A Macroeconomic Model with Heterogeneous Banks

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- Mark Gertler's 2018 Nobel Symposium lecture:

$$\mathrm{E}_t\left[M_{t+1}\big(\underbrace{R^T_{t+1}}_{\text{risky return}} - \underbrace{R_{t+1}}_{\text{bank cost of funds}}\big)\right] \geq 0$$

$$\left[(R^T_{t+1} - R_{t+1})\underbrace{\phi_t}_{\text{bank leverage}} + R_{t+1}\right] N_t = \underbrace{N_{t+1}}_{\text{bank net worth}}$$

$$\underbrace{\phi_t}_{\text{leverage constraint}} \leq \underbrace{V_t}_{\text{franchise value}}$$

- Negative shock $\rightarrow V_t \downarrow$ constraint tightens $\rightarrow \mathrm{E}_t\left(R^T_{t+1} - R_{t+1}\right) \uparrow \rightarrow$ macro crisis
- Can do bank runs, macropru, credit policy

Micro-Consistent Macro-Banking

- Incomplete markets + uninsured idiosyncratic risk:

$$\mathrm{E}_t \left[M_{t+1} (\underbrace{R^T_{t+1}(j)}_{\text{risky return}} \quad \underbrace{R_{t+1}(j)}_{\text{bank cost of funds}}) \right] \quad 0$$

$$\left[\left(R^T_{t+1}(j) \quad R_{t+1}(j) \right) \underbrace{{}_t(j)}_{\text{bank leverage}} + R_{t+1}(j) \right] N_t(j) = \underbrace{N_{t+1}(j)}_{\text{bank net worth}}$$

$$\underbrace{\qquad}_{\text{leverage constraint}} \quad {}_t(j) \quad \underbrace{V_t(j)}_{\text{franchise value}}$$

- Ex-ante identical, ex-post heterogeneous
- Intensive margin: banks with different size-return profiles pick different (j)
- Extensive margin: stationary distribution $\int n(j)$ matters
- Macro response to aggregate shocks depends on interaction of the two margins
- Can do targeted bank runs, micropru, bank-specific credit policy

Important Questions

1. Where could bank heterogeneity come from?

   Idiosyncratic shocks to (granular) borrowers survive loan portfolio aggregation and affect both bank outcomes and the macroeconomy

   Empirical evidence from bank-firm matched administrative data from Norway

   "Granular Credit Risk" (with Galaasen, Juelsrud, and Rey)

2. What about aggregate uncertainty?

   Distribution of bank net worth $^{R}\ n_j(\mathbf{S})$ now varies over the business cycle

   A Krusell-Smith-Gertler-Kiyotaki economy

   "Bewley Banks" (with Monacelli)

3. What does (j) stand for?

   Banks, branches, ZIP codes, countries, financial varieties . . .

Paper Overview

- Theme

  Micro-Consistent Macro-Banking

- This Paper

  Positive, normative, and policy implications of bank heterogeneity

- Framework

$$\text{Macro} + \underbrace{\text{scale variance}}_{\textbf{Bank size distribution}} + \underbrace{\text{idios. bank return risk}}_{\textbf{Efficiency}} + \underbrace{\text{heterog. credit markups}}_{\textbf{Competition}} + \underbrace{\text{default risk}}_{\textbf{Stability}}$$

- Unifying Main Result

  Financial efficiency, competition, and stability are incompatible: a **trilemma**!

LITERATURE

- **Financial frictions + representative intermediary**: Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), Gertler and Kiyotaki (2010), Gertler and Karadi (2011), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), Adrian and Shin (2010, 2014), Nuno and Thomas (2016), Gertler, Kiyotaki and Prestipino (2020), Lee et al. (2020), Bigio and Sannikov (2021)

- **Heterogeneous intermediaries**: Boissay et al. (2016), Coimbra and Rey (2019), Corbae and D'Erasmo (2020), Bianchi and Bigio (2020), Rios Rull et al. (2020), Begenau and Lanvoigt (2020), Begenau et al. (2020), Goldstein et al. (2020), Dempsey (2020), Jamilov and Monacelli (2021)

- **Bank market power**: Dempsey and Faria-e-Castro (2021), Wang et al. (2021), Pasqualini (2021), Drechsler et al. (2017, 2021), Egan et al. (2017)

- **Incomplete markets**: Bewley (1977), Huggett (1993), Aiyagari (1994), Rios-Rull (1994), Imrohoglu (1996), Den Haan (1996), Quadrini and Rios-Rull (1996), Krusell and Smith (1997, 1998)

- **Empirical evidence for uninsured idiosyncratic credit risk**: Galaasen et al. (2020)

Model

Capital Goods Producer

Non-CES aggregator (Kimball):

$$K_t = \int_0^{H_t} \frac{k_t(j)}{K_t} \, dj$$

Capital goods firm solves:

$$\max_{k_t(j)} \left[P_t K_t \int_0^{H_t} p_t(j) k_t(j) dj \right] \quad \text{s.t. technology}$$

Solution yields demand function for bank funds:

$$p_t(j) = {}' \frac{k_t(j)}{K_t} \, Z_t$$

where Z_t is the demand index:

$$Z_t := \left[\int_0^{H_t} {}' \frac{k_t(j)}{K_t} \frac{k_t(j)}{K_t} dj \right]^{1}$$

Klenow-Willis Specification

Klenow-Willis formulation for $\Upsilon(y)$, with $y := \frac{k(j)}{K}$:

$$\Upsilon(y) = 1 + (\sigma - 1)\exp\left(\frac{1}{\varepsilon}\right)\varepsilon^{\frac{\sigma}{\varepsilon}-1}\left[\Gamma\left(\frac{\sigma}{\varepsilon};\frac{1}{\varepsilon}\right) - \Gamma\left(\frac{\sigma}{\varepsilon};\frac{y^{\frac{\varepsilon}{\sigma}}}{\varepsilon}\right)\right]$$

$\Gamma(s; q)$ is the upper-incomplete Gamma function:

$$\Gamma(s; q) := \int_q^{\infty} t^{s-1}\exp(-t)\,dt$$

The markup function is:

$$\mu(y) = \frac{\sigma y^{-\frac{\varepsilon}{\sigma}}}{\sigma y^{-\frac{\varepsilon}{\sigma}} - 1}$$

CES case is nested for $\varepsilon = 0$

Banks

Balance sheet constraint:

$$\underbrace{d_t(j)}_{\text{Deposits}} + \underbrace{n_t(j)}_{\text{Net Worth}} = p_t(j)k_t(j)$$

Portfolio return:

$$R_t^T(j) = \underbrace{\quad_t(j)}_{\text{Idiosyncratic}} + (1 \quad) \underbrace{R_t^k}_{\text{Systematic}} \quad ; \quad 0 < \quad < 1$$

Uninsurable idiosyncratic rate of return risk:

$$_t(j) = (1 \quad) \quad + \quad _{t \quad 1}(j) + \quad _t(j) \quad ; \quad 0 < \quad < 1$$

This process is estimated in Galaasen et al. (2020) using administrative Norwegian firm-bank matched data

BANKS (CONTINUED)

Leverage constraint:

$$p_t(j)k_t(j) \quad V_t(j) \quad ; \quad 0 < \quad < 1$$

Law of motion of net worth:

$$n_{t+1}(j) = R^T_{t+1}(j)p_t(j)k_t(j) \quad R_t(j)d_t(j) \quad \underbrace{\frac{1}{\ } k_t(j) \ ^2}_{\text{Non-Interest Costs}}$$

Default risk:

$$_t(j) = Pr \;\; n_{t+1}(j) \quad 0$$

Banks Dynamic Problem

$$V_t\left(n_t(j);\ {}_t(j)\right) = \max_{\{k_t(j);p_t(j);d_t(j)\}} E_t \left[\max \left\{ \underbrace{\ }_{\text{MRS}}{}_{t+1} \underbrace{(1\ \ )}_{\text{Dividends}} n_{t+1}(j) + V_{t+1}\left(n_{t+1}(j);\ {}_{t+1}(j)\right) \underbrace{;0}_{\text{Limited Liability}} \right\} \right]$$

s.t.

$$n_{t+1}(j) = R^T_{t+1}(j)p_t(j)k_t(j) \quad R_t(j)d_t(j) \quad \frac{1}{1}k_t(j)^{2}$$ Law of motion of net worth

$$d_t(j) + n_t(j) = p_t(j)k_t(j)$$ Balance sheet constraint

$$p_t(j)k_t(j) \quad V_t(j)$$ Leverage constraint

$$R^T_t(j) = \ {}_t(j) + (1\ \ )R^k_t$$ Portfolio return

$${}_t(j) = (1\ \ ) \quad + \quad {}_{t\ 1}(j) + \quad {}_t(j)$$ Idiosyncratic shocks

$${}_t(j) = Pr\ \ n_{t+1}(j) \quad 0$$ Default risk

$$p_t(j) = \ {}^{0}\ \frac{k_t(j)}{K_t} \quad Z_t$$ Demand for financial varieties

Potential entrants maximize:

$$V^e(n_0;\ _0) \quad \max \left[\underbrace{(n_0;\ _0)}_{\text{Startup Draws}} \quad \underbrace{e}_{\text{Entry Cost}} ; 0 \right]$$

Distribution law of motion:

$$^0(n^0;\ ^0) = \underbrace{\sum G(\ ^0;\ ) \int \mathbb{1}_{\{(n;\ )|K(n;\ )\in \mathbf{B}\}} \mathbb{1}_{\{d(n;\ )=0\}} (dn; d\ )}_{\text{Incumbents}} + \overbrace{M^0}^{\text{Entry Mass}} \underbrace{\int \mathbb{1}_{\{(n_0;\ )|K(n;\ )\in \mathbf{B}\}} G_0(\ )}_{\text{New Entrants}}$$

Household

Preferences:

$$\max_{\{C_t; b_t(j)\}} \left[\sum_{t=1}^{\infty} {}^{t}_{h} u(C_t) \right]$$

s.t.

$$C_t + \int_0^{H_t} b_t(j)dj \quad W_t + \int_0^{H_t} R_t(j) b_{t\ \ 1}(j)dj + \int_0^{H_t} {}_t(j)dj$$

FOC determines interest rate on deposits:

$$\underbrace{R_t(j) = \frac{1 \quad \overbrace{{}_t(j)}^{\text{Default Probability}} \quad x_t(j) E\left[R^T_{t+1}(j) \quad {}_{t+1} \right]}{1 \quad {}_t(j) \quad E(\quad {}_{t+1})}}_{\text{Deposit Interest Rate}} \qquad \underbrace{x_t(j) = \min \left[\frac{\overbrace{{}_t(j)}^{\text{Leverage Ratio}}}{{}_t(j) k_t(j) \quad 1}; 1 \right]}_{\text{Deposit Recovery Rate}}$$

Final Goods Producer

Technology

$$Y_t = AK_t \, L^{1}$$

Capital law of motion

$$K_{t+1} = I_t$$

Returns

$$R^k_{t+1} = \frac{AK_{t+1}{}^{1}}{P_t} \qquad W_t = (1 \quad)AK_t$$

Stationary Industry Equilibrium

Credit market clearing:

$$\underbrace{K}_{\text{Aggregate Supply}} = \underbrace{\int_B k(n;\ )\ (dn; d\ )}_{\text{Incumbent Demand}} + M \underbrace{\int_B k(n_0;\ _0)\ dG(\ _0)}_{\text{Entrants Demand}} + \underbrace{Me}_{\text{Entry Cost}}$$

Deposit market clearing:

$$\underbrace{\int_0^H b(j)dj}_{\text{Household Supply}} = \underbrace{\int_B d(n;\ )\ (dn; d\ )}_{\text{Banks Demand}}$$

Goods market clearing:

$$Y = C + I$$

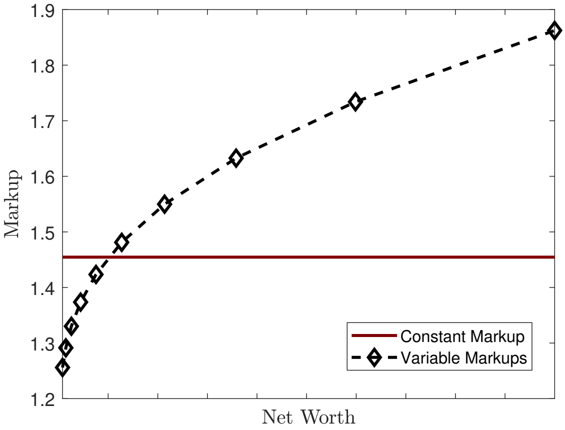
Analysis of Bank Heterogeneity

Decompose relative prices into markups and marginal costs:

$$\frac{p(j)}{P} = \underbrace{\frac{y^{-}}{y^{-} \quad 1}}_{\text{Markups}} \underbrace{\frac{k(j)^{2 \quad 1}}{R^T(j) \quad R(j)}}_{\text{Marginal Costs}}$$

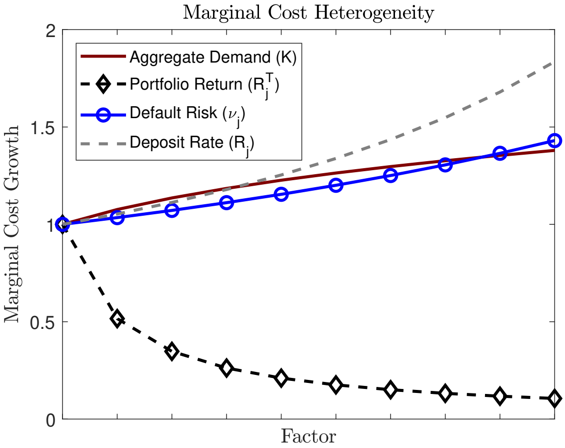
Credit Markups

- As long as > 0, markups **increase** with size (as in data)
- Because larger banks face lower credit demand elasticities



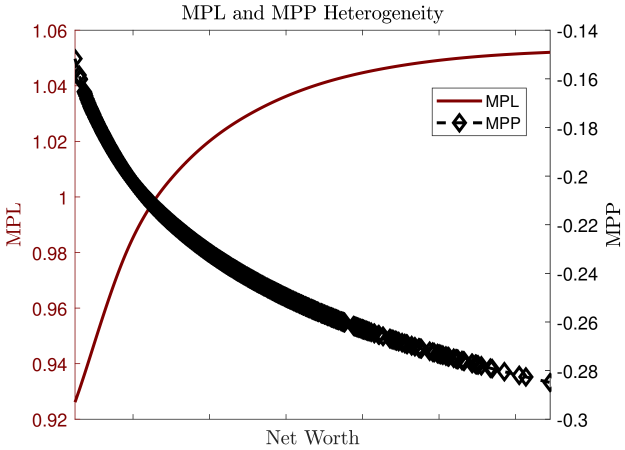
Economies of Scale

- Marginal costs are function of aggregate demand, returns, default risk, and deposit rates
- As long as $0 <$ < 1, equilibrium marginal costs **fall** with size (as in data)



Micro to Macro

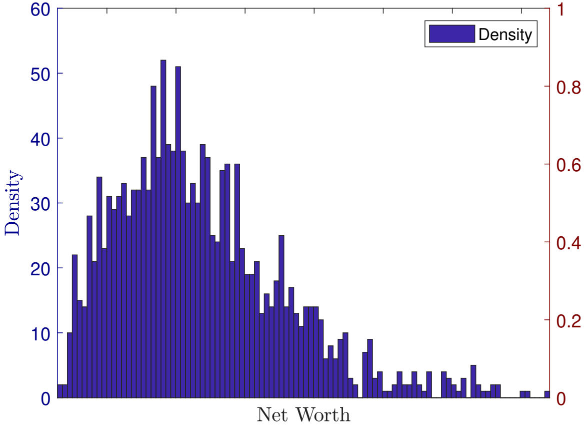
- Marginal Propensity to Lend & Price: MPL $= \int_{\mathcal{B}} \frac{\partial k(j)}{\partial n(j)} (dn; d\ )$ MPP $= \int_{\mathcal{B}} \frac{\partial p(j)}{\partial n(j)} (dn; d\ )$



Main Result

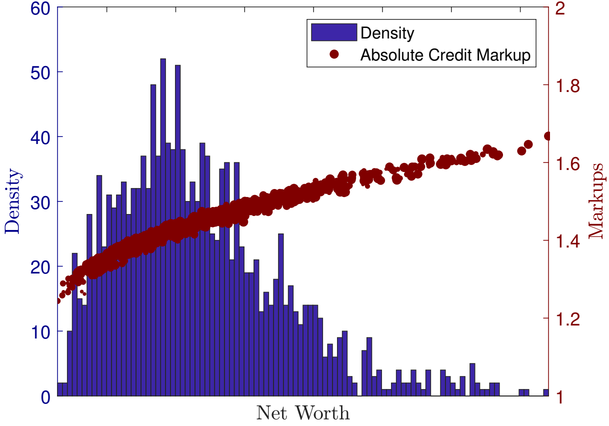
Main Result

- **Concentrated** stationary distribution of bank net worth



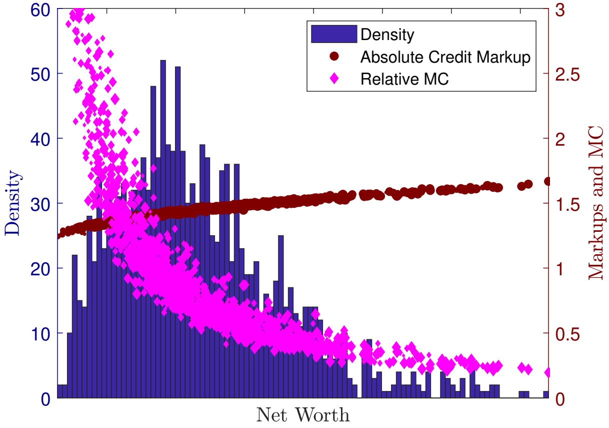
Main Result

- **Endogenous competition**: larger banks charge higher markups



Main Result

- **Economies of scale**: larger banks face lower marginal costs



Main Result

- **Financial stability**: larger banks face lower default risk

The Banking Industry Trilemma

- **The same** banks that are stable and efficient also have greater credit market power
- **No single re-allocative** shock or policy regime can simultaneously improve financial competition, stability, and efficiency

Quantitative Applications

Constrained Efficiency

- Externality 1: aggregate demand (monopolistic credit market competition)
- Externality 2: distributive pecuniary (uninsurable idiosyncratic shocks)
- Social planner internalizes the impact of bank-level choices on aggregate returns

$$n_{t+1}(j) = \underbrace{R^T \quad n(j); \quad (j); \{k_t(j); d_t(j); p_t(j)\}}_{\text{Planner}} \quad p_t(j)k_t(j) \quad R_t(j)d_t(j) \quad \frac{1}{1}k_t(j) \ ^2$$

- Compare to the private net worth LoM

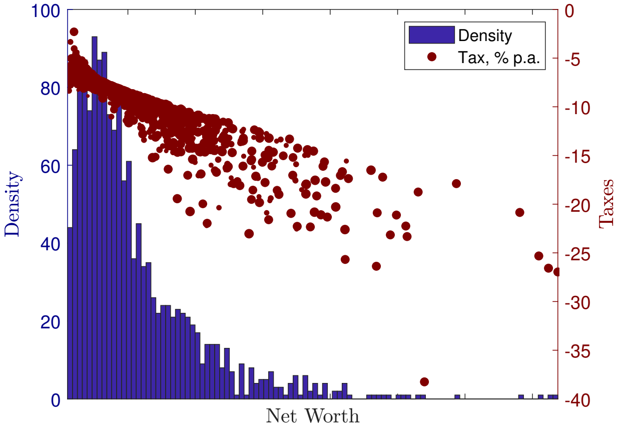
$$n_{t+1}(j) = \underbrace{R^T_{t+1}(j)}_{\text{Market}} p_t(j)k_t(j) \quad R_t(j)d_t(j) \quad \frac{1}{1}k_t(j) \ ^2$$

- Decentralization with taxation of bank gross returns

$$n_{t+1}(j) = R^T_t(j) \left[1 \quad \underbrace{\quad n(j); \quad (j)}_{\text{Tax}} \right] p_t(j)k_t(j) \quad R_t(j)d_t(j) \quad \frac{1}{1}k_t(j) \ ^2$$

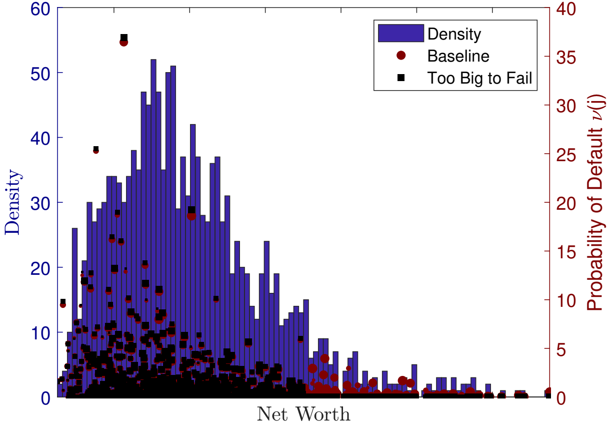
Optimal Policy

- The average bank tax is a **subsidy** (agg. credit demand externality)
- Subsidies **increase** with bank size (distrib. externality)



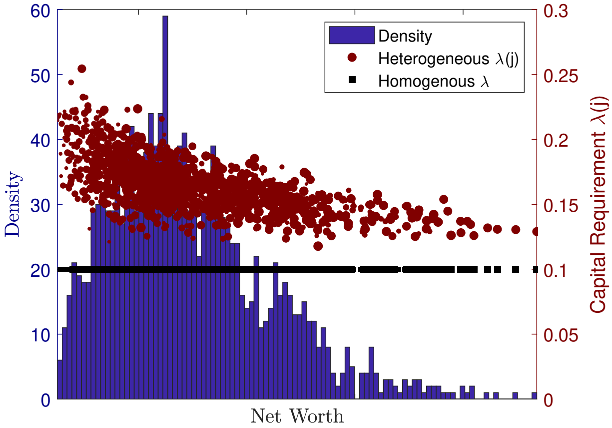
Too Big to Fail

- Exogenous **cost of funds subsidy** for banks in the top decile
- Strategic complementarity in bank leverage - systemic risk up (Farhi & Tirole, 2017)



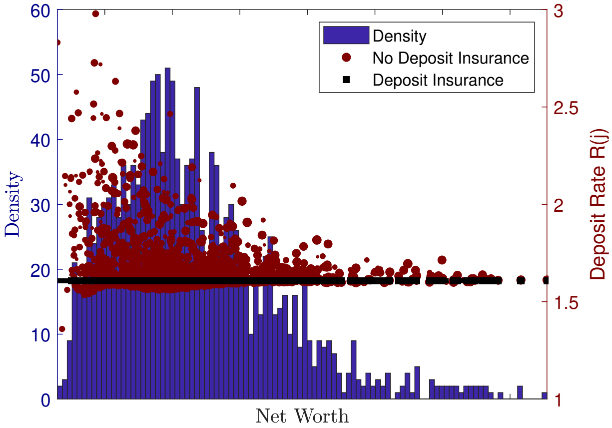
Heterogeneous Capital Requirements

- Micropru: **heterogeneous** (j), falls with $n(j)$
- Financial stability up but aggregate output down and markups up



Deposit Insurance

- **No equilibrium pass-through** from default risk (j) to price of deposits $R(j)$
- Aggregate output up but financial stability down



All Quantitative Applications in Paper

The banking policy trilemma is shown to be relevant for:

- Optimal, constrained efficient bank taxation
- Size-dependent capital requirements
- Deposit insurance schemes
- The “Too-Big-to-Fail” externality
- The rise of banking concentration
- Emergence of fintech-intermediated credit
- Targeted, bank-specific bailouts and liquidity facilities
- Intermediary asset pricing with heterogeneity

CONCLUSION

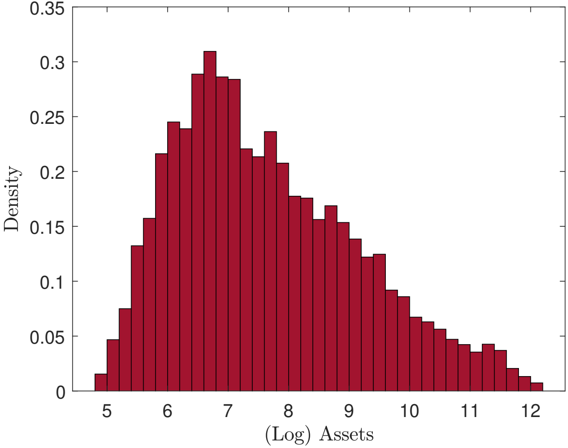
- A framework to think about concentration, competition, stability, and efficiency in macro-banking
- Matches key cross-sectional patterns of the U.S. banking sector
- A novel **trilateral trade-off** that applies to classic and new policy-relevant issues

- "**Bewley Banks**": aggregate uncertainty and counter-cyclical bank income risk (with T. Monacelli)
- Work in progress: "**HBANK**" - nominal rigidity and monetary policy (with M. Bellifemine and T. Monacelli)

Appendix

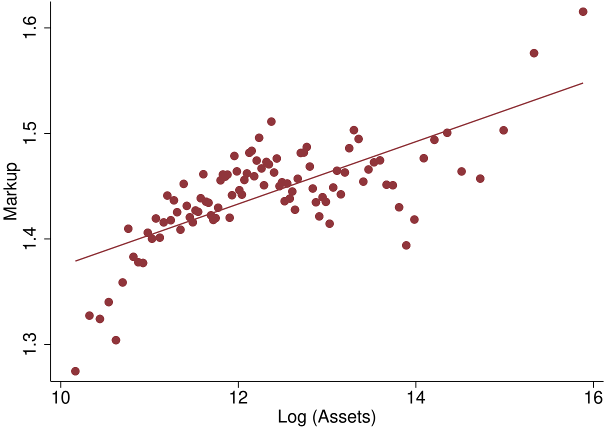
DATA

- Fact 1: The U.S. commercial banking sector is very **concentrated**



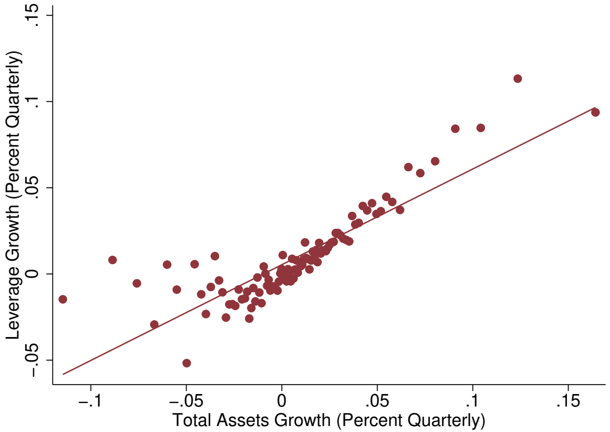
DATA

- Fact 2: Bank markups **increase** with size



Data

- Fact 3: Intermediation efficiency (marginal costs) **increases** (fall) with size



Data

- Fact 4: Exit risk **decreases** with size