Bank Regulation with Uninformed Regulators

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- **Key tradeoffs:**
  - Banks have better information about credit risk
  - Banks have incentive to underreport credit risk to loosen requirements
- **Question:** How should bank regulators deal with the incentive to underreport credit risk?

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- How do allocations change if regulators miss information friction?

Institutional Background

- Regulators use risk-weighted capital requirements:

$$E \geq \mathbf{A} \cdot \mathbf{w}$$

where E is shareholder equity, $\mathbf{A}$ are assets, and $\mathbf{w}$ are risk weights

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- *Standardized approach* (SA): Regulators estimate set of risk weights

- *Internal ratings based approach* (IRB): Bank reports credit risk estimates from models they develop and regulators approved

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  - Dang et al (2017), Orlov, Zryumov, Skrzypacz (2022)

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  - Here, atomistic banks; in AG (2004), n banks with Cournot equilibrium

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- Assume $p'(S) < 0$ and $p''(S) \leq 0 \implies$ risk-return trade-off

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- Deposits are insured $\implies$ depositors do not run

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- The regulator can subject bank to capital requirement

$$\theta \cdot E \geq D$$

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  - Regulator pays $r(\bar{D}) \cdot D$ to depositors

Functional Forms and Parameters

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- Inverse deposit supply curve:

$$r(D) = \gamma D + \alpha$$
$$\text{with } \gamma = 1$$
$$\alpha = 0$$

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Full Commitment Planner Problem

- Planner problem

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  - Bank is price taker in deposits

Planner FOC wrt S

- FOC wrt S

$$\underbrace{p(S)\cdot A\cdot(D+E)}_{\substack{\text{higher } S \implies \text{more output if success}\\ \text{(MB)}}} = \underbrace{-p'(S)\cdot A\cdot S\cdot(D+E)}_{\substack{\text{but failure more likely}\\ \text{(MC)}}}$$

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[1] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

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- With functional forms and parameters,[1]

$$S^P = \frac{1}{2}$$

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Planner FOC wrt D

- FOC wrt D

$$
\begin{aligned}
\underbrace{p(S)\cdot A\cdot S}_{\substack{\text{higher } D \implies \text{more output} \\ \text{(MB)}}} &= \underbrace{r(D)}_{\substack{\text{but pay for marginal deposits} \\ \text{(MC)}}} \\
&+ \underbrace{r'(D)\cdot D}_{\substack{\text{and pay inframarginal deposits more} \\ \text{(MC)}}}
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- With functional forms and parameters,[2]

$$D^P = \frac{1}{8}$$

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Decentralize with Capital Requirement

- Regulator can implement efficient allocation with capital requirement:

$$\theta^P(S, E) = \begin{cases} \frac{D^P}{E}, & \text{if } S = S^P \\ 0, & \text{otherwise} \end{cases}$$

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- θ allows deposits up to D^P if chooses S^P and zero deposits otherwise

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Bank Problem

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$$\text{s.t. } \theta \cdot E \geq D$$

Relaxed Bank Problem Details on Capital Requirements

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- If the capital requirement binds, the bank problem becomes

$$\max_{S} p(S)\cdot A\cdot S\cdot(\theta+1)\cdot E - p(S)\cdot r(\bar{D})\cdot\theta\cdot E$$

Relaxed Bank Problem | Details on Capital Requirements

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- FOC wrt S

$$\underbrace{p(S) \cdot A \cdot (\theta + 1) \cdot E}_{\substack{\text{higher } S \implies \text{more output if success} \\ \text{(MB)}}} \quad - \quad \underbrace{p'(S) \cdot r(\bar{D}) \cdot \theta \cdot E}_{\substack{\text{and less likely to pay deposits} \\ \text{(MB)}}}$$

$$= \underbrace{-p'(S) \cdot A \cdot S \cdot (\theta + 1) \cdot E}_{\substack{\text{but failure is more likely} \\ \text{(MC)}}}$$

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- With functional forms and parameters[3]

$$S = \frac{1}{2}\left[\frac{E\theta^2+\theta+1}{\theta+1}\right] = \frac{1}{2}\left[\frac{D^2+D+E}{D+E}\right]$$

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Efficient allocation not incentive compatible

- To be incentive compatible for bank with equity E, S needs to optimal project riskiness with D deposits

$$S = \arg\max_{\hat{S}} \left\{ p(\hat{S}) \cdot A \cdot S \cdot (D + E) - p(\hat{S}) \cdot r(\bar{D}) \cdot D \right\}$$

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- With functional forms and parameters[4], bank IC becomes

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$$S = \frac{1}{2} \left[\frac{D^2 + D + E}{D + E} \right]$$

- Efficient allocation ($S^P = 1/2$ and $D^P = 1/8$) violates bank IC

$$1/2 < \frac{1}{2} \left[\frac{(1/8)^2 + (1/8) + E}{(1/8) + E} \right]$$

[4] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Constrained Planner Problem

- Constrained planner problem

$$\max_{S,D} p(S) \cdot A \cdot S \cdot (D + E) - r(D) \cdot D$$

$$\text{s.t.} \quad p(S) \cdot A \cdot (\theta + 1) - p'(S) \cdot r(D) \cdot \theta = -p'(S) \cdot A \cdot S \cdot (\theta + 1) \quad [IC]$$

$$\theta \cdot E = D$$

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- With functional forms and parameters[5]

$$\max_{S,D} (1 - S) \cdot S \cdot (D + E) - D^2$$
$$\text{s.t. } S = \frac{1}{2}\left[\frac{D^2 + D + E}{D + E}\right]$$

[5] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Constrained Efficient Allocation

- Solution[6]

$$D^C(E) = \left\{ D \;\middle|\; \frac{D^4}{4(D+E)^2} - \frac{D^3}{D+E} - 2D + \frac{1}{4} = 0 \right\}$$

$$S^C(E) = \left\{ S \;\middle|\; S = \frac{1}{2}\left[\frac{D^2 + D + E}{D+E}\right], D = D^C(E) \right\}$$

[6] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Constrained Efficient Allocation

- Solution[6]

$$D^C(E) = \left\{ D \,\middle|\, \frac{D^4}{4(D+E)^2} - \frac{D^3}{D+E} - 2D + \frac{1}{4} = 0 \right\}$$

$$S^C(E) = \left\{ S \,\middle|\, S = \frac{1}{2}\left[\frac{D^2+D+E}{D+E}\right], D = D^C(E) \right\}$$

- Regulator can implement with capital requirement

$$\theta^C(E) = \frac{D^C(E)}{E}$$

[6] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Outline

Naive Regulator

- Sophisticated regulator uses constrained efficient capital requirements

[7] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Naive Regulator

- Sophisticated regulator uses constrained efficient capital requirements
- Naive regulator uses planner capital requirements[7]

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- Sophisticated regulator uses constrained efficient capital requirements
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$$D^N = D^P = \frac{1}{8}$$

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Naive Regulator

- Sophisticated regulator uses constrained efficient capital requirements
- Naive regulator uses planner capital requirements[7]
  - Naive regulator can observe deposits
$$D^N = D^P = \frac{1}{8}$$
  - Naive regulator cannot observe project riskiness. Bank reports
$$\hat{S}^N = S^P = 1/2$$

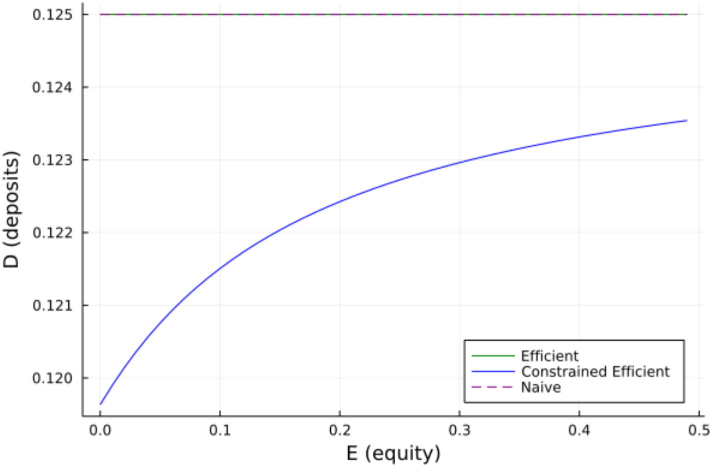
[7] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Naive Regulator

- Sophisticated regulator uses constrained efficient capital requirements
- Naive regulator uses planner capital requirements[7]
  - Naive regulator can observe deposits
  $$D^N = D^P = \frac{1}{8}$$
  - Naive regulator cannot observe project riskiness. Bank reports
  $$\hat{S}^N = S^P = 1/2$$
  - True project riskiness is pinned down by bank IC
  $$S^N = \frac{1}{2}\left[\frac{(1/8)^2 + (1/8) + E}{(1/8) + E}\right] > \frac{1}{2} = S^P$$

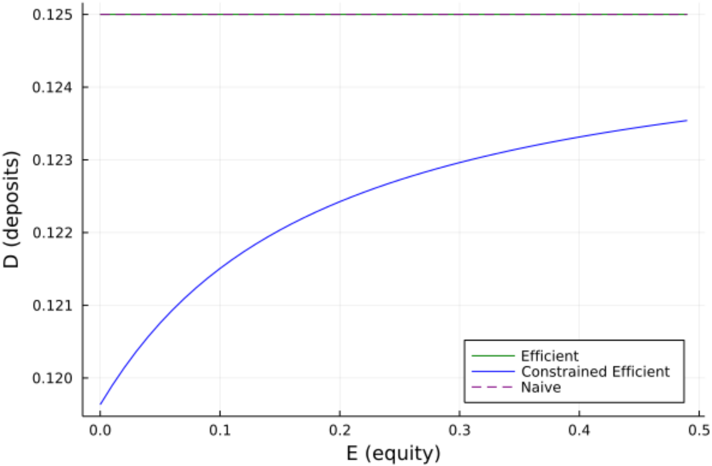
[7] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

Quantity of Deposits



- $D^P = D^N$ by construction

Quantity of Deposits



- $D^P = D^N$ by construction
- Constrained planner restricts D^C more in order to lower S^C

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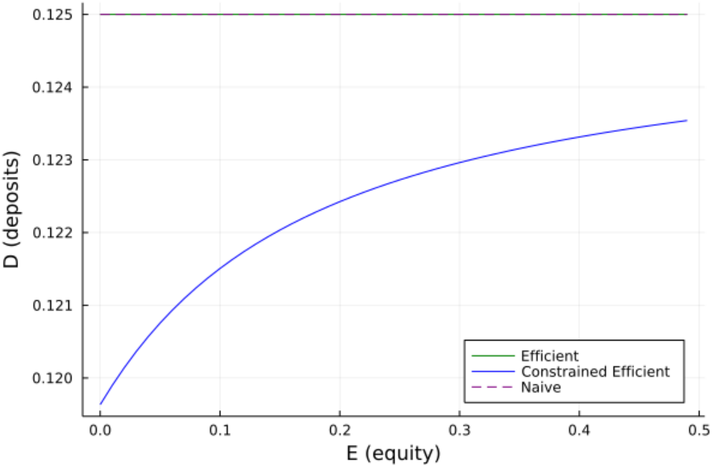
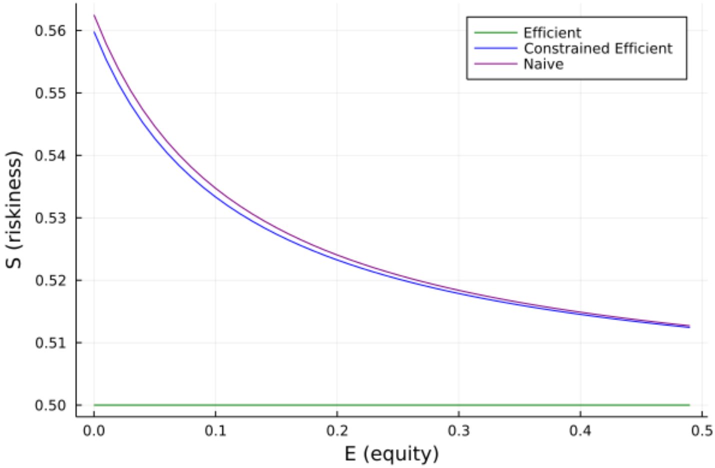


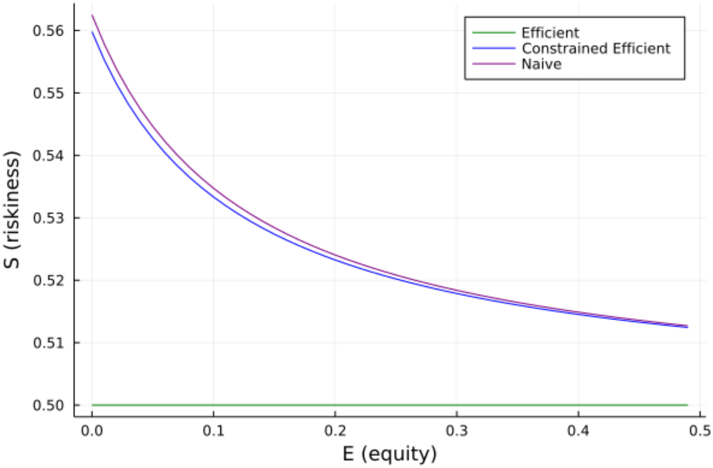
- $D^P = D^N$ by construction
- Constrained planner restricts D^C more in order to lower S^C
- $D^C \rightarrow D^P$ as $E \rightarrow \infty$

Project Riskiness



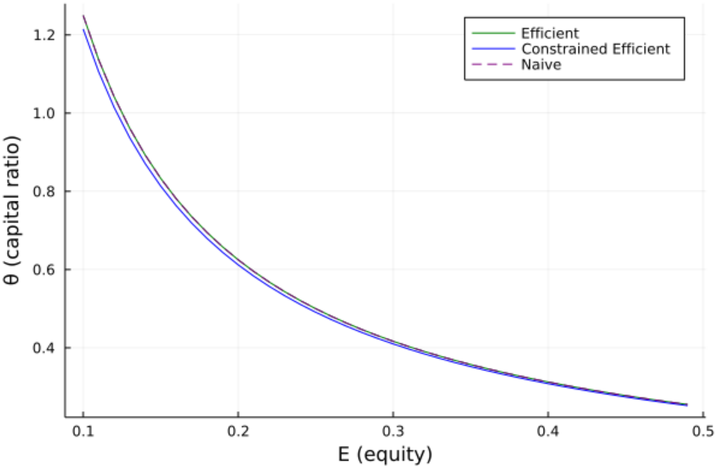
- S^N is higher than S^C to satisfy bank FOC with more deposits

Project Riskiness



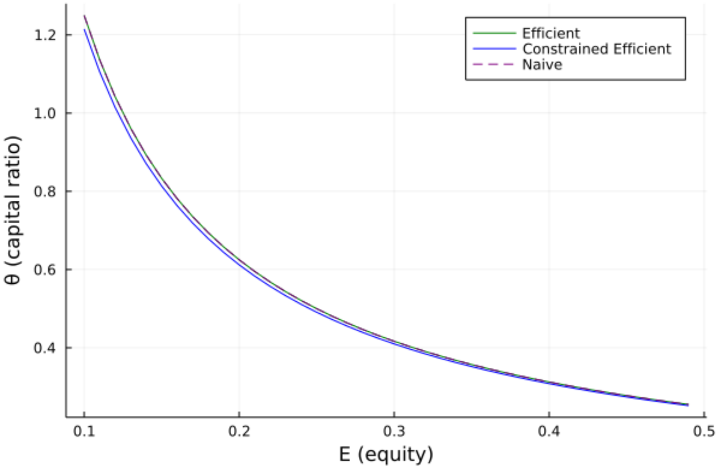
- S^N is higher than S^C to satisfy bank FOC with more deposits
- $S^C \to S^P$ and $S^N \to S^P$ as $E \to \infty$

Capital Requirement



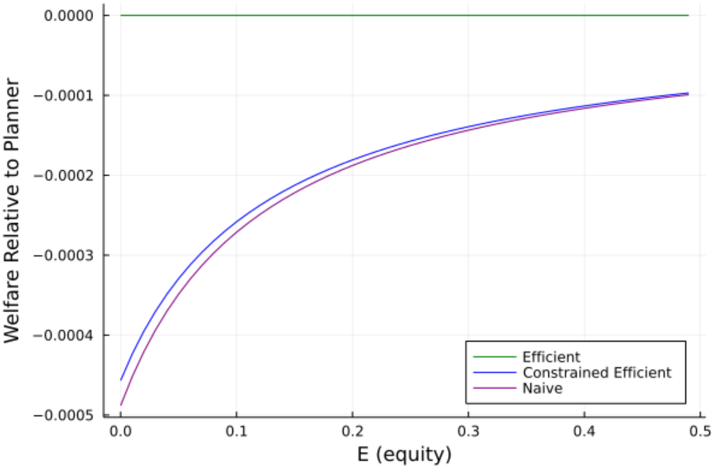
- θ^C is more strict than θ^P

Capital Requirement



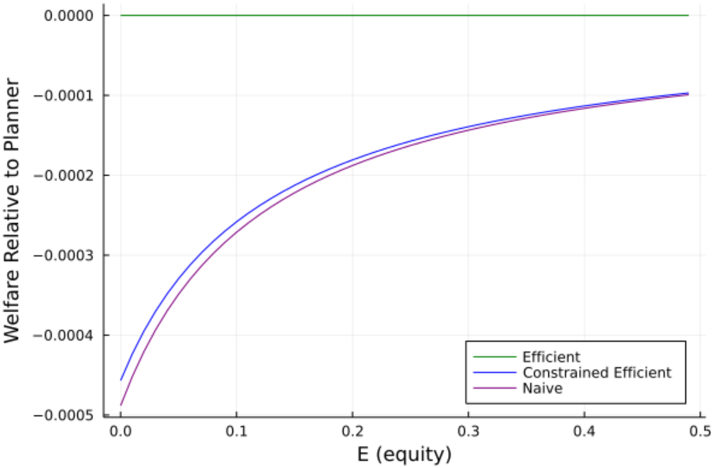
- θ^C is more strict than θ^P
- $\theta^N = \theta^P$ by construction

Welfare



- Constrained planner has lower welfare than planner

Welfare



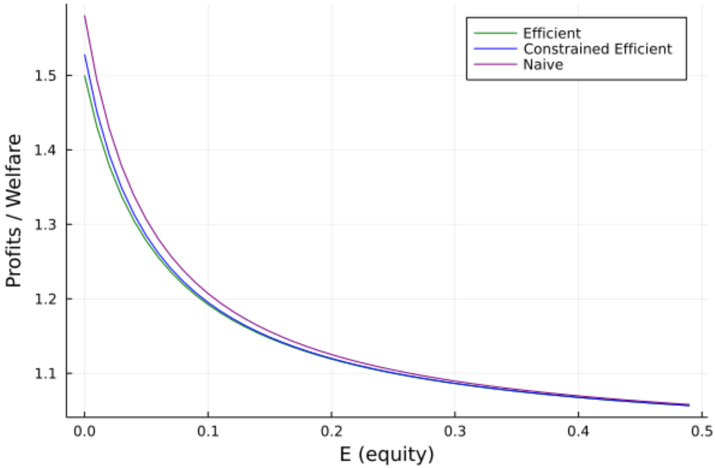
- Constrained planner has lower welfare than planner
- Naive regulation further lowers welfare

Welfare Decomposition

- Welfare can be decomposed

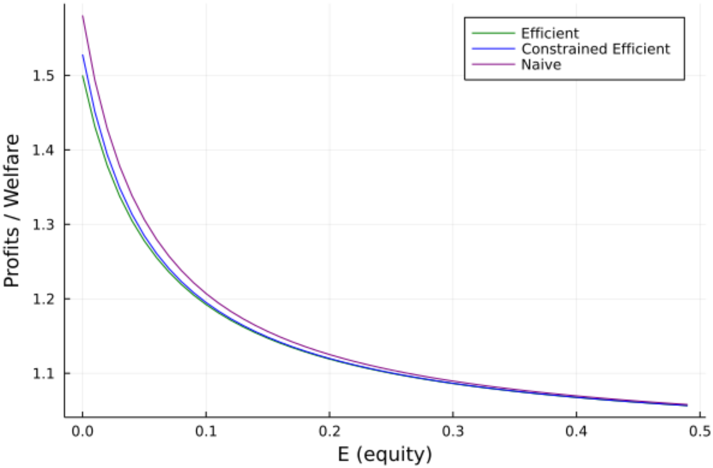
$$\underbrace{p(S) \cdot A \cdot S \cdot (D + E) - r(D)D}_{\text{welfare}} = \underbrace{p(S) \cdot A \cdot S \cdot (D + E) - p(S)r(D)D}_{\text{expected bank profit}} - \underbrace{(1 - p(S))r(D)D}_{\text{expected deposit insurance payout}}$$

Expected Bank Profits



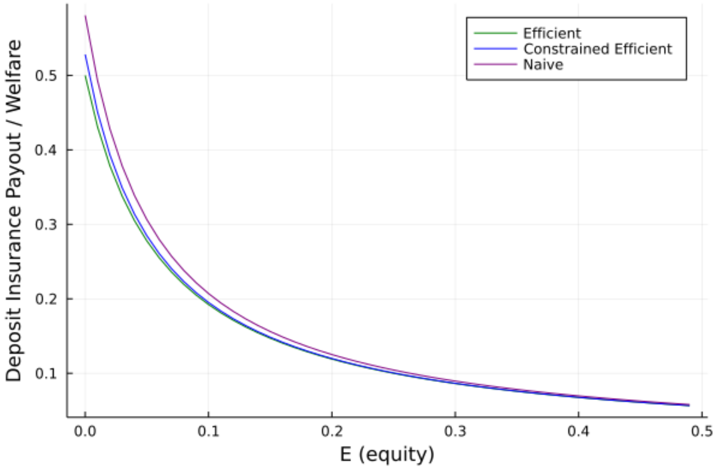
- Constrained planner increases profits to equate bank FOC

Expected Bank Profits



- Constrained planner increases profits to equate bank FOC
- Naive regulation further increases bank profits

Expected Deposit Insurance Payout



- But, higher profits result in higher expected deposit insurance payouts

Outline

Conclusion

- Simple model of bank lending with limited liability

Ramsey Problem with Constant Capital Requirement

Conclusion

- Simple model of bank lending with limited liability
- Solved planner problem and constrained planner problem

Ramsey Problem with Constant Capital Requirement

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Ramsey Problem with Constant Capital Requirement

Conclusion

- Simple model of bank lending with limited liability
- Solved planner problem and constrained planner problem
- Effects of naive regulation not accounting for misreporting
- How to change environment to have naive IRB vs sophisticated SA?

Ramsey Problem with Constant Capital Requirement

Next Steps

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Next Steps

1. Add private info about project returns
   - For example, risky technology with $A_H > A_L$ is private info
2. Extend treatment to more general specification
   - Then calibration
3. Embed in dynamic setting for endogenous E distribution
   - If SA vs. IRB depend on E, then would depend on size distribution

Outline

Underreporting Risk with IRB

- Bank can manipulate IRB risk weights by underreporting risk
- Behn, Haselmann, and Vig (JF, 2022) find evidence of banks gaming
- Delays in IRB model approval result in loans under both SA and IRB
- In *absolute* terms, banks underreport PD when using IRB risk weights
- And no downward bias in implied PD for SA loans
- So, IRB loans have lower capital requirement *relative* to SA loans
- Despite IRB loans having higher realized losses than SA loans
- Higher interest rates on IRB loans $\implies$ bank aware IRB loans riskier
- BHV (2022) also find that lending by IRB banks grew relative to SA banks (consistent with effectively a lower capital requirement)

Back

Relaxed Bank Problem

- If the capital requirement does not bind, the bank problem is

$$\max_{S,D} p(S) \cdot A \cdot S \cdot (D+E) - p(S) \cdot r(\bar{D}) \cdot D$$

- FOC wrt S:

$$\underbrace{p(S) \cdot A \cdot (D+E)}_{\substack{\text{higher } S \implies \text{more output if success} \\ \text{(MB)}}} - \underbrace{p'(S) \cdot r(\bar{D}) \cdot D}_{\substack{\text{and less likely to pay deposits} \\ \text{(MB)}}}$$

$$= \underbrace{-p'(S) \cdot A \cdot S \cdot (D+E)}_{\substack{\text{but failure more likely} \\ \text{(MC)}}}$$

- S^U is decreasing in E

Back

Relaxed Bank Problem

- FOC wrt D:

$$\underbrace{p(S)\cdot A\cdot S}_{\substack{\text{higher } D \implies \text{more output} \\ \text{(MB)}}} = \underbrace{p(S)\cdot r(\bar{D})}_{\substack{\text{but pay for marginal deposits} \\ \text{(MC)}}}$$

- D^U is also decreasing in E

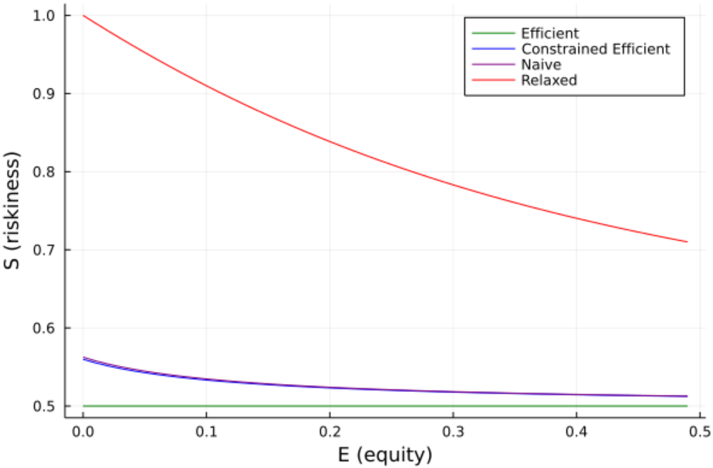
- Solution[8]

$$S^U = D^U = \frac{1}{2}\left(\sqrt{4E^2+1} - 2E + 1\right)$$

Back

[8] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.

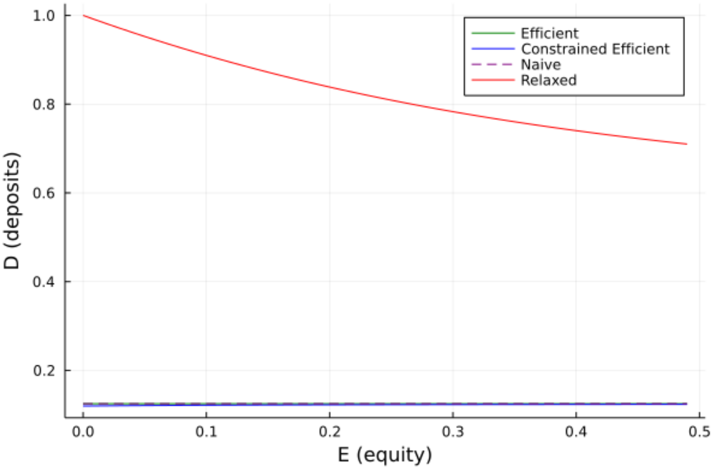
Project Riskiness



- $S^U \to S^P$ as $E \to \infty$

Back

Quantity of Deposits



- $D^U \to \tilde{D} > D^P$ because effect on deposit rate not internalized

Back

Risk-Weighted Capital Requirements

- Basel III IRB risk-weighted capital requirements take the form:

$$\frac{E}{w(\hat{S})(D+E)} \geq \tilde{\theta}(D, E)$$

  where
  - $w : [0, 1] \to \mathbb{R}$ is the IRB risk weight

- Equivalently,

$$\theta(\hat{S}, D, E)E \geq D$$

  where

$$\theta(\hat{S}, D, E) \equiv \frac{1 - w(\hat{S})\theta(D, E)}{w(\hat{S})\theta(D, E)}$$

Back

Risk-Weighted Capital Requirements

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$$\frac{E}{w(\hat{S})(D+E)} \geq \tilde{\theta}(D, E)$$

where

  - $w : [0,1] \to \mathbb{R}$ is the IRB risk weight
  - $\tilde{\theta} : \mathbb{R}_+ \times \mathbb{R}_+ \to \mathbb{R}$ is the minimum ratio

- Equivalently,

$$\theta(\hat{S}, D, E)E \geq D$$

where

$$\theta(\hat{S}, D, E) \equiv \frac{1 - w(\hat{S})\theta(D, E)}{w(\hat{S})\theta(D, E)}$$

Back

Ramsey problem with constant capital requirement

- Assume $E \sim F$
- Ramsey regulator sets θ before E realized
- There exists a bank with equity $\tilde{E}$ such that
  - Banks with equity $E \leq \tilde{E}$ capital requirement θ binds
  - Banks with equity $E > \tilde{E}$ capital requirement θ is slack
- Choosing θ is equivalent to choosing $\tilde{E}$ where $\theta \equiv \frac{D^U(\tilde{E})}{\tilde{E}}$

Back

Ramsey problem with constant capital requirement

- Banks with equity $E \leq \tilde{E}$, constrained bank FOC holds
- Banks with equity $E > \tilde{E}$, relaxed bank FOC holds
- Thus, Ramsey regulator solves problem

$$\max_{\tilde{E}} \int_0^\infty \Big[p(S(E)) \cdot S(E) \cdot A \cdot (D(E) + E) - r(D(E)) \cdot D(E)\Big] dF(E)$$

$$\text{where } D(E) = \begin{cases} \theta \cdot E & \text{if } E \in (0, \tilde{E}] \\ D^U(E) & \text{if } E \in (\tilde{E}, \infty) \end{cases}$$

$$\text{and } S(E) = \begin{cases} < \textit{constrained bank FOC} > & \text{if } E \in (0, \tilde{E}] \\ S^U(E) & \text{if } E \in (\tilde{E}, \infty) \end{cases}$$

$$\text{and } \theta \equiv \frac{D^U(\tilde{E})}{\tilde{E}}$$

Back

Ramsey problem with constant capital requirement[9]

- Thus, Ramsey regulator solves problem

$$\max_{\tilde{E}} \int_0^\infty \left[(1 - S(E)) \cdot S(E) \cdot (D(E) + E) - D(E)^2\right] dF(E)$$

$$\text{where } D(E) = \begin{cases} \theta \cdot E & \text{if } E \in (0, \tilde{E}] \\ \frac{1}{2}\left(\sqrt{4E^2+1} - 2E + 1\right) & \text{if } E \in (\tilde{E}, \infty) \end{cases}$$

$$\text{and } S(E) = \begin{cases} \frac{1}{2}\left(\frac{E\theta^2+\theta+1}{\theta+1}\right) & \text{if } E \in (0, \tilde{E}] \\ \frac{1}{2}\left(\sqrt{4E^2+1} - 2E + 1\right) & \text{if } E \in (\tilde{E}, \infty) \end{cases}$$

$$\text{and } \theta \equiv \frac{D^U(\tilde{E})}{\tilde{E}}$$

- Assume $\log E \sim N(0,1)$

Back

[9] $p(S) = 1 - S$, $A = 1$, and $r(D) = D$.