Optimal macroprudential policy with preemptive bailouts

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Introduction

- Achieving constrained efficient allocations may require interventions in financial markets.
  - Pecuniary externalities (Dávila and Korinek, 2018).
  - Aggregate demand externalities (Farhi and Werning, 2016).
  - Macroprudential policy.
- Well understood in economies with collateral constraints.
  - Direct finance from lenders to borrowers (Lorenzoni, 2008; Dávila and Korinek, 2018).
  - Closed endowment economies (Jeanne and Korinek, 2019).
  - Small open endowment economies (Bianchi, 2011; Benigno et al., 2016; Schmitt-Grohé and Uribe, 2021; Ottonello et al., 2022).
  - Small open production economies (Benigno et al., 2013; Bianchi and Mendoza, 2018; Ottonello et al., 2022).
- Banks?
  - At the heart of the 2007–2008 global financial crisis.
  - Endogenous cost of borrowing (e.g., deposits are priced by households).
  - The DSGE literature mostly focuses on specific policy instruments. (Are they the appropriate instruments in the first place?)

This paper

- Infinite-horizon economy with a financial sector (Gertler and Kiyotaki, 2010).
  - Agency friction: bankers may divert a fraction of assets and default.
  - Enforcement constraint: bank value $\geq$ value of default.
  - Exogenous entry and exit: rotation between bankers and workers.
- Decentralized competitive equilibrium is constrained inefficient.
  - Pecuniary externalities through prices of assets *and* liabilities.
  - Inefficient net worth distribution: banks make symmetric decisions.
- Implementing constrained efficient allocation.
  - Pecuniary externalities: asset tax/subsidy. (Bank capital requirements are generally ineffective.)
  - Net worth distribution: net worth subsidy/tax that varies between survived and newly entered banks.
- Preemptive bailouts: $\uparrow$ future subsidy conditional on survival $\rightarrow \uparrow$ future value conditional on survival $\rightarrow \uparrow$ current value $\rightarrow$ relaxed enforcement constraint $\rightarrow$ towards first best.
  - Ergodic distribution: non-binding enforcement constraint $\implies$ solvency.
  - Subsidy is systemic—does *not* depend on individual net worth.

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Environment

- Infinite discrete time.
- Households—families of workers and bankers.
  - Family makes a standard consumption-saving, labor-leisure choice.
- Final good producers need external finance to purchase physical capital from capital good producers.
- Banks intermediate funds between households and final good producers.
- The aggregate state is $S = (D, K, s)$, $s = (A, \xi) \in \mathbb{R}^2_{++}$.
  - D is aggregate bank debt.
  - K is aggregate capital stock.
  - A is total factor productivity (TFP).
  - ξ is "capital quality": K_{t+1} chosen at $t \implies \xi_{t+1}K_{t+1}$ at $t+1$.
  - $\{s_t\}$ is stationary Markov chain.

Banker's problem

The Bellman equation is

$$v(n,S) = \max_{d,k} \mathbb{E}_s \left\{ \Lambda_{S,S'} \left[(1-\sigma)n' + \sigma v(n',S') \right] \right\}$$

subject to the perceived law of motion $(D', K') = h(S)$ and

$$\begin{aligned}
\text{next-period net worth}: &\quad n' \equiv X_{S'} k - d, \\
\text{balance sheet}: &\quad Q_S k = n + \frac{d}{R_S}, \\
\text{self-enforcement}: &\quad \mathbb{E}_s \left\{ \Lambda_{S,S'} \left[(1-\sigma)n' + \sigma v(n',S') \right] \right\} \geq \theta Q_S k.
\end{aligned}$$

The solution is $v(n,S) = \nu_S n$, where

$$\nu_S = \mathbb{E}_s [\Lambda_{S,S'}(1-\sigma+\sigma\nu_{S'})] R_S.$$

Countercyclical "credit spread":

$$\frac{\theta\lambda_S}{1+\lambda_S} = \mathbb{E}_s \left[\Lambda_{S,S'}(1-\sigma+\sigma\nu_{S'}) \left(\frac{X_{S'}}{Q_S} - R_S \right) \right].$$

Constant returns to scale in n.

Banking system

- Net worth:

$$N_S = \underbrace{\sigma(X_S K - D)}_{\text{survivors}} + \underbrace{\omega(Q_S K)}_{\text{entrants}}.$$

- Balance sheet:

$$Q_S K'_S = N_S + \frac{D'_S}{R_S}.$$

- Value:

$$V_S = \nu_S N_S.$$

- Value share of old banks (bank value distribution):

$$\Delta_S \equiv \frac{V_S^1}{V_S} = \frac{\sigma(X_S K - D)}{N_S}.$$

Households and firms

Household labor supply, Euler equation, and stochastic discount factor (SDF):

$$W_S = -\frac{U_L(C_S, L_S)}{U_C(C_S, L_S)},$$
$$\frac{1}{R_S} = \mathbb{E}_s(\Lambda_{S,S'}),$$
$$\Lambda_{S,S'} \equiv \beta \frac{U_C(C_{S'}, L_{S'})}{U_C(C_S, L_S)}.$$

Final good technology: $(k, l, s) \mapsto AF(\xi k, l)$. Factor demands:

$$X_S = [AF_K(\xi K, L_S) + Q_S(1-\delta)]\xi,$$
$$W_S = AF_L(\xi K, L_S).$$

Capital good technology: $i \mapsto f(i)$. Supply curve:

$$Q_S = \frac{1}{f'(I_S)}.$$

Decentralized equilibrium (DE)

- Markets for capital and final goods clear:

$$K'_S = (1-\delta)\xi K + f(I_S),$$
$$AF(\xi K, L_S) = C_S + I_S.$$

- A recursive equilibrium reduces to a list of functions:
  1. real allocation C, L, K', and I;
  2. financial allocation D', N, and V;
  3. prices Q, R, W, and X;
  4. Lagrange multipliers ν and λ.
- The equilibrium law of motion $(D', K') = h(S)$ is generated by
  - the banking sector balance sheet (D'),
  - the market clearing condition for capital (K').

Nonlinearities Financial crises

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First best

The first-best problem is

$$\max_{\{C_t, L_t, K_{t+1}, I_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

subject to

$$\begin{aligned} K_{t+1} &= (1-\delta)\xi_t K_t + f(I_t), \\ A_t F(\xi_t K_t, L_t) &= C_t + I_t. \end{aligned}$$

First-order conditions:

$$\begin{aligned} \text{labor}: &\quad -\frac{U_{L,t}}{U_{C,t}} = A_t F_{L,t}, \qquad (\text{holds in DE}) \\ \text{capital}: &\quad \frac{1}{f'(I_t)} = \mathbb{E}_t \left\{ \beta \frac{U_{C,t+1}}{U_{C,t}} \left[A_{t+1} F_{K,t+1} + \frac{1-\delta}{f'(I_{t+1})} \right] \xi_{t+1} \right\}. \end{aligned}$$

There is a capital wedge due to the agency friction in the banking sector. The DE allocation is first best if banks cannot divert any assets ($\theta = 0$).

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Planning problem

$$\max_{\{D_{t+1}, K_{t+1}, V_t, \Delta_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$$

subject to $\Delta_t \in [0,1]$,

$$\text{balance sheet}: Q_t K_{t+1} = \sigma(X_t K_t - D_t) + \omega(Q_t K_t) + \frac{\beta \mathbb{E}_t(U_{C,t+1})}{U_{C,t}} D_{t+1},$$

$$\text{value}: V_t = \mathbb{E}_t \left\{ \beta \frac{U_{C,t+1}}{U_{C,t}} \left[(1-\sigma)(X_{t+1} K_{t+1} - D_{t+1}) + \Delta_{t+1} V_{t+1} \right] \right\},$$

$$\text{self-enforcement}: V_t \geq \theta Q_t K_{t+1},$$

and functions encapsulating remaining implementability constraints:

$$Q_t = q(\underset{-}{K_t}, \underset{+}{K_{t+1}}, s_t), \qquad C_t = c(\underset{+}{K_t}, \underset{-}{K_{t+1}}, s_t),$$

$$L_t = l(\underset{+}{K_t}, \underset{+}{K_{t+1}}, s_t), \qquad X_t = x(\underset{-}{K_t}, \underset{+}{K_{t+1}}, s_t).$$

Fact: $\Delta_t(s^t) = 1$ for all t, s^t is optimal, i.e., redistribution new entrants $\rightarrow$ survived banks.

Lagrangian variations

- The choice of capital K_{t+1} affects
  - consumption $C_t = c(\underset{+}{K_t}, \underset{-}{K_{t+1}}, s_t)$,
  - labor $L_t = l(\underset{+}{K_t}, \underset{+}{K_{t+1}}, s_t)$,
  - asset payoff $X_t = x(\underset{-}{K_t}, \underset{+}{K_{t+1}}, s_t)$,
  - asset price $Q_t = q(\underset{-}{K_t}, \underset{+}{K_{t+1}}, s_t)$.
- $\downarrow C_t \implies \downarrow U(C_t, L_t)$ and the effects on the SDF:
  - $\downarrow \Lambda_{t,t+1} \implies$ tightening of balance sheet and enforcement constraints at t,
  - $\uparrow \Lambda_{t-1,t} \implies$ relaxation of balance sheet and enforcement constraints at $t-1$.
- $\uparrow L_t \implies \downarrow U(C_t, L_t)$ and symmetric effects through the SDF if U is nonseparable.
- $\uparrow X_t \implies \uparrow X_t K_t \implies \uparrow N_t \implies$ relaxation of balance sheet constraint at t and enforcement constraint at $t-1$.
- $\uparrow Q_t \implies \uparrow Q_t K_{t+1}$ and $\uparrow \omega(Q_t K_t) \implies$ tightening of balance sheet (ω effect is small) and enforcement constraints at t.
- Moral of story: depending on the history s^t, it might be better to invest/borrow less *or* more than in the DE allocation.

Asset Euler equation

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Bank regulation

Balance sheet of bank i:

$$\left(1+\tau_t^K\right) Q_t k_{t+1}^i = \left(1+\tau_t^{j(i)}\right) n_t^i + \frac{d_{t+1}^i}{R_t},$$

where

$$j(i) = \begin{cases} 1 & \text{if bank } i \text{ survived from } t-1, \\ 0 & \text{if bank } i \text{ entered at } t. \end{cases}$$

Regulatory capital requirements:

$$\xi_t : \qquad \left(1+\tau_t^{j(i)}\right) n_t^i \geq \kappa_t Q_t k_{t+1}^i.$$

Government budget constraint:

$$\tau_t^K Q_t K_{t+1} = \tau_t^1 \sigma N_t^1 + \tau_t^0 \omega (Q_t K_t),$$

where $N_t^1 \equiv X_t K_t - D_t$.

Equilibrium equity constraint

The equilibrium banking system value, $V_t = (\tilde{\nu}_t + \tilde{\xi}_t)(N_t + \tau_t^K Q_t K_{t+1})$, and the enforcement constraint, $V_t \geq \theta Q_t K_{t+1}$, imply the equilibrium equity constraint

$$\frac{N_t}{Q_t K_{t+1}} \geq \max\left\{\frac{\theta}{\tilde{\nu}_t + \tilde{\xi}_t}, \kappa_t\right\} - \tau_t^K.$$

Capital requirements are generally effective only if the enforcement constraint is non-binding at the optimal allocation. (One constraint at a time matters.)

On the effectiveness of bank capital requirements

A measure of credit spread:

$$\underbrace{\kappa_t \tilde{\xi}_t + \theta \tilde{\lambda}_t}_{\geq 0} + \tau_t^K \tilde{\nu}_t$$

$$= \underbrace{(1+\tilde{\lambda}_t)}_{\geq 1} \mathbb{E}_t \left[\underbrace{\beta \frac{U_{C,t+1}}{U_{C,t}} \left(1 - \sigma + \sigma \frac{\Delta_{t+1} V_{t+1}}{N_{t+1}^1}\right)}_{>0} \underbrace{\left(\frac{X_{t+1}}{Q_t} - R_t\right)}_{\gtrless 0} \right].$$

- The right-hand side is negative whenever there is sufficiently strong underinvestment in the DE: $\frac{X_{t+1}}{Q_t} - R_t < 0$.
  - If $\tau_t^K = 0$, the above equation cannot hold, i.e., capital requirements (without the asset tax) cannot implement the constrained efficient allocation.
  - Alternatively, one would need to set *maximum* (not minimum) capital requirements to encourage more lending.
- Generally, need an asset subsidy $\tau_t^K < 0$ to be available for implementation.
- On the other hand, if the asset tax/subsidy is unrestricted, capital requirements are redundant.

Optimal asset tax

Primal form:

$$1+\tau_t^K \le \frac{\mathbb{E}_t\left[U_{C,t+1}\left(1-\sigma+\sigma\frac{\Delta_{t+1}V_{t+1}}{N_{t+1}^1}\right)X_{t+1}\right]}{\mathbb{E}_t\left[U_{C,t+1}\left(1-\sigma+\sigma\frac{\Delta_{t+1}V_{t+1}}{N_{t+1}^1}\right)\right]Q_tR_t},$$

equality if $V_t > \theta Q_t K_{t+1}$.

The tax is unique when the enforcement constraint is non-binding. (Otherwise, any tax that implies the binding constraint would do.)

Optimal preemptive bailouts

The bank value distribution maps to the subsidy conditional on survival:

$$1 + \tau_t^1 = \frac{N_t + \tau_t^K Q_t K_{t+1}}{\sigma N_t^1} \Delta_t.$$

The government budget constraint pins down the subsidy to entrants:

$$\tau_t^0 = \frac{\tau_t^K Q_t K_{t+1} - \tau_t^1 \sigma N_t^1}{\omega(Q_t K_t)}.$$

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Bank debt: DE-based bank value distribution

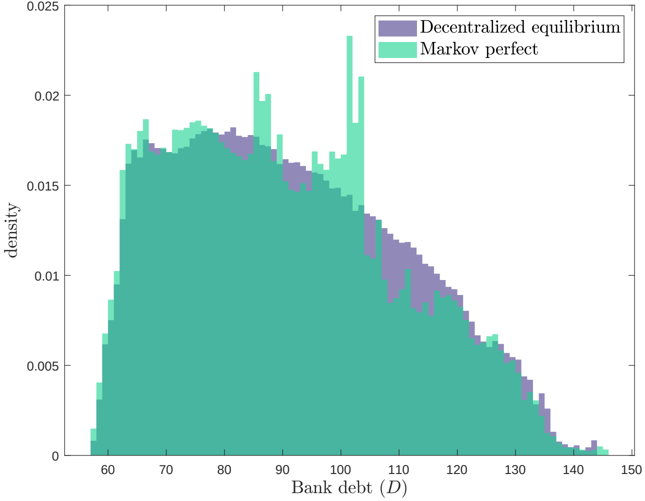

Figure 1: Bank debt, $\Delta_S = \frac{\sigma(X_S K - D)}{N_S}$

Bank debt: optimal bank value distribution

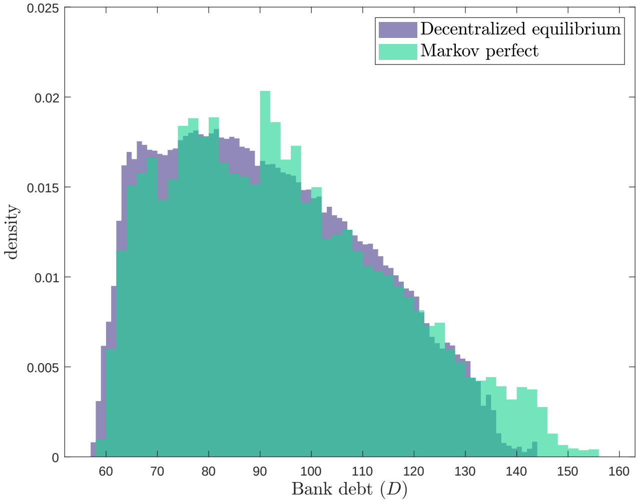

Figure 2: Bank debt, $\Delta_S \to 1$

Capital stock: DE-based bank value distribution

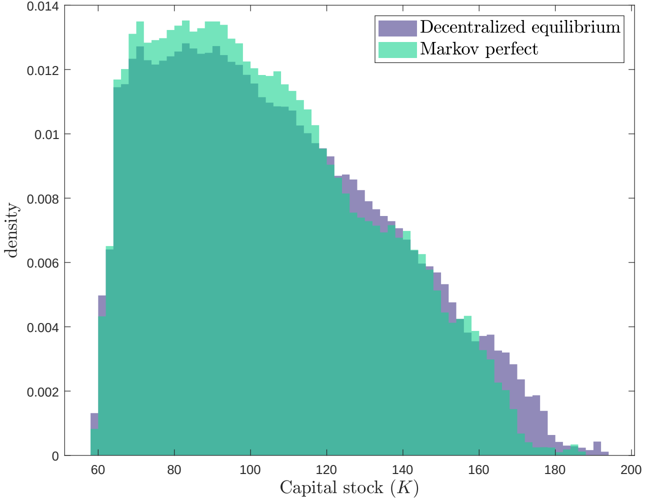

Figure 3: Capital stock, $\Delta_S = \frac{\sigma(X_S K - D)}{N_S}$

Capital stock: optimal bank value distribution

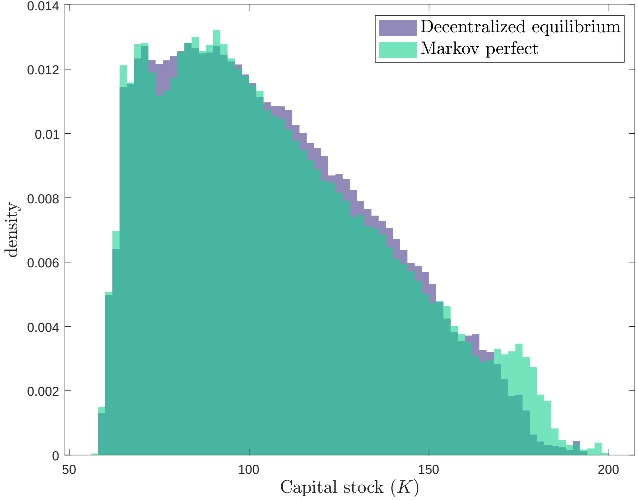

Figure 4: Capital stock, $\Delta_S \to 1$

Optimal asset tax: DE-based bank value distribution

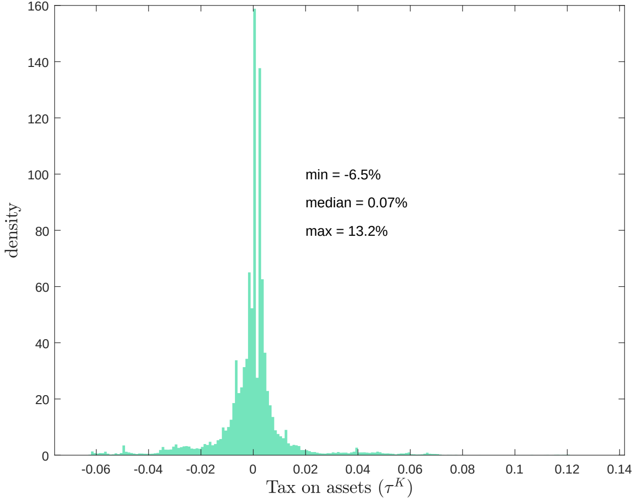

Figure 5: Asset tax, $\Delta_S = \frac{\sigma(X_S K - D)}{N_S}$

Average welfare gain with respect to DE ergodic distribution $= 0.02\%$.

Optimal asset tax: optimal bank value distribution

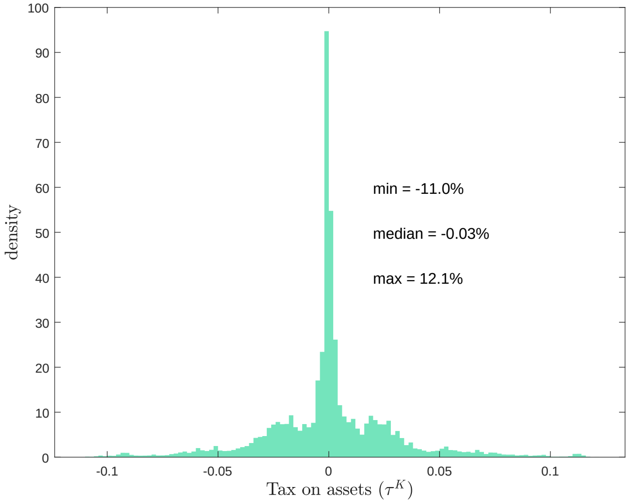

Figure 6: Asset tax, $\Delta_S \to 1$

Average welfare gain with respect to DE ergodic distribution $= 0.11\%$.

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Conclusion

Thank you!

Nonlinearities

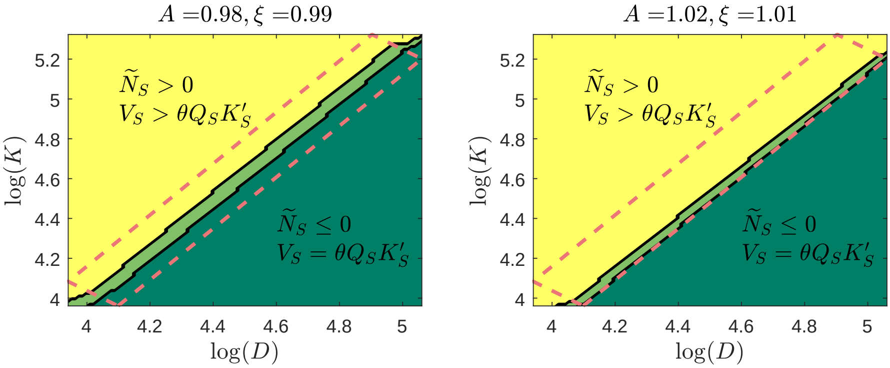

Figure 7: Bank solvency and enforcement constraint regimes, decentralized equilibrium

Note: $\tilde{N}_S \equiv X_S K - D$. Equilibrium

Financial crises

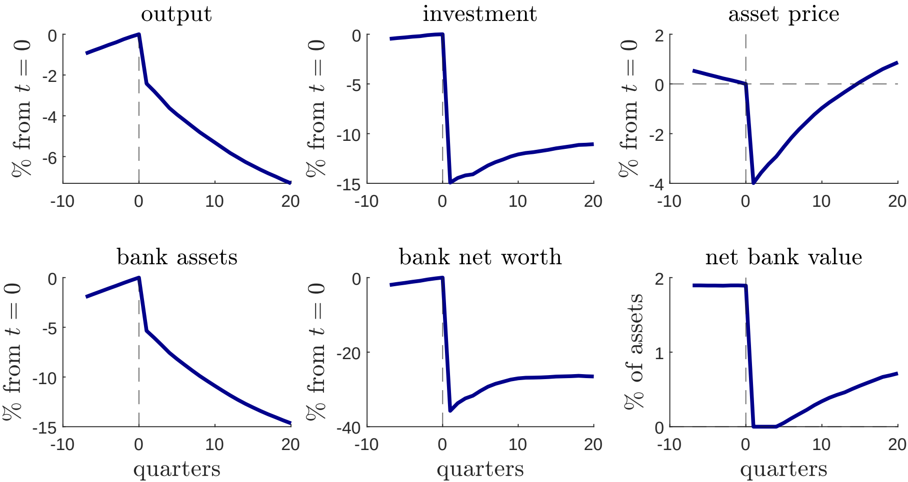

Figure 8: Financial crises, decentralized equilibrium

Equilibrium

Optimal supply of bank credit

The planner's first-order condition for K_{t+1} is

$$\theta\tilde{\lambda}_t + \tilde{\nu}_t = (\Delta_t + \tilde{\lambda}_t)\mathbb{E}_t\left[\beta\frac{U_{C,t+1}}{U_{C,t}}(1-\sigma+\sigma\tilde{\nu}_{t+1})\frac{X_{t+1}}{Q_t}\right] + \underbrace{\frac{\omega(\Delta_t+\tilde{\lambda}_t)}{Q_t}\mathbb{E}_t\left(\beta\frac{U_{C,t+1}}{U_{C,t}}\tilde{\nu}_{t+1}Q_{t+1}\right)}_{\text{effect on } t+1 \text{ entrants' net worth}}$$
$$+ \frac{1}{\gamma_{t-1}Q_t}(\underbrace{\mathcal{L}_{C,t}c_{K',t} + \mathcal{L}_{L,t}l_{K',t} + \mathcal{L}_{X,t}x_{K',t} + \mathcal{L}_{Q,t}q_{K',t}}_{t \text{ externalities}})$$
$$+ \frac{1}{\gamma_{t-1}Q_t}\mathbb{E}_t\left[\beta\frac{U_{C,t+1}}{U_{C,t}}(\underbrace{\mathcal{L}_{C,t+1}c_{K,t+1} + \mathcal{L}_{L,t+1}l_{K,t+1} + \mathcal{L}_{X,t+1}x_{K,t+1} + \mathcal{L}_{Q,t+1}q_{K,t+1}}_{t+1 \text{ externalities}})\right].$$

Social versus private marginal benefit of capital: the overall effect is ambiguous.

Lagrangian variations