Dynamic Banking and the Value of Deposits

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- A dynamic model of depository institution with endogenous risk-taking, payout policy, equity issuance, deposit-taking, and short-term borrowing
  - Deposit inflow brings uncertainty in future leverage
  - Deposit inflow destroys value for undercapitalized, risk-sensitive banks

Introduction

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Results

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Model: Balance Sheet

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  - If $B_t < 0$ (holding risk-free asset), $(A_t - B_t) / K_t = (K_t + X_t) / K_t \leq \xi_L$

Model: Income Statement

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

- Deposit maintenance costs: $C\left(n\left(i_t\right), X_t\right) dt$ (branches, customer services)
- Payout to shareholders: dU_t
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$$\textit{Shareholders' value: } \max_{\{A,B,i,U,F\}} \mathbb{E}\left[\int_{t=0}^{\infty} e^{-\rho t} \left(dU_t - dF_t - dH_t \right) \right]$$

- Friction: equity issuance is subject to issuance costs dH_t (≥ 0)

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Results: Bank Equity, Issuance, and Payout Policy under Issuance Costs

- The shareholders' value $V_t = V(K_t, X_t) = v(k_t) X_t$
  - Proportional cost is from the empirical literature
  - Fixed cost is calibrated to generate empirical issuance-to-book equity ratio
- Capital-to-deposit ratio, $k_t \equiv K_t / X_t \in [\underline{k}, \overline{k}]$, drives the choice variables

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  - $V_K(K_t, X_t) = v'(k_t) = 1$ only at **dividend payout boundary** $k_t = \overline{k}$ Detail

Dynamic Optimization Dynamic Optimization under Parametric Choices

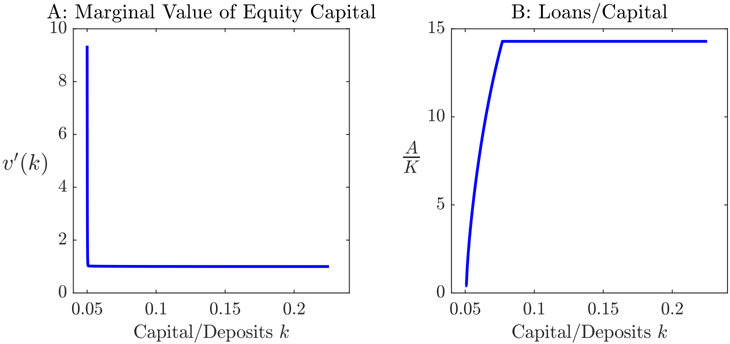
Results: Risk-Taking

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

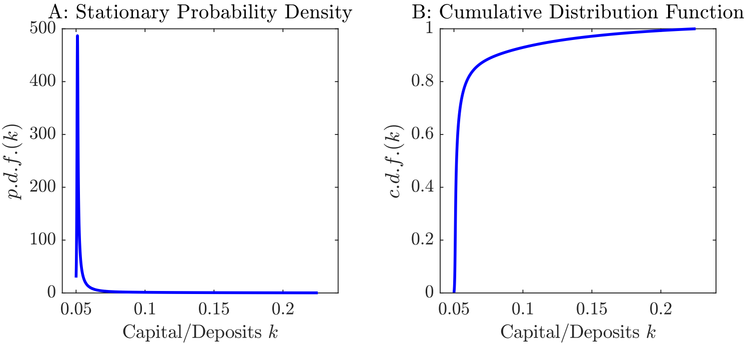
$\rightarrow$ Merton portfolio choice, wealth K (equity) and risky asset A (loans)

- $\gamma(k) \equiv \frac{-V_{KK}(X,K)K}{V_K(X,K)} = -\frac{v''(k)k}{v'(k)} > 0$: concavity in k from issuance costs
- $\frac{\sigma_X}{\sigma_A}\phi$: Hedging the" background risk" in deposit-flow uncertainty

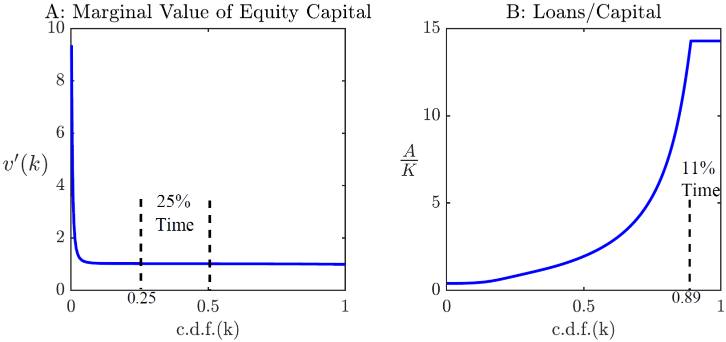
The Value of Equity Capital and Risk-Taking



Stationary Distribution of Capital-Deposit Ratio



The Value of Equity Capital and Risk-Taking over the Long Run



- Capital requirement does not always bind (Begenau, Bigio, Majerovitz, Vieyra, 2019)

Results: Optimal Deposit Rate

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

$\rightarrow$ Hayashi "investment" policy, investing in depositor/customer base

- $\frac{V_X(X,K)}{V_K(X,K)}$ is an adjusted Hayashi's Q
  - Deposit-taking (numerator) vs. return on equity (denominator)
- ω: semi-elasticity of deposit demand (Drechsler, Savov, Schnabl, 2017)
  - The rate-depedent component of deposit flow: $n(i)dt = \omega i dt$
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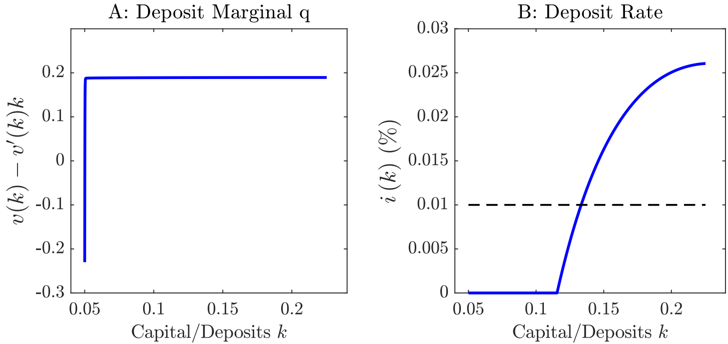
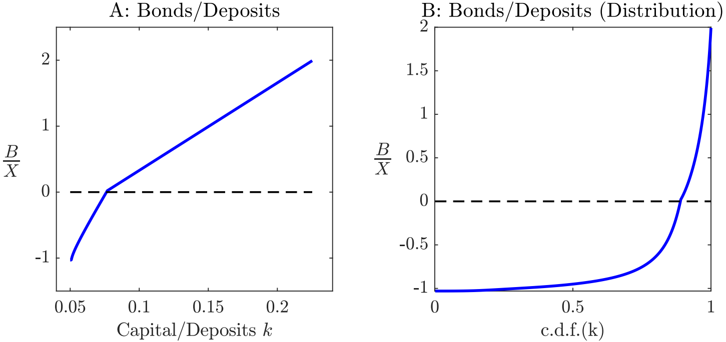
- Deposit-rate lower bound: $i(k) \geq 0$

Bank Optimization

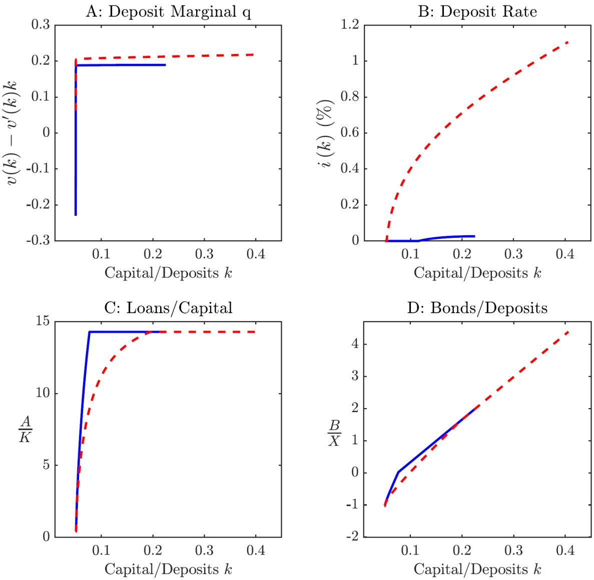
The Value of Deposits and Optimal Deposit Rate



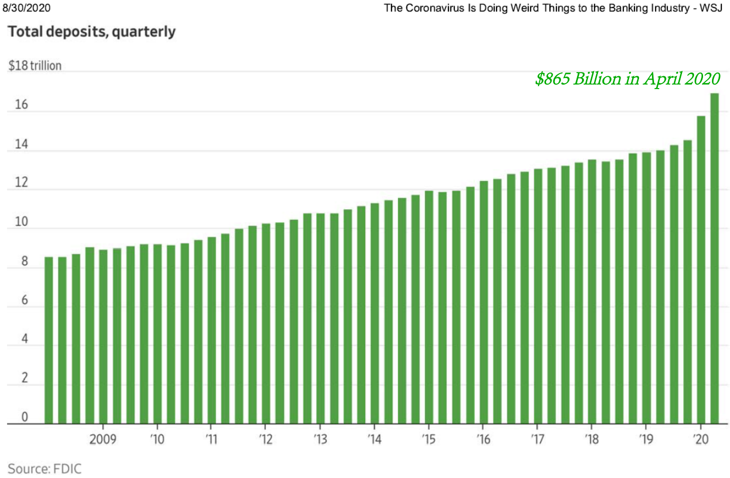
Short-Term Debts



Introducing Jump Risk in Loan Returns

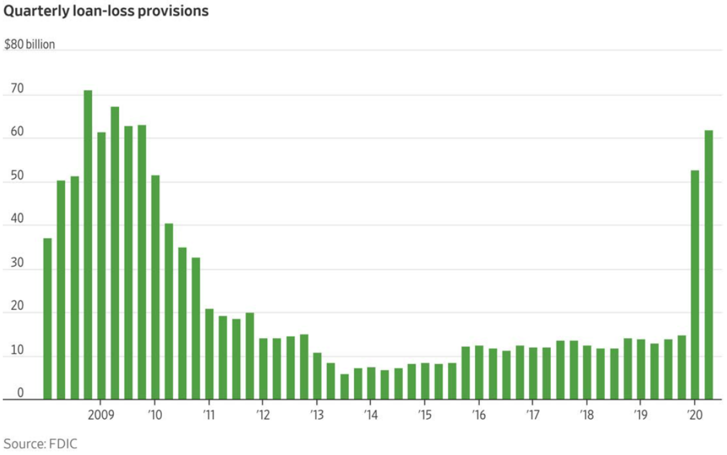


What Happened during Covid-19 Crisis – Deposit Influx



What Happened during Covid-19 Crisis – Weakened Capital

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



What Happened during Covid-19 Crisis – Depressed Valuation

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- A new perspective on the deposit-spread component of NIM

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  - Tightening SLR requirement $\rightarrow$ more risk-taking in the long run (reaching for yield to compensate more frequently incurred issuance costs)
- Relaxing SLR requirement has a long-lasting positive effect on bank value
  - Less frequent equity issuance $\rightarrow$ the bank is less risk-averse $\rightarrow$ deposit q $\uparrow$ $\rightarrow$ deposit rate $\uparrow$ and deposit rate lower bound becomes less binding

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

Conclusion: Deposit Risk and Deposit Marginal q

- Deposit accounts commit banks to accept inflows and outflows
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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

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

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  2. The increase of default probability leads to higher insurance premium

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- Public liquidity: Woodford, 1990; Holmström, Tirole, 1998; Krishnamurthy, Vissing-Jørgensen, 2012, 2015; Greenwood, Hanson, Stein, 2015; Drechsler, Savov, Schnabl, 2018; Moreira, Savov, 2017; Li, 2017; d'Avernas, Vandeweyer, Pariès, 2019; Liu, Schmid, Yaron, 2019; Vandeweyer, 2019

Model: Optimization – HJB Equation

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

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

- 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 Model | 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

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

  - 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)

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

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