Firm Heterogeneity, Capital Misallocation and Optimal Monetary Policy

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2022 Annual Bank of Canada Economic Conference

How does firm heterogeneity affect the optimal conduct of monetary policy

- Firm heterogeneity affects the transmission of monetary policy (e.g. Ottonello and Winberry, 2020; Jeenas, 2019; Koby and Wolf, 2020; Jungherr et al., 2022, ...)
- One particular channel of interest is through changes in the allocation of capital when financial frictions matter (Reis 2013, Gopinath et al 2017, Asriyan et al. 2021,...).
- Which are the implications of firm heterogeneity and financial frictions for the optimal conduct of monetary policy?

What we do: analyze monetary policy in a model with heterogeneous firms and capital misallocation

- Benchmark model to understand the impact of monetary policy on misallocation and endogenous TFP.
  - Standard New Keynesian block.
  - Heterogeneous firms block as in Moll (2014).

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- Benchmark model to understand the impact of monetary policy on misallocation and endogenous TFP.
  - Standard New Keynesian block.
  - Heterogeneous firms block as in Moll (2014).
- New algorithm to solve nonlinearly for Ramsey optimal policies with heterogeneous agents using continuous time.
  - Discretize the continuous time/continuous space problem (Ahn et al, 2018).
  - Compute planner's FOC using symbolic differentiation.
  - Solve non-linear transitional dynamics using Newton algorithm in the sequence space.

What we find

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  - In line with aggregate responses found in the literature (Moran and Queralto, 2018; Baqaee, Farhi and Sangani, 2021; Meier and Reinelt, 2021..), but different mechanism
    - ★ Expansionary monetary policy increases investment of more productive firms relatively more, channeling resources towards high-productivity constrained firms ("misallocation channel")
  - Empirical support for the mechanism based on Spanish firm-level micro data.

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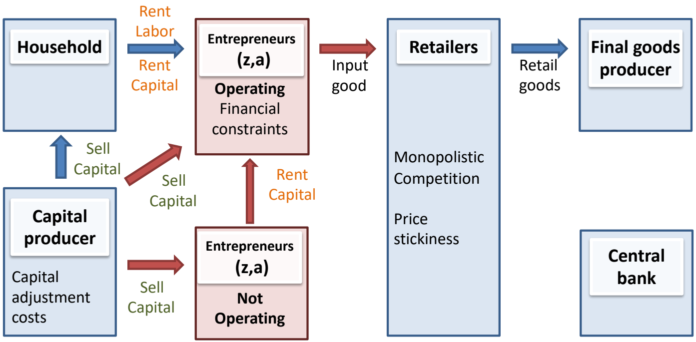
    - ⋆ Expansionary monetary policy increases investment of more productive firms relatively more, channeling resources towards high-productivity constrained firms ("misallocation channel")
  - Empirical support for the mechanism based on Spanish firm-level micro data.
- Optimal monetary policy:
  - Misallocation creates a *time inconsistent* motive to temporarily expand the economy.
  - Timeless response to demand shocks: "divine coincidence" holds...
  - ... but at the ZLB: low for much longer.

Literature Review (non-exhaustive!)

- **Misallocation**. *Hsieh and Klenow (2009, 2014)*, *Restuccia and Rogerson (2013)*, *Moll (2014)*...
  - Introduce monetary policy in a New Keynesian framework.
- **Monetary policy with firm heterogeneity**. *Ottonello and Winberry (2020)*, *Jeenas (2019)*,*Koby and Wolf (2020)*,*Jungherr et al. (2022)*,*David and Zeke (2022)*...
  - Solve optimal monetary problem.
- **Optimal Monetary Policy with Heterogeneous Agents**. *Acharya, Challe and Dogra (2020)*, *Bhandari et al (2019)*, *Nuño and Thomas (2020)*, *Le Grand, Martin-Baillon, and Ragot (2019)*...
  - Focus on heterogeneous firms.
  - Simple, general computational approach.

Model

The model in a nutshell



- Heterogeneity in entrepreneurs' net worth (a_t) and productivity (follows OU-diffusion process, $dlog(z_t) = -(1/\theta)\ log\ z\ dt + \sigma\ \sqrt{1/\theta}\ dW$;).
- Firms produce the input good using labor (l_t) and capital (k_t) (CRS).
- Entrepreneurs can borrow capital $b_t = k_t - a_t$, subject to a borrowing constraint $k_t \leq \gamma a_t$.

Entrepreneurs maximize the discounted flow of dividends

- Entrepreneurs maximize profits; $\Phi_t(z_t, a_t) = \max_{k_t, l_t}\{m_t f_t(z_t, k_t, l_t) - w_t l_t - R_t k_t\}$; s.t. $k_t \leq \gamma a_t$
- Entrepreneurs can pay dividends d_t or accumulate net worth a_t; they retire at rate η.
- Entrepreneurs are household's members (as in Gertler & Karadi, 2011, unlike Moll, 2014).

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$$V_0(z,a) = \max_{a_t, d_t \geq 0} \mathbb{E}_0 \int_0^\infty e^{-\int_0^t (r_s + \eta) ds} \left(d_t + \overbrace{\eta q_t a_t}^{\text{liquidation value}} \right) dt$$

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s.t.

$$\dot{a}_t q_t + d_t = \underbrace{\left(\overbrace{\max\{\tilde{\Phi}_t(z), 0\}\gamma}^{\text{operating profits}} + \overbrace{\left(\frac{R_t - \delta q_t}{q_t} \right)}^{\text{return on capital}} \right)}_{S_t(z)} q_t a_t$$

$$k_t(z,a) = \begin{cases} \gamma a, & \text{if } z \geq z_t^*, \\ 0, & \text{if } z < z_t^*, \end{cases}$$

$$z_t^* = \frac{R_t}{\alpha \left(\frac{(1-\alpha)}{w_t} \right)^{(1-\alpha)/\alpha} m_t^{\frac{1}{\alpha}}} = \frac{R_t}{\varphi_t}$$

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- Entrepreneurs optimally never distribute dividends until liquidation.
  - Intuition: return of funds inside the firm is always at least the real rate $\left(\frac{R_t - \delta q_t}{q_t}\right)$, and the liquidation value of the firm is all its net worth .

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- New entrepreneurs enter replacing exiting ones.
  - Inherit the same firm (same productivity)
  - Start with lower net worth $\psi q_t a_t$, $0 < \psi < 1$.

Distribution in net worth shares and aggregation

- Entrepreneur's behavior is linear in net worth but nonlinear in productivity.
- Only need the distribution of net worth shares $\omega_t(z) = \frac{1}{A_t}\int_0^\infty a g_t(z,a)da$.

$$\frac{\partial \omega_t(z)}{\partial t} = \left[s_t(z) - \frac{\dot{A}_t}{A_t} - (1-\psi)\eta\right]\omega_t(z) - \frac{\partial}{\partial z}\mu(z)\omega_t(z) + \frac{1}{2}\frac{\partial^2}{\partial z^2}\sigma^2(z)\omega_t(z)$$

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- Model is isomorphic to standard RANK with endogenous TFP $\tilde{Z}_t$.

Aggregate output Y_t and TFP $\tilde{Z}_t$ are

$$Y_t = \tilde{Z}_t K_t^\alpha L_t^{1-\alpha}, \quad \tilde{Z}_t = \Bigg(\underbrace{\mathbb{E}_{\omega_t(z)}\left[z \mid z > z_t^* \right]}_{\text{Endogenous TFP}} \Bigg)^\alpha .$$

Joint distribution of net worth and productivity | New Keynesian Block | Calibration

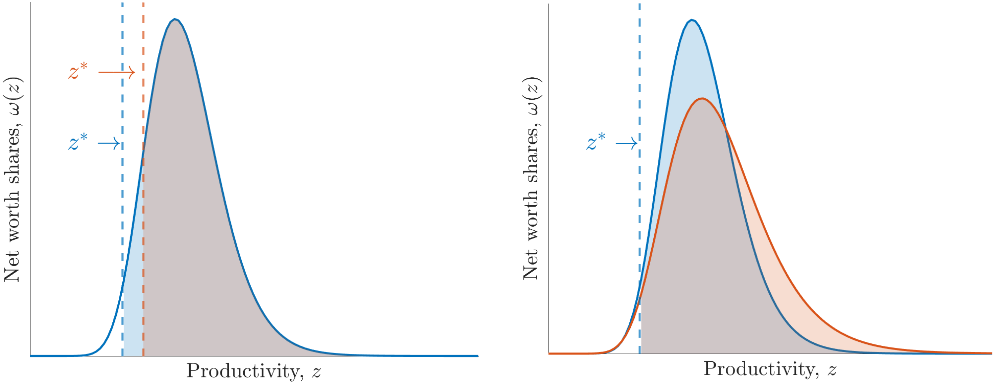
MP affects endogenous TFP

Productivity-threshold channel

$$z^* = \frac{R_t}{\varphi_t}$$

Net-worth distribution channel

$$\tilde{\Phi}_t(z) = \frac{1}{q_t}\left(z_t\varphi_t - R_t\right)$$



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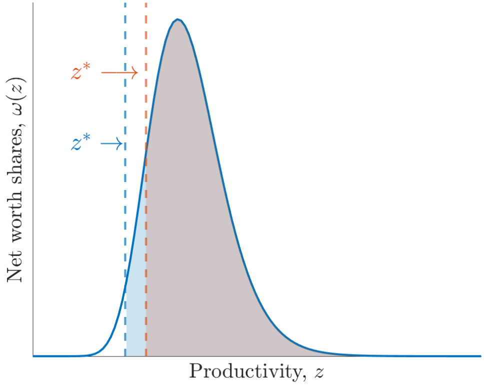

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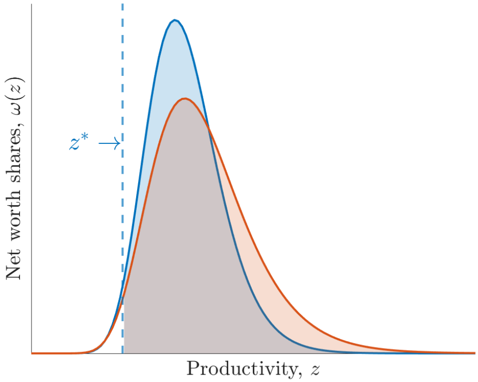

$$\tilde{Z}_t = \left(\mathbb{E}_{\omega_t(z)}\left[z \mid z > z_t^*\right]\right)^{\alpha}$$

- Empirical evidence: expansionary monetary policy shocks increases investment of high MRPK firms relatively more ▸ More

Optimal Monetary Policy

Central Bank's Ramsey problem

$$\max_{\{\omega_t(z),\,\text{Prices}_t,\text{Quantities}_t\}_{t\in\,[0,\,\infty)}} \mathbb{E}_0 \int_0^{\infty} e^{-\rho^h t} u(C_t, L_t)dt$$

subject to private equilibrium conditions $\forall t \in [0, \infty)$ and initial conditions

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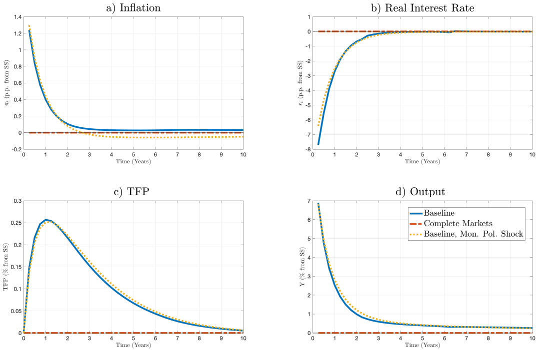
- Need to keep track of the whole distribution of firms $\omega_t(z)$
- We propose a new algorithm to solve for Ramsey optimal policies with heterogeneous agents.
  - Discretize the continuous time and continuous-space problem and solve non-linearly for the optimal monetary policy in the sequence space using symbolic differentiation and Newton methods. ▸ More

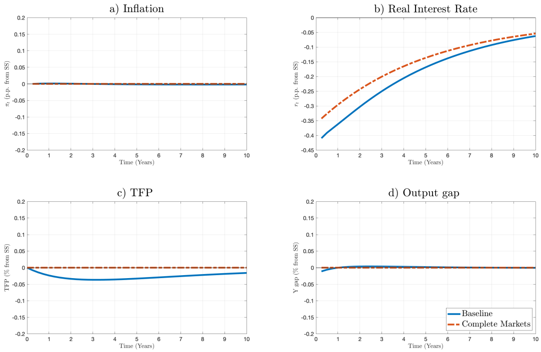
Optimal Ramsey policy: a new time inconsistency

▸ Importance of borrowing constraints ▸ Importance of persistence of idiosyncratic shocks ▸ Importance of volatility of idiosyncratic shocks



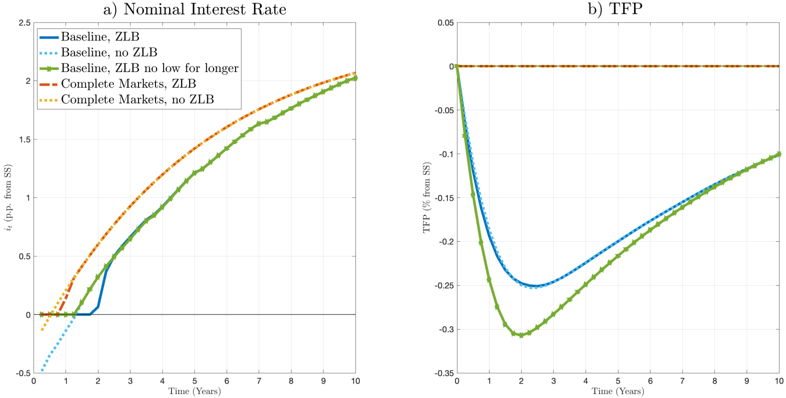
- Complete Markets economy (CM): zero inflation is optimal (steady state is first-best due to subsidy undoing mark-up distortion) ▸ CE vs Baseline
- Baseline economy: surprise inflation is optimal since it reduces capital misallocation
- Same response as expansionary monetary policy shock ▸ More

Timeless optimal response to a demand shock: divine coincidence holds



- Exogenous decrease in HH subjective discount rate: The increase in savings of the HH reduces the return to savings of entrepreneurs, which makes low productivity firms starts operating, increasing the share of constrained firms in the economy and shifting away resources from high productivity entrepreneurs.
- Planner finds a divine coincidence optimal.
- Reponse TFP is in line with Reis 2013, Gopinath et al 2017 or Asriyan et al. 2021 ▸ More

Timeless optimal response to a demand shock with ZLB: low for even longer



- If planner were not constrained by ZLB (blue), she would decrease further nominal rates (light blue) as compared to the ZLB case.
- Heterogeneity and financial frictions calls for '*low for longer*' compared to the complete markets case (orange): avoid further losses in TFP (green).

Conclusions

- New model of heterogeneous firms, financial frictions and monetary policy
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- New model of heterogeneous firms, financial frictions and monetary policy
  - Including a new algorithm to solve and compute optimal policy
- Expansionary MP reduces misallocation by shifting resources towards high productivity firms
  - Empirical evidence supporting higher investment of high MRPK firms after expansionary monetary policy shock
- Normative analysis: important implications for optimal monetary policy
  - New source of inflationary time inconsistency: undoing financial frictions.
  - Divine coincidence holds when facing demand shocks (timeless)
    - ★ Zero-Lower Bound: *Low for even longer*.

Thank you!

Merci beaucoup!

Appendix

New Keynesian Block

Back to distribution

- Representative Household More
- Capital good producer More
- Retailers More
  - New Keynesian Phillips Curve More
- Final good producers More
- Central Bank More

Representative household

Back

Standard consumption-labor-savings choice

$$\max_{C_t, L_t, D_t, B_t^N} \mathbb{E}_0 \int_0^{\infty} e^{-\rho^h t} u(C_t, L_t) dt$$

$$s.t.$$

$$\dot{D}_t q_t + \dot{B}_t^N + C_t = (R_t - \delta q_t) D_t + (i_t - \pi_t) B_t^N + w_t L_t + T_t$$

- C_t: consumption
- D_t: capital holdings
- B_t^N holdings of nominal bonds (zero net supply)
- L_t: labor supply
- i_t: nominal interest rate
- T_t : profits of *retailers*, *capital good producer* and *net dividends* from firms

Capital good producer

Produces capital and sells it to the household and the firms at price q_t

Back

$$\max_{\iota_t, K_t} \mathbb{E}_0 \int_0^{\infty} e^{-\int_0^t r_s ds} \left(q_t \iota_t - \iota_t - \Xi\left(\iota_t\right)\right) K_t dt.$$

$$s.t. \quad \underbrace{\dot{K}_t = \left(\iota_t - \delta\right) K_t}_{\text{LOM of } K_t}.$$

- ι_t: investment *rate*,
- $\Xi\left(\iota_t\right) = \frac{\phi^k}{2}\left(\iota_t - \delta\right)^2$: quadratic adjustment costs.

New Keynesian block

Back

- Final good producers aggregate varieties $j \in [0,1]$. Cost minimization implies demand for variety j is given by

$$y_{j,t}\left(p_{j,t}\right) = \left(\frac{p_{j,t}}{P_t}\right)^{-\varepsilon} Y_t, \text{ where } \underbrace{P_t = \left(\int_0^1 {p_{j,t}}^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}}_{\text{Agg. Price index}}.$$

- Retailers maximize

$$\max_{p_{j,t}} \int_0^\infty e^{-\int_0^t r_s ds} \left\{ \underbrace{\left(\frac{p_{j,t}}{P_t} - m_t\right)}_{\text{Mark-up}} \left(\frac{p_{j,t}}{P_t}\right)^{-\varepsilon} Y_t - \frac{\theta}{2}\left(\frac{\dot{p}_{j,t}}{p_{j,t}}\right)^2 Y_t \right\} dt$$

  - ε: elasticity of substitution across goods $\varepsilon > 0$.
  - $p_{j,t}$: price of variety j.
  - θ: price adjustment cost parameter.

New Keynesian block

Back

- The symmetric solution to the pricing problem yields the New Keynesian Phillips curve

$$\left(r_t - \frac{\dot{Y}_t}{Y_t}\right)\pi_t = \frac{\varepsilon}{\theta}\left(m_t - m^*\right) + \dot{\pi}_t, \qquad m^* = \frac{\varepsilon - 1}{\varepsilon},$$

- $\pi_t = \frac{\dot{P}}{P_t}$ is inflation,
- m_t are relative prices of intermediate good (inverse mark-ups of retailers),
- m^* is the optimal inverse mark-up,
- Real rates are defined as $r_t \equiv \frac{R_t - \delta q_t + \dot{q}_t}{q_t}$.

Back

$$w_t = (1-\alpha) m_t Z_t K_t^{\alpha} {L_t}^{-\alpha},$$

$$R_t = \alpha m_t Z_t K_t^{\alpha-1} {L_t}^{1-\alpha} \frac{z_t^*}{\mathbb{E}\left[z \mid z > z_t^*\right]},$$

$$\frac{\dot{A}_t}{A_t} = \frac{1}{q_t}\left[\gamma(1-\Omega(z_t^*))\left(\alpha m_t Z_t K_t^{\alpha-1} {L_t}^{1-\alpha} - R_t\right) + R_t - \delta q_t - q_t(1-\psi)\eta)\right].$$

Distribution of entrepreneurs

- The evolution of the joint distribution of net worth and productivity $g_t(z,a)$ is given by the KFE:

$$\frac{\partial g_t(z,a)}{\partial t} = \underbrace{-\frac{\partial}{\partial a}[g_t(z,a)s_t(z)a]}_{\text{Entrepreneurs' savings}} \underbrace{-\frac{\partial}{\partial z}[g_t(z,a)\mu(z)] + \frac{1}{2}\frac{\partial^2}{\partial z^2}[g_t(z,a)\sigma^2(z))]}_{\text{idiosyncratic TFP shocks}}$$

$$\underbrace{-\eta g_t(z,a)}_{\text{Entrepreneurs retire}} \underbrace{+\eta g_t(z,a/\psi)/\psi}_{\text{New entrepreneurs}}$$

Back

Complete-markets economy vs Baseline

Back

Complete-markets economy

- All capital is owned by HH $D_t = K_t$
- No financial frictions.
- TFP is exogenous
  $Z = \bar{z}$

Baseline

- Capital is owned by HH and entrepreneurs: $D_t + A_t = K_t$
- Financial frictions: $k_t \leq \gamma a_t$
- TFP is endogenous
  $Z = \left(\mathbb{E}_t \left[z \mid z > z_t^*\right]\right)^{\alpha}$

- Introduce subsidies in both economies, such that the SS mark-up distortion is undone.

Direct and indirect effects on profits and threshold

Back

Profits

$$\Phi_t(z,a) = \underbrace{(z\varphi_t - R_t)}_{\tilde{\Phi}_t}\gamma a = \left(z\alpha \left(\frac{(1-\alpha)}{w_t} \right)^{(1-\alpha)/\alpha} m_t^{\frac{1}{\alpha}} - (q_t(r_t+\delta) + \dot{q}_t) \right)\gamma a$$

Productivity threshold z^*

$$z_t^* = \frac{R_t}{\varphi_t} = \frac{(q_t(r_t+\delta)+\dot{q}_t)}{\alpha\left(\frac{(1-\alpha)}{w_t}\right)^{(1-\alpha)/\alpha} m_t^{\frac{1}{\alpha}}}$$

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- $\downarrow q_t$ and $\downarrow r_t$ increase profits *homogenously* for all firms, and *decrease* threshold z^*.

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- $\downarrow q_t$ and $\downarrow r_t$ increase profits *homogenously* for all firms, and *decrease* threshold z^*.
- $\downarrow w_t$ and $\uparrow m_t$ increase profits *relatively more* for more productive firms, and *decrease* threshold z^*.

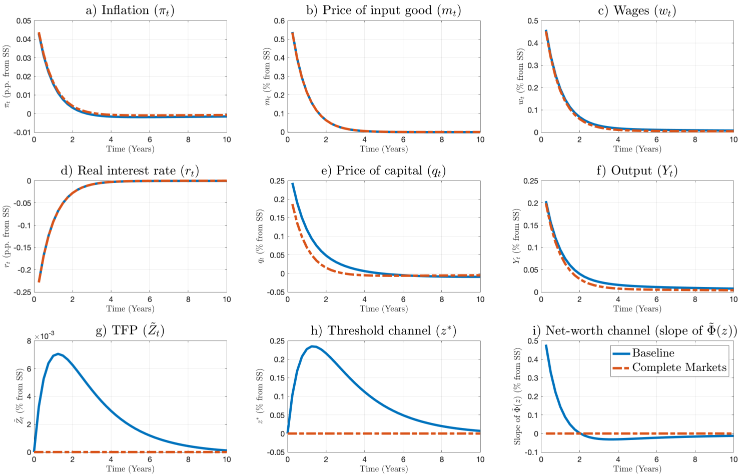
Calibration

Back to distribution

	Parameter	Value	Source/target
ρ^h	Household's discount factor	0.025	Av. 10Y bond return of 2.5% (FRED)
δ	Capital depreciation rate	0.065	Aggregate depreciation rate (NIPA)
ψ	Fraction firms' assets at entry	0.1	Av. size at entry 10% (OECD, 2001)
η	Firms' death rate	0.12	Av. real return on equity 11% (S&P500)
γ	Borrowing constraint parameter	1.43	Corporate debt to net worth of 43% (FRED)
α	Capital share in production function	0.3	Standard
ζ	Relative risk aversion parameter HH	1	Log utility in consumption
ϑ	Inverse Frisch Elasticity	1	Kaplan et al. (2018)
Υ	Constant in disutility of labor	0.71	Normalization $L = 1$
ϕ^k	Capital adjustment costs	10	VAR evidence
ϵ	Elasticity of substitution retail goods	10	Mark-up of 11%
θ	Price adjustment costs	100	Slope of PC of 0.1
$\bar{\pi}$	Inflation target	0	-
ϕ	Slope Taylor rule	1.25	-
υ	Persistence Taylor rule	0.8	-
Γ	SS Aggregate Productivity	1	Normalization
ς_z	Mean reverting parameter	0.8	Persistence Gilchrist et al. (2014)
σ_z	Volatility of the shock	0.30	Volatility Gilchrist et al. (2014)

Expansionary monetary policy shock increases TFP

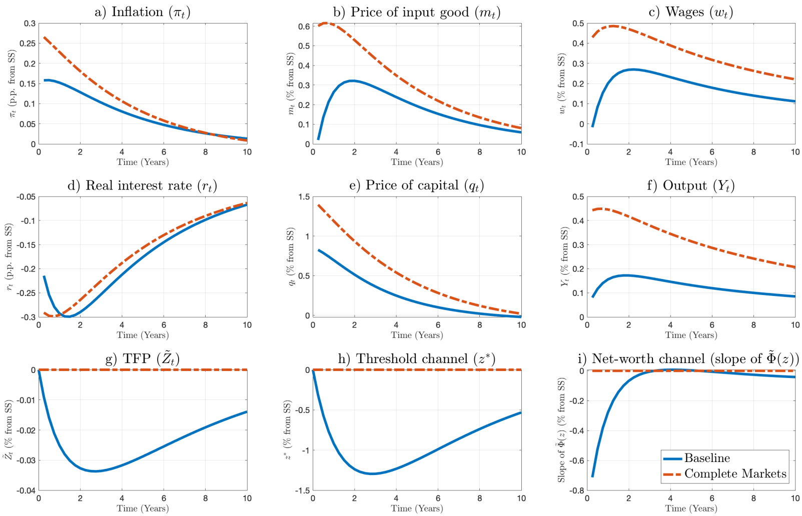
▸ Back to t0



▸ Empirical evidence supporting the mechanism in the data

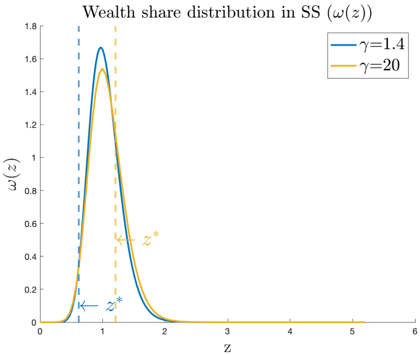
Response to demand shock following Taylor rule

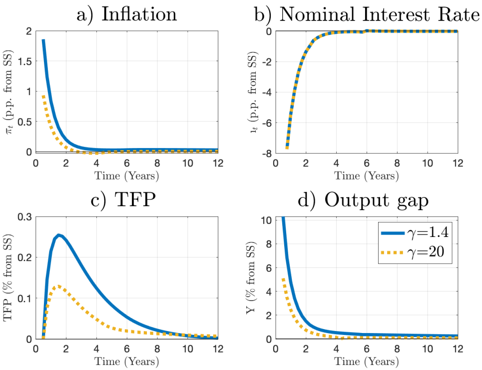
▸ Back to Timeless Demand Shock



The tighter the borrowing constraint is, the more expansionary optimal monetary policy is

Back

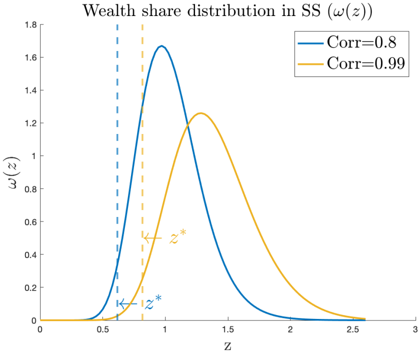


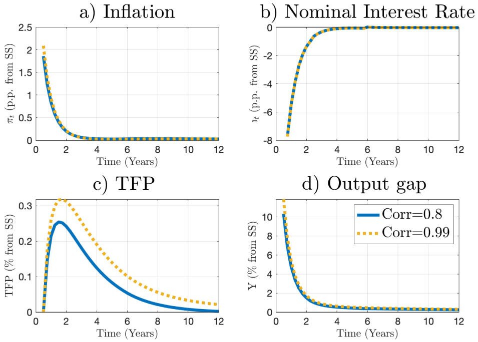


- ...since it allows entrepreneurs to undo financial frictions faster.

Higher persistence of the idiosyncratic shocks allows the increase in TFP to last longer

▸ Back

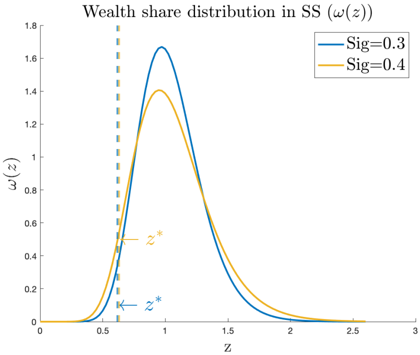


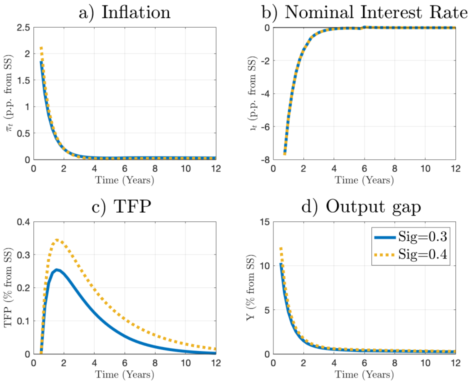


- More productive firms invest relatively more, and since the idiosyncratic shock is persistent, the increase in TFP lasts longer. However, policy prescription does not change much

Higher volatility of the idiosyncratic shocks allows the increase in TFP to last longer

Back





Sketch of solution algorithm

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1. Discretize the time space (Δt); and the state space (Δz) into J grid points using finite differences (Achdou et al, 2017):
   - system of $2J$ equations and $2J$ unknowns for the HJB and the KFE equation (we don't have a HJB).

$$\begin{pmatrix} \frac{1}{\Delta t}\left(\mathbf{v}^{n+1} - \mathbf{v}^{n}\right) + \rho \mathbf{v}^{n+1} & = \mathbf{u}^{n+1} + \mathbf{A}^{n+1}\mathbf{v}^{n+1} \\ \frac{\mathbf{g}^{n+1} - \mathbf{g}^{n}}{\Delta t} & = \left(\mathbf{A}^{n+1}\right)^{T} \mathbf{g}^{n+1} \end{pmatrix}$$

   - set of X equilibrium conditions (MC, FOCs of representative agents)

2. Compute the planner's optimality conditions on discretized problem : $(2J + X) + (2J + X + 1)$ equations using symbolic differentiation

3. Solve the transitional dynamics up to horizon T using a Newton algorithm to solve a large equation set of $[(2J + X) + (2J + X + 1)]\ T$ equations (cf. Auclert et al., 2020)

Using Dynare

Use Dynare to solve the OMP problem in Discrete Time / Discrete Space non-linearly

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- Provide
  - the SS of the problem conditional on the policy instrument,
  - the set of discretized non-linear equilibrium conditions of the private economy,
  - the planner's objective function.

Use Dynare to solve the OMP problem in Discrete Time / Discrete Space non-linearly

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- Provide
  - the SS of the problem conditional on the policy instrument,
  - the set of discretized non-linear equilibrium conditions of the private economy,
  - the planner's objective function.
- Use *ramsey_model* command:
  - Dynare computes FOCs for the Ramsey problem by symbolic differentiation.
- Use *steady* command:
  - Dynare computes SS of the Ramsey problem.
- Use *perfect_foresight_solver* command:
  - Uses Newton method to solve simultaneously all the non-linear equations for every period, using sparse matrices.

Use Dynare to solve the OMP problem in Discrete Time / Discrete Space non-linearly

Back

- Provide
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Easy to use and general!

Can we see this pattern in the data after an expansionary MP shock?

After a monetary policy expansion, constrained high productivity firms increase their investment relatively more.

- Data: yearly balance sheet and cash flow data for the quasi-universe of Spanish firms.
- Monetary policy shocks identified à la Jarociński and Karadi (2020). more
- Empirical specification following Ottonello and Winberry (2020):

$$\Delta log\ k_{j,t} = \alpha_j + \alpha_{st} + \beta \left(MRPK_{j,t-1} - \mathbb{E}_j \left[MRPK_j \right] \right) \varepsilon_t^{MP} + \Lambda' Z_{j,t-1} + u_{j,t}.$$

	(1)	(2)
ϵ_t^{MP1} x $MRPK_{t-1}$	0.716***	0.779***
	(0.05)	(0.05)
Observations	5,567,706	5,482,589
R^2	0.267	0.274
MRPK control	YES	YES
Controls	NO	YES
Time-sector FE	YES	YES
Time-firm clustering	YES	YES

Yes!

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Empirical evidence: Details

MP shock

- high-frequency data and sign restrictions in a SVAR to identify monetary policy shocks in the Euro area at the monthly level, aggregated at a yearly frequency.
- renormalized so that ε_t^{MP} is a 100bps expansionary monetary policy shock.

Empirical evidence: Details

MP shock

- high-frequency data and sign restrictions in a SVAR to identify monetary policy shocks in the Euro area at the monthly level, aggregated at a yearly frequency.
- renormalized so that ε_t^{MP} is a 100bps expansionary monetary policy shock.

Marginal Revenue Product of Capital

- $MRPK_t = \frac{\partial m_t f_t(z,k,l^*)}{\partial k} = \left[\left(\frac{1-\alpha}{w_t} \right)^{\frac{1-\alpha}{\alpha}} m_t^{\frac{1}{\alpha}} \right] z \propto z.$
- Demean MRPK to ensure that the results are not driven by permanent heterogeneity in responsiveness across firms.
- Controls $Z_{j,t-1}$ include: MRPK, total assets, leverage, sales growth, net financial assets as a share of total assets, MRPK $\times$ GDP growth.

Empirical evidence: Robustness

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ϵ_t^{MP} x $MRPK_{t-1}$	1.40***	1.51***	0.611***	0.446**				
	(0.00)	(0.00)	(0.00)	(0.00)				
Inv_{t-1}	-0.0308***	-0.0276***						
	(0.00)	(0.00)						
ϵ_t^{MP2} x $MRPK_{t-1}$					2.95***	2.99***		
					(0.00)	(0.00)		
ϵ_t^{MP} x $MRPK_{t-1}$ (not demeaned)							0.584***	0.500**
							(0.00)	(0.00)
Observations	4,162,114	4,099,700	283,835	279,844	5,551,870	5,467,189	283,835	279,844
R^2	0.279	0.283	0.152	0.155	0.273	0.281	0.152	0.155
MRPK control	YES	YES	YES	YES	YES	YES	YES	YES
Controls	NO	YES	NO	YES	NO	YES	NO	YES
Time-sector FE	YES	YES	YES	YES	YES	YES	YES	YES
Time-firm clustering	YES	YES	YES	YES	YES	YES	YES	YES
Panel	FULL	FULL	BALANCED	BALANCED	FULL	FULL	FULL	FULL

Notes: Results of estimating equation (44), departing from some of the specifications of the estimation in the main text (Section 3.3). Columns (1) and (2) include as control the lag of the investment rate ($log(k_{t-1}) - log(k_{t-2})$). Columns (3) and (4) restrict the sample to a balanced panel. Columns (5) and (6) consider the alternative yearly aggregation of the monetary policy shocks. Columns (7) and (8) use MRPK in levels, $MRPK$ (not demeaned), instead of the demeaned standardized value. Columns (1) , (3) and (5) use only lagged MRPK as controls, while columns (2), (4) and (6) include all the controls, lagged: MRPK, total assets, sales growth, leverage and net financial assets as a share of total assets; and the interaction of MRPK with GDP growth. Columns (1),(2), (5) and (6) use the demeaned standardized measure of MRPK explained in the main text, while columns (3)-(4) do not demean MRPK.

MP shocks

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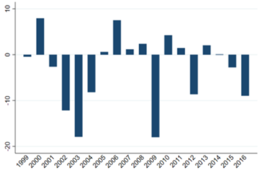
Panel 1 - Baseline weighting - ε_t^{MP}



Panel 2 - Alternative weighting - ε_t^{MP2}