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

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- Understand better the transmission channels to the macro–economy of capital and liquidity regulations
  - Trade–offs, interactions, synergies/conflicts, general equilibrium effects, unintended effects

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  - Provide guidance for the coordination of those regulations (e.g., optimal regulatory mix)
- Develop a quantitative general equilibrium framework, with financial frictions confined to the banking sector and wholesale funding markets

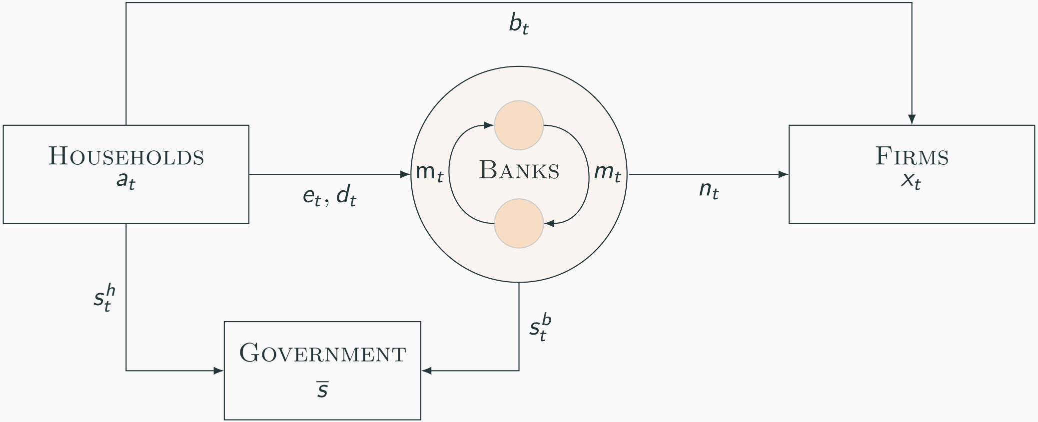
Main Takeaways

1. Liquidity and capital regulations mutually reinforce each other (i.e. tightening one regulation makes the other more effective)

2. There may be tensions between the two regulations due to general equilibrium effects; but those tensions are meaningful only when liquid assets are scarce (this is not the case in the version of our model calibrated for the US)

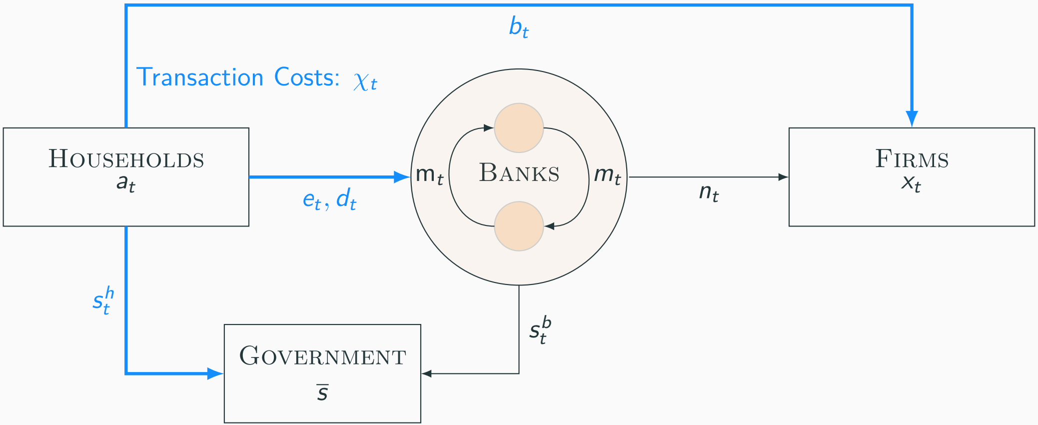
3. The optimal regulatory mix in our model consists of a leverage ratio requirement at around 17% and a liquidity ratio requirement at around 12%

Model



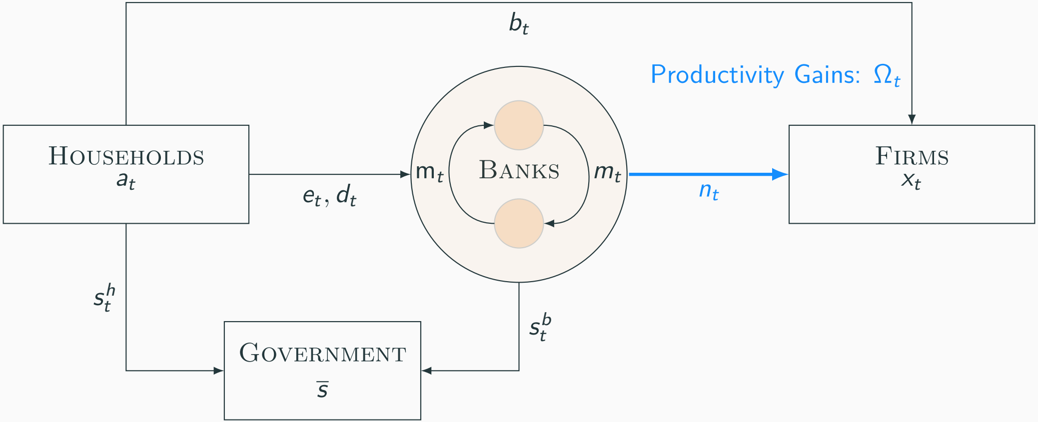
b_t
HOUSEHOLDS
a_t
e_t, d_t
m_t
BANKS
m_t
n_t
FIRMS
x_t
s_t^h
s_t^b
GOVERNMENT
$\bar{s}$

Model



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

Model



b_t
Productivity Gains: Ω_t
Households
a_t
e_t, d_t
m_t
Banks
m_t
n_t
Firms
x_t
s_t^h
s_t^b
Government
$\bar{s}$

Household Sector – "Cost Channel" of Regulation

- The representative household works h_t, consumes c_t, invests in physical assets i_t and financial assets d_{t+1}, e_{t+1}, b_{t+1}, and s^h_{t+1}, with convex transaction costs χ^d_t, χ^e_t, χ^b_t, and χ^s_t

$$\max_{\{c_t,h_t,i_t\}_{t=0,\dots,\infty}} \sum_{s=0}^{\infty} \beta^s \mathbb{E}_q \left[\max_{\{d_{t+1},e_{t+1},s^h_{t+1},b_{t+1}\}_{t=0,\dots,\infty}} u(c_{t+s}) - v(h_{t+s}) \right]$$

- subject to the constraint:

$$c_t + i_t + d_{t+1} + e_{t+1} + s^h_{t+1} + b_{t+1} + \chi^d_t + \chi^e_t + \chi^s_t + \chi^b_t = r^d_t d_t + r^e_t e_t + r^s_t s^h_t + r^b_t b_t + \rho_t k_t + w_t h_t + \pi^f_t + \pi^x_t + \pi^b_t - T_t$$

Solution

Firms – "Credit Quality" Channel of Regulation

$$\max_{k_t, h_t, x_t, b_t, l_t} \pi_t^f \equiv \Omega_t \left(z \min\left[f(k_t, h_t); \varsigma x_t \right] - \tilde{\rho}_t k_t - \tilde{w}_t h_t - \tilde{r}_t^b b_t - \tilde{r}_t^\ell l_t \right)$$

with $l_t + b_t = x_t$

- Continuum of *ex ante* identical firms, each of which borrowing l_t from one bank and b_t from the household to purchase intermediate goods x_t
- Aggregate productivity $\Omega_t \equiv \int_{\frac{r_t^m}{\tilde{r}_t^\ell}}^1 q^\ell \frac{\mathrm{d}\mu_\ell(q^\ell)}{1-\mu_\ell\left(\frac{r_t^m}{\tilde{r}_t^\ell}\right)}$ is determined by the the average financial intermediation skill of the banks that lend to the firms, i.e. on how savings are re–allocated inside the banking sector

▸ Solution

Banking Sector

- 1^{st} Stage: Representative bank issues $d_t + e_t$ and purchases government bonds s_t^b
- 2^{nd} Stage: The bank consists of a continuum of bankers; each banker draws financial intermediation skill q^ℓ:
  - q^ℓ = success probability of the firms that borrow from banker q^ℓ
  - Banker q^ℓ's effective return on corporate loans is $q^\ell \tilde{r}_t^\ell$, with $q^\ell \in [0, 1]$
  - Banker q^ℓ invests wealth $n_t \equiv d_t + e_t - s_t^b$

Banking Sector

- Interbank transactions help to migrate savings from low–q^ℓ to high–q^ℓ bankers
- Banker q^ℓ chooses whether she lends or borrows on the interbank market

- Frictions on the interbank market:
    - Bankers can divert cash for private benefit γ (cash is "risky")
    - Skills q^ℓ are private information

- A borrowing limit is needed to restore bankers' incentives

Banking Sector

- The bank maximizes its expected profit:

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

- subject to the incentive compatibility constraint:

$$\text{(IC)} \ \gamma(1 + \phi_t) n_t - r_t^e e_t \le r_t^m n_t + r_t^s s_t^b - r_t^d d_t - r_t^e e_t$$

→ Deposits are subject to moral hazard

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→ No banker absconds

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→ Equity is not subject to moral hazard

Banking Sector

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→ Government bonds are seizable/pledgeable

Banking Sector

- Banker q^ℓ borrows funds if $q^\ell > \frac{r_t^m}{\tilde{r}_t^\ell}$, and lends otherwise
- The borrowing limit is

$$\overline{\phi}_t \equiv \frac{r_t^d \frac{e_t}{d_t+e_t} + (r_t^s - r_t^m)\frac{s_t^b}{d_t+e_t} + r_t^m - r_t^d}{\gamma\left(1 - \frac{s_t^b}{d_t+e_t}\right)} - 1$$

Externalities and Capital Regulation

$$\overline{\phi}_t \equiv \frac{r_t^d \frac{e_t}{d_t+e_t} + (r_t^s - r_t^m)\frac{s_t^b}{d_t+e_t} + r_t^{m\star} - r_t^d}{\gamma\left(1 - \frac{s_t^b}{d_t+e_t}\right)} - 1$$

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- Pecuniary externalities:

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

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

Externalities and Liquidity Regulation

$$\overline{\phi}_t \equiv \frac{r_t^d \frac{e_t}{d_t+e_t} + (r_t^s - r_t^m)\frac{s_t^b}{d_t+e_t} + r_t^{m\star} - r_t^d}{\gamma\left(1 - \frac{s_t^b}{d_t+e_t}\right)} - 1$$

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

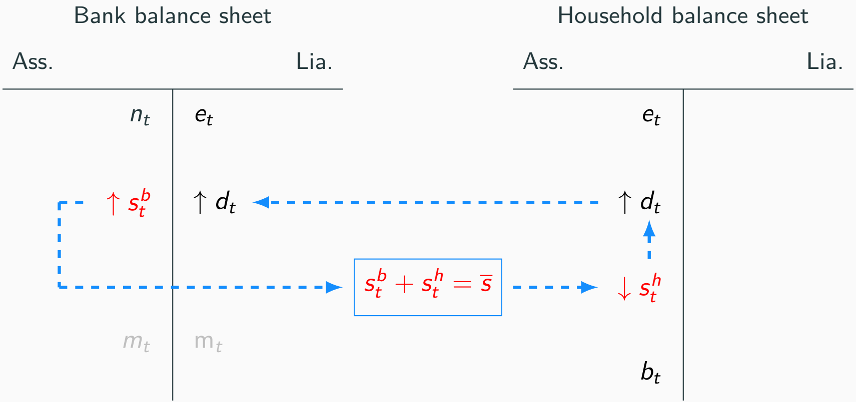
Synergies: Partial Equilibrium Effects

- By "mechanically" reducing the volume of risky cash per unit of equity capital, liquidity regulation makes capital regulation more effective

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

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

Tensions: General Equilibrium Effects and Portfolio Re–balancing



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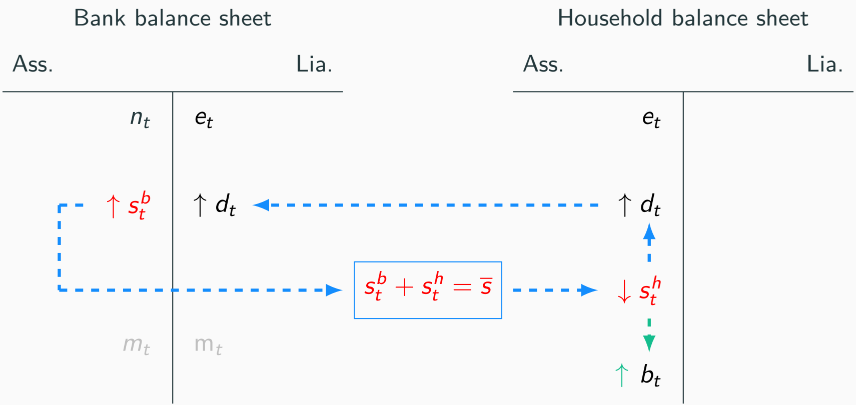


Steady State Welfare Gains

	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

- Regulation reduces banks' overall cost of funding
- A risk–weighted capital requirement is almost as effective as both leverage and liquidity requirements
- The leverage ratio is useful as a backstop if banks misreport their risk weights
- Financial dis–intermediation acts as a "safety valve"
- The "sterilization" of liquidity regulation through government bond issuance can reduce the cost of regulation

Conclusion

- Macro–framework to understand better the transmission of multiple banking regulations
- In a regulated economy, banks supply less credit, but their credit is more productive

- In the case of the US, capital and liquidity regulations reinforce each other, despite GE feedback effects; those GE effects are not model–specific and may be more relevant for countries where liquid assets are scarce

- The optimal regulatory mix features relatively high capital and liquidity requirements
- More results on risk–weighted capital, financial dis–intermediation, leverage ratio as a backstop, sterilization

THANK YOU

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

Back

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%.

▸ Back

Calibration

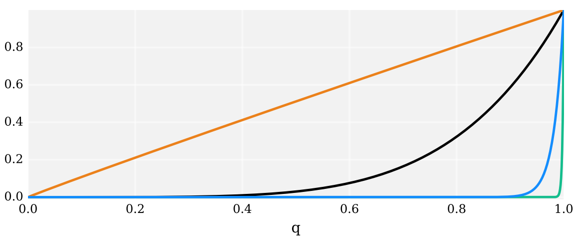
Table 1: Calibration

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

▸ Back

Calibration

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



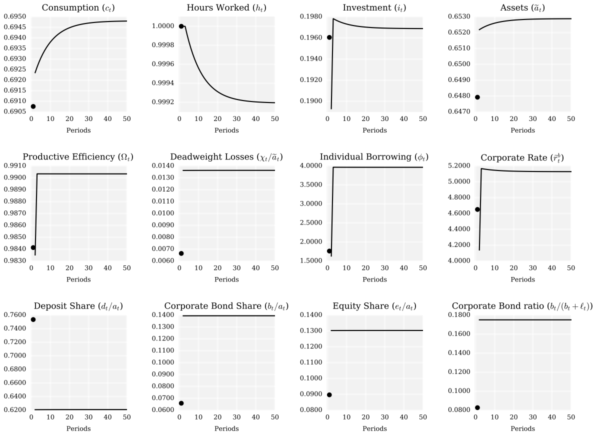
$\mu_e(q)$, $\mu_b(q)$, $\mu_{sh}(q)$, $\mu_d(q)$.

Back to portfolio re–balancing

Timeline

1. The government issues debt $\bar{s}$. 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.

Transition Toward Regulated Economy



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

Back

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

- 2nd Stage: Household member with transaction cost $1 - q^d$ (resp. q^e, q^{s^h}, q^b) invests $\tilde{a}_{t+1}$ into d (resp. e, s^h, b) iff

$$q^d > q^j \frac{r^j_{t+1}}{r^d_{t+1}} \; \forall j \neq d$$

- 1st Stage: Representative household supplies h_t, invests i_t, and transfers financial wealth $\tilde{a}_{t+1}$

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

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

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

Back

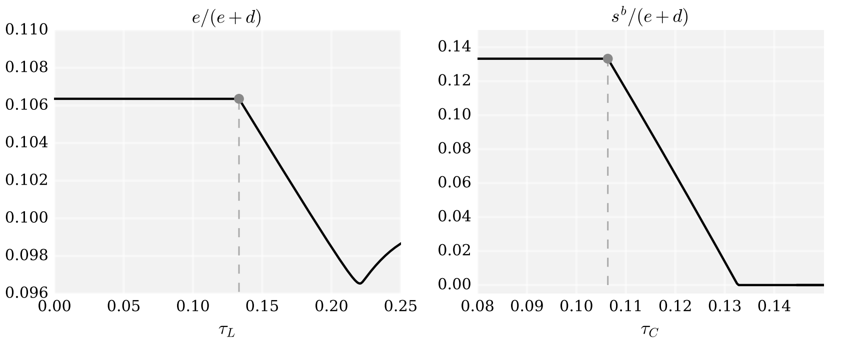
Costs of Funding

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.

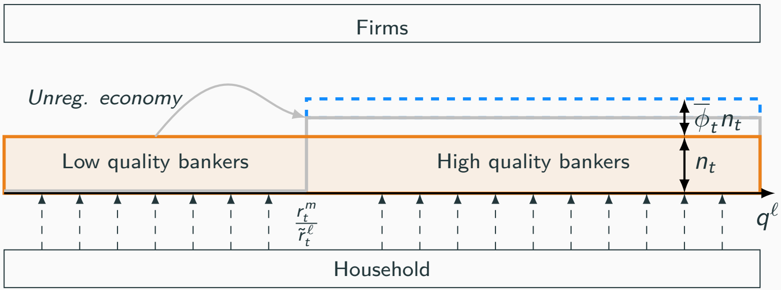
Tensions: General Equilibrium Effects and Portfolio Re–balancing

Figure 1: Capital and Liquidity Ratios at Steady State



Left panel: Capital ratio when the regulator imposes a liquidity requirement (τ_L) only. Right panel: Liquidity ratio when the regulator imposes a capital requirement (τ_C) only.

The Credit Quality Channel of Banking Regulation



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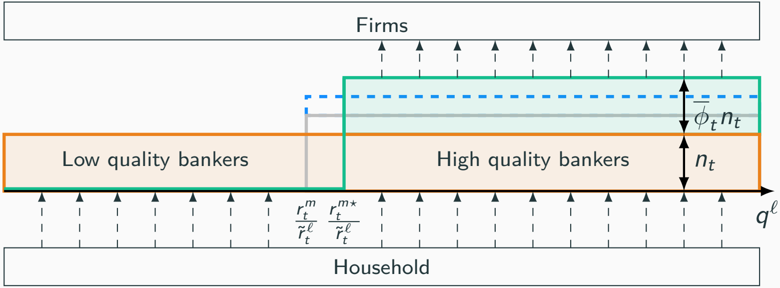


Back

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/bankers 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))

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")

Decentralized General Equilibrium

A competitive general equilibrium is:

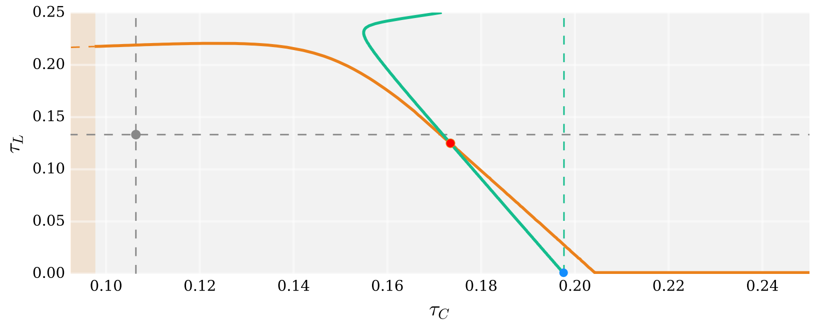
- A sequence of prices $\mathcal{P}_t \equiv \{r^s_{t+i}, r^m_{t+i}, r^d_{t+i}, \tilde{r}^b_{t+i}, \tilde{r}^\ell_{t+i}, r^e_{t+i}, w_{t+i}, \rho_{t+i}, p^x_{t+i}\}_{i=0}^{\infty}$;
- A sequence of quantities $\mathcal{Q}_t \equiv \{y_{t+i}, c_{t+i}, i_{t+i}, x_{t+i}, k_{t+i}, h_{t+i}, \tilde{a}_{t+i},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

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.

Optimal Regulatory Mix

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



Liquidity frontier, Capital frontier, Optimal capital regulation w/o liquidity regulation,
● Optimal regulatory mix, ● Unregulated equilibrium, ● Outcome with two myopic regulators.
Orange area: capital requirements do not bind.

Risk–weighted Capital Requirements

Bank balance sheet

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

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

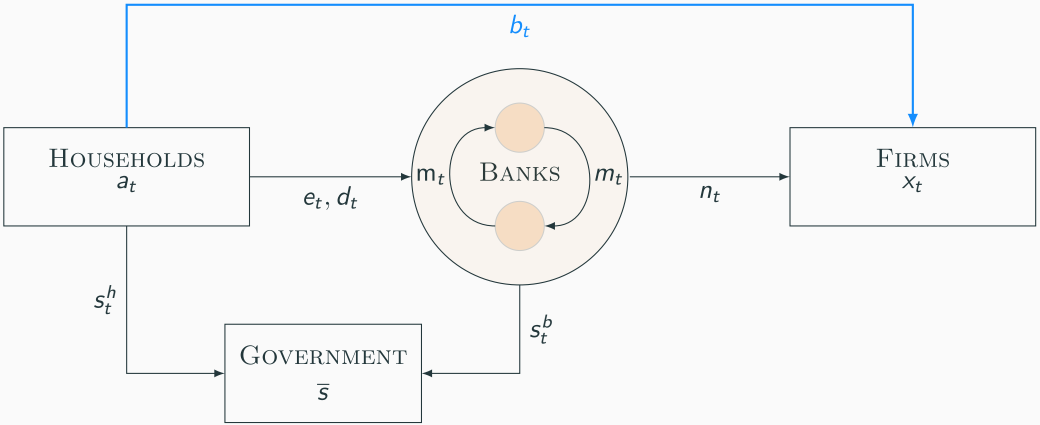
Risk–weighted Capital Requirements

Table 2: 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

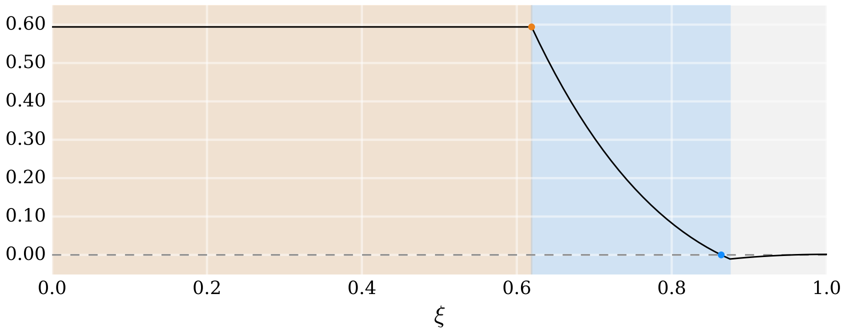
	Perm. cons. gain (%)	Regulation (%)		
		τ_C	τ_L	τ_B
NR $\rightarrow$ ORM+TCBR	0.6604	17.38	12.55	-0.33
ORM $\rightarrow$ ORM+TCBR	0.0013			

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).

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.