Discussion of:

Sorting Out the Real Effects of Credit Supply

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This paper

Summary

1. **Simple resolution to an important puzzle**
   - **Puzzle:** We suspect that there is lots of ex-ante bank-borrower sorting in (some) credit markets, but literature using Khwaja-Mian (2008) empirical designs often argues that there is little sorting
   - **Resolution:** Empirical literature on credit supply effects has not always drawn correct conclusions about bank-borrower sorting

2. **Strong independent evidence of ex ante bank-borrower sorting in syndicated loan market**
   - Prior to the GFC, **ex ante riskier borrowers** more likely to use a **more aggressive bank** as lead lender
   - **Ex ante riskier borrowers** = Higher spreads or leverage in early 2007
   - **More aggressive banks** = More Lehman syndication connections, lower deposit-to-asset ratios, or lower ex post loan growth
   - Most aggressive banks (most "talented" banks) were investment banks

This paper

Summary

3. **Write down a classic assignment model of credit market**
   - Cross-sectional heterogeneity in firm credit risk and in bank risk tolerance
   - Each firm matched to one bank
   - Equilibrium sorting: Riskier firms borrow from more risk tolerant banks
   - Riskiest firm who obtains credit indifferent between borrowing and not

4. **Use model to estimate fraction of contraction in syndicated lending during GFC that was due inward shift in credit supply**
   - Use (1) information on **loan spreads** and **firm credit ratings** and (2) assignment model to **back out distribution of lender risk tolerance** in pre-crisis period (2005-2007) and crisis period (2008-2010)
   - Compute **counterfactual equilibrium** where loan demand (distribution of firm characteristics) is held constant at pre-crisis levels but there is an inward shift in loan supply (distribution of lender risk tolerance)
   - Estimate $(L_{Pre} - L_{Counter}) \,/\, (L_{Pre} - L_{GFC}) \sim 60\%$ of GFC contraction in loan volume was due to inward supply shift $\sim 40\%$ due to demand

This paper

Assessment

- **Fantastic paper that will shape how I think about credit markets**
  1. Firm-bank sorting seems underappreciated and likely to be of first-order importance
  2. Fantastic point: Literature seems to have drawn inappropriate conclusions about sorting from Khwaja-Mian (2008) empirical designs
  3. Applaud the authors for writing down an assignment model of equilibrium credit market sorting and then taking it to the data
  4. Conclusion that credit supply shocks played an important role in GFC is intuitive/plausible
- **My discussion:**
  1. Amplify authors' point about Khwaja-Mian (2008) empirical designs
  2. A few quibbles with the assignment model and thoughts on directions for future research ... but, again, I am a big fan overall!

1. Implications for Khwaja-Mian ('08) Empirical Designs

Traditional argument in the literature

- **Key assumption:** Loans from banks b_1 and b_2 are neither complements nor substitutes for f. Instead, $\Delta L^*_{fb_1}$ and $\Delta L^*_{fb_2}$ are equilibrium quantities of two completely unrelated goods.
- **Loan demand** from **firm** f from **bank** b is

$$\Delta L^D_{fb} = -\delta \times \Delta r_{fb} + \Delta D_f$$

  where $\delta > 0$ and ΔD_f = **Firm-level demand shifter**
- **Loan supply** of **bank** b to **firm** f is

$$\Delta L^S_{fb} = \sigma \times \Delta r_{fb} + \Delta S_b$$

  where $\sigma > 0$ and ΔS_b = **Bank-level supply shifter**
- **Impose market clearing:** $\Delta L^D_{fb} = \Delta L^S_{fb}$

$$\Delta r^*_{fb} = \frac{\Delta D_f - \Delta S_b}{\sigma + \delta} \text{ and } \Delta L^*_{fb} = \frac{\sigma \times \Delta D_f + \delta \times \Delta S_b}{\sigma + \delta}$$

1. Implications for Khwaja-Mian (‘08) Empirical Designs

Comparing Fixed-Effects and OLS estimates

- Suppose $\Delta S_b = \beta \times X_b +$ Noise

$$\beta_{FE} \;=\; \frac{Cov[\Delta L^*_{fb} - \Delta \overline{L}^*_f, \Delta X_b - \Delta \overline{X}_f]}{Var\left[X_b - \overline{X}_f\right]} = \frac{\delta}{\sigma+\delta} \times \beta$$

$$\beta_{OLS} \;=\; \frac{Cov[\Delta L^*_{fb}, X_b]}{Var\left[X_b\right]} = \frac{\delta}{\sigma+\delta} \times \beta + \frac{\sigma}{\sigma+\delta} \times \frac{Cov\left[\Delta D_f, X_b\right]}{Var\left[X_b\right]} - .$$

- Thus, $\beta_{FE} = \beta_{OLS}$ implies:

$$\overbrace{\frac{Cov\left[\Delta D_f, X_b\right]}{Var\left[X_b\right]}}^{\text{Bank-Firm Sorting}} = 0$$

- Argument appears repeatedly in the literature on credit supply effects
- **Concern:** 100% clear that β_{FE} isolates a credit supply effect, but less clear that $\beta_{FE} = \beta_{OLS}$ necessarily implies random matching.

1. Implications for Khwaja-Mian ('08) Empirical Designs

A slightly more sophisticated view of firm borrowing

- **Key assumption:** Firms substitute elastically between existing lenders
- **Loan demand** from **firm** f is

$$\Delta L_f^D = -\delta \times \Delta r_f + \Delta D_f$$

where $\delta > 0$ and $\Delta D_f =$ **Firm-level demand shifter**

- **Loan supply** of **bank** b to **firm** f is

$$\Delta L_{fb}^S = \sigma \times \Delta r_f + \Delta S_b$$

where $\sigma > 0$ and $\Delta S_b =$ **Bank-level supply shifter**

- **Impose market clearing:** $\Delta L_f^D = \Delta \overline{L}_f^S \equiv N^{-1} \sum_{b \in f} \Delta L_{fb}^S$ and define $\Delta \overline{S}_f \equiv N^{-1} \sum_{b \in f} \Delta S_b$

$$\Delta r_f^* = \frac{\Delta D_f - \Delta \overline{S}_f}{\sigma + \delta} \text{ and } \Delta \overline{L}_f^* = \frac{\sigma \times \Delta D_f + \delta \times \Delta \overline{S}_f}{\sigma + \delta}$$

$$\Delta L_{fb}^* = \Delta S_b + \sigma \times \frac{\Delta D_f - \Delta \overline{S}_f}{\sigma + \delta} \Rightarrow \Delta L_{fb}^* - \Delta \overline{L}_f^* = \Delta S_b - \Delta \overline{S}_f$$

Assumption that each firm has N equal relationships is WLOG

1. Implications for Khwaja-Mian ('08) Empirical Designs

Comparing Fixed-Effects and OLS estimates

- Suppose $\Delta S_b = \beta \times X_b +$ Noise

$$\beta_{FE} = \frac{Cov[\Delta L^*_{fb} - \Delta \overline{L}^*_f, \Delta X_b - \Delta \overline{X}_f]}{Var\left[X_b - \overline{X}_f\right]} = \beta$$

$$\beta_{OLS} = \frac{Cov[\Delta L^*_{fb}, X_b]}{Var[X_b]} = \beta + \frac{\sigma}{\sigma + \delta}\left(\frac{Cov[\Delta D_f, X_b]}{Var[X_b]} - \frac{Cov[\Delta \overline{S}_f, X_b]}{Var[X_b]}\right)$$

- Now, $\beta_{FE} = \beta_{OLS}$ implies

$$\overbrace{\frac{Cov[\Delta D_f, X_b]}{Var[X_b]}}^{\text{Bank-Firm Sorting}} = \overbrace{\frac{Cov[\Delta \overline{S}_f, X_b]}{Var[X_b]}}^{\text{Bank-Syndicate Sorting}} = \text{Any Constant}$$

- But **does not** imply **random matching**

$$\overbrace{\frac{Cov[\Delta D_f, X_b]}{Var[X_b]}}^{\text{Bank-Firm Sorting}} = \overbrace{\frac{Cov[\Delta \overline{S}_f, X_b]}{Var[X_b]}}^{\text{Bank-Syndicate Sorting}} = 0$$

Argument generalizes so long as loans from banks b_1 and b_2 are partial substitutes for firm f

1. Implications for Khwaja-Mian ('08) Empirical Designs

Equilibrium implications of sorting

1. **Sorting increases cross-sectional variance of firm outcomes**

$$Var[\Delta L_f^*] = \frac{\sigma^2 \times Var\left[\Delta D_f\right] + \delta^2 \times Var\left[\Delta \overline{S}_f\right] + 2\sigma\delta \times Cov\left[\Delta D_f, \Delta \overline{S}_f\right]}{(\sigma + \delta)^2}$$

   1.1 Positive (Bank-Firm Sorting) raises $Cov\left[\Delta D_f, \Delta \overline{S}_f\right]$

$$0 < Cov\left[\Delta D_f, \Delta \overline{S}_f\right] < Cov\left[\Delta D_f, \Delta S_b\right]$$

   1.2 Positive (Bank-Syndicate Sorting) raises $Var\left[\Delta \overline{S}_f\right]$

$$\frac{Var\left[\Delta S_b\right]}{N} < Var\left[\Delta \overline{S}_f\right] < \frac{Var\left[\Delta S_b\right]}{N} + \frac{(N-1)}{N} Cov\left[\Delta S_b, \Delta S_{b'}\right]$$

2. **Riskier (more cyclical) firms have larger changes in credit**

$$\frac{Cov[\Delta L_f^*, \Delta D_f]}{Var\left[\Delta D_f\right]} = \frac{\sigma}{\sigma + \delta} + \frac{\delta}{\sigma + \delta} \times \overbrace{\frac{Cov\left[\Delta \overline{S}_f, \Delta D_f\right]}{Var\left[\Delta D_f\right]}}^{\text{Firm-Syndicate Sorting}} > \frac{\sigma}{\sigma + \delta}$$

2. Assignment Model

Setting

- **Continuum of firms $f \in [0, N]$ and banks $b \in [0, N]$**
- **Firm f has project with expected payoff Y.**
  - Finances using loan with expected payoffs $L(f)$.
- **Firm payoff:** $U(f) = Y - L(f)$
  - Outside option of $U = 0$
- **Bank b maximizes:** $W(b) = \max_f \{L(f) - (1 + r_f) - C(f, b)\}$
  - Outside option of $W = 0$
  - $C(f, b)$ is "holding cost" of bank b when lending to firm f
    1. $C_1(f, b) > 0$;
    2. $C_2(f, b) < 0$;
    3. $C_{12}(f, b) < 0$ (ensures positive sorting in equilibrium)
  - Bank b's FOC: $L'(f) = C_1(f, b)$
- **Surplus is** $S(f, b) = Y - (1 + r_f) - C(f, b)$

2. Assignment Model

Equilibrium solution

- **Positive sorting: Firm f is matched to bank $b^*(f) = (N - f^*) + f$**
  1. Lowest risk firm receives full surplus $\Rightarrow L(0) = (1 + r_f) + C(0, N - f^*)$
  2. FOC: $L'(f) = C_1(f, b)$
  3. Combining **1)** and **2)** implies

$$L(f) = [(1 + r_f) + C(0, N - f^*)] + \int_0^f C_1(i, N - f^* + i)\, di.$$

  4. Marginal firm receives nothing $\Rightarrow L(f^*) = Y$
  5. **Marginal firm $f^* \in [0, N]$ pinned down by**

$$Y = L(f^*) = [(1 + r_f) + C(0, N - f^*)] + \int_0^{f^*} C_1(i, N - f^* + i)\, df$$

- **Comparative statics on f^***: Suppose $C(f, b) = V(f) \div \tau(b)$ where $V'(f) > 0$ and $\tau'(b) > 0$.
  1. Increase in Y raises f^*
  2. Outward shift in $V(f)$ curve lowers f^*
  3. Outward shift in $\tau(b)$ curve raises f^*

2. Assignment Model

Comment 2.a: Interpretation of banks' "holding costs"

- **Most natural interpretation to me:** $C(f, b) = V(f) \div \tau(b)$
  1. $V(f) =$ **firm f's risk**: $V'(f) > 0$
  2. $\tau(b) =$ **bank b's risk tolerance** (reciprocal of risk aversion): $\tau'(b) > 0$
     - **Note:** $\tau(b)$ could also reflect b's optimism about defaults
     - Evidence that intermediaries w/ weaker risk management practices and better past luck took more risk prior to GFC: Fahlenbrach, Prilmeier, Stulz (2012), Berg (2015), Bouwman and Malmendier (2015), Chernenko, Hanson, Sunderam (2017), etc.
- **Equilibrium loan pricing equation:**

$$\overbrace{L'(f)}^{\text{Change in credit risk premium}} = \overbrace{V'(f)}^{\text{Change in loan risk}} \div \overbrace{\tau(b^*(f))}^{\text{Risk tolerance of } b^*(f)}$$

- **Firm f's risk premium depends** on (i) **distribution of firm risk** (among firms less risky than f) and (ii) **distribution of bank risk tolerance** (among banks w/ less tolerant than $b^*(f) = (N - f^*) + f$)

$$L(f) = (1 + r_f) + \frac{V(0)}{\tau(N - f^*)} + \int_0^f \frac{V'(i)}{\tau(N - f^* + i)} di$$

2. Assignment Model

Comment 2.b: An empirical quibble

- **Key empirical step:** Procedure for infering distribution of bank risk tolerance from loan spreads and PDs:

$$L'(f) = V'(f) \div \tau(b^*(f))$$

  1. Sort issuers f based on credit ratings (lowest = AAA to highest = CCC)
  2. Proxy for $L(f) = 1 + Spread(f) \times (1 - PD(f)) - LGD \times PD(f)$ (Note: Set $LGD = 0$ as opposed to e.g. 50%)
  3. Proxy for $V(f) = PD(f)$
  4. Bin issuing firms into groups by ratings and compute averages
  5. Pre-crisis versus GFC changes in $\tau(b^*(f))$
     $=$ Changes in mapping between slope of $V(f)$ and slope of $L(f)$

- **Empirical nitpick:** PDs are based on ratings
  - **Assume a time-invariant mapping from ratings to PDs**
  - But there is a lot time-variation in true mapping from ratings to PDs
  - By ignoring this time-variation, potential to overstate shifts in $\tau(b^*(f))$

2. Assignment Model

Comment 2.c: How heavily are we leaning on assignment framework?

1. **Assignment models used to study efficient allocation of indivisible factors of production—e.g., managers and firms.**
   - Well-suited to study sorting between firms and lenders?
   - Procedure for inferring bank risk tolerance distribution from spreads and PDs takes assignment model seriously: $L'(f) = V'(f) \div \tau(b^*(f))$
2. **Other ways to generate equilibrium sorting in credit markets:**
   - Heterogeneity in borrower risk and in lender risk tolerance;
   - Banks hold portfolio of loans but are subject to borrowing/capital constraints a la Black (1972) and Frazzini and Pederson (2014)

   2.1 Aggregate lending volume will have similar comparative statics
   2.2 More risk tolerant lenders overweight riskier borrowers in equilibrium.
   2.3 But, mapping between loan spreads, borrower risks, lender risk tolerances is far more complicated: $L'(f) \neq V'(f) \div \tau(b^*(f))$

- **How robust are quantitative conclusions ($\sim 60\%$ due to supply) to other structural models w/ similar qualitative implications?**

2. Assignment Model

Comment 2.d: Incorporating switching costs

1. **Firms face important switching costs in loan market (especially in bad times) due to asymmetric information**
   - **One polar case:** Assignment model or capital-markets-style equilibrium with no switching costs
   - **Other polar case:** Empirical literature often proceeds as if switching costs are infinite
   - **Middle ground:** Possible to build models that feature (i) switching and meaningful bank-firm sorting in the long run, but (ii) large short-run switching costs (especially in bad times)?
2. **Dynamic implications of switching costs**
   - Adding short-run switching costs likely to lead larger contractions in credit during bad times
   - Precautionary motive for risky, bank-dependent firms to match with conservative banks (Schwert (2018))
   - If easier for f to switch to more aggressive b than more conservative b
     - Failure of a conservative b will have smaller ex post consequences
     - Failure of an aggressive b will have larger ex post consequences
     - But, aggressive bs are more likely to fail due to ex ante sorting

Conclusion

- **Fantastic paper that will shape how I think about credit markets**
- **Firm-bank sorting seems underappreciated and likely to be of first-order importance**
- **Area with many opportunities for future research**
- **THANKS!**