BANK FOR INTERNATIONAL SETTLEMENTS

Macroeconomics of Bank Capital and Liquidity Regulations

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The views expressed in this presentation are our own and do not necessarily reflect those of the BIS

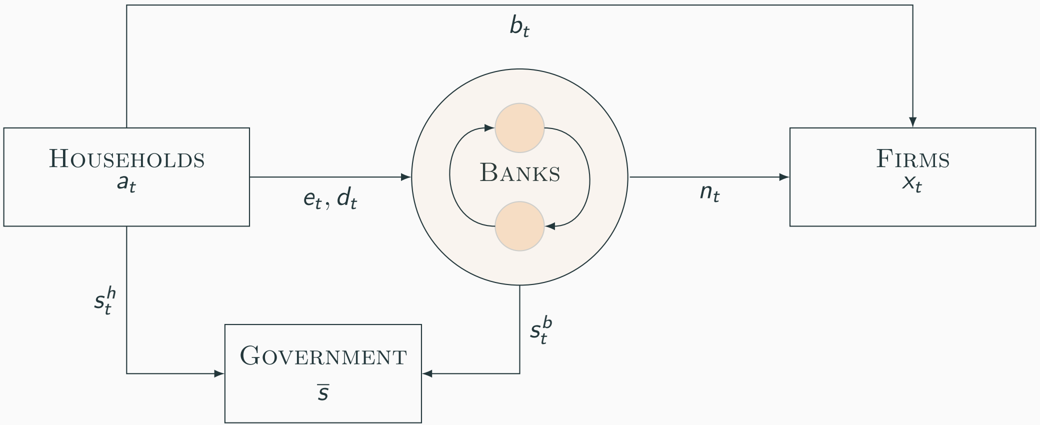
Objectives

- Study the transmission channels of capital and liquidity regulations
    - Trade–offs, interactions, synergies/conflicts, general equilibrium (unintended?) effects
- Derive the net welfare gain from stacking multiple regulations on the top of each other
    - Optimal regulatory mix, guidance for the coordination of those regulations
- Quantitative dynamic deterministic general equilibrium model

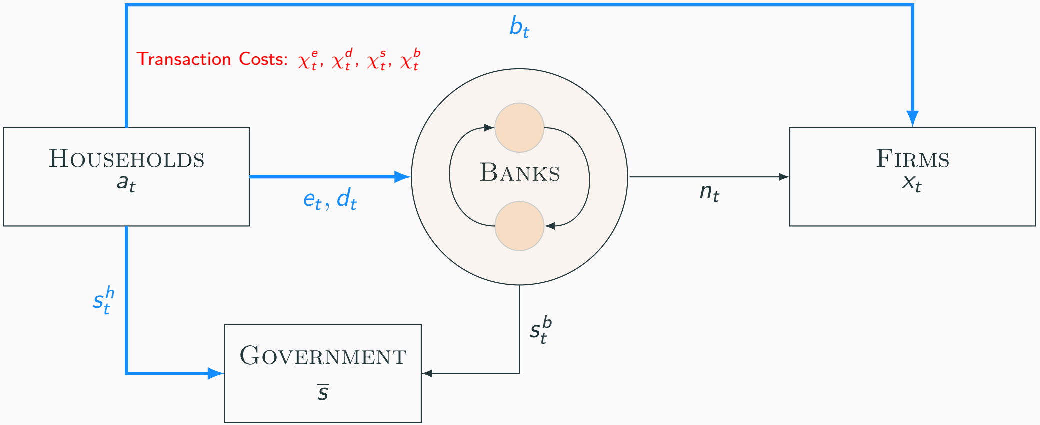
Main Takeaways

1. Stacking liquidity regulation on the top of capital regulation improves welfare
2. Most of the time, tightening one regulation makes the other more effective. Tensions between the two regulations may arise, if there is a shortage of liquid assets in the economy
3. Quantitative insights:
   - Optimal regulatory mix: a 17% leverage ratio combined with a 12% liquidity ratio
   - The elasticity of capital requirements to liquidity requirements is -0.2

Model


b_t
Households
a_t
e_t, d_t
Banks
n_t
Firms
x_t
s_t^h
s_t^b
Government
$\overline{s}$

Model



b_t
Transaction Costs: χ_t^e, χ_t^d, χ_t^s, χ_t^b
Households
a_t
e_t, d_t
Banks
n_t
Firms
x_t
s_t^h
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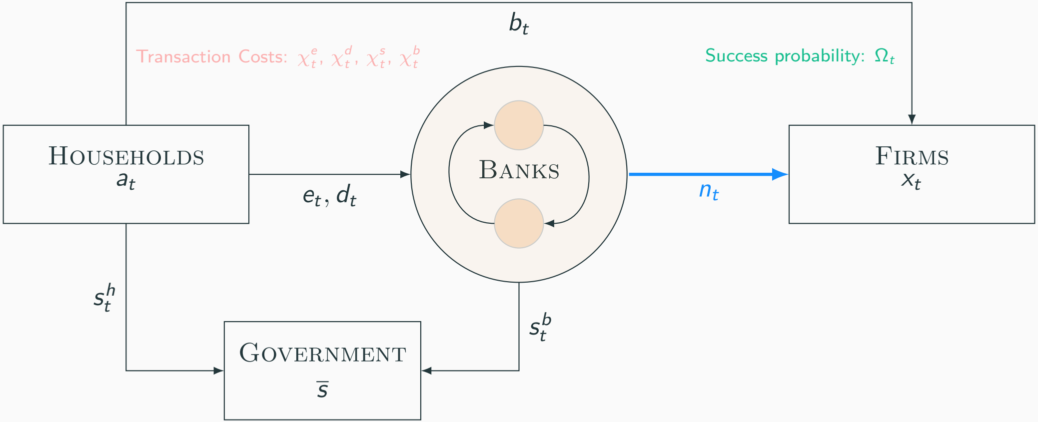
Government
$\bar{s}$

Model



b_t
Transaction Costs: χ_t^e, χ_t^d, χ_t^s, χ_t^b
Success probability: Ω_t
HOUSEHOLDS
a_t
e_t, d_t
BANKS
n_t
FIRMS
x_t
s_t^h
s_t^b
GOVERNMENT
$\bar{s}$

Banking Sector

- 2^{nd} stage decisions:
  - Banks draw their individual financial intermediation skills, $q^\ell \in [0,1]$

    $\rightarrow$ Firms that borrow from bank q^ℓ succeed with probability q^ℓ
  - Banks invest $n_t \equiv d_t + e_t - s_t^b$
  - Interbank transactions help to migrate savings from low–q^ℓ to high–q^ℓ banks
  - Frictions on the interbank market:

    $\rightarrow$ Banks can divert cash for private benefit γ, and abscond
    $\rightarrow$ Skills q^ℓ are private information

Banking Sector

The bank maximizes its expected profit:

$$\max_{s_t^b, d_t, e_t} \Psi_{t-1,t} \int_0^1 \max_{\phi_t, \mathbb{1}_t} \Big(r_t^s s_t^b - r_t^d d_t - r_t^e e_t + \mathbb{1}_t r_t^m n_t + (1 - \mathbb{1}_t) \left(q^\ell \tilde{r}_t^\ell (1 + \phi_t) - r_t^m \phi_t \right) n_t \Big) \mathrm{d}\mu_\ell(q^\ell)$$

s.t. the incentive compatibility constraint:

$$\gamma(1 + \phi_t) n_t - r_t^e e_t \leq r_t^s s_t^b - r_t^d d_t - r_t^e e_t + r_t^m n_t$$

→ Deposits are subject to moral hazard

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$\rightarrow$ The opportunity cost of absconding increases with the interbank rate

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$\rightarrow$ Equity is not subject to moral hazard

Banking Sector

The bank maximizes its expected profit:

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$\rightarrow$ Government bonds are seizable (i.e. they are "liquid")

Externalities and Capital Regulation

- High–q^ℓ banks' interbank funding:

$$\phi_t = \frac{r_t^d \frac{e_t}{d_t+e_t} + \left(r_t^s - r_t^{m\star}\right)\frac{s_t^b}{d_t+e_t} + r_t^{m\star} - r_t^d}{\gamma\left(1 - \frac{s_t^b}{d_t+e_t}\right)} - 1$$

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- Pecuniary externalities:

$$\frac{\mathrm{d}\phi_t}{\mathrm{d}\left(\frac{e_t}{d_t+e_t}\right)} = \frac{\partial\phi_t}{\partial\left(\frac{e_t}{d_t+e_t}\right)} + \frac{\partial\phi_t}{\partial r_t^{m\star}} \times \frac{\partial r_t^{m\star}}{\partial\overline{\Phi}_t} \times \frac{\partial\overline{\Phi}_t}{\partial\left(\frac{E_t}{D_t+E_t}\right)}$$

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$\Longrightarrow$ **Regulatory capital constraint:** $\dfrac{e_t}{d_t+e_t} \geq \tau_C$

Externalities and Liquidity Regulation

- High–q^ℓ banks' interbank funding:

$$\phi_t = \frac{r_t^d \frac{e_t}{d_t+e_t} + (r_t^s - r_t^{m\star})\frac{s_t^b}{d_t+e_t} + r_t^{m\star} - r_t^d}{\gamma\left(1 - \frac{s_t^b}{d_t+e_t}\right)} - 1$$

- Pecuniary externalities:

$$\frac{\mathrm{d}\phi_t}{\mathrm{d}\left(\frac{s_t^b}{d_t+e_t}\right)} = \frac{\partial \phi_t}{\partial\left(\frac{s_t^b}{d_t+e_t}\right)} + \frac{\partial \phi_t}{\partial r_t^{m\star}} \times \frac{\partial r_t^{m\star}}{\partial \overline{\Phi}_t} \times \frac{\partial \overline{\Phi}_t}{\partial\left(\frac{S_t^b}{D_t+E_t}\right)}$$

$\Longrightarrow$ **Regulatory liquidity constraint:** $\frac{s_t^b}{d_t+e_t} \geq \tau_L$

Synergies: Partial Equilibrium Effects

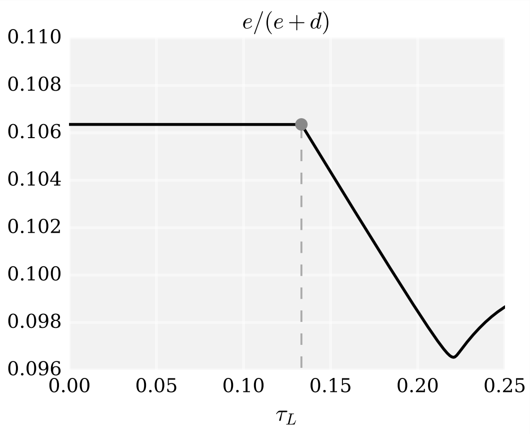
- Liquidity regulation "mechanically" reduces the volume of risky assets per unit of equity

$$\frac{\partial^2 \phi_t}{\partial\left(\frac{e_t}{d_t+e_t}\right)\partial\left(\frac{s_t^b}{d_t+e_t}\right)} > 0$$

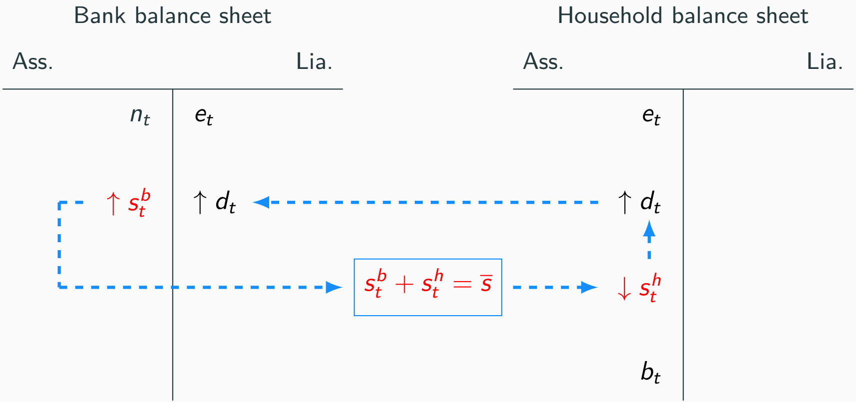
$\implies$ In this sense, **liquidity and capital** requirements mutually **reinforce** each other

Tensions: General Equilibrium Effects and Portfolio Re–balancing

Figure 1: Banks' Leverage Ratio with Liquidity Requirements (at SS)

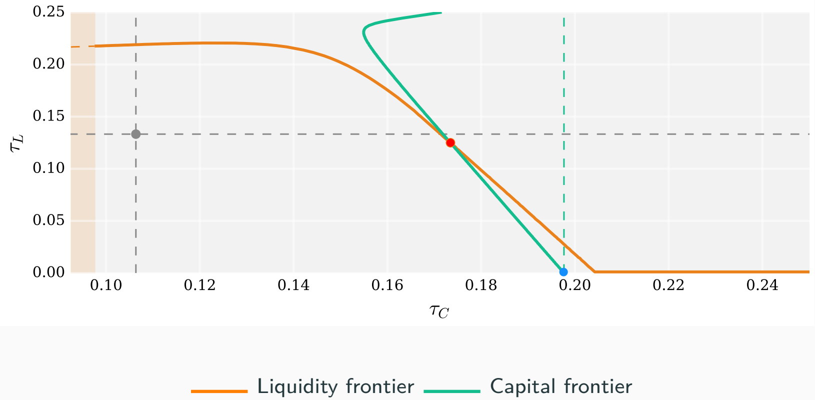


Tensions: General Equilibrium Effects and Portfolio Re–balancing



Optimal Regulatory Mix

Figure 2: Regulatory Frontiers ("Best Response Functions")



Steady State Welfare Gains

	Perm. cons. gain (%)		Regulation (%)	
	St. St.	Incl. Transition	τ_C	τ_L
NR $\rightarrow$ ORM	0.6591	0.5888	17.35	12.50

Note: NR $\rightarrow$ ORM: Permanent Consumption gain (in percent) from the non-regulated (NR) economy to the economy with the optimal regulatory mix (ORM).

Other Points of Discussion in the Paper

- Risk–weighted capital requirements can improve welfare almost as much as both leverage and liquidity requirements combined
- The leverage ratio is useful as a backstop if banks mis–report their risk–weights by more than 12%
- Financial dis–intermediation acts as a “safety valve”, and reduces the cost of regulations
- Regulation reduces banks’ total cost of funding
- Sterilization of liquidity requirements

THANK YOU

Risk–weighted Capital Requirements

Bank balance sheet

Ass.			Lia.
([risky] cash)	n_t	d_t	*(deposits)*
(gvt bonds)	s_t^b	e_t	*(equity)*

Leverage: $\frac{e_t}{d_t+e_t} \geq \tau_C$

Liquidity: $\frac{s_t^b}{d_t+e_t} \geq \tau_L$

RW capital: $\frac{e_t}{n_t} \equiv \frac{\frac{e_t}{d_t+e_t}}{1-\frac{s_t^b}{d_t+e_t}} \geq \tau_W$

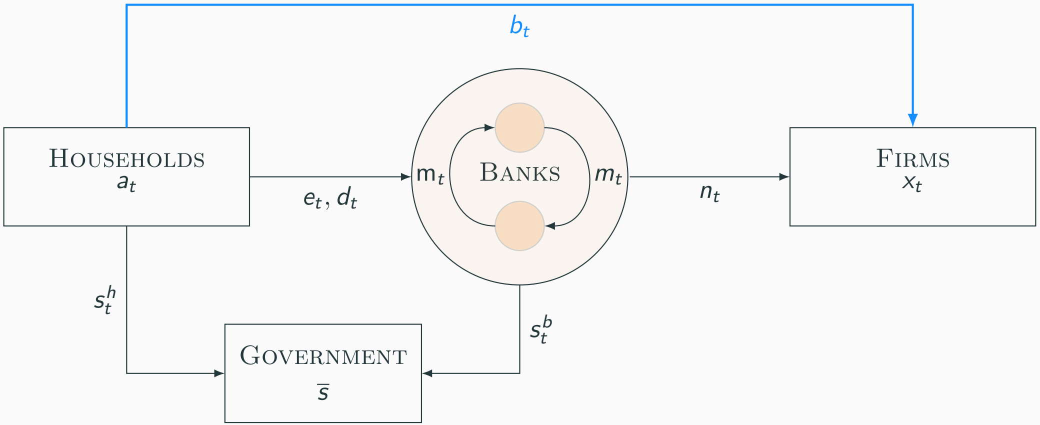
Risk–weighted Capital Requirements

Table 1: Welfare Analysis

	Perm. cons. gain (%)	Regulation (%)		
		τ_W	τ_C	τ_L
NR $\rightarrow$ RW	0.6576	19.81	-	-
NR $\rightarrow$ ORM*	0.6591	19.83	17.35	12.50
RW $\rightarrow$ ORM*	0.0014			

Note: NR $\rightarrow$ RW: Permanent Consumption gain (in percent) from the non-regulated (NR) economy to the economy with the risk–weighted capital requirements (RW). RW $\rightarrow$ ORM: Permanent Consumption gain (in percent) from the risk–weighted capital requirements (RW) economy to the economy with optimal regulatory mix (ORM). $^{\star}\tau_W \equiv \tau_C/(1-\tau_L)$.

Dis–intermediation as a Safety Valve

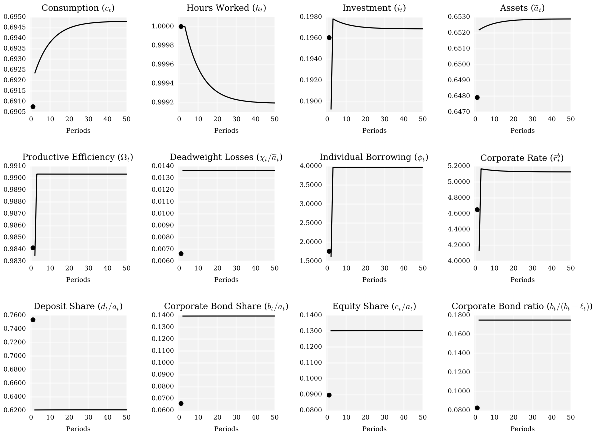


Dis–intermediation as a Safety Valve

	Perm. cons. gain (%)	Regulation (%)		
		τ_C	τ_L	τ_B
NR $\rightarrow$ ORM+TCBR	0.6604	17.38	12.55	-0.33
ORM $\rightarrow$ ORM+TCBR	0.0013			

Note: NR $\rightarrow$ ORM+TCBR: Permanent Consumption gain (in percent) from the non-regulated (NR) economy to the economy with both the optimal regulatory mix and the tax on corporate bond revenues (OMR+TCBR). ORM $\rightarrow$ ORM+TCBR: Permanent Consumption gain (in percent) from the economy with the optimal regulatory mix (ORM) to the economy with both the optimal regulatory mix and the tax on corporate bond revenues (OMR+TCBR).

Transition Toward Regulated Economy



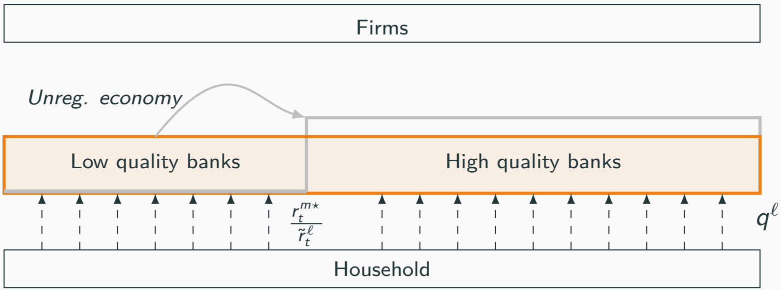
Note: Transition path from the unregulated to the regulated equilibrium.

Costs of Funding

in pp	$r_t^e - r_t^m$	$r_t^d - r_t^m$	$r_t^f - r_t^m$
Non-Regulated	10.72	0.00	0.73
Optimal Regulation	14.49	-2.44	0.29

Note: $r_t^f \equiv \left(r_t^e e_t + r_t^d d_t + r_t^m(1-\mu(\overline{q}_t^\ell))\phi_t n_t\right) / \left(e_t + d_t + (1-\mu(\overline{q}_t^\ell))\phi_t n_t\right)$ denotes the representative bank's overall cost of funding.

The Credit Quality Channel of Banking Regulation



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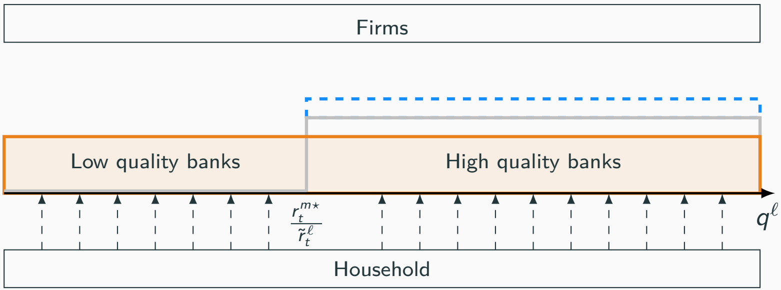

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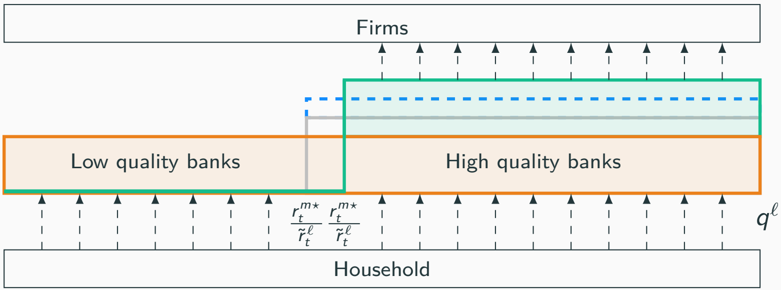


Decentralized General Equilibrium

A competitive general equilibrium is:

- A sequence of prices $\mathcal{P}_t \equiv \{r^s_{t+i}, r^m_{t+i}, r^d_{t+i}, \tilde{r}^b_{t+i}, \tilde{r}^\ell_{t+i}, r^e_{t+i}, w_{t+i}, \rho_{t+i}, p^x_{t+i}\}_{i=0}^{\infty}$;
- A sequence of quantities $\mathcal{Q}_t \equiv \{y_{t+i}, c_{t+i}, i_{t+i}, x_{t+i}, k_{t+i}, h_{t+i}, \tilde{a}_{t+i}, d_{t+i}, e_{t+i}, s^h_{t+i}, b_{t+i}, s^b_{t+i}, \ell_{t+i}\}_{i=0}^{\infty}$

such that:

- For a given sequence of prices $\mathcal{P}_t$, quantities $\mathcal{Q}_t$ solve agents' optimization problems
- For a given sequence of quantities $\mathcal{Q}_t$, prices $\mathcal{P}_t$ clear the markets.

Timeline

1. The government issues debt $\overline{s}$. Firms produce, pay the wages, pay the rent of physical capital, pay their debts; and die. Banks pay their debts, distribute dividends; and die.
2. The household consumes c_t, invests into i_t units of physical capital goods, and saves $\tilde{a}_{t+1}$.
3. The goods market clears and closes.
4. Household members draw their financial skills (q^{s^h}, q^b, q^d, q^e) and invest $\tilde{a}_{t+1}$ into sovereign bonds s^h_{t+1}, corporate bonds b_{t+1}, bank deposits d_{t+1}, and bank equity e_{t+1}.
5. New banks are born and demand sovereign bonds, s^b_{t+1}, deposits, d_{t+1}, and equity e_t.
6. The sovereign bond, deposit, and equity markets clear and close.
7. Period $t+1$ starts. New firms are born and issue corporate bonds b_{t+1}. Household members purchase corporate bonds. Bankers draw intermediation skills q^ℓ, and invest $\mathrm{d}_{t+1} + \mathrm{e}_{t+1} - s^b_{t+1}$ into corporate loans, ℓ_{t+1}, and interbank loans, m_{t+1}.
8. Firms hire labour h_{t+1}, rent physical capital k_{t+1}, demand loans l_{t+1}, and purchase material goods, x_{t+1}.
9. The markets for labour, capital goods, material goods, corporate bonds, corporate loans, and interbank loans clear and close.

Calibration

- Unregulated economy
- Standard for the real sector
- Nine financial parameters and nine financial variables to match:
  - Two interest rates (interbank, corporate loan)
  - Five balance sheet ratios (households and banks)
  - Proportion on non–performing loans
- US data from 1970–2009

Calibration

1. $r^m = r^d = r^s = 1.0167$. The real returns on interbank loans, deposits, and government bonds match the Federal Fund Rate, and are equal to 1.67%;
2. $\tilde{r}^b = 1.0465$. The contractual real corporate bond yield matches Moody's 3–month Seasoned Baa Corporate Bond Yield and is equal to 4.65%;
3. $e/d = 0.1190$. Banks' equity to deposit ratio is equal to 11.90%;
4. $b/a = 0.0658$. The share of corporate bond holding in households' financial wealth is equal to 6.58%;
5. $s^h/a = 0.0910$. The share of sovereign bonds in households' financial wealth is equal to 9.10%;
6. $d/\ell = 1.0310$. The bank deposit to loan ratio is equal to 103.10%.
7. $\phi n/d = 1.7086$. The ratio of no–core liabilities to core liabilities is equal to 170.86%;
8. $\Omega = 0.9841$. The proportion of non–performing loans is 1.58%.

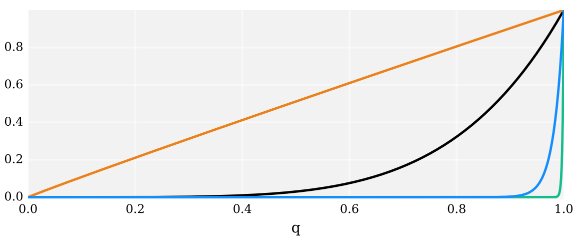
Calibration

Table 2: Calibration

Parameter		Values
Supply of sovereign bonds	$\bar{s}$	0.131
Private benefits	γ	0.045
Distribution – $\mu_d(q^d)$	λ^d	456.341
Distribution – $\mu_e(q^e)$	λ^e	0.967
Distribution – $\mu_b(q^b)$	λ^b	5.062
Distribution – $\mu_{s^h}(q^{s^h})$	λ^{s^h}	55.128
Distribution – $\mu_\ell(q^\ell)$		
Slope	λ^ℓ	0.387
Lower bound	θ	0.959

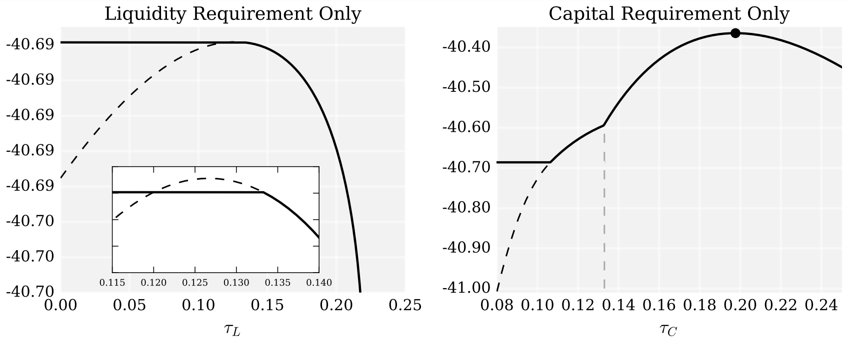
Calibration

$$\mu_j(q) = (q)^{\lambda^j}$$



$\mu_e(q)$, $\mu_b(q)$, $\mu_{sh}(q)$, $\mu_d(q)$.

Figure 3: Welfare Effect of Regulations

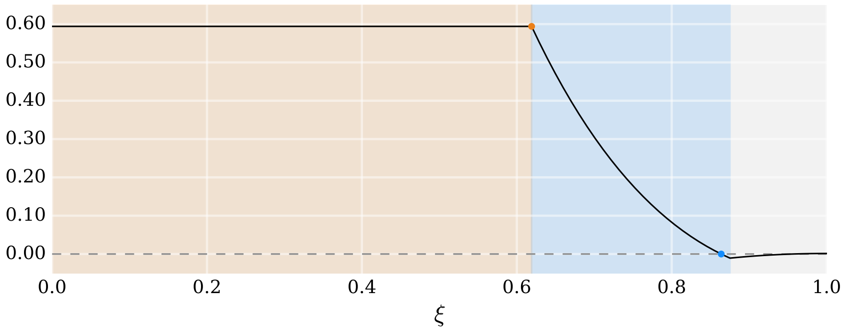


Welfare when the regulator imposes a liquidity requirement τ_L only (left panel) or a capital requirement τ_C (right panel) only.

Leverage Ratio as a Backstop: Welfare Gains

- Banks may mis–report their risk–weights (IRB approaches) and undermine risk–weighted capital regulation
- $\frac{e_t}{\xi n_t} \geq \tau_W$ instead of $\frac{e_t}{n_t} \geq \tau_W$, with $\xi \in [0, 1)$
- What is the welfare gain of using a leverage ratio as a backstop?
- Compare welfare with (τ_W, τ_C) and welfare with $(\tau_W, \cdot)$

Leverage Ratio as a Backstop: Welfare Gains



The risk–weighted capital constraint (RWCC) binds, with or without backstop. The RWCC is slack with or without backstop. The RWCC binds without backstop, but is slack with the backstop.

Related Literature

- **Link between finance and aggregate productivity**
  - Finance and growth literature (Greenwood and Jovanovic (1990); Greenwood et al. (2013); Hsieh and Klenow (2009))
  - Venture capital and relationship lending literature: VCs/banks improve firm productivity with market knowledge, strategic planning, mentoring, etc (Kortum and Lerner (2000); Hellman and Puri (2000), Bolton et al. (2016))
  - Allocative efficiency and the recent crisis (Gopinath et al. (2015); Cuñat and Garicano (2009))
- **Macroeconomic models with financial frictions**
  - Frictions between banks and depositors (Gertler and Karadi (2012), Martinez-Miera and Suarez (2014))
  - Frictions on wholesale funding markets (Boissay, Collard, Smets (2016))
- **Banking regulation in macroeconomic models**
  - Capital requirements only (Clerc et al. (2015); Begeneau (2015))
  - With capital and liquidity requirements (Covas and Driscoll (2014), Van den Heuvel (2016), Kashyap, Tsomocos, Vardoulakis (2014))

Households and Firms

- Households:

$$\begin{cases} \max\limits_{\{c_t, h_t, i_t\}_{t=0,\dots,\infty}} \sum\limits_{s=0}^{\infty} \beta^s \mathbb{E}_q \left[\max\limits_{\{d_{t+1}, e_{t+1}, s^h_{t+1}, b_{t+1}\}_{t=0,\dots,\infty}} u(c_{t+s}) - v(h_{t+s}) \right] \\ \text{s.t.: } c_t + i_t + d_{t+1} + e_{t+1} + s^h_{t+1} + b_{t+1} + \chi^d_t + \chi^e_t + \chi^s_t + \chi^b_t = r^d_t d_t + r^e_t e_t + r^s_t s^h_t + r^b_t b_t + \rho_t k_t + w_t h_t + \Pi_t - T_t \end{cases}$$

- Firms:

$$\begin{cases} \max\limits_{k_t, h_t, x_t, b_t, l_t} \pi^f_t \equiv \Omega_t \left(z \min\left[f(k_t, h_t); \varsigma x_t\right] - \tilde{\rho}_t k_t - \tilde{w}_t h_t - \tilde{r}^b_t b_t - \tilde{r}^\ell_t l_t \right) \\ \text{s.t.: } l_t + b_t = x_t \end{cases}$$

Firms

$$\mathrm{x}_t = \frac{1}{\varsigma} f(\mathrm{k}_t, \mathrm{h}_t) \tag{1}$$

$$\tilde{r}_t^{\ell} = \tilde{r}_t^{b} \tag{2}$$

$$\mathrm{x}_t = \mathrm{l}_t + \mathrm{b}_t \tag{3}$$

$$\tilde{\rho}_t = \left(z - \frac{\tilde{r}_t^{\ell} p_t^x}{\varsigma} \right) f_k'(\mathrm{k}_t, \mathrm{h}_t) \tag{4}$$

$$\tilde{w}_t = \left(z - \frac{\tilde{r}_t^{\ell} p_t^x}{\varsigma} \right) f_h'(\mathrm{k}_t, \mathrm{h}_t). \tag{5}$$

Note: $\rho_t \equiv \Omega_t \tilde{\rho}_t \quad ; \quad r_t^b \equiv \Omega_t \tilde{r}_t^b \quad ; \quad w_t \equiv \Omega_t \tilde{w}_t.$

Back

Household Sector – "Cost Channel" of Regulation

- 2nd Stage: Household member with draw $(q^d, q^e, q^{s^h}, q^b) \in [0,1]^4$ gets net unit returns $q^d r_t^d$, $q^e r_t^e$, $q^{s^h} r_t^s$, and $q^b r_t^b$, and invests in d_t if

$$q^d r_{t+1}^d > q^j r_{t+1}^j \ \forall j \neq d$$

- 1st Stage: Representative household works, invests, and saves

$$v'(h_t) = u'(c_t) w_t$$

$$\Psi_{t,t+1} r_{t+1} = 1 \ , \quad \text{where } \Psi_{t,t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)}$$

$$r_{t+1} = \rho_{t+1} + 1 - \delta$$

Banking Sector

- 1st Stage solution: Choice of d_t, e_t, and s_t^b:

$$r_t^s = r_t^m$$
$$r_t^d = r_t^m$$
$$r_t^e = (1 + \Delta_t) r_t^d$$

Equity frees up borrowing capacity ex post ("Shadow value of equity")

Banking Sector

- 2nd Stage solution: Choice of $\mathbb{1}_t$ and ϕ_t knowing q^ℓ:

$$\text{Bank } q^\ell \text{ borrows funds } (\mathbb{1}_t = 0) \text{ iff } q^\ell > \underline{q}_t^\ell \equiv \frac{r_t^m}{\tilde{r}_t^\ell}, \text{ and lends otherwise} \tag{6}$$

and

$$\phi_t = \frac{r_t^s s_t^b - r_t^d d_t + r_t^m n_t}{\gamma n_t} - 1$$