Capital Regulation, Liquidity Requirements and Taxation in a Dynamic Model of Banking

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Motivation

- New Basel III regulations include a raise in bank capital requirements and the introduction of new liquidity requirements
- Taxation of bank liabilities have been proposed to discourage bank leverage and/or finance rescue funds

- **Yet, the literature offers no *dynamic* model of banking where banks play a role, and in which the impact of these policies on bank risk, lending, efficiency and welfare can be assessed *jointly***

Open questions

- **Do capital requirements reduce the risk of bank failure?** (YES or NO depending on models, see Gale, 2010)
- **How do capital requirements affect lending?** (Uncertain, see Basel Committee, 2010)
- **What is the impact of liquidity requirements and taxation on bank lending?** (Unexplored)
- **What is the *joint* impact of bank regulations and taxation on welfare?** (Unexplored)

Our contribution: A dynamic model of banking

- Banks are (i) **exposed to *both credit and liquidity risk*, (ii)** undertake **maturity transformation** (***a key intermediation function***), and (iii) can resolve **financial distress** in three costly forms: **fire sales,** (risk-free) **bond issuance** and **equity issuance.**
- The impact of regulations and taxation is gauged comparing **bank optimal policies and metrics of bank efficiency and welfare** ***relative to an unregulated bank*** (the benchmark)
- **Three sets of results**

Results on Capital Regulation (1)

- **Capital regulation reduces bank default risk**
- **There is an inverted U-shape relationship between *tightness* of capital requirements, *efficiency, and welfare***

- **Intuition:** mild capital requirements prompt banks to retain more earnings and invest them in productive lending relative to the unregulated bank.
- When requirements are too tight, however, doing this becomes too costly . Bank efficiency and welfare decline.

Results on Liquidity Requirements (2)

- Liquidity requirements **reduce** efficiency and social value and **nullify the benefits of mild capital requirements**
- **Efficiency and social losses increase** with their stringency

- **Intuition:** liquidity requirements severely hamper banks' maturity transformation, forcing banks to reduce lending.

Results on Taxation (3)

- **An increase** in both corporate income and bank liabilities taxes **reduce** efficiency and welfare.
- **Under the calibrated parameters, the value of tax receipts increases** with a hike in corporate income and liability taxes, but is comparatively lower under liability taxation (due to substitution effects).
- **Corporate taxes seem preferable to taxes on liabilities**

- **Intuition**: Interplay of income and substitution effects

Plan

- The model
- Introducing bank regulation
- Impact of bank regulation
- Impact of taxation

The model

- Time is discrete and horizon is infinite
- The bank receives a random stream of short term deposits, can issue risk–free short term debt, and invests in longer-term assets and short term bonds
- The bank manager maximizes shareholders' value (no agency conflicts)
- Universal risk-neutrality (shareholders, depositors, government)

Bank's Investment and Maturity Transformation

The bank can invest in:

1. A one–period bond (B>0), or borrow (B<0)
2. Borrowing is fully collateralized
3. The risk–free rate is r
4. a portfolio of risky assets, called loans, L_t

Assumption 1 (Revenue function). The total revenue from loan investment is given by $Z_t\pi(L_t)$, where $\pi(L_t)$ satisfies conditions $\pi(0) = 0$, $\pi > 0$, $\pi' > 0$, and $\pi'' < 0$.

Assumption 2. (Loan reimbursement) A constant proportion $\delta \in (0, 1/2)$ of the existing stock of loans at t, L_t, becomes due at $t+1$.

Loan Adjustment Costs, Deposit Insurance and (ex-ante) Book Capital

Assumption 3 (Loan Adjustment Costs). The adjustment costs function for loans is quadratic:

$$m(I_t) = |I_t|^2 \left(\chi_{\{I_t>0\}} \cdot m^+ + \chi_{\{I_t<0\}} \cdot m^-\right), \tag{2}$$

where $\chi_{\{\mathcal{A}\}}$ is the indicator of event $\mathcal{A}$, and $m^+ > m^- > 0$ are the unit cost parameters.

Assumption 4 (Deposit insurance). The deposit insurance agency insures all deposits. In the event the bank defaults on deposits and on the related interest payments, depositors are paid interest and principal by the deposit insurance agency, which absorbs the relevant loss.

To summarize, at $t-1$ (or at the beginning of period t), after the investment and financing decisions have been made, the balance sheet equation is

$$L_t + B_t = D_t + K_t, \tag{3}$$

Corporate Taxation

Assumption 5 (Corporate Taxation). Corporate taxes are paid according to the following convex function of EBT:

$$\tau(y) = \tau^{+} \max\{y, 0\} + \tau^{-} \min\{y, 0\}, \tag{6}$$

where τ^{-} and τ^{+}, $0 \leq \tau^{-} \leq \tau^{+} < 1$, are the marginal corporate tax rates in case of negative and positive EBT, respectively.

Financial Distress

- **Total internal cash**:

$$w_t = w(x_t) = y_t - \tau(y_t) + B_t + \delta L_t + (D_{t+1} - D_t)$$

- **If w_t is negative, the bank is in financial distress.**
- The bank can finance the shortfall either by
  a) selling loans at "fire sale" prices
  b) by issuing bonds,
  c) by injecting equity capital.
- All these choices are costly

Collateral constraint and Equity floatation costs

Assumption 6 (Collateral constraint). If $B_t < 0$, the amount of bond issued by the bank must be fully collateralized. In particular, the constraint is

$$L_t - m(-L_t(1-\delta)) + \pi(L_t)Z_d - \tau(y_{t+1}^{\min}) + (B_t - D_t)(1+r) + D_d \geq 0, \tag{7}$$

where Z_d is the worst possible credit shock (i.e., the lower bound of the support of Z), D_d is the worst case scenario flow of deposits, and $y_{t+1}^{\min} = \pi(L_t)Z_d + (B_t - D_t)r$ is the EBT in the worst case end–of–period scenario for current L_t, B_t and D_t.

Assumption 7 (Equity floatation costs). The bank raises capital by issuing seasoned shares incurring a proportional floatation cost $\lambda > 0$ on new equity issued.

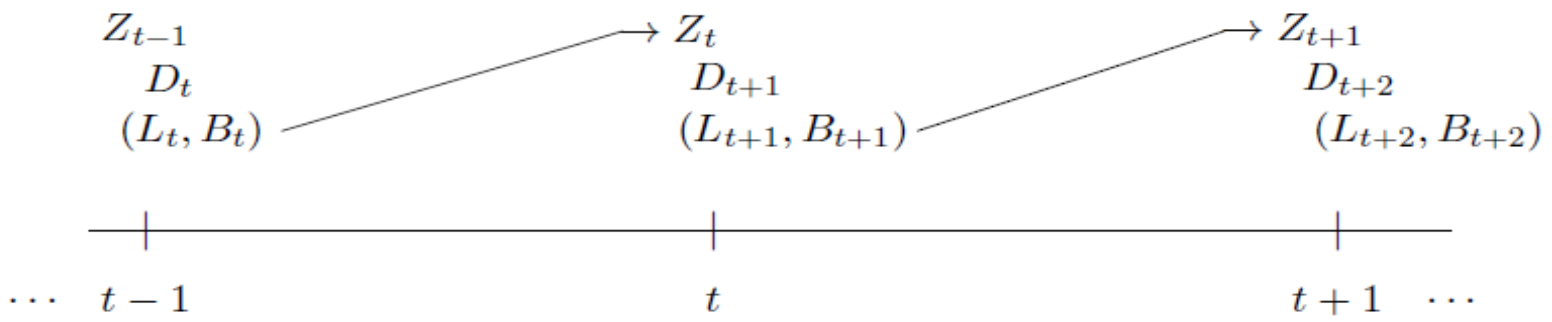
Cash flow to shareholders and evolution of the state variables

As a result of the choice of (L_{t+1}, B_{t+1}), the residual cash flow to shareholders at date t is

$$u_t = u(x_t, L_{t+1}, B_{t+1}) = w_t - B_{t+1} - L_{t+1} + L_t(1-\delta) - m(I_{t+1}). \tag{9}$$

When u_t is positive, it is distributed to shareholders (either as dividends or stock repurchases). If u_t is negative, it is the amount of newly issued equity. Hence, the actual cash flow to equity holders is

$$e_t = e(x_t, L_{t+1}, B_{t+1}) = \max\{u_t, 0\} + \min\{u_t, 0\}(1+\lambda). \tag{10}$$



Bank Insolvency and Bankruptcy Costs

Assumption 8 (Insolvency). In the case of bank's default, shareholders exercise the limited liability option (i.e., equity value is zero), and bank assets are transferred to the deposit insurance agency, net of verification and bankruptcy costs in proportion $\gamma > 0$ of the face value of deposits, γD_t. Right after default, the bank is restructured as a new entity endowed with capital $K_{t+1} = D_u - D_d > 0$ and deposits D_d, where D_u is the upper bound of deposit process. The restructured bank invests initially only in risk–free bonds, $B_{t+1} = D_u$, so that $L_{t+1} = 0$.

Probabilistic assumptions and Bellman equation

Assumption 9. The state space $\mathcal{S}$, is compact. The random vector s evolves according to a stationary and monotone (risk–neutral) Markov transition function $Q(s_{t+1} \mid s_t)$ defined as

$$Z_t - Z_{t-1} = (1 - \kappa_Z)\left(\overline{Z} - Z_{t-1}\right) + \sigma_Z \varepsilon_t^Z \tag{11}$$

$$\log D_t - \log D_{t-1} = (1 - \kappa_D)\left(\log \overline{D} - \log D_{t-1}\right) + \sigma_D \varepsilon_t^D. \tag{12}$$

The error terms ε_t^Z and ε_t^D are i.i.d and have jointly normal truncated distribution with correlation coefficient ρ.[9]

$$E(x) = \max\left\{0, \max_{(L',B')\in\Gamma(D')}\left\{e(x, L', B') + \beta\mathbb{E}\left[E(x')\right]\right\}\right\}. \tag{13}$$

Solution

We denote with $(L^*(x), B^*(x))$ the optimal policy when the bank is solvent. When it is insolvent, shareholders exercise the limited liability option, which puts a lower bound on E at zero. The default indicator function is denoted $\Delta(x)$.

We solve equation (13) to determine the value of equity, the optimal policy including the optimal default policy, Δ, as a function of the current state, x. We denote φ, the state transition function based on the optimal policy:

$$\varphi(x) = \begin{pmatrix} L^* \\ B^* \\ D' \end{pmatrix} (1 - \Delta) + \begin{pmatrix} 0 \\ D_d \\ D_u \end{pmatrix} \Delta, \tag{15}$$

the new state is (L^*, B^*, D') if the bank is solvent

Metrics of efficiency and welfare

- **Enterprise value:** $V(x) = E(x) + F(x) - B$

- **Welfare criterion**: $SV(x) = V(x) + G(x)$
- Sum of values of stake-holders in the model:
- the firm value (equity): $E(x)$
- deposits' value (fair value of new deposits): $F(x)$
- government value (tax receipts net of bankruptcy and recapitalization costs): $G(x)$

Capital and Liquidity Requirements

- **Capital Requirement**: $K_d = kL$
- **Liquidity Requirement (liquidity coverage ratio)**:

Liquidity> fraction Λ of discounted value of cash outflows in the worst state of the world

$$B > \Lambda[D(1+r) - D_d - \delta L - Z_d \pi(L) + \tau(y^{\min})] \frac{1}{1+r}$$

The impact of bank regulation

- To simulate the model, we use a set of benchmark parameters computed using selected statistics from U.S. banking data and taken from the literature
- The unregulated bank is the benchmark

- **Results:**

1. State-dependent analysis
2. Steady state analysis

Steady State Results

- **Capital requirements**:
- Bank's capital ratio is above regulatory levels, consistent with empirical evidence
  - **An inverted U-shaped relationship between lending, efficiency, welfare and capital requirements**
- **Liquidity requirements:**
  - Nullify the benefits of mild capital requirements
  - Lending , efficiency ,and welfare metrics decline significantly

Table IV: The Impact of Bank Regulations

	Unregulated	*Capital*		*Capital & Liquidity*		
	base	base	$k = 12\%$	base	$k = 12\%$ $\ell = 20\%$	$k = 4\%$ $\ell = 50\%$
Loan (book)	4.78	6.37	5.90	2.68	2.67	2.65
Net Bond Holdings (book)	-3.48	-3.89	-3.05	0.16	0.22	0.26
Bank Capital (book)	-0.70	0.47	0.84	0.82	0.87	0.90
Equity (mkt)	4.49	4.87	4.90	3.69	3.72	3.74
Deposits (mkt)	1.89	1.91	1.91	1.91	1.91	1.91
Enterprise Value (mkt)	9.88	10.71	9.90	5.43	5.40	5.38
Government Value (mkt)	0.54	0.88	0.85	0.37	0.37	0.37
Social value (mkt)	10.56	11.72	10.87	5.91	5.89	5.86
Default/Closure Rate (pct)	5.34	0.00	0.00	0.00	0.00	0.00

The impact of taxation

- **Increase in corporate income taxes**
- Lending and debt are reduced due to income effects
- Bank efficiency and social value are reduced
- Government value increases due to a rise in tax receipts under capital regulation only
- **Increase in taxes on non-deposit debt**
- Same qualitative effects (due to substitution), but smaller quantitatively

Table V: Impact of Taxation

	Capital			*Capital & liquidity*		
	base	τ	τ_B	base	τ	τ_B
Loan (book)	6.37	6.09	5.89	2.68	2.48	2.63
Net Bond Holdings (book)	-3.89	-3.62	-3.44	0.16	0.24	0.21
Bank Capital (book)	0.47	0.45	0.45	0.82	0.70	0.81
Equity (mkt)	4.87	4.49	4.46	3.69	3.38	3.65
Deposits (mkt)	1.91	1.91	1.91	1.91	1.91	1.91
Enterprise Value (mkt)	10.71	10.06	9.84	5.43	5.05	5.34
Government Value (mkt)	0.88	1.14	1.10	0.37	0.48	0.38
Social value (mkt)	11.72	11.31	11.05	5.91	5.64	5.83

The role of equity issuance costs, adjustment costs and maturity transformation

- Equity issuance costs are relatively less important relative to retained earnings in determining the inverted U-shape relationship
- The benefits of mild capital requirement are larger the higher are "fire sales" costs
- Liquidity requirements have higher private and social costs the more intense is banks' maturity transformation (perhaps unsurprisingly)

Table VI. The role of equity issuance costs, adjustment costs and maturity transformation

	Unregulated	base	$\lambda = 0$	$\lambda = .2$	$m^{-} = .08$	$\delta = .1$
			Capital			
Loan (book)	4.78	6.37	6.45	6.29	6.46	8.55
Net Bond Holdings (book)	-3.48	-3.89	-3.95	-3.80	-3.97	-5.51
Bank Capital (book)	-0.70	0.47	0.48	0.47	0.48	1.04
Equity (mkt)	4.49	4.87	4.90	4.85	4.87	6.70
Enterprise Value (mkt)	9.88	10.71	10.84	10.60	10.79	14.09
Government Value (mkt)	0.54	0.88	0.90	0.87	0.89	1.14
Social value (mkt)	10.56	11.72	11.85	11.60	11.80	15.34
			Capital & liquidity			
Loan (book)	4.78	2.68	3.15	2.47	2.72	3.47
Net Bond Holdings (book)	-3.48	0.16	0.05	0.23	0.13	0.19
Bank Capital (book)	-0.70	0.82	1.21	0.70	0.83	1.68
Equity (mkt)	4.49	3.69	4.18	3.51	3.70	4.70
Enterprise Value (mkt)	9.88	5.43	6.02	5.19	5.47	6.40
Government Value (mkt)	0.54	0.37	0.44	0.34	0.37	0.49
Social value (mkt)	10.56	5.91	6.58	5.64	5.96	7.02

Conclusions

- The relationship between the *tightness* of capital requirements and *efficiency and social value* is inverted U-shaped

- **Liquidity requirements severely hamper banks' maturity transformation**

- To raise tax revenues, **corporate income taxes seems preferable to taxes on liabilities**