The Reserve Supply Channel of Unconventional Monetary Policy

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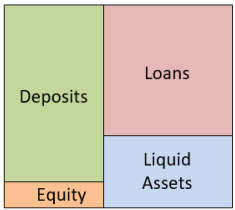
Introduction

- In both the 2020 and 2008 recessions, a key policy of the Federal Reserve was Quantitative Easing (QE):
  - issuances of trillions of central bank reserves to buy debt securities
  - central bank reserves are safe, liquid assets that can only be held by banks
- What is the impact of this increase in reserve supply on borrowing and lending by banks?
- Main Finding: $1 of reserves created by QE crowds out 13 cents of bank lending
- Approach: a structural supply and demand model for bank borrowing and lending estimated using cross-sectional instrumental variables.

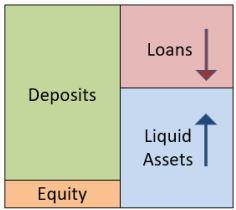
Reserves and Bank Lending: Previous Theory

The impact of reserves on bank lending is ambiguous in theory

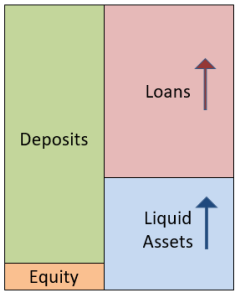
1. Reserves could crowd-in bank lending:
   - Reserves are a scarce liquid asset whose supply constrains bank lending (e.g. Kashyap Stein 93)
2. Reserves could also crowd-out bank lending
   - Scarce supply of bank equity (e.g. He Krishnamurthy 13) and bank leverage regulation (e.g. Du Tepper Verdelhahn 18) makes it costly for banks to expand.



Benchmark

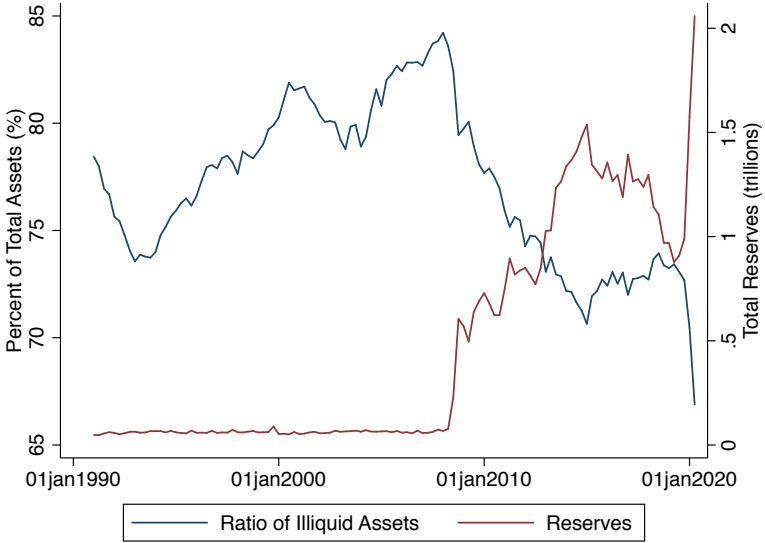


Crowd-out of Loans



Crowd-in of Loans

Reserves and Bank Lending: Time Series Data



Approach

- Time-series trends suggestive but could be caused by the recession that led to QE
- We estimate a structural model of the market for bank deposits and loans, which answers two key questions.
  1. How elastic is the demand for deposits/loans?
  2. How does holding reserves change the cost of supplying deposits/loans?
- Counterfactual analysis: increase supply of bank reserves and compute new deposit/loan interest rates and quantities.

Findings

The "Reserve Supply Channel" of QE:

1. We find that each dollar of reserves added to the banking system crowds out 13 cents of corporate bank lending.
2. Deposit and mortgage quantities are effectively unchanged.
   - Demand for large corporate loans is much more rate-elastic than deposit and mortgage demand
3. Adding $4.23 trillion of reserves increases the excess reserves-federal funds rate spread by 15 bps
   - 6 bps passthrough to deposit rates
   - 5 bps passthrough to loan rates.

Key mechanism: only banks can hold reserves and adjusting bank asset holdings is costly

Relation to Literature

1. Estimate a new channel of QE transmission through bank balance sheets
   - Asset prices: e.g. Krishnamurthy and Vissing-Jorgensen 11
   - Bank balance sheet: e.g. Rodnyansky and Darmouni 17, Chakraborty et al. 20, Kandrac and Schlusche 2021
   - Conventional montary policy transmission: Drechsler et al. 17, Scharfstein and Sunderam 16 , Wang et al. 20
2. Quantify synergies between illiquid loans, liquid securities and deposit liabilities on bank balance sheets
   - Synergies: e.g. Kashyap and Stein 93, Diamond and Rajan 00, Kashyap et al. 02
   - Balance sheet constraints: e.g. He and Krishnamurthy 13, Du et al. 18
3. Develop a structural banking model identified using cross-sectional instruments
   - BLP: Egan, Hortacsu, and Matvos 17, Buchak 18, Wang et al. 20, Xiao 20, Buchak et al. 20
   - Revealed preferences: Akkus et al 16, Schwert 18, Craig and Ma 18

Roadmap

1. Model
2. Demand System
3. Cost Function
4. Counterfactual
5. Conclusion

Model

Model in One Slide

- Each bank i faces a residual demand curve $Q_L(r_L^i, r_L^{-i})$ for the quantity it can lend at rate r_L. Similar for deposits and mortgages.
- Bank pays a "liquidity cost" $C(Q_L, Q_D, Q_M, Q_S)$, maximizes profits

$$(r_L^i - r_{0,L}) \cdot Q_L(r_L^i; r_L^{-i}) + (r_M^i - r_{0,M}) \cdot Q_M(r_M^i; r_M^{-i}) + (r_D^i - r_{0,D}) \cdot Q_D(r_D^i; r_D^{-i}) + (r_S - r_0) Q_S - C(Q_L, Q_D, Q_M, Q_S).$$

- Optimal loan rate r_L given by

$$\overbrace{\frac{d}{dr_L}((r_L^i - r_0) \cdot Q_L(r_L^i, r_L^{-i}))}^{\text{Marginal Revenue}} = \overbrace{C_L(Q_L, Q_D, Q_M, Q_S) Q_L'(r_L^i; r_L^{-i})}^{\text{Marginal Cost}}.$$

- Similar equations for deposits and mortgages. For liquid securities, market is competitive:

$$(r_S - r_0) = C_S(Q_L, Q_D, Q_M, Q_S).$$

Prices and Quantities in Imperfectly Competitive Banking Markets

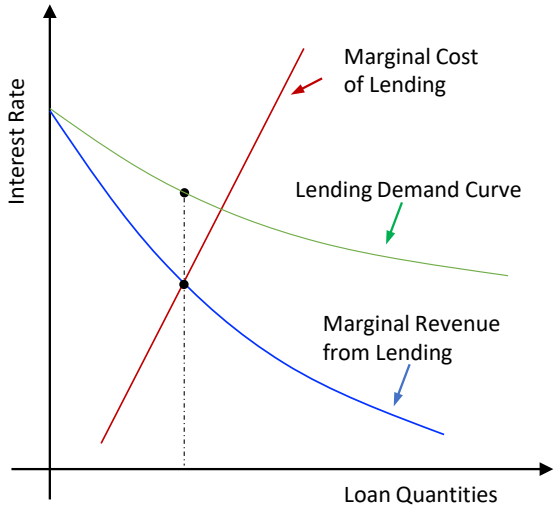
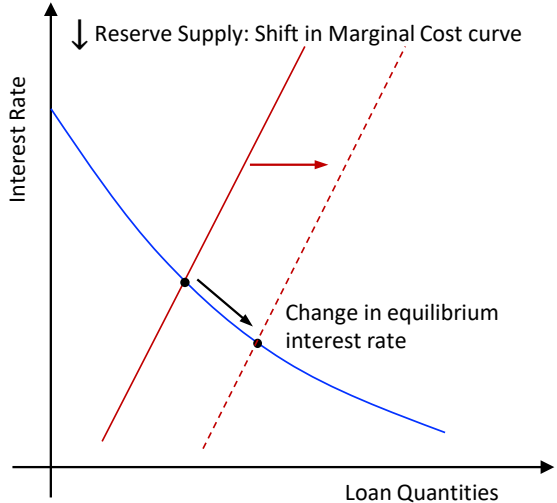


Figure: Supply of Central Bank Reserves and Bank Asset Illiquidity

Prices and quantities in imperfectly competitive banking markets



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Prices and Quantities in Imperfectly Competitive Banking Markets

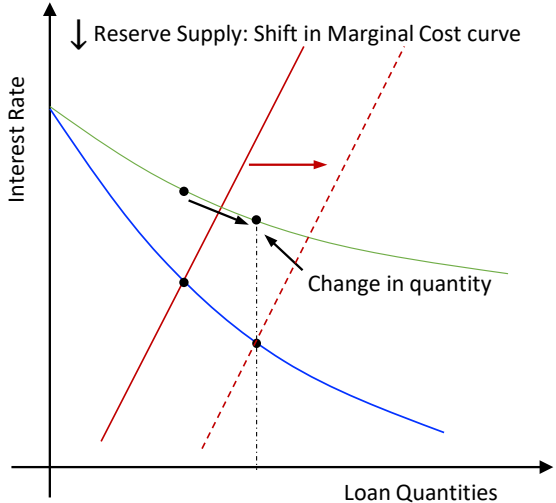

Figure: Supply of Central Bank Reserves and Bank Asset Illiquidity

Our Approach: Objects to Estimate

$$\overbrace{\frac{d}{dr_L}((r_L^i - r_0) \cdot \frac{Q_L(r_L^i, r_L^{-i}))}{Q_L'(r_L^i; r_L^{-i})}}^{\text{Marginal Revenue}} = \overbrace{C_L(Q_L, Q_D, Q_M, Q_S)}^{\text{Marginal Cost}}.$$

1. The residual demand curve $Q_L(r_L^i, r_L^{-i})$ for bank loans, deposits, mortgages
   - IO-style demand estimation (Berry, Levinsohn, Pakes (1995))
   - Need: supply shock IV
2. Banks' marginal cost of lending in terms of balance sheet composition
   - Multiple balance sheet components simultaneously respond
   - Need: multiple IVs

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Demand System

Demand System Estimation: Data

- Annual bank-market-level data from 2001 to 2017
  1. Deposits
     - ⋆ County-level market
     - ⋆ Deposit volume: FDIC
     - ⋆ Deposit rate: RateWatch (10K Money Market rate)
  2. Mortgages
     - ⋆ County-level market
     - ⋆ Mortgage volume: HMDA
     - ⋆ Mortgage rate: RateWatch (15 Year Fixed Rate)
  3. Loans
     - ⋆ State-level market (defined by location of borrower)
     - ⋆ Loan volume and rates: Dealscan
- Bank-level characteristics from Call Reports

Demand System Estimation: Instrument

- Need: Exogenous shock to loan/deposit supply to trace out demand curves
- Supply shock: Reallocation after disasters following Cortes and Strahan 17
  - Natural disasters provide a positive shock to local loan demand
  - Banks reallocate funds away from other bank branches to meet demand
  - $\rightarrow$ negative loan supply shocks at other branches of bank
- Assumption for validity: Natural disasters do not directly affect demand for deposits, loans, and mortgages in unaffected counties

Demand System Estimation

- We use a Logit demand system, where deposit quantities $Q_{D,nmt}$ satisfy linear relationship

$$\log Q_{D,nmt} - \log Q_{D,nm't} = \alpha_D(R_{D,nmt} - R_{D,nmt}) + \beta_D(X_{D,nmt} - X_{D,nm't}) + (\delta_{D,nmt} - \delta_{D,nm't})$$

- Key parameter α_D: how the desirability of deposits, mortgages, and loans changes with rates.
- Estimate α_D by 2 stage least squares using natural disaster instrument.

Demand System Estimation: 2SLS Results

$$\log Q_{D,nmt} = \zeta_{D,nt} + \alpha_D \hat{R}_{D,nmt} + X_{D,nmt}\beta_D + \delta_{D,nmt}.$$

	(1)	(2)	(3)
	Deposit Market Share	Mortgage Market Share	Loan Market Share
Rate (with IV)	46.45***	−556.81***	−519.04***
	(9.49)	(96.72)	(82.94)
Loan Loss Provision	−1.58***	−9.80	7.15
	(0.27)	(8.38)	(4.86)
Lag Deposit Market Share	0.91***		
	(0.01)		
Lag Insured Deposit Ratio	−0.32***		
	(0.05)		
Log Property Damage	0.11***	0.76***	
	(0.01)	(0.06)	
Observations	234,857	70,519	23,829
R^2	0.98	-0.78	-5.65
Adjusted R^2	0.97	-1.96	-5.92

10 bps increase in deposit rate ⇒ deposit volume increase by 4.6%

Outside Options and Mark-up

- α_D describes how the **difference** between two bank's log quantities depends on the **difference** between their interest rates.
- We aggregate our instrument to a county-level shock to see how aggregate quantities respond to an aggregate shock to interest rates δ^o.
- Estimate $\beta_{D,o}$ from IV regression:

	(1)	(2)
	Deposit Share	Mortgage Share
δ^o (with IV)	0.29^{**}	0.08^{*}
	(0.13)	(0.04)

Interpretation: If a bank changes its deposit rates, 29% (or 8% for mortgages) of its new customers will come from outside the market. Roughly 40% for corporate loans.

Cost Function

Cost Function Estimation: Data

- Bank-level interest rates and mark-up estimates
  - Obtained from demand-system results
  - Averaged to the bank-level
- Bank-level volumes from Call reports
  - Deposits: total deposits
  - Mortgages: residential loans
  - Loans: loans other than residential loans
  - Securities: cash, reserves, Fed funds, Treasury securities, agency securities

Cost Function Estimation

- Recall the key first-order condition for bank i's lending rate:

$$\overbrace{\frac{d}{dr_L}((r_L^i - r_0) \cdot \frac{Q_L(r_L^i, r_L^{-i}))}{Q_L'(r_L^i; r_L^{-i})}}^{\text{Marginal Revenue}} = \overbrace{C_L(Q_L, Q_D, Q_M, Q_S)}^{\text{Marginal Cost}}.$$

- We estimated the demand system on the left hand side- we now observe realized data of banks' marginal cost of providing deposits/mortgages/loans.
- Next step: See how marginal costs respond when bank adjusts balance sheet (Q_L, Q_D, Q_M, Q_S) in response to a demand shock.
- Multiple endogenous variables- need to use multiple exogenous shocks together.

Cost Function Estimation

- Instruments: 1.Natural disaster shock (reused at bank level) 2.Bank's exposure to regional deposit demand shocks (Bartik-type instrument).
- We regress marginal costs of borrowing/lending and all balance sheet quantities on each demand IV

$$C_{D,mt} = \theta_t^D + \kappa^{i,D} z_{mt}^i + u_{D,mt}^Q$$

and

$$\begin{aligned} Q_{D,mt} &= \alpha_t^D + \gamma^{i,D} z_{mt}^i + \varepsilon_{D,mt}^Q \\ Q_{M,mt} &= \alpha_t^M + \gamma^{i,M} z_{mt}^i + \varepsilon_{M,mt}^Q \\ Q_{L,mt} &= \alpha_t^L + \gamma^{i,L} z_{mt}^i + \varepsilon_{L,mt}^Q \\ Q_{S,mt} &= \alpha_t^S + \gamma^{i,S} z_{mt}^i + \varepsilon_{S,mt}^Q \end{aligned}$$

Cost Function Estimation: Results

Cost function Hessian: How balance sheet quantities impact marginal costs of borrowing and lending.

	$\frac{\partial C}{\partial D}$	$\frac{\partial C}{\partial M}$	$\frac{\partial C}{\partial L}$	$\frac{\partial C}{\partial S}$
Q_D	0.0616	−0.0365	−0.0330	−0.0125
Q_M	−0.0365	0.0060	0.0060	0.0060
Q_L	−0.0330	0.0060	0.0063	0.0081
Q_S	−0.0125	0.0060	0.0081	0.0203

- \$1 trillion in reserves distributed equally to observed bank branches in 2007:
  - $0.0125 \times 184 = 2.30$ bps drop in the marginal cost of deposits
  - $0.0203 \times 184 = 3.73$ bps drop in the marginal benefit of securities.

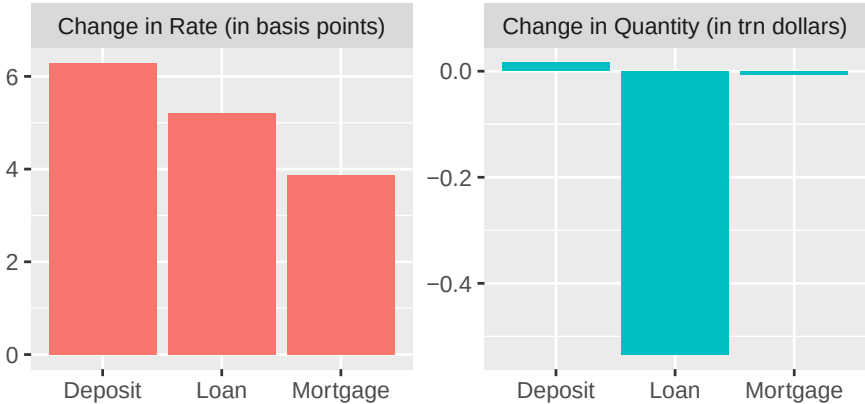
Counterfactual Analysis

Counterfactual Analysis: QE

- We use our model to simulate the impact of an increase in reserve supply like QE.
- We increase reserves enough to raise required return on reserves by 15 basis points, $4.76 trillion.
- Banks trade new reserves in a competitive market with each other, and choose new optimal deposit/mortgage/loan interest rates.
- Both interest rates and quantities respond in deposit/mortgage/loan markets in new equilibrium.

Counterfactual Analysis: Results

Figure: Effect of QE on the Banking Sector



Conclusion

- This paper: new "reserve supply channel" of QE transmission through bank balance sheets
- Structural model:
  - Demand: Imperfect competition in deposits, mortgages, and loans
  - Supply: cost synergies between bank balance sheet components
  - Identification: cross-sectional instruments
- Counterfactual: \$1 of reserves **crowd out** 13 cents of loans from bank balance sheets
- Potential solutions for crowding out: relax bank leverage regulation (SLR), allow non-banks to hold reserves.