# Tight Money-Tight Credit: Coordination Failure in the Conduct of Monetary and Financial Policies[1]

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[1] The views and conclusions presented herein are exclusively the responsibility of the authors and do not necessarily reflect those of Banco de México or the Inter-American Development Bank.

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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: Is strategic interaction relevant?**
  - MP and FP targets are GE outcomes that depend on both MP and FP
  - Strategic interaction makes non-cooperative regime suboptimal

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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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   - ATR adds external finance premium (*efp*)
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   - Study how welfare & macro responses to risk shocks differ
2. 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 relevant
   - ATR yields a 1.4% welfare loss & much larger responses to risk shocks relative to DRR
   - Tight money-tight credit with ATR (MP responds too much to $\pi$ and not enough to *efp*)
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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 0.3% loss relative to "First Best," 0.25% v. symmetric Coop.
    - Tight money-tight credit in Nash relative to First Best
    - Standard Taylor rule is inferior even to Nash (2.3% welfare loss)
    - Coop. eq. with 77% bias for FP approximates First Best (0.001% loss)

# Intuition

1. Risk shocks affect both spreads and inflation (akin to financial shocks that make BG accelerator more powerful)
2. Response via MP has 1st-order effects on $\pi$ (NK channels) and *efp* (opp. cost of lenders), and FP has 1st-order effects on *efp*
   - Tinbergen's rule applies: FP provides a separate tool to target spreads
3. Policy interactions: In the DSGE setup, $\pi$ and *efp* are eq. outcomes partly determined by both MP and FP instruments
4. Since actions of one policymaker affect the other's target & payoff, standard arguments for strategic interaction apply
   - Depending on the size of each authority's response elasticity, the other's best response can be strategic substitute or complement

# Layout of the presentation

1. Model structure (CMR + FP instrument)
2. Tinbergen's rule: comparison of DRR, ATR and Taylor rule
3. Strategic interaction: reaction curves, comparison of Nash, Coop., and First-Best equilibria
4. Extensions, conclusions, and caveats

# 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 $\pi$
  - FP: financial subsidy/tax ($\tau_f$) reacts to *efp*
  - Constructed to remove steady-state effects of sticky prices and costly monitoring (focus only on stabilizing inefficient fluctuations)

# Financial subsidy in the BG setup

- 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)

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

- *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)
- Similar to Kannan et al. (2012) but derived from optimal contract

# Effects of policies on financial wedge

- Rewrite *efp* condition:

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

- $\uparrow \tau_{f,t}$ or $\downarrow R_t$ reduce *efp* (both FP & MP have 1st-order effects)
- MP is "more powerful" because it also has direct effects on agg. demand and $\pi$ via NK transmission through price dispersion and intertemporal choices
- ...but MP targeting $\pi$ in general cannot simultaneously target *efp*
- Indirect effects via $\mathrm{E}_t\left\{1+\pi_{t+1}\right\}$, $\mathrm{E}_t\left\{r^k_{t+1}\right\}$ and $s(\cdot)$

# Welfare comparisons

- Welfare with policy rule elasticities $a_\pi$, $a_{rr}$, and model parameters $\varrho$:

$$\mathbb{W}\left(a_\pi, a_{rr}; \varrho\right) \equiv \mathrm{E}\left\{\sum_{t=0}^{\infty} \beta^t \mathcal{U}\left(c_t\left(a_\pi, a_{rr}; \varrho\right), \ell_t^h\left(a_\pi, a_{rr}; \varrho\right)\right)\right\}$$

  - Computed using "pruned" 2nd-order approx

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- Welfare reference level $\mathbb{W}\left(a_\pi, a_{rr}; \varrho\right)$ w.o. shocks

- Welfare cost ($ce$) of a given policy regime:

$$\mathbb{W}\left(a_\pi, a_{rr}; \varrho\right) = \mathcal{U}\left(\left(1 + ce\right) c_d, \ell_d^h\right) / \left(1 - \beta\right)$$

  - Welfare in policy regime $x$ v. $y$ is $ce^x - ce^y$

# Calibration

- Quarterly frequency, U.S. data, 1981-2010
- DSGE parameters from CMR
- BG parameters from BGG
- Risk shocks from CMR
- Constants of policy rules set to neutralize steady-state effects of nominal rigidities and costly monitoring

# Quantitative relevance of Tinbergen's rule

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- Dual Rules Regime (DRR):

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

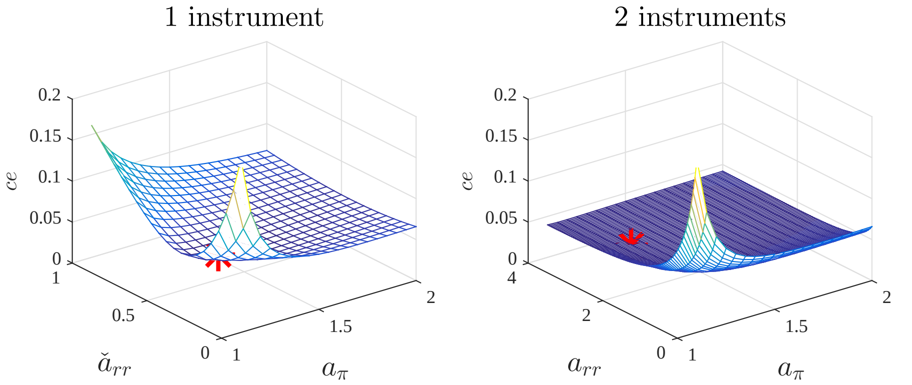
# Comparing policy regimes

- Compute welfare costs for sets of $(a_\pi)$, $(a_\pi, \check{a}_{rr})$ and $(a_\pi, a_{rr})$, and find "optimized" elasticities (i.e. values of elasticities that yield min. welfare cost)
- We label the optimized DRR as the "First Best" (it yields the lowest welfare cost of all the regimes we examined)
- Questions:
  1. How do TR, ATR, and DRR compare in terms of welfare?
  2. How do the regimes compare in terms of macro effects of risk shocks?
  3. How does price flexibility affect $\check{a}^*_{rr}$?

# Welfare & elasticities in alternative regimes

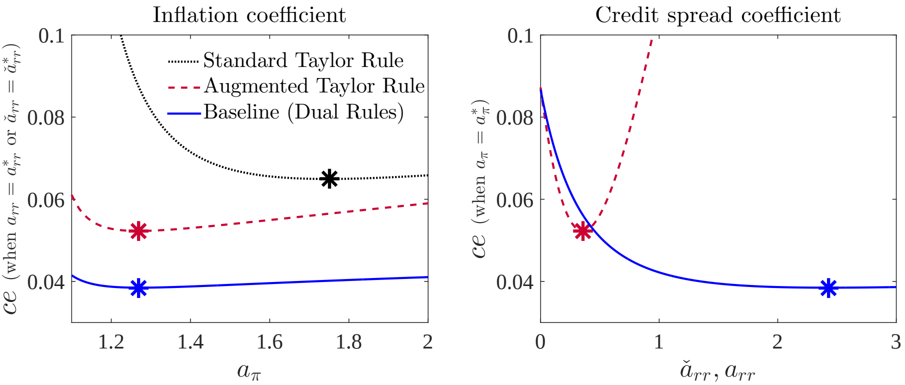
| Regime $x$ *v.* regime w.o. shocks | % diff. in *ce* | Param. values of $x$ | | |
|---|---|---|---|---|
| | | $a_\pi$ | $a_{rr}$ | $\check{a}_{rr}$ |
| DRR (First Best) | 3.85% | 1.27 | 2.43 | - |
| ATR *v.* DRR | 5.23% | 1.27 | - | 0.36 |
| Standard Taylor rule | 6.49% | 1.75 | - | - |

# Surface plot of welfare costs: ATR v. DRR




*Note:* The asterisks identify the optimized elasticities.

# Welfare interactions




- Welfare costs as a function of each elasticity keeping the other at its optimized value
- Stronger interactions with ATR

# Quantitative analysis: Strategic interaction

- With a common payoff, Cooperative & Nash outcomes are equal by construction, so Coop. eq. can be sustained without coordination
- With different payoffs, the Cooperative outcome is not sustainable, because MP and/or FP acting unilaterally deviate

# Quantitative analysis: Strategic interaction

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- 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 ($a_\pi$,$a_{rr}$): MP (FP) picks "best" $a_\pi$ ($a_{rr}$) for a given $a_{rr}$ ($a_\pi$)
  - Solve three types of games:
    1. Noncooperative (Nash): Intersection of reaction functions
    2. Cooperative: $a_\pi$, $a_{rr}$ max. weighted sum of MP and FP payoffs
    3. Stackelberg: either MP or FP leads
  - Games are one-shot, but payoffs depend on full DSGE dynamics

# Games with individual payoffs

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

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

- FP chooses $a_{rr}$ for given $a_\pi$ so as to minimize

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

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

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

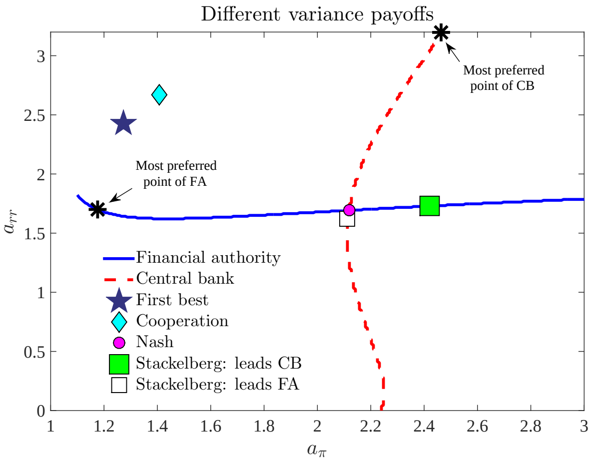
# Games with common payoff

- With welfare as common payoff, each authority chooses its policy rule elasticity so as to maximize expected lifetime utility (identical to optimized DRR by construction)

- With a common loss function, each authority chooses its policy rule elasticity to minimize:

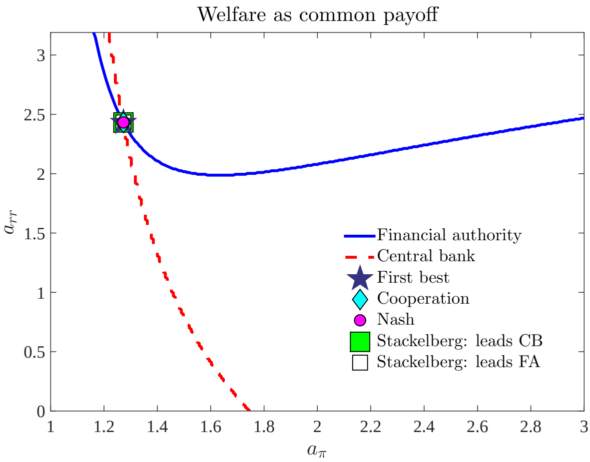
$$\tilde{L}_{CB} = \tilde{L}_F = Var(\pi_t) + Var(R_t) + Var(r_t^k / r_t) + Var(\tau_{f,t})$$

# Reaction curves & equil.: Diff. payoffs



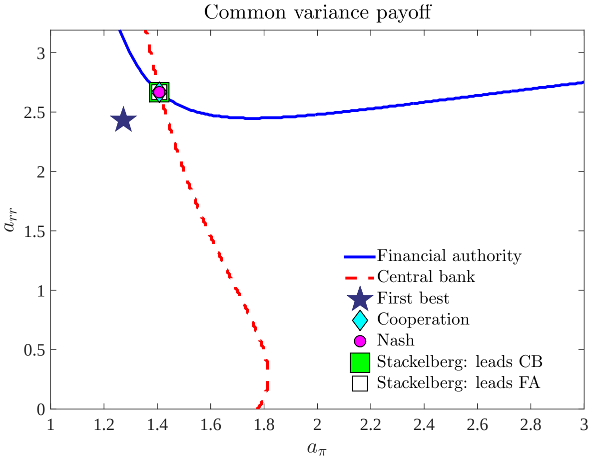

- $a_{rr}$ SS for low $a_{\pi}$ and SC for high $a_{\pi}$
- $a_{\pi}$ is SC for low $a_{rr}$, then SS, and SC again for high $a_{rr}$

# Reaction curves & equil.: Welf. as payoff




- $a_\pi$ always SS for $a_{rr}$, but $a_{rr}$ is SS for low $a_\pi$ and SC otherwise

# Reaction curves & equil.: Comm.Loss payoff



# Welfare & elasticities

| Regime $x$ *v.* regime $y$ | % diff. in $ce$ | Param. values of $x$ | |
|---|---|---|---|
| | | $a_{\pi}$ | $a_{rr}$ |
| Nash *v.* FB | 0.30% | 2.12 | 1.69 |
| Cooperative ($\varphi = 0.5$) *v.* FB | 0.04% | 1.41 | 2.67 |
| Cooperative (optimal $\varphi$) *v.* FB | 0.01% | 1.33 | 2.10 |
| Standard Taylor rule *v.* Nash | 2.34% | 1.75 | - |

*Note*: Optimal $\varphi$ is the value that yields a Cooperative equilibrium with the highest social welfare, which is attained with $\varphi = 0.23$.

# Extensions & robustness checks

1. **TFP, gov. exp. and mark-up shocks**: $a_{\pi}^{*}$ rises to around 2.25 in all three, but $a_{rr}^{*} = 0$ for TFP, G shocks v. 2.5 for mark-up shocks ($\pi$ and $y$ move in opposite directions), Nash has tighter money & credit

2. **Added output gap to Taylor rule and ATR**: setting output elasticity around zero is optimal

3. **FP rules that target credit or leverage**: 1st-order equivalence, and with 2nd order, Coop. outcomes nearly identical while Nash yields smaller $a_{\pi}$ and nearly identical $a_{rr}$, similar SS/SC shifts

4. **"Stickier" prices:** Nash has similar $a_{rr}$ and SS/SC shifts, higher $a_{\pi}$

# Conclusions

1. Costly policy coordination failure due to MP-FP interactions in NK-DSGE model with financial frictions & risk shocks
2. Tinbergen's Rule is relevant: 1.4% welfare cost under ATR relative to DRR (but ATR dominates TR), ATR is too tight and yields larger responses to risk shocks
3. Large policy spillovers: reaction functions show SS/SC shifts
4. Strategic interaction is costly: 0.25% welfare gains from coordination, but both Nash and Coop. dominate ATR
5. ATR, Nash, and Coop. equilibria yield policy rules that are too tight relative to First Best (DRR)
6. Cooperation with 77% weigh on FP approximates First Best

# Limitations & caveats

1. *Local analysis* (2nd order, pruned): missing strong convexity of *efp*, prec. savings effects, nonlinear crisis dynamics
2. *Financial, not macroprudential, policy*: missing pre-emptive prudential role, ex-ante incentives & pecuniary externalities
3. *Closed economy*: few open-economy studies (e.g. Aoki et al. (2016)), this would add extra dimensions of coordination failure
4. *Simple financial intermediation*: idiosyncratic shocks only, representative, risk-neutral intermediary, standard banking
5. *"Classic" rational expectations*: no role for optimistic/pessimistic beliefs (costly monitoring is the only informational friction)

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**Yellen, Janet**, "Monetary Policy and Financial Stability," Technical Report, Board of Goverments of the Federal Reserve System July 2014.

# Related New Keynesian DSGE literature

1. *Comparisons of Taylor v. ATRs*: Angeloni and Faia (2013), Angelini et al. (2014), Kannan et al. (2012) and Quint and Rabanal (2014)–ATRs are better, abstracting from strategic interaction
2. *MP/FP spillovers at different elasticities*: Aoki et al. (2016)–large welfare spillovers as elasticities change, in line with our finding of SC/SS shifts –not focusing on Tinbergen's rule or strategic interaction
3. *Comparisons of cooperative v. noncooperative MP/FP*: Angelini et al. (2014), Bodenstein et al. (2014), De Paoli & Paustian (2017), Van der Ghote (2016)–not examining reaction curves (strategic substitutes/complements), tend to find small gains from coordination

# 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** $\omega_{t+1}$ $\omega_{e,t+1} \sim \log \mathbb{N}(1, \sigma_{\omega,t})$; 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,** $\mu$, to observe entrepreneur returns

# Lender

- The lender participates if expected returns across $\omega$ 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
- $\tau_t$ 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

  - 1st argument: Usual interpretation, $\downarrow$ net worth implies $\uparrow$ risk
  - 2nd argument: $\uparrow$ uncertainty about investment projects implies $\uparrow$ risk
  - **3rd argument: $\uparrow$ $\tau_t$ 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 $\nu_t$ 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, $\omega_{t+1}$, 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
- **Risk shocks:**

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

- $\varepsilon_t$ 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 $\Delta_t$**

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 $\tau$ such that $r^k/r = 1$ in the steady state, even when there are financial frictions

- Resource constraint

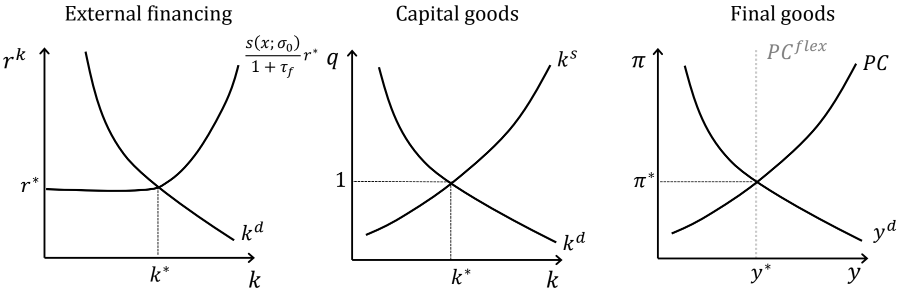
$$\frac{1}{\Delta_t}\left(k_{t-1}\right)^{\alpha}\left(\ell_t\right)^{1-\alpha} = c_t + i_t + c^e_t + g_t + \mu G(\bar{\omega}_{e,t}) r^k_t q_{t-1} k_{t-1}$$

Go back

# Diagrammatic Analysis

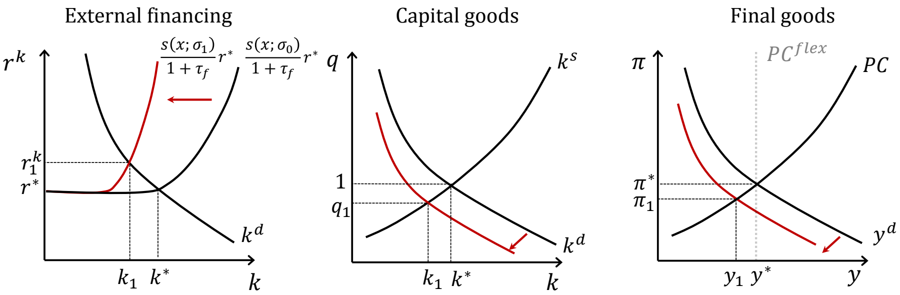
- One-period snapshot to show effects of risk shocks & policy responses
- **Credit (entrepreneurs' capital) market**
  - **S:** External Finance Premium, efp: $r^k_{t+1} = s\left(\frac{q_t k_t}{n_t}\right)\frac{1}{1+\tau_{f,t}} r_t$.
  - **D:** Credit demand, $k^d$: $r^k_{t+1} = \left[mpk_{t+1} + q_{t+1}(1-\delta)\right]/q_t$.
- **Capital goods market**
  - **S:** Tobin's Q, $k^s$: $q_t = q\left(k_t, i_t, i_{t+1}\right)$.
  - **D:** Demand for capital, $k^d$: $q_t = \left[mpk_{t+1} + q_{t+1}(1-\delta)\right]/r^k_{t+1}$.
- **Final goods market (ignoring monitoring costs)**
  - **S:** Phillips curve, $PC$: $\pi_t = \pi\left(mc_t, \pi_{t+1}\right)$.
  - **D:** Aggregate demand, $y^d$: $y_t = c_t + i_t$.

# Steady-state equilibrium



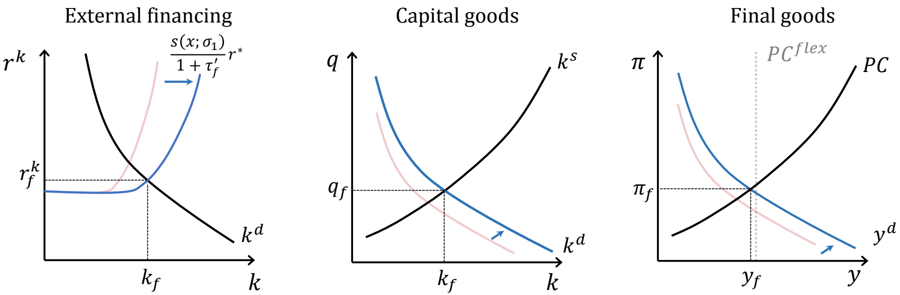

- Credit market: $k^*$ such that $s\left(\frac{qk}{n}\right)\frac{1}{1+\tau_f} = 1$
- Investment market: $k^*$ such that $q = 1$
- Goods market: $y^*$ such that $\pi$ is at its target

# A positive risk shock



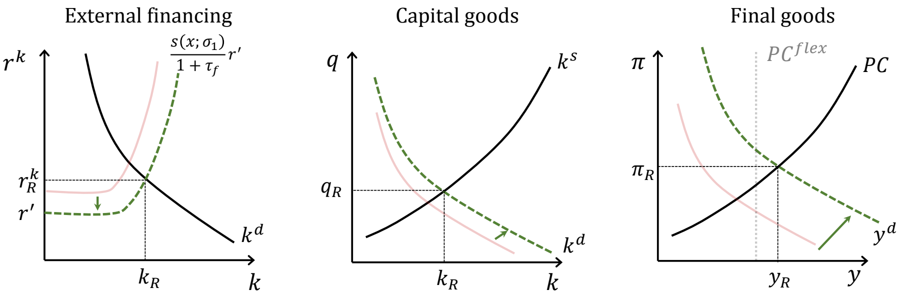

- Higher $\sigma_{\omega,t}$ shifts *efp* curve to the left, increasing $r^k$ capital returns,
- ...which reduces demand for capital goods (investment),
- ...which causes a fall in aggregate demand, reducing inflation.

# Responding with financial policy



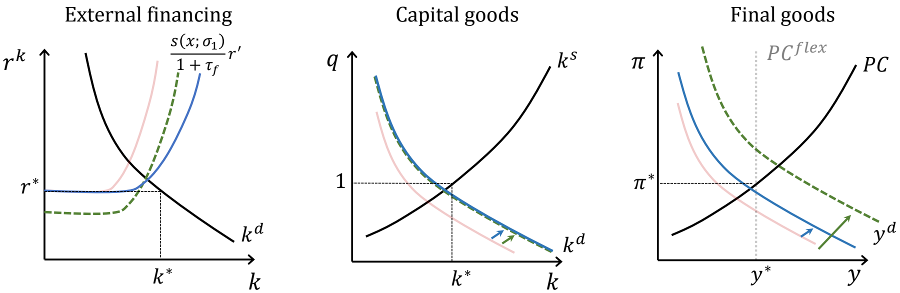

- Higher financial subsidy relaxes lender's participation constraint,
- ...which shifts *efp* curve to the right, reducing $r^k$ towards target
- ...which increases investment and aggregate demand,
- ...increasing inflation towards initial equilibrium

# Responding with monetary policy




- Cut in $R$ is similar to higher $\tau_f$, 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

# Risk shock & policy responses




- **Tinbergen's rule:**
  - Augmented MP (reacting to *efp* and $\pi$) better than std. MP (only $\pi$)
  - But separate FP and MP should (weakly) dominate
- **Strategic interaction:**
  - Policy spillovers: FP affects $\pi$, MP affects *efp*
  - Best choice of MP (FP) elasticity given FP (MP) elasticity can be strategic complement or substitute

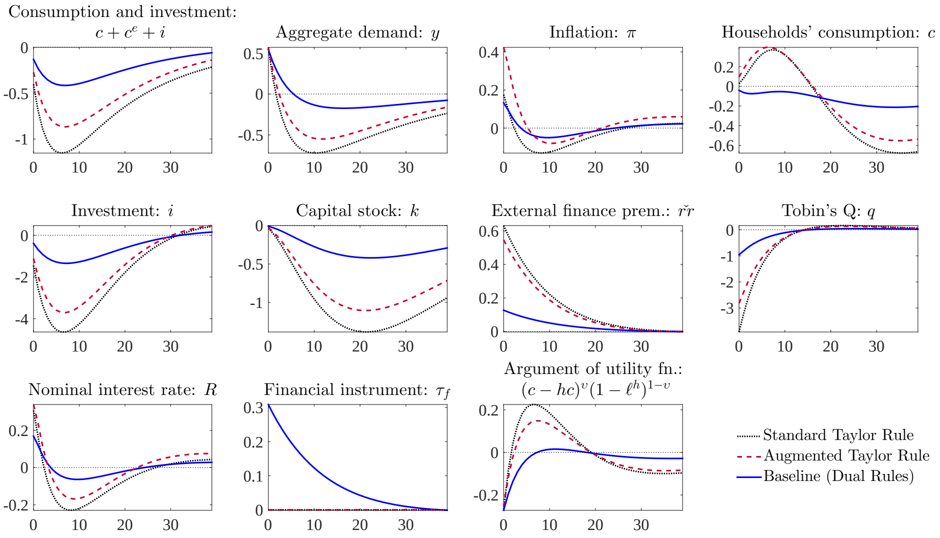
# Calibration

- Quarterly frequency, U.S. data, 1981-2010
- DSGE parameters from CMR(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

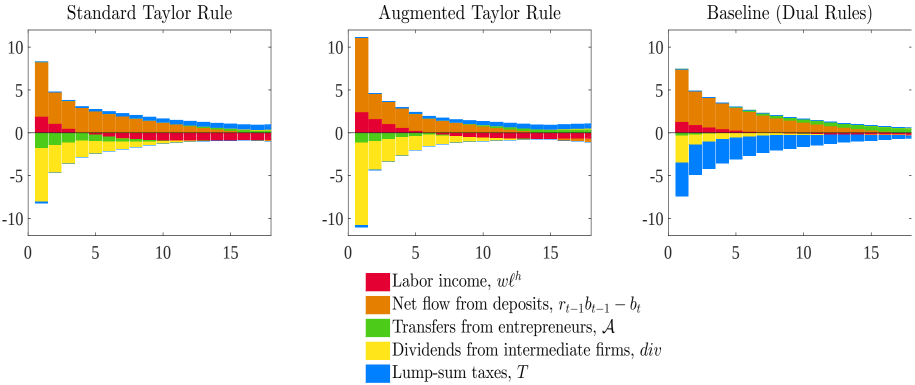
# Calibration parameters

| | | |
|---|---|---|
| *Preferences and technology* | | |
| $\beta$ | Subjective discount factor | 0.99 |
| $\sigma$ | Coefficient of relative risk aversion | 1.00 |
| $\upsilon$ | Disutility weight on labor | 0.06 |
| $h$ | Habit parameter | 0.85 |
| $\alpha$ | Capital share in production function | 0.40 |
| $\delta$ | Depreciation rate of capital | 0.02 |
| $\eta$ | Investment adjustment cost | 10.78 |
| $\bar{g}$ | Steady state government spending-GDP ratio | 0.20 |
| $\vartheta_p$ | Price indexing weight | 0.10 |
| $\vartheta$ | Calvo price stickiness | 0.74 |
| $\theta$ | Elasticity of demand for intermediate goods | 11.00 |
| *Financial sector* | | |
| $1-\varrho$ | Transfers from failed entrepreneurs to households | 0.01 |
| $\gamma$ | Survival rate of entrepreneurs | 0.98 |
| $\Omega$ | Share of households' labor on total labor | 0.98 |
| $\bar{\sigma}_\omega$ | Standard error of idiosyncratic shock | 0.27 |
| $\rho_{\sigma_\omega}$ | Persistence of risk shock | 0.89 |

# Impulse response functions to risk shock



# Why is Consumption smoother with DRR?




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

# Strategic Interactions