Tight Money-Tight Credit: Coordination Failure in the Conduct of Monetary and Financial Policies

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- **Q1: How relevant is Tinbergen's rule?**
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  - Should we augment MP rules with financial stability factors and/or implement a separate FP rule? (Cúrdia and Woodford, 2010, Smets, 2014, Svensson, 2014, 2015, Yellen, 2014)

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  - Should we augment MP rules with financial stability factors and/or implement a separate FP rule? (Cúrdia and Woodford, 2010, Smets, 2014, Svensson, 2014, 2015, Yellen, 2014)
- **Q2: How important is strategic interaction?**
  - MP and FP targets are GE outcomes that depend on both MP and FP
  - Strategic interaction makes non-cooperative regime suboptimal
  - Related to broader issue of institutional & policy design (Angelini et al., 2014, Aoki et al., 2015, Bodenstein et al., 2014, De Paoli and Paustian, 2013)

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    - ATR adds external finance premium (*efp*)
    - FP rule targets *efp* via subsidy on lenders' part. constraint
    - Study how welfare & macro responses to risk shocks differ

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   - Study how welfare & macro responses to risk shocks differ
3. Strategic interaction: Solve for reaction functions in choice of rule elasticities, and for Nash & Cooperative equilibria
   - Different payoffs (variance loss functions) v. common payoff

Results

1. Tinbergen's rule is quantitatively relevant
   - ATR yields a 15% welfare loss & much larger responses to risk shocks relative to DRR
   - Tight money-tight credit with ATR (MP responds too much to π and not enough to *efp*)
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    - Nonlinear reaction curves (strategic substitutes v. complements)

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2. Reaction functions show strong spillovers between MP and FP
   - Nonlinear reaction curves (strategic substitutes v. complements)
3. Large costs of strategic interaction
   - Nash yields 7.3% loss relative to First Best, 6% v. symmetric Coop.
   - Tight money-tight-credit in Nash or Coop. relative to First Best
   - Standard Taylor rule is inferior even to Nash (25% welfare loss)
   - Coop. eq. with 87% bias for FP approximates First Best (0.03% loss)

Model structure

- New Keynesian block (Calvo pricing)
  - Households work, consume and save with financial intermediary ▸ HHs
  - Investment adjustment costs lead to a variable price of capital ▸ Q
  - Nominal price rigidities cause **inefficient output fluctuations** ▸ Firms
- Financial block (BGG with risk shocks)
  - Entrepreneurs use external financing, engage in risky projects
  - Risk shocks: Shocks to variance of entrpreneurs' project returns
  - Monitoring costs yield **inefficient fluctuations of credit and output** ▸ Financial block
- Policy rules
  - MP: simple Taylor rule, nom. interest rate (R) reacts to π
  - FP: financial subsidy/tax (τ_f) reacts to *efp*
  - Calibrated to remove steady-state effects of sticky prices and costly monitoring (focus only on stabilizing inefficient fluctuations)

Financial subsidy in the B-G contract

- Subsidy $\tau_{f,t}$ drives a wedge in lender's participation constraint
- Expected return on loans across entrepreneurs must be at least as large as returns paid on deposits, for each realization of r^k_{t+1}

$$\left[\Gamma(\bar{\omega}_{t+1}) - \mu G(\bar{\omega}_{t+1})\right] r^k_{t+1} q_t k_t (1 + \tau_{f,t}) \geq r_t b_t,$$

where

$$\Gamma(\bar{\omega}_{t+1}) r^k_{t+1} q_t k_t = \text{expected gross gains from loans}$$

$$\mu G(\bar{\omega}_{t+1}) r^k_{t+1} q_t k_t = \text{expected monitoring costs}$$

$$r_t b_t = \text{return paid on deposits}$$

Credit market equilibrium

- Standard demand for credit (capital) from diminishing mpk
- Optimal contract determines *efp* and supply of credit (capital)

$$\mathrm{E}_t\left\{\frac{r^k_{t+1}}{r_t}\right\} = s\left(\underset{(+)}{\frac{q_t k_t}{n_t}}; \underset{(+)}{\sigma_{\omega,t}}\right)\frac{1}{1+\tau_{f,t}},$$

- *efp* rises with leverage because entrepreneurs' prob. of default rises.
- *efp* rises with $\sigma_{\omega,t}$, because more entrepeneurs are likely to default.
- *efp* > 1 is a financial wedge that makes allocation of capital inefficient (the larger the wedge, the bigger the misallocation).

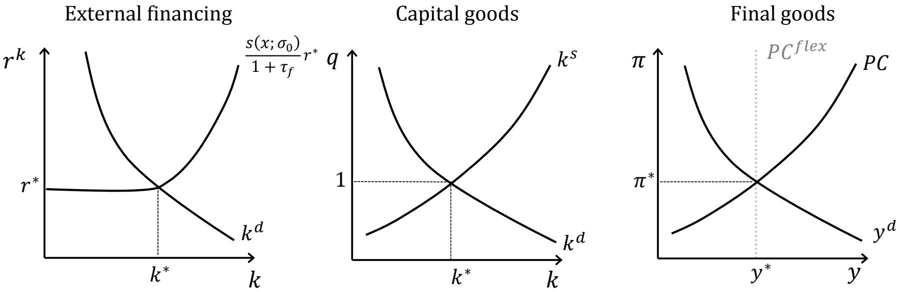
Effects of policies on financial wedge

- Rewrite *efp* condition:

$$\mathrm{E}_t\left\{r_{t+1}^k\right\}\mathrm{E}_t\left\{1+\pi_{t+1}\right\} = s\left(\frac{q_t k_t}{n_t};\sigma_{\omega,t}\right)\frac{1}{1+\tau_{f,t}}R_t$$

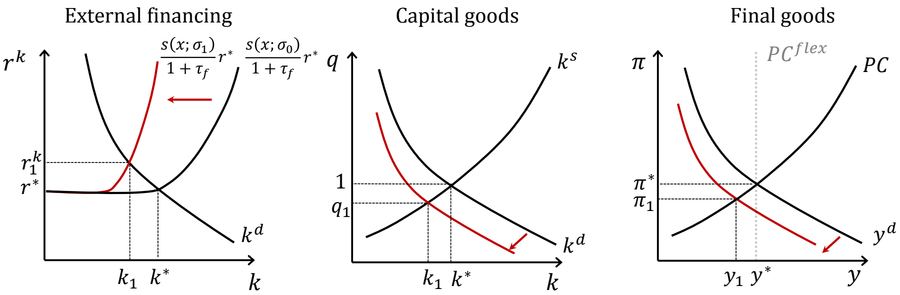
- $\uparrow \tau_{f,t}$ or $\downarrow R_t$ reduce *efp* directly (MP affects financial conditions)
- Indirect effects via $\mathrm{E}_t\left\{1+\pi_{t+1}\right\}$ and $s(\cdot)$
- MP also has direct effects on goods market via NK transmission operating through households' intertemporal choices (i.e. it is "more powerful")

Steady-state equilibrium



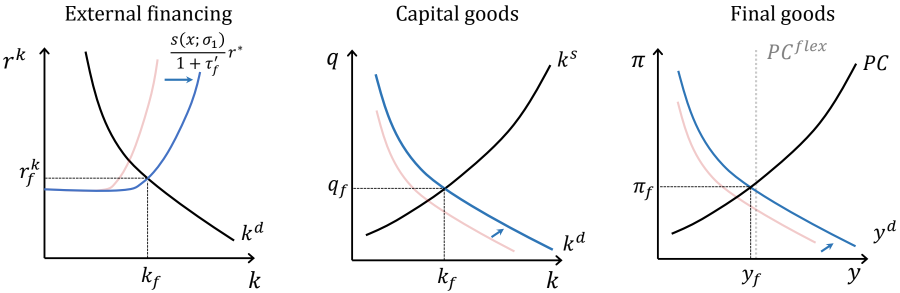
- Credit market: k^* such that $s\left(\frac{qk}{n}\right)\frac{1}{1+\tau_f} = 1$
- Investment market: k^* such that $q = 1$
- Goods market: y^* such that π is at its target

A positive risk shock



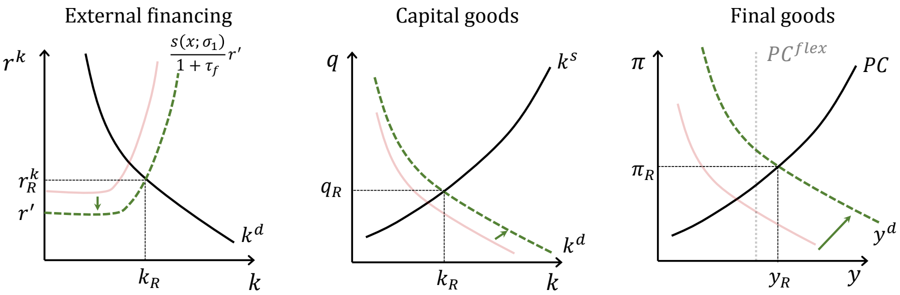
- Higher $\sigma_{\omega,t}$ shifts *efp* curve to the left, increasing r^k capital returns,
- ...which reduces demand for capital goods (investment),
- ...which causes a fall in aggregate demand, reducing inflation.

Responding with financial policy



- Higher financial subsidy relaxes lender's participation constraint,
- ...which shifts *efp* curve to the right, reducing r^k towards target
- ...which increases investment and aggregate demand,
- ...increasing inflation towards initial equilibrium

Responding with monetary policy



- Cut in R is similar to higher τ_f, causing fall in r^k, higher investment and agg. demand
- But lower r boosts consumption too, causing stronger push on demand and inflation
- Since MP is neutral with flexible prices, nominal rigidities increase MP's trade-off between price and financial stability

Calibration

- Quarterly frequency, U.S. data, 1981-2010
- DSGE parameters from Christiano et al. (2014)
- BG parameters from BGG (1999)
- Risk shocks from Lambertini et al. (2017), which has same mean variance as BGG with 0.9 persistence of risk shocks
- Constants of policy rules set to neutralize steady-state effects of nominal rigidities and costly monitoring

Quantitative relevance of Tinbergen's rule

- Augmented Taylor Rule:

$$R_t = R\left(\frac{1+\pi_t}{1+\pi}\right)^{a_\pi}\left(\mathrm{E}_t\left\{\frac{r^k_{t+1}}{r_t}\right\}\right)^{-\check{a}_{rr}}$$

  - Negative spread coefficient$\rightarrow$ higher spread calls for lower R_t

- "Optimized" elasticities that maximize social welfare

$$a_\pi{}^* = 1.25, \check{a}^*_{rr} = 0.26$$

- Questions:
  1. How does ATR compare relative to DRR in terms of welfare?
  2. How do the regimes compare in terms of macro effects of risk shocks?
  3. How does price flexibility affect $\check{a}^*_{rr}$?

Comparing ATR v. DRR

- Compare ATR v. DRR, which has these separate rules:

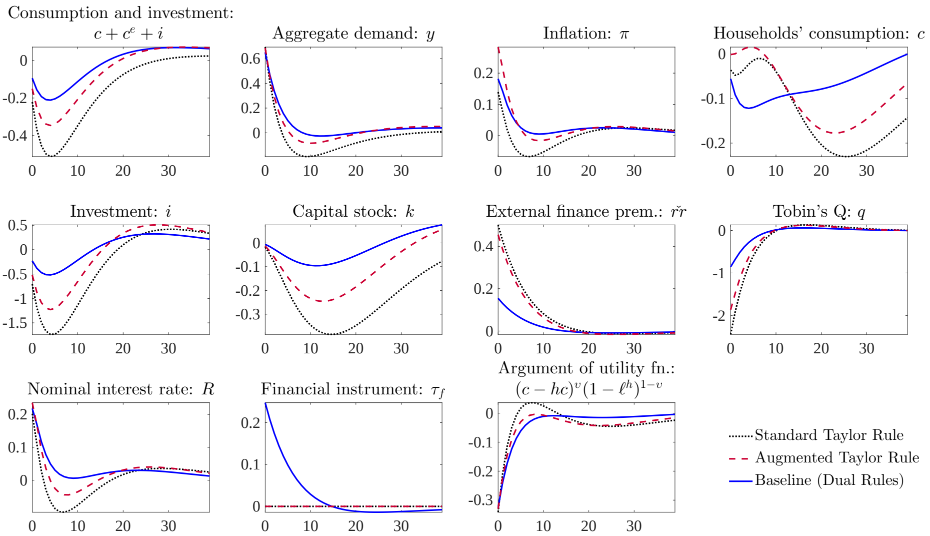
$$R_t = R\left(\frac{1+\pi_t}{1+\pi}\right)^{a_\pi} \qquad \tau_{f,t} = \tau_f\left(\mathrm{E}_t\left\{\frac{r^k_{t+1}}{r_t}\right\}\right)^{a_{rr}}$$

- Compute welfare costs for sets of $(a_\pi, \check{a}_{rr})$ and (a_π, a_{rr}), and find "optimized" (welfare-maximizing) pairs
- Optimized (a_π, a_{rr}) define "First Best" (DRR elasticities that maximize social welfare)

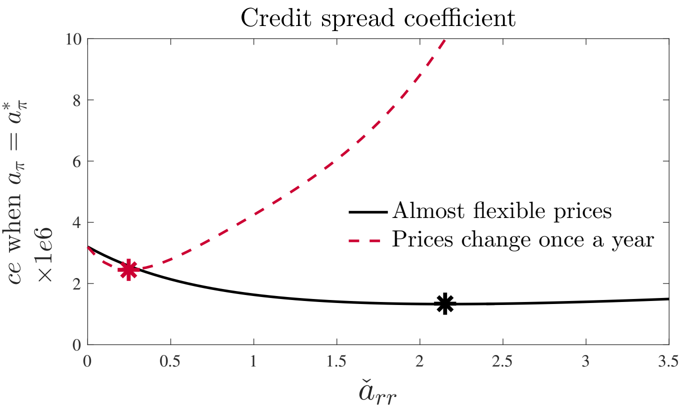
Welfare & elasticities in alternative regimes

Regime x *v.* regime y	% diff. in *ce*	Param. values of regime x a_π	a_{rr}	$\check{a}_{rr}$
	(payoff is welfare)			
DRR *v.* First best	0%.	1.22	1.56	-
ATR *v.* DRR	14.7%	1.25	-	0.26
Standard Taylor rule *v.* DRR	34.5%	1.45	-	-
Standard Taylor rule *v.* ATR	17.3%	1.45	-	-

Risk shock IRFs: ATR, DRR & Taylor rule



Price stickiness & welfare costs of ATR



- Responding to *efp* always better than not ($\check{a}_{rr}^*$ is always positive)
- But $\check{a}_{rr}^*$ falls sharply as stickiness rises (pricing inefficiencies relatively stronger than financial wedge)

Games with different payoffs

- Payoffs defined by "quadratic" (variance) loss functions: sum of variances of target and instrument, as in Williams (2010)
- MP chooses a_π for given a_{rr} so as to minimize

$$L_{CB} = Var(\pi_t) + Var(R_t)$$

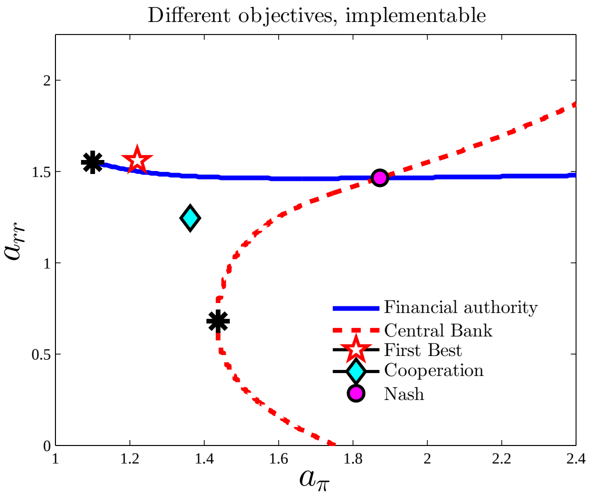
- FP chooses a_{rr} for given a_π so as to minimize

$$L_F = Var(r_t^k / r_t) + Var(\tau_{f,t})$$

- Cooperative planner chooses a_{rr},a_π so as to minimize weighted sum of individual payoffs (for weights that yield Pareto improvements)

$$L_{coop} = \varphi L_{CB} + (1 - \varphi) L_F$$

Reaction curves & equilibria: Different payoffs



- a_{rr} always SS for a_π, but a_π is SS for low a_{rr} and SC otherwise

Welfare & elasticities

Regime x *v.* regime y	% diff. in *ce*	Elasticities of regime x a_π	a_{rr}
(payoffs are quadratic loss functions, except for the first best)			
Nash *v.* First best	7.3%	1.87	1.47
Cooperative ($\varphi = 0.5$) *v.* First best	1.3%	1.37	1.25
Cooperative (optimal φ) *v.* First best	$\frac{3}{100}$%	1.22	1.45
Standard Taylor rule *v.* Nash	25.3%	1.45	-

Note: Optimal φ is the value that yields a Cooperative equilibrium with different payoffs that yields thehighest social welfare, which is attained with $\varphi = 0.13$.

Conclusions

- Costly policy coordination failure due to MP-FP interactions in NK-DSGE model with financial frictions & risk shocks
- Tinbergen's rule is relevant: 15% welfare cost under ATR relative to DRR (but ATR dominates TR), ATR is too tight and yields larger responses to risk shocks
- Large policy spillovers: nonlinear reaction functions with shifts between SS and SC
- Strategic interaction is costly: 6% welfare gains from coordination, but both Nash and Coop. dominate ATR
- ATR, Nash and Coop. equilibria yield policy rules that are too tight relative to First Best

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Households

- Households' objective is to maximize their expected discounted utility subject to their budget constraint, choosing consumption, labor, and deposits:

$$\max_{c_t,\ell_t,d_t} \mathrm{E}_t \left\{ \sum_{t=0}^{\infty} \beta^t \mathcal{U}\left(c_t, \ell_t^h\right) \right\}$$

$$\text{subject to } c_t + d_t \leq w_t \ell_t^h + \frac{R_{t-1}}{1+\pi_t} d_{t-1} - \Upsilon_t + \mathcal{A}_t + \mathrm{div}_t,$$

where

$$\mathcal{U}\left(c_t, \ell_t^h\right) = \frac{\left[\left(c_t - hC_{t-1}\right)^{\upsilon}\left(1-\ell_t^h\right)^{1-\upsilon}\right]^{1-\sigma} - 1}{1-\sigma},$$

- Habits imply that big variations in consumption cause welfare losses

Go back

Entrepreneurs

- Consider a continuum of entrepreneurs indexed by $e \in [0, 1]$
- Each entrepreneur finances capital expenditures with own net worth and **debt**

$$q_t k_{e,t} = n_{e,t} + b_{e,t}$$

- Entrepreneurs rent capital services to firms at rental rate and sell undepreciated capital in the market
- Real gross return of capital from t to $t + 1$ is

$$r^k_{t+1} \equiv \frac{z_{t+1} + (1 - \delta) q_{t+1}}{q_t}$$

Entrepreneurs

- Entrepreneurs' returns are affected by an **idiosyncratic shock** ω_{t+1} $\omega_{e,t+1} \sim \log \mathbb{N}(1, \sigma_{\omega,t})$; at the end of $t+1$ returns are

$$\omega_{e,t+1} r^k_{t+1} q_t k_{e,t}$$

- The loan contract is signed before knowing $\omega_{e,t+1}$ and r^k_{t+1}
- If $\omega_{e,t+1} \geq \bar{\omega}_{e,t+1}$, entrepreneur pays back its debt at rate r^L_{t+1}. Otherwise, she declares bankruptcy
- If the entrepreneur defaults, the lender audits the entrepreneur and gets to keep all of her earnings
- Lender must pay a **monitoring cost,** μ, to observe entrepreneur returns

Lender

- The lender participates if expected returns across ω for each aggregate state equal the returns of the alternative use of funds

$$(1+\tau_t)\left\{\left[\Gamma(\bar{\omega}_{t+1}) - \mu G(\bar{\omega}_{t+1})\right] r^k_{t+1} q_t k_t\right\} \geq r_t b_t,$$

where

- $\Gamma(\bar{\omega}_{t+1}) r^k_{t+1} q_t k_t$ are expected gross gains from the loan
- $\mu G(\bar{\omega}_{t+1}) r^k_{t+1} q_t k_t$ are expected monitoring costs to be paid
- $r_t b_t$ are returns on government bonds
- τ_t is a financial instrument that affects the incentives to lend to entrepreneurs

Equilibrium in credit market

- In equilibrium, the external finance premium (EFP) depends on

$$\mathrm{E}_t \left\{ \frac{r^k_{t+1}}{r_t} \right\} = f(\underset{(+)}{x_t}, \underset{(+)}{\sigma_{\omega,t}}, \underset{(-)}{\tau_t}, \ldots),$$

where $x_t \equiv q_t k_t / n_t$ is a measure of leverage

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  - 1st argument: Usual interpretation, $\downarrow$ net worth implies $\uparrow$ risk
  - 2nd argument: $\uparrow$ uncertainty about investment projects implies $\uparrow$ risk
  - **3rd argument: $\uparrow$ τ_t raises incentives to lend, and thus $\downarrow$ the EFP**

- The EFP measures the importance of the financial wedge; the larger the ratio, the bigger the wedge

Equilibrium in credit market

- The BGG model, as others with agency costs, implies too little credit in the economy due to information asymmetries

$$\frac{r^k}{r} = f(x, \sigma_\omega, \tau, ...) \geq 0$$

- Without financial frictions ($\mu = 0$), returns on capital and bonds equalize, $r^k = r$

- With financial frictions and without financial intervention ($\mu > 0$ and $\tau = 0$), there is a lower capital stock in equilibrium and $r^k > r$

- **An optimal financial policy aims at minimizing the financial wedge, r^k/r, eliminating the distortions created by information asymmetries**

Entrepreneurs

In General Equilibrium

- Entrepreneurs offer one unit of labor each period and earn the wage w_t^e
- With probability $1-\gamma$ an entrepreneur leaves the economy. They are replaced in same numbers, so that aggregate net worth is

$$n_t = \gamma \nu_t + w_t^e,$$

where ν_t is entrepreneurs' equity:

$$\nu_t = r_t^k q_{t-1} k_{t-1} \left[1 - \mu G(\bar{\omega}_t)\right] - r_{t-1} b_{t-1} \frac{1}{1+\tau_t}$$

- Exiting entrepreneurs consume part of their equity

$$c_t^e = (1-\gamma)\varrho \nu_t,$$

while the rest is transferred to households as a lump sum

Entrepreneurs

- The idiosyncratic shock, ω_{t+1}, is an i.i.d. random variable across time and types, with a continuous and once-differentiable c.d.f., $F(\omega)$, with $E(\omega) = 1$ and $Var(\omega) = \sigma_{\omega,t}$

Entrepreneurs

- The idiosyncratic shock, ω_{t+1}, is an i.i.d. random variable across time and types, with a continuous and once-differentiable c.d.f., $F(\omega)$, with $E(\omega) = 1$ and $Var(\omega) = \sigma_{\omega,t}$
- The only source of fundamental shocks in the economy is given by a time varying distribution in the returns of investment projects
- A $\uparrow \sigma_{\omega,t}$ implies that the distribution widens, so a larger proportion of entrepreneurs may default

Entrepreneurs

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- A $\uparrow \sigma_{\omega,t}$ implies that the distribution widens, so a larger proportion of entrepreneurs may default
- **Risk shocks:**

$$\log(\sigma_{\omega,t}) = (1-\rho)\log(\sigma_{\omega}) + \rho\log(\sigma_{\omega,t-1}) + \varepsilon_t$$

- ε_t has the usual interpretation of an unexpected shock

Entrepreneurs

- The idiosyncratic shock, ω_{t+1}, is an i.i.d. random variable across time and types, with a continuous and once-differentiable c.d.f., $F(\omega)$, with $E(\omega) = 1$ and $Var(\omega) = \sigma_{\omega,t}$
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- ε_t has the usual interpretation of an unexpected shock
- Christiano et al. (2014) argue that risk shocks explain more than 60% of the fluctuations in the growth rate of aggregate U.S. output since 1985.

Go back

Capital Producer: Tobin's Q

- Similar to Christiano et al. (2005), we assume investment adjustment costs

$$k_t = (1-\delta)\, k_{t-1} + \left[1 - \frac{\eta}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t$$

where $\eta > 0$ controls size of cost

- Profit maximization by capital producers yields

$$q_t = q\left(i_{t-1}, i_t, \mathrm{E}_t\{i_{t+1}\}; \eta\right)$$

Go back

Firms: technology

- A perfectly competitive firm combines a continuum of intermediate goods, $y_{j,t}$ for $j \in [0,1]$ to produce the final good, y_t
- Each $y_{j,t}$ is produced by a single monopolistic firm using the technology $y_{j,t} = \ell_{j,t}^{1-\alpha} k_{j,t-1}^{\alpha}$
- Each period, with probability $1 - \gamma_p$, firm j re-optimizes its price by solving

$$P_{j,t}^{\star} \in \arg\max_{P_{j,t}} \mathrm{E}_t \sum_{T=t}^{\infty} (\beta\gamma_p)^{T-t} \varphi_{t,T} \left[\frac{\iota_{t,T} P_{j,t}}{P_T} y_{j,t,T} - (1+\tau_p) s_T y_{j,t,T} \right],$$

$$\text{subject to } y_{j,t,T} = \left(\frac{\iota_{t,T} P_{j,t}}{P_T} \right)^{-\theta_p} y_T,$$

where $\iota_{t,T}$ is a price indexation rule.

Firms: technology

- Nominal rigidities imply an efficiency cost because of price dispersion

- At the aggregate level, the production function is

$$y_t = \frac{1}{\Delta_t} \left(k_{t-1}\right)^{\alpha} \left(\ell_t\right)^{1-\alpha}$$

where $\Delta_t \equiv \int_0^1 \left(\frac{P_{j,t}}{P_t}\right)^{-\theta} dj \geq 0$

- **An optimal monetary policy aims at minimizing the efficiency wedge given by Δ_t**

Go back

Policy and equilibrium

- Monetary Policy

$$R_t = R\left(\frac{1+\pi_t}{1+\pi}\right)^{a_\pi}$$

- Macroprudential Policy

$$1+\tau_t = (1+\tau)\left(\frac{\mathrm{E}_t\left\{r^k_{t+1}/r_t\right\}}{r^k/r}\right)^{a_{rr}}$$

- In what follows, we set τ such that $r^k/r = 1$ in the steady state, even when there are financial frictions

- Resource constraint

$$\frac{1}{\Delta_t}\left(k_{t-1}\right)^\alpha\left(\ell_t\right)^{1-\alpha} = c_t + i_t + c^e_t + g_t + \mu G(\bar{\omega}_{e,t}) r^k_t q_{t-1} k_{t-1}$$

Go back

Calibration parameters

Preferences and technology		
β	Subjective discount factor	0.99
σ	Coefficient of relative risk aversion	1.00
υ	Disutility weight on labor	0.06
h	Habit parameter	0.85
α	Capital share in production function	0.40
δ	Depreciation rate of capital	0.02
η	Investment adjustment cost	10.78
$\bar{g}$	Steady state government spending-GDP ratio	0.20
ϑ_p	Price indexing weight	0.10
ϑ	Calvo price stickiness	0.74
θ	Elasticity of demand for intermediate goods	11.00
Financial sector		
$1-\varrho$	Transfers from failed entrepreneurs to households	0.01
γ	Survival rate of entrepreneurs	0.98
Ω	Share of households' labor on total labor	0.98
$\bar{\sigma}_\omega$	Standard error of idiosyncratic shock	0.27
ρ_{σ_ω}	Persistence of risk shock	0.89

Optimal financial policy in the steady state

	BGG	No Finan Fric	BGG + τ
Habits h	0.85	0.85	0.85
Investment Adj. Costs η	10.78	10.78	10.78
Interest Rate R	4.04	4.04	4.04
Return on Capital R_k	6.05	4.04	4.04
EFP r^k/r	2.00	0.00	0.00
Leverage x	2.00	13.50	2.20
Default Rate	3.00	-	7.81
Monitoring Cost μ	0.12	0.00	0.12
Macroprudential Policy τ	0.00	0.00	0.01
Consumption over Output $\frac{c}{y}$	0.55	0.52	0.50
Investment over Output $\frac{i}{y}$	0.25	0.28	0.28
Output over Efficient Output $\frac{y}{y_{nf}}$	0.91	1.00	1.00
Consumption equivalence (welfare costs)	0.11	0.00	0.00

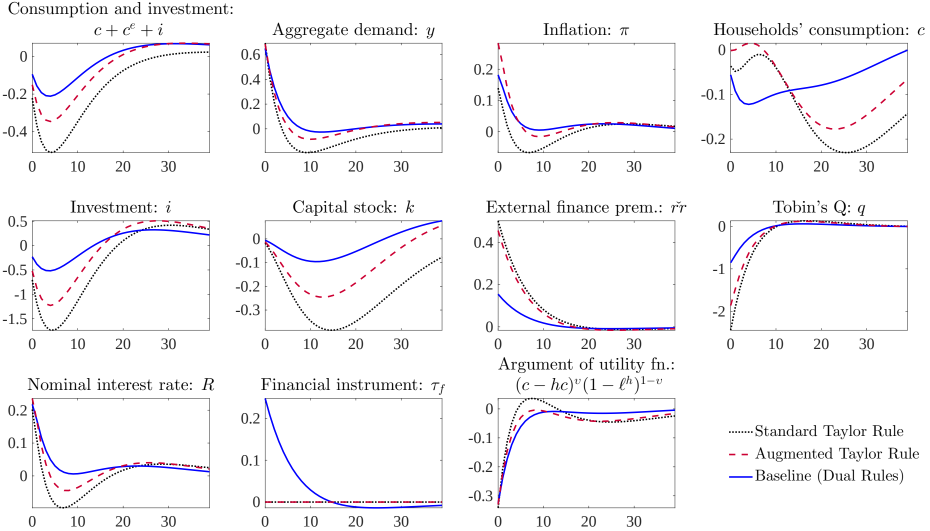
Table: Non-stochastic steady state

Go back

Are 2 instruments better than 1?

Go back

- IRFs are smoother with 2 instr. than with 1 (optimal parameters)



Quantitative analysis: Strategic interaction

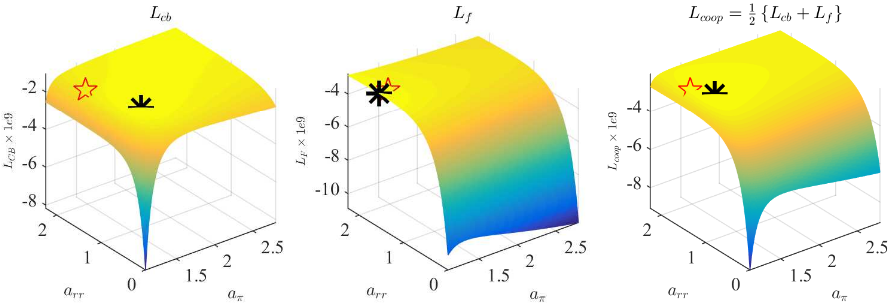
- With a common payoff function, Cooperative outcome is sustained even if authorities do not cooperate
- With different payoffs, the Cooperative outcome is not sustainable, because MP and/or FP acting unilaterally deviate

Quantitative analysis: Strategic interaction

- With a common payoff function, Cooperative outcome is sustained even if authorities do not cooperate
- With different payoffs, the Cooperative outcome is not sustainable, because MP and/or FP acting unilaterally deviate
- Quantitative strategy:
  - Compute reaction curves for a strategy space defined over (a_{π}, a_{rr}) pairs: MP (FP) picks "best" a_{π} (a_{rr}) for a given a_{rr} (a_{π})
  - Solve two types of one-shot games:
    1. Noncooperative (Nash): Intersection of reaction functions
    2. Cooperative: a_{π}, a_{rr} max. weighted sum of MP and FP payoffs
  - Alternative payoff functions
    1. Different: Individual variance loss functions
    2. Common: Welfare (Coop.$\equiv$ First Best) or common variance loss
  - Games are one-shot, but payoffs depend on full DSGE dynamics

Implementation analysis

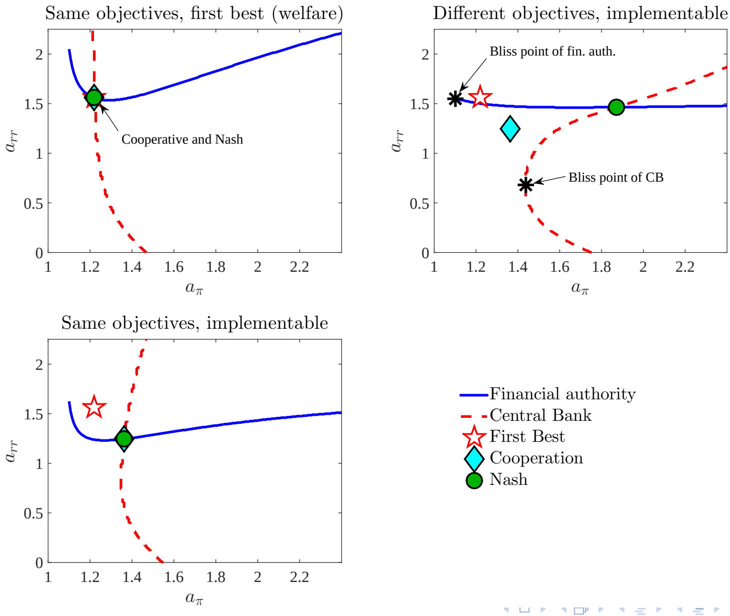
- The losses evaluated at stochastic steady states for the different payoff functions



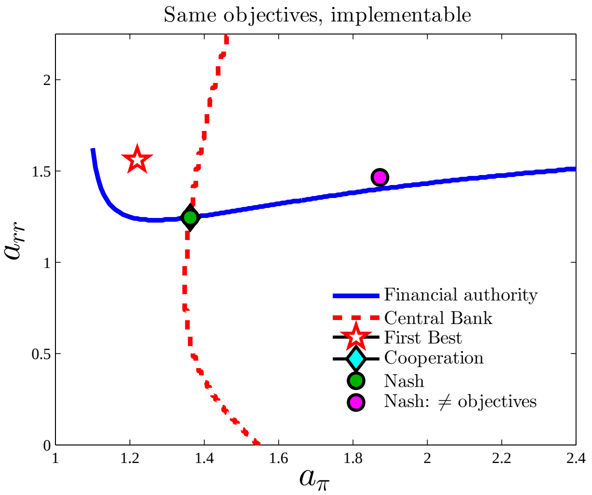
Note: The stars in the figures show the first best (the maximum welfare), while the asterisks are the maximum for each case.

Go back

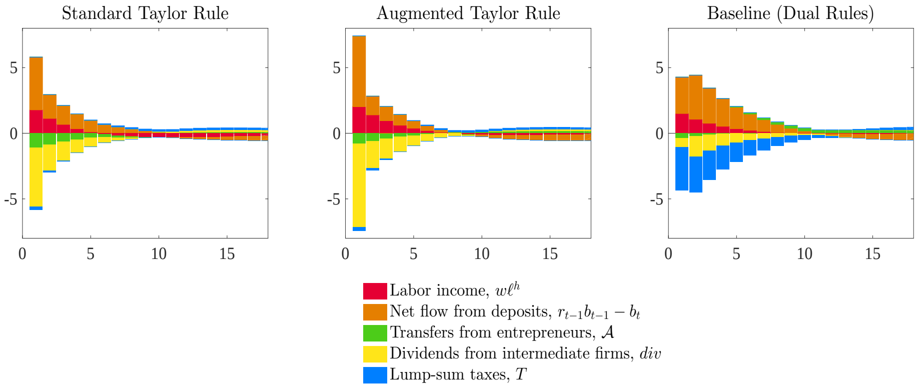
Strategic Interactions



Reaction curves & equilibria: Common Loss payoff



Contributions to Consumption IRF



Note: Sources of disposable income measured as weighted deviations from det. steady state (bars add up to percent deviations of consumption in IRF).