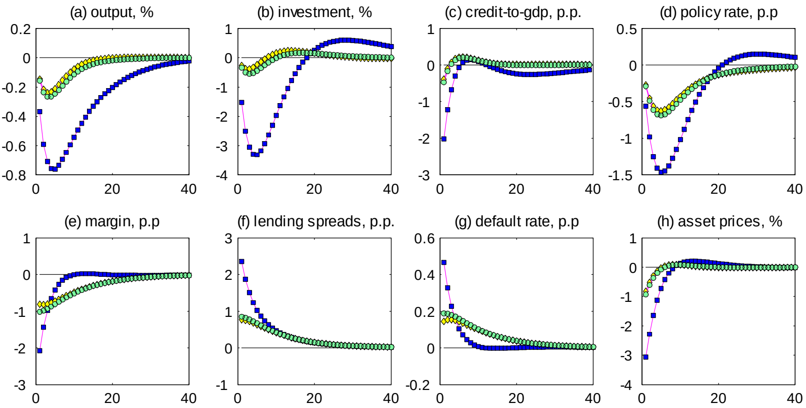

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Figure: Leverage Tax vs Reserve Requirement

Conclusion

- We have developed a dynamic-general-equilibrium model in which financial intermediaries
  - Face financial friction that limit arbitrage,
  - Implying socially inefficient responses to shocks
  - Which a Ramsey social planner would mitigate by accounting for the pecuniary externalities associated with the leverage choices of intermediaries.
- While the Ramsey policy may be infeasible (and model-specific),
  - A tax on leverage can yield similar outcomes, if adjusted properly;
  - As can a reserve requirement (echoing, in a large model, a suggestion of others);
  - Especially if the tax/reserve requirement leans against credit spreads.
  - In contrast, macroprudential policies leaning against broad measures of credit aggregates or asset values may be less effective.