A Q-Theory of Banks

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Motivation

- **Post Financial Crisis Banking Theory**
  - Many macro-finance models with different frictions
    - Effects of regulatory policies / welfare
    - Bank net-worth key state variable
    - Net-worth $\approx$ bank leverage (scaled bank equity)
  - What frictions & constraints determine bank leverage dynamics?
  - How to measure bank leverage?
    - Important difference between theory and data: accounting values
    - Not just measurement issue: reg. constraints in accounting values
    - Lowers incentives to report losses (Caballero et al, 2008; Milbradt, 2012; Blattner et al, forthcoming)
This paper

- **Five stylized facts**
  - Informative about what frictions and constraints matter
  - Many potential micro-foundations

- **Dynamic bank optimization model**
  - Built to quantitatively match stylized facts pre- and post-(fin)-crisis
    - Endogenous leverage target (trade-off)
    - Balance sheet stickiness
    - Accounting rules & regulatory constraints
  - Use model to conduct counterfactual exercise
    - What are the effects of new accounting towards early recognition of losses?
    - How does regulatory forbearance affect banks in this model?
Five Stylized facts


1. TS: Market & book equity values diverge - esp. during crises
2. XS: Books are slow to recognize losses
3. XS: Book equity buffer, leeway on market leverage
4. XS: Leverage dynamics consistent with target leverage ratio:
   - Negative net-worth shock increases market leverage (IRFs)
   - Slow reversion back to target
5. How do banks delever after negative net-worth shock?
   - Pre-crisis: adj. primarily by reducing assets
   - Post-crisis: faster adj. compared to before / also increasing equity
Bank Data

- FR Y-9C quarterly filings for bank holding companies (BHC)
  - BHC consolidates banks’ position across different subdivisions
  - Exclude new entrants (e.g. GS, MS, ...)
  - Merge with CRSP data
Fact 1:

Book Equity and Market Capitalization of BHCs

- Equity
- Equity (Public BHCs)
- Preferred Equity
- Market Capitalization
Fact 2: Market Information

![Graphs showing relationships between log(1 + Return on Equity Over Next Year) and log(Market-to-Book Ratio) for 2006 Q1 and 2009 Q1. The graphs illustrate positive and negative correlations.]

- The left graph shows a positive correlation between log(Market-to-Book Ratio) and log(1 + Return on Equity Over Next Year) for both quarters.
- The right graph illustrates a negative correlation between log(Market-to-Book Ratio) and log(1 + Net Charge-Off Rate) for both quarters.
Fact 3: Market-leverage dispersion [1/2]

- note: log scale
- binding market based constraints: opposite prediction
Fact 3: Book-Leverage buffer [2/2]

- minor fraction of banks below capital ratio
- much more compressed distribution than market values
Taking Stock: Book/Market Value Differences?

- **Historical cost accounting**
  - banks must acknowledge asset impairments:
    - after “estimable and probable” (will change in 2020)
  - Other securities are held at “fair value”
    - fair values based on similar assets (Level 2), or model (Level 3)

- **Off-balance sheet items**

- **Evergreening**
By using our databases and customer insight, we have been able to identify customers at risk of delinquency and reach out to them to restructure their loans before they slip into default. Our Citi Homeownership Assistance Program (CHAP) is a proactive program that helps avoid the loss of homes and protects credit scores and future borrowing potential. Through new assistance programs, we have helped about 440,000 homeowners weather the downturn. We are also pleased to support the Administration’s approach to mortgage loan modifications.
Fact 4: response to "wealth" shocks

- How banks respond to equity losses:

\[ \Delta \log(y_{i,t}) = \alpha_t + \sum_{h=0}^{20} (\gamma_h \cdot \varepsilon_{i,t-h} + \gamma_h \cdot Post_t \varepsilon_{i,t-h}) + \varepsilon_{i,t} \]

- \( y_{i,t} \): dividends, liability growth, leverage, market leverage
- \( \varepsilon_{i,t-h} \): equity loss \( h \) periods ago
- \( i \) is bank, \( t \) is a quarter

Fact 4: response to "wealth" shocks

- How banks respond to equity losses:

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- $y_{i,t}$: dividends, liability growth, leverage, market leverage
- $\varepsilon_{i,t-h}$: equity loss $h$ periods ago
- $i$ is bank, $t$ is a quarter


- Challenge: $\varepsilon_{i,t-h}$ not registered in books
Fact 4: response to equity losses

- Approach: estimate $\hat{\varepsilon}_{i,t}$ using

\[
\hat{r}_{it} - \hat{r}_t^f = \alpha_i + X_t \beta_i + \varepsilon_{it}
\]

- $r_{i,t}$: stock return
- $\hat{\varepsilon}_{i,t}$: “idiosyncratic wealth shocks”
Fact 4: response to equity losses

- **Approach:** estimate $\hat{\varepsilon}_{i,t}$ using

$$r_{it} - r_t^f = \alpha_i + X_t \beta_i + \varepsilon_{it}$$

- $r_{i,t}$: stock return
- $\hat{\varepsilon}_{it}$: “idiosyncratic wealth shocks”

- **Identification:**
  - controls for aggregate risk premia (market, interest rates, credit factors)
  - assumption: shocks *unpredictable*, first observable to markets, not in books
    $$\Rightarrow$$ cross-sectional return $\approx$ idiosyncratic shock to wealth
  - corroborate $\hat{\varepsilon}_{it}$ with narrative (newspaper article approach)
  - alternatives: stress-testing, size, investment opportunities
Fact 4: banks target market leverage

- No restrictions on $\sum \gamma_h = 0$
Fact 5: how did they return to target?

- reflects maturity or asset sales
Wells Fargo - 2019Q3 Basel III Pillar 3 Regulatory Capital Disclosures:

"Wells Fargo’s objective in managing its capital is to maintain capital at an amount commensurate with our risk profile and risk tolerance objectives, and to meet both regulatory and market expectations. We primarily fund our regulatory capital needs through the retention of earnings net of both dividends and share repurchases, as well as through the issuance of preferred stock, long-term debt and other qualifying instruments. We manage capital to meet internal capital targets with the goal of ensuring that sufficient capital reserves remain in excess of regulatory requirements and applicable internal buffers."
Robustness Checks

- Asymmetries
- Big vs. Small Banks
- Stress Tests
- Placebo
- Flight-to-Quality + Bank profitability?
Dynamic bank optimization model
Model set up

- Cross-section of dynamic bank optimization problems

- Balance sheet
  - Long term loans
  - Funded with equity and deposits
  - Balance sheet stickiness via convex loan funding costs

- Endogenous capital structure
  - Cannot issue equity only retained earnings / dividend smoothing motive
  - Liquidation costs

- Three equity value concepts:
  - Fair value / fundamental value
  - Accounting value
  - Market value

- Regulatory constraints & fair value leverage cap w/ costly liquidation
• Balance sheet

\[ \text{Loans} = \text{Deposits} + \text{Equity} \]

• Loans long term: \( \delta L \) mature and deliver exogenous return \( r^L \)

• New loan issuance \( I \) requires issuing deposits:

\[
\Phi (I, L) = I + \frac{\gamma}{2} \left( \frac{I}{L} - \delta \right)^2 L
\]
Asset risk & Accounting

- Poisson process $N_t$ governs loan default events
  - w/ prob $\sigma$ idiosyncratic share $\varepsilon$ of loans defaults
- Distinction b/w book value $\bar{L}$ and fair value $L$ loans
Asset risk & Accounting

- Poisson process $N_t$ governs loan default events
  - w/ prob $\sigma$ idiosyncratic share $\varepsilon$ of loans defaults
- Distinction b/w book value $\bar{L}$ and fair value $L$ loans
In equations

- **Fair value:**

\[
dL_t = \left( -\delta L_t + I_t \right) dt - \varepsilon L_t dN_t
\]

- **Accounting value:**

\[
d\bar{L}_t = \left( -\delta L_t + I_t \right) dt - \alpha (\bar{L}_t - L_t) dt - \tau \varepsilon L_t dN_t
\]

- **Fair value / accounting value ratio:**

\[
q_t \equiv \frac{L_t}{\bar{L}_t}
\]
Deposits

- Perfectly elastic supply of deposits at exogenous rate $r^D$
- Law of motion for deposits $D_t$

$$dD_t = \begin{bmatrix}
\text{repay deposits} & \text{interest & principal on loans} & \text{loan funding costs} & \text{dividends}
\end{bmatrix} dt$$
• Define leverage $\lambda_t \equiv D_t/W_t$ and equity $W_t = L_t - D_t$

• Law of motion for equity

$$\frac{dW}{W} = \left[ r^L (\lambda + 1) - r^D \lambda - \frac{\gamma}{2} (\iota - \delta)^2 (\lambda + 1) - c \right] dt$$

$$\equiv \mu^W$$

$$(-\varepsilon (\lambda + 1)) dN$$

$$\equiv J^W$$
Banks are liquidated if they violate
(i) reg. constraint, (ii) fair value constraint, or (iii) cannot repay deposits

Liquidation is costly
• **Bankers:** Recursive utility with Duffie-Epstein aggregator \( f \)

\[
V_t = \mathbb{E}_t \left[ \int_t^\infty f(C_s, V_s) \, ds \right],
\]

with time discount factor \( \rho \), RA = 0 and EIS = 1/\( \theta \).

• **Bank Problem:** max value \( V(L, \bar{L}, D) \) subject to:

  • loan, book, and deposit laws of motion, liquidation sets

  • **Prop:** only depends on \( \{\lambda, q\} \):
    • \( V(L, \bar{L}, D) = v(\lambda, q) \) \( W \)
    • \( c \equiv C(\lambda, q) / W \)
    • \( \iota \equiv I(\lambda, q) / L \)
    • \( d\lambda = (\iota - \delta - \text{drift}_{\text{Equity}}) (\lambda + 1) \, dt + \frac{\varepsilon(\lambda+1)}{1-\varepsilon(\lambda+1)} \lambda dN \)
    • \( dq = (\iota - \delta + \alpha) (1 - q) \, qdt - \left( \frac{\varepsilon - \tau \varepsilon q}{1-\tau \varepsilon q} \right) q dN \)
Frictionless solution

- No difference in market-to-book values: $\tau = 1 \implies q = 1$.
- No balance sheet frictions: $\gamma = 0$.
- Leverage solves the static problem:

$$
\max_{\lambda \in \left[0, \frac{\xi}{1-\xi}\right]} (1 + \nu) (r^L - r^D) \lambda + \sigma \left\{ (1 + \nu) \left[ (1 + J^W) \mathbb{I}[\lambda \leq \Lambda] + U(\eta) \mathbb{I}[\lambda > \Lambda] \right] \right. \\
\left. \text{wealth upon default shock} \quad \text{liquidation value} \right\}
$$

- Solution:
  - if bank not profitable (i.e. spread $(r^L - r^D)$ is too low) set $\lambda = 0$
  - if sufficiently profitable optimal leverage $\lambda > 0$
    - [interior] guarantees not to hit regulatory constraint: set at shadow liquidation boundary $\lambda^* = \Lambda$.
    - [corner] if $\varepsilon \to 0$
- Full model: slows down return to target over shocks
Frictionless model

- Difference in market-to-book values: $\tau < 1 \ (\Rightarrow q < 1)$.
- No balance sheet frictions: $\gamma = 0$.

**Figure 1**: Illustration of $\{q, \lambda\}$ dynamics.
- Solve the model using finite differences (numerical method).
- Match to quarterly BHC data matched to market data from CRSP
- Parameter set 1: independently calibrated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r^L = 1.01%$</td>
<td>Loan yield</td>
<td>BHC data: interest income / loans</td>
</tr>
<tr>
<td>$r^D = 0.51%$</td>
<td>Bank debt yield</td>
<td>BHC data: interest expense / debt</td>
</tr>
<tr>
<td>$\delta = 7.69%$</td>
<td>Loan maturity</td>
<td>FFIEC 031/041: avg mat of loans &amp; sec</td>
</tr>
<tr>
<td>$\bar{\lambda} = 50$</td>
<td>Market leverage constraint</td>
<td>CRSP/BHC: xs 97.5% prct leverage</td>
</tr>
<tr>
<td>$\xi = 0.926$</td>
<td>Capital requirement</td>
<td>Capital req of 8% to be well-capitalized</td>
</tr>
<tr>
<td>$\rho = 0.25%$</td>
<td>Banker’s discount rate</td>
<td>CRSP: Mean dividend rate</td>
</tr>
<tr>
<td>$\varepsilon = 0.25%$</td>
<td>Average default shocks</td>
<td>Accumulated bank losses</td>
</tr>
<tr>
<td>$\sigma = 0.4791$</td>
<td>Arrival rate of Poisson process</td>
<td>Match loan charge-off rate</td>
</tr>
<tr>
<td>$\alpha = 4%$</td>
<td>Recognition rate of books</td>
<td>Peak of charge-off rate fin crisis</td>
</tr>
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- Parameter set 2: jointly estimated/calibrated matching IRFs of the data
Investor valuation

- Construct outside investor (risk-neutral) valuation of bank
- Investors can buy bank shares but not directly emulate banking activities
  - Wealth inside a bank can grow at a higher rate than alternative implied by investors’ discount rate
  - Market value of $W$ can therefore be higher than $W$
Construct impulse response function from simulated data

- Excess return shocks in model:

\[ \Delta R_{t,t'} = R_{t,t'} - E_t [R_{t,t'}] \]

where

\[ R_{t,t'} = \int_t^{t'} c(\tau) W(\tau) d\tau + s(\lambda(t'), q(t')) W(t') \]

\[ s(\lambda, q) \text{ is the valuation of 1 dollar of bank equity by a risk-neutral investor} \]
Estimation

- Balance sheet adjustment costs: \( \Phi(\nu, 1) \equiv 1 + \frac{\nu}{2} (\nu - \delta)^2 \)

- Estimate \( \{\gamma, \theta\} \) to match market leverage and liabilities IRFs to net-worth shocks pre-crisis & post-crisis

- Estimate \( \tau \) to match book leverage initial response pre-crisis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-Crisis</th>
<th>Post-Crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma )</td>
<td>0.01</td>
<td>3.95</td>
</tr>
<tr>
<td>( \theta )</td>
<td>2.31</td>
<td>2.00</td>
</tr>
<tr>
<td>( \tau )</td>
<td>1%</td>
<td>-</td>
</tr>
</tbody>
</table>
Pre-crisis Fit

Market Leverage: \((\lambda - 1)/V_s\)

Total Liabilities: \((\lambda - 1) \cdot W\)
Post-crisis Fit

Market Leverage: $(\lambda - 1)/V_s$

Total Liabilities: $(\lambda - 1) \cdot W$

Data | Model | Frictionless Model $(\theta = \gamma = 0)$
Distribution of banks
Impact of accounting rules

- Recall evolution of book value of loans

\[ d\bar{L}_t = \left( -\delta L_t + I_t \right) dt - \alpha (\bar{L}_t - L_t) dt - \tau \epsilon L_t dN \]

- What are the effects of changing the speed of recognition of losses?
Impact of accounting rules

• Recall evolution of book value of loans

\[ d\bar{L}_t = \left( \begin{array}{c} -\delta L_t \\ + I_t \end{array} \right) dt - \alpha (\bar{L}_t - L_t) dt - \tau \varepsilon L_t dN \]

(matured principal, new loan issuance, delayed accounting, recognized losses)

• What are the effects of changing the speed of recognition of losses?

• All steady states are observationally equivalent: same book leverage.
Trade-off for delayed recognition

Higher leverage $\rightarrow$ higher loan/equity growth & higher default rates.
Delayed recognition $\rightarrow$ slower adjustment to default shock

Total Liabilities: $(\lambda - 1) * W$
Conclusion

- Use five stylized facts to inform bank optimization model.
- Model w/ book vs. market distinction, equity financing frictions, adjustment costs, occasionally binding constraints.
- Match bank leverage dynamics quantitatively.
- Implication for policy:
  - Balance sheet frictions key to determine leverage dynamics.
  - Accounting rules matter:
    - for how accurate books reflect fundamental values
    - effective risk-taking by banks
    - for how close to the constraints banks effectively are.
  - Elements are key to think about effects of accounting changes and regulatory forbearance during crises.
• IRF for positive and negative shock
  • negative shock minus the negative of positive shock

• There is evidence of some asymmetry, but not well-powered to detect nonlinearities
No evidence of a trend before the shock hits
No “Flight to Quality” After Shocks

Liquid Assets Ratio: \( \frac{(\text{Cash} + \text{T-Bills})}{\text{Total Assets}} \)

Average \( = 0.05 \)
Size and Stress Tests

- Run regressions dropping banks subject to stress testing
- no difference