Dynamic Banking and the Value of Deposits

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  - Equity issuance costs → bank is endogenously risk-averse → deposit inflow destroys shareholders' value when bank equity is low, close to issuance
  - A dynamic model of depository institution with endogenous risk-taking, deposit-taking, short-term borrowing, payout policy, equity issuance

Literature

US banks

Cash-rich US banks move to reduce corporate deposits

JPMorgan Chase and Citigroup take unusual step to avoid additional capital requirement

Imani Moise in New York MAY 4 2021

Financial Times

Banks including JPMorgan Chase and Citigroup have held conversations with some large corporate clients about putting cash into money market funds rather than in deposits, according to people briefed on the talks.

Deposits held at the three largest US banks by assets — JPMorgan, Bank of America and Citi — climbed $243bn in the first three months of the year, on top of a record $1tn inflow last year. In 2019 they rose by $92bn.

Introduction

Model

Results

Model: The Setup

- A_t loans: return $\frac{dA_t}{A_t} = (r + \alpha_A)\,dt + \sigma_A d\mathcal{W}_t^A$
- B_t short-term bonds: interest expenses $r\,dt$
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- X_t deposits: $\frac{dX_t}{X_t} = -\left(\delta_X dt - \sigma_X d\mathcal{W}_t^X\right) + n\left(i_t\right) dt$, with $n'\left(i_t\right) > 0$
  - Net withdrawal rate: $\delta_X dt - \sigma_X d\mathcal{W}_t^X$, $corr.\left(d\mathcal{W}_t^X, d\mathcal{W}_t^A\right) = \phi dt$
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  - Under equity issuance costs H_t: max $\mathbb{E}\left[\int_{t=0}^{\infty} e^{-\rho t}\left(dU_t - dF_t - dH_t\right)\right]$

Results: Endogenous Risk Aversion, Payout Policy and Equity Issuance

- 2 state variables: equity capital K_t and deposit stock X_t
  - A transformation from (K_t, X_t) to (k_t, X_t) where $k_t = K_t / X_t$
  - The value function $V_t = V(K_t, X_t) = v(k_t) X_t$

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  - $V_{KK}(K_t, X_t) < 0$, risk-averse towards K_t fluctuation under issuance costs

(Brunnermeier, Sannikov,2014; Klimenko, Pfeil, Rochet, Nicolo,2016; Phelan,2016)

Dynamic Optimization | Dynamic Optimization under Parametric Choices

Results: Optimal Deposit Rate

$$i(k) = \frac{\frac{V_X(X,K)}{V_K(X,K)} - \frac{1}{\omega}}{\theta\omega} = \frac{\frac{v(k) - v'(k)k}{v'(k)} - \frac{1}{\omega}}{\theta\omega}$$

- ω: semi-elasticity of deposit demand (Drechsler, Savov, Schnabl, 2017)
  - The rate-dependent component of deposit flow: $n(i)dt = \omega i dt$ calibration
- θ: the convex cost of running deposit franchise $C\left(n\left(i\right), X\right) = \frac{\theta n(i)^2}{2} X$

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  - Adjusted Q, $\frac{V_X(X,K)}{V_K(X,K)}$: building the deposit base vs. earnings

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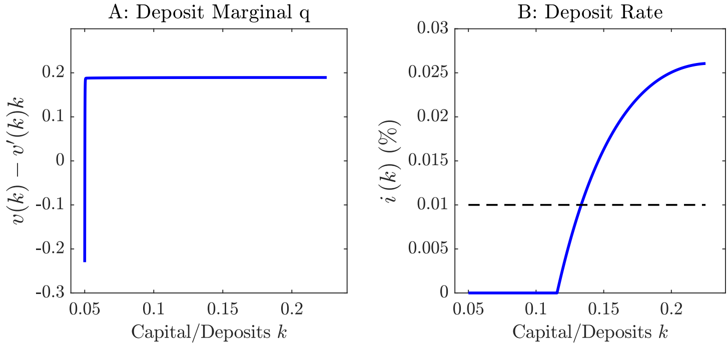
- Deposit-rate lower bound: $i(k) \geq 0$ (Heider, Saidi, Schepens, 2019)

Bank Optimization under Parametric Choices

Results: Deposit Marginal q and Optimal Deposit Rate



Results: The Mechanism of Dynamic Deposit Marginal q

$$dK_t = A_t \left[(r + \alpha_A)\, dt + \sigma_A d\mathcal{W}_t^A \right] - B_t r dt - X_t i_t dt - C\left(n\left(i_t\right), X_t\right) dt - dU_t + dF_t$$

$$C\left(n\left(i_t\right), X_t\right) = \frac{\theta}{2} n(i_t)^2 X_t \text{ and balance-sheet identity } X_t + K_t = A_t - B_t \quad \Rightarrow$$

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  - The bank is endogenously risk averse under equity issuance costs
  - $\rightarrow$ Deposit marginal q, $V_X\left(X, K\right)$, turns negative as k falls to $\underline{k}$

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- The distance between r and 0 measures the flexibility in managing deposits
  - Low r: deposit risk management is more difficult and bank value declines

Results: Risk-Taking

$$\frac{A}{K} = \frac{K + X + B}{K} = \frac{\alpha_A}{\gamma(k)\sigma_A^2} + \frac{\sigma_X}{\sigma_A}\phi$$

- Merton's portfolio choice, wealth K (equity) and risky asset A (loans)
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- $\frac{\sigma_X}{\sigma_A}\phi$: Hedging the" background risk" in deposit-flow uncertainty
  - A large literature on the synergy between deposit-taking and lending

Results: Risk-Taking

$$\frac{A}{K} = \frac{K + X + B}{K} = \frac{\alpha_A}{\gamma\left(k\right)\sigma_A^2} + \frac{\sigma_X}{\sigma_A}\phi$$

- Merton's portfolio choice, wealth K (equity) and risky asset A (loans)
- $\gamma\left(k\right) \equiv \frac{-V_{KK}(X,K)K}{V_K(X,K)} = -\frac{v''(k)k}{v'(k)}$ decreases in $k = K/X$
  - $\frac{A}{K}$ increases in k, so capital requirement limits procyclicality in risk-taking
  - A high-k bank uses $B > 0$ to amplify leverage
  - A low-k bank uses $B < 0$ (i.e., hold bonds) to de-risk asset side of B/S
  - Evidence from Copeland, Duffie, and Yang (2021): intraday payment risk $\sigma_X \rightarrow \gamma\left(k = \frac{K}{X}\right) \rightarrow$ bank demands safe assets, i.e., $B < 0$
- $\frac{\sigma_X}{\sigma_A}\phi$: Hedging the" background risk" in deposit-flow uncertainty
  - A large literature on the synergy between deposit-taking and lending

Dynamic Optimization under Parametric Choices | A/K Graphs (State Space) | A/K Graphs (Long Run) | B Graphs

Results: Total Leverage Regulation and Reaching For Yield

- The supplementary leverage requirement (SLR) was relaxed in 2020

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- SLR was restored in 2021 (to prevent banks being "lazy", holding bonds?)
  - Banks will take risk, and the outcome depends on what kind of risk

Summary: Deposit Risk Management under Equity Issuance Costs

- Net interest margin: loan return - $r + r$ - deposit rate

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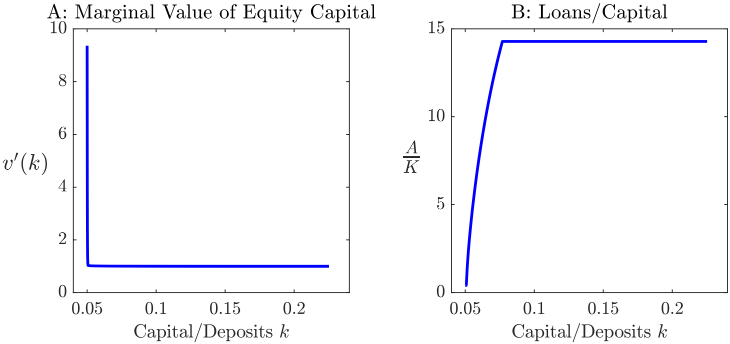
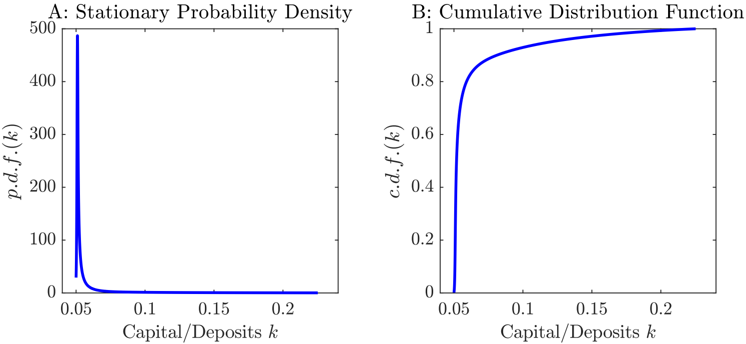
- A dynamic model of depository institution with practical applications:
  - (1) procyclical risk-taking; (2) procyclical short-term debt; (3) procyclical dividend payout; (4) countercyclical equity issuance; (5) jump risk graphs

Equity Capital Marginal q and Risk-Taking

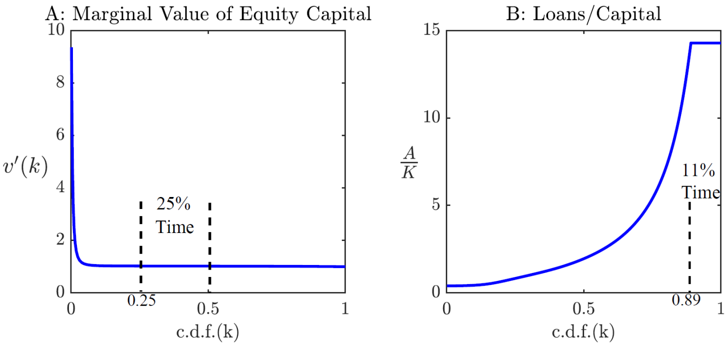


Back to Risk-Taking

Stationary Distribution of Capital-Deposit Ratio



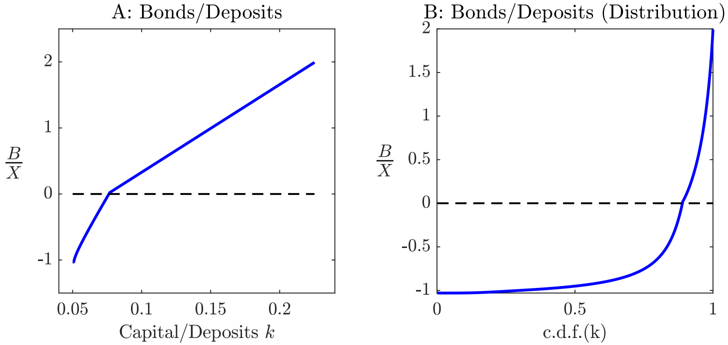
Equity Capital Marginal q and Risk-Taking over the Long Run



- Capital requirement does not always bind (Gropp, Heider, 2010; Begenau, Bigio, Majerovitz, Vieyra, 2019)

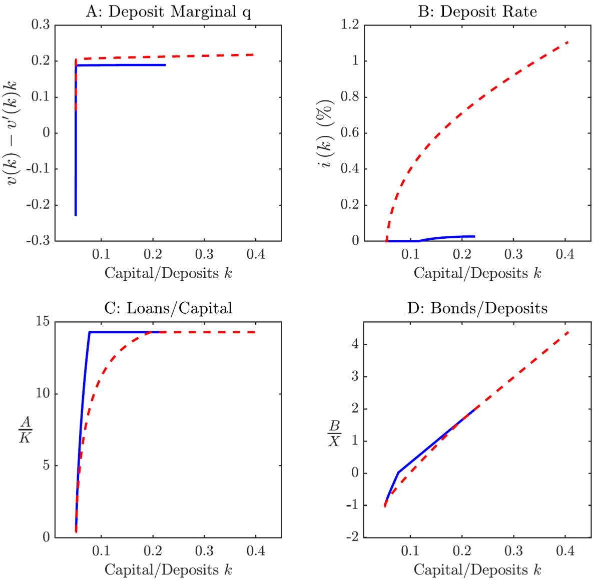
Back to Risk-Taking

Short-Term Debts



Back to Risk-Taking

Introducing Jump Risk in Loan Returns



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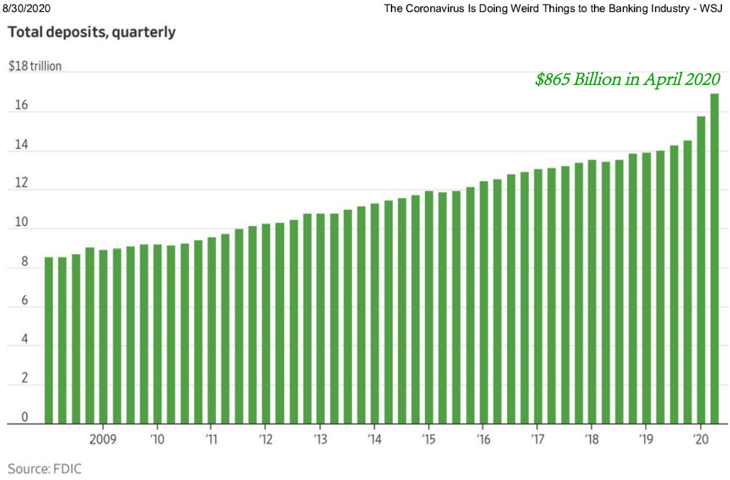
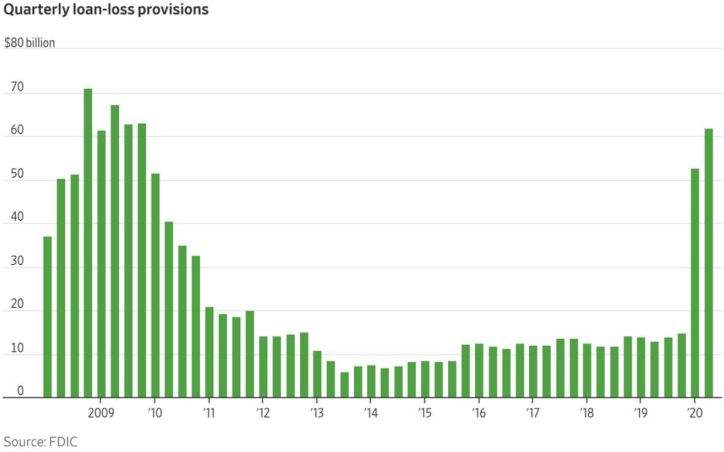
What Happened during Covid-19 – Deposit Influx



Back to Summary

What Happened during Covid-19 – Weakened Capital

8/30/2020 The Coronavirus Is Doing Weird Things to the Banking Industry - WSJ



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What Happened during Covid-19 – Depressed Valuation

Back to Summary

Literature

- Deposits pay an interest rate below the prevailing risk-free rate
  - Banks have deposit market power (Drechsler, Savov, and Schnabl, 2017)
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$\rightarrow$ Marginal value of deposits is positive and banks only worry about outflows

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→ Marginal value of deposits is positive and banks only worry about outflows

- Deposit marginal q can be negative, and inflow implies future risk

Back to Introduction

Calibration

Table: Parameter Values

Parameters	Symbol	Value	Target
risk-free rate	r	1%	FRED: Fed Fund Rate
discount rate	ρ	4.5%	Literature
bank excess return	α_A	0.2%	FRED: Bank ROA
asset return volatility	σ_A	10%	Literature
deposit flow (mean)	δ_X	0	Literature
deposit flow (volatility)	σ_X	5%	Literature
deposit maintenance cost	θ	0.5	Deposits/Total Liabilities
deposit demand semi-elasticity	ω	5.3	Literature
corr. between deposit and asset shocks	ϕ	0.8	Prob.(Capital Requirement Binds)
equity issuance fixed cost	ψ_0	0.1%	Issuance-to-Equity Ratio
equity issuance propositional cost	ψ_1	5.0%	Literature
SLR requirement parameter	ξ_L	20	Regulation
capital requirement parameter	ξ_K	14.3	Regulation

Back to Deposit Rate

Model: Optimization – HJB Equation

- Payout, dU_t, and issuance, dF_t, set boundaries for bank capital K_t
  - In the interior region, the value function satisfies the HJB equation

$$\rho V(X,K) = \max_{\pi^A,\, i} \; V_X(X,K)\left[-X\delta_X + n(i)X\right] + \frac{1}{2}V_{XX}(X,K)\,X^2\sigma_X^2$$
$$+ V_K(X,K)(X+K)\left(r+\pi^A\alpha_A\right) - V_K(X,K)\left[iX + C(n(i),X)\right]$$
$$+ \frac{1}{2}V_{KK}(X,K)(X+K)^2\left(\pi^A\sigma_A\right)^2 + V_{XK}(X,K)(X+K)\,\pi^A\sigma_A X\sigma_X\phi\,.$$

- The bank controls $\pi^A = A/(X+K)$ and i
  - Given states X and K, B/S identity, $A = X + B + K$, implies B

Back to Solution | Optimal Payout and Issuance | Optimal π^A | Optimal i

Model: Equity Issuance and Payout

- The bank raises equity only if

$$V\left(X, K + dF_t\right) - V\left(X, K\right) \geq dF_t + dH_t = \psi_0 X + \left(1 + \psi_1\right) M_t\,.$$

- Capital raised: $dF_t = M_t$, given by $V_K\left(X, K + M_t\right) = 1 + \psi_1$
- Issuance costs: $dH_t = \psi_0 X + \psi_1 M_t$
  - Fix cost scaled by X for value function be homogeneous in X

- The bank pays out dividend only if

$$V\left(X, K\right) - V\left(X, K - dU_t\right) \leq dU_t \text{ i.e., } V_K\left(X, K\right) \leq 1\,.$$

  - Optimality and smooth-pasting condition: $V_{KK}\left(X, K\right) = 0$

Back to Optimization

Model: Optimal Risk-Taking

$$\frac{A}{K} = \min\left\{ \frac{\alpha_A + \epsilon\left(X,K\right)\sigma_A\sigma_X\phi}{\gamma\left(X,K\right)\sigma_A^2}\,,\ \ \xi_K \right\}$$

$$\textit{Endogenous Risk Aversion:}\quad \gamma\left(X,K\right) \equiv \frac{-V_{KK}\left(X,K\right)K}{V_K\left(X,K\right)}$$

$$\textit{Hedging Motive:}\quad \epsilon\left(X,K\right) \equiv \frac{V_{XK}\left(X,K\right)X}{V_K\left(X,K\right)}$$

γ: Concavity, $V_{KK}\left(X,K\right) < 0$, from the equity issuance costs

ϵ: Hedging motive from background risk in the randomness of deposit flow

Back to Optimization

Model: Optimal Deposit Rate

$$V_X(X,K)\,n'(i) = V_K(X,K)\left[1 + C_n(n(i),X)\,n'(i)\right].$$

LHS : Marginal benefit of adding deposits

RHS : Marginal cost of paying deposit rates and deposit maintenance costs (from adding more deposits)

Back to Optimization

Model: Solution under Homogeneity

- State space transformation: $(K_t, X_t) \to (k_t, X_t)$ where

$$k_t = \frac{K_t}{X_t}$$

- Value function: $V(X, K) = v(k)X$ and HJB equation (ODE)

$$\begin{aligned}
\rho v(k) = \max_{\pi^A, i} \; & \left[v(k) - v'(k)k\right](-\delta_X + \omega i) + \frac{1}{2}v''(k)k^2\sigma_X^2 \\
& + v'(k)(1+k)\left(r + \pi^A \alpha_A\right) + \frac{1}{2}v''(k)(1+k)^2\left(\pi^A\sigma_A\right)^2 \\
& - v'(k)\left[i + \frac{\theta}{2}(\omega i)^2\right] - v''(k)k(1+k)\pi^A\sigma_A\sigma_X\phi \, .
\end{aligned}$$

- The bank controls $\pi^A = A/(X+K)$ and i
  - Given states X and K, B/S identity, $A = X + B + K$, implies B

Back to Solution | Back to Risk-Taking | Back to Deposit Rate | Optimal Payout and Issuance | Optimal π^A | Optimal i

Model: Equity Issuance and Payout under Homogeneity

- The bank pays out dividend at $k_t = \overline{k}$ with the ODE boundary

$$v'\left(\overline{k}\right) = 1\,,$$

  - Optimality and smooth-pasting condition: $v''\left(\overline{k}\right) = 0$ to pin down $\overline{k}$

- The bank raises equity at $k_t = \underline{k}$ with the ODE boundary

$$v'\left(\underline{k} + m\right) = 1 + \psi_1\,,$$

  - Capital raised: $dm = M_t / X_t$, given by $v\left(\underline{k} + m\right) - v\left(\underline{k}\right) = \psi_0 + \left(1 + \psi_1\right) m$
  - Determining $\underline{k}$: $v\left(k\right)$ is globally concave so $\underline{k} = 0$
  - SLR: the bank raises equity to stay in compliance $\left(X + K\right) / K = \frac{1}{k} + 1 \leq \xi_L$

Back to Model Back to Optimization