Financial Amplification, Regulation and Long-term Lending

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Introduction

- Lessons of the 07/08 financial crisis and European sovereign debt crisis:
  - Large aggregate risks in the financial sector
  - Substantial share of banks default (US: 3% in Q4 2008)
  - Severe disruption in the flow of credit to the private sector
- We study these dynamics in a macroeconomic model
- What are the consequences for regulation?
- Does lower risk come at the cost of lower credit supply?

Summary

- We build a macroeconomic model with a banking sector, where
  - Banks are limited liability firms $\Rightarrow$ default in equilibrium
  - Engage in long term lending to firms
  - Face financial risks, unrelated to corporate lending
  - Losses to banks disrupt supply of credit
- Obtain a global non-linear solution
- Results
  - Study financial amplification in a calibrated economy
  - Policy experiment: Tighter capital regulation can reduce default risk and increase credit supply
  - Financial amplification mechanism remains present

Related Literature

- Empirical literature on the disruption of credit supply:
  - US: Adrian et al. (2013), Greenstone et al. (2014), Chodorow-Reich (2014)
  - Europe: Bentolila et al. (2015), Acharya et al. (2015), Alfaro et al. (2016)
- Theoretical (DSGE):
  - Early: Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Brunnermeier and Sannikov (2014)
  - Long-term lending: Andreasen et al. (2013), Paul (2016), Landvoigt et al. (2017)
  - Risk taking and capital regulation: Angeloni and Faia (2013), Begenau (2016), Mendicino et al. (2016)

Disruption of credit supply

- Banks are highly levered, equity is highly sensitive to low returns
- Banks cannot adjust equity, shrink balance sheet
- $\Rightarrow$ reduce credit supply
- Two important questions:
  - Why are banks so highly levered?
  - Why don't issue equity, when it is scarce?
- Earlier models (e.g. Gertler and Karadi, 2010): bank equity is limited by the net worth of bankers, dividend decision exogenous

Why are banks so highly levered?

- If default is costly, why take on so much debt?
- In our model (and in reality) banks can issue equity
- We model two reasons:
  - Agents value deposits for their safety and liquidity (e.g. DeAngelo and Stulz, 2013)$\Rightarrow$ deposit financing cheaper compared to equity
  - Regulatory subsidy for debt: Differential tax treatment, deposit insurance and implicit bailout guarantees (Admati and Hellwig, 2013)

Why not issue equity in a crisis?

- There is evidence that bank equity is sticky (Adrian et al., 2013)
  - Dilution costs of equity issuance
  - Signaling effect of cutting dividends/issuing equity
  - Especially severe in crises
- Modeled as convex adjustment costs for deviations of dividends from target level d^*

$$c(d_t; d^*)$$

The model economy

- Standard: representative household, competitive producers
- Entrepreneurs
  - Undertake long-term investment
  - Use their own net worth and external financing
- Banks
  - Issue equity and deposits to households
  - Provide long-term lending
- Regulator: Insures deposits, regulates bank risk taking

Household side

- Households
  - Save in bank deposits D_{t+1} at interest rate R_t
  - Own the banking sector and receive dividends d_t and transfer T_t
  - Provide labor L_t for wage w_t

$$\max_{\{c_t, D_t, L_t\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \beta^t [u(c_t) + \eta ln(1 - L_t) + \xi D_{t+1}]$$

s.t.

$$D_{t+1} = R_t(D_t + w_t L_t - c_t + d_t + T_t)$$

Household side (ctd.)

- This leads to the Euler equation:

$$u'(c_t) = \xi + \beta R_t u'(c_{t+1})$$

- And the labor supply equation:

$$w_t u'(c_t) = \frac{\eta}{1 - L_t}$$

Production

- Output is produced in a competitive sector, with CRS technology
- Capital K_t and Labor L_t are used as inputs

$$Y(K_t, L_t) = Z_t K^{\alpha} L^{(1-\alpha)}$$

- Productivity Z_t follows an AR-1 process:

$$Z_t = \bar{Z} + \rho^Z Z_{t-1} + \epsilon^Z$$

Entrepreneurial Sector

- Entrepreneurs invest in capital, which depreciates at rate δ
- Use their own net worth and bank loans to fund investment
- Loan: bond with geometrically declining coupon payments
  - Entrepreneur receives funds p_t
  - Amount repaid in period t+i: $\mu(1-\mu)^{t+i-1}$
  - p_t determines the interest rate: $R_t^l = (1-\mu) + \frac{\mu}{p_t}$
- Assume: Entrepreneurs always have sufficient net worth to avoid default

Entrepreneurial Sector (ctd.)

- Each period a fraction $\varepsilon > 1 - \beta$ of entrepreneurs exits and consumes their net worth
- Higher consumption share makes entrepreneurs natural borrowers
- Entrepreneurs have linear utility $\Rightarrow$ they maximize expected net worth:
  $N_{t+1} = (R^k_{t+1} + p^k_{t+1}(1-\delta))K_t - (\mu + (1-\mu)p_{t+1})B_{t+1}$
- They take out loans according to the no-arbitrage condition:

$$\mathbb{E}\frac{p_t}{p^k_t}(R^k_{t+1} + p^k_{t+1}(1-\delta)) = \mathbb{E}\mu + (1-\mu)p_{t+1}$$

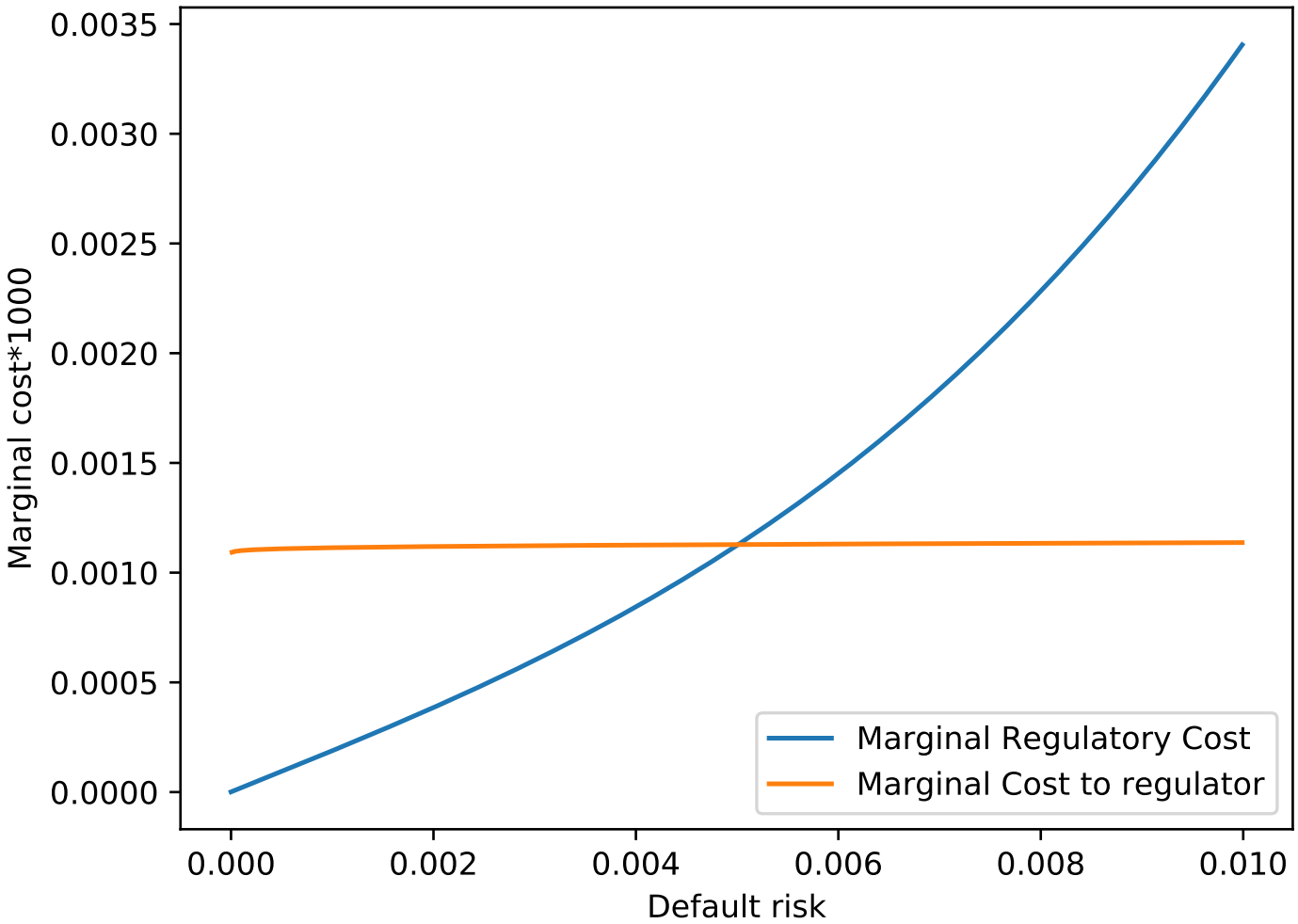
Banking Sector

- Banks maximize expected discounted dividends d_t to households
- Assets: long-term loans B_t, with market price p_t
- Liabilities: equity and fully insured one-period deposits
- Banks face regulatory costs $ic(B_t, D_t)$ that are increasing in bank size and risk
- Aggregate and idiosyncratic financial shocks to bank income

Regulatory Regime

- Regulation is sensitive to bank risk
  - FDIC charges deposit insurance premia that are increasing risk assessment
  - Risk based capital adequacy requirements (Basel II & III)
- To avoid a hard constraint, we assume that regulatory costs are a convexly increasing in bank risk taking
- Calibrate this function to match mean and volatility of bank leverage
- $\Rightarrow$ at low levels risk taking is subsidized

Regulatory Subsidy for Risk-taking



Financial Shocks

- Every period, each bank draws an income shock:
  - Idiosyncratic: each bank draws a shock α^i from $G_t(\alpha)$
  - Aggregate: The mean of $G_t(\alpha)$ follows an AR-1 process
- Idiosyncratic component of the financial shock: Trading gains/losses, efficiency of management
- Aggregate component: Fall in financial asset values, exposure to govt. debt or mortgages ...

Bank Default

- Uncertainty is resolved:
  - Banks draw their return shock α^i
  - Value of assets p_t realizes
- If a bank's equity turns negative it declares bankruptcy:

$$E_t = p_t B_t(1-\mu) + B_t(\alpha^i + \mu) - D_t < 0$$

- Assets of defaulted banks are sold to surviving banks by the insurer, who faces dead-weight costs of δ^d
- Note that owners prefer to default, when equity at market value turns negative

Bank Problem

- The bank maximizes:

$$V(B_t, D_t, \alpha_t^i) = max_{d_t, D_{t+1}, B_{t+1}} d_t + \mathbb{E}[\Lambda_{t,t+1} \int_{\alpha^d(B_{t+1}, D_{t+1})}^{\infty} V(B_{t+1}, D_{t+1}, \alpha) dG_t(\alpha)]$$

s. t.

$$B_{t+1} = (1-\mu)B_t + \frac{1}{p_t}[(\mu + \alpha_t^i)B_t + \frac{D_{t+1}}{R_t} - ic(D_{t+1}, B_{t+1}) - D_t - c(d_t, d_t^*)]$$

- Under appropriate assumptions on $ic(D_{t+1}, B_{t+1})$ and $c(d_t, d^*)$:
  - Bank operations are constant returns to scale
  - There is a unique optimal $\frac{D}{B}$

Bank Optimality Conditions

Bank discount factor:

$$\Lambda^B_{t,t+1} = \frac{u(c_{t+1})}{u(c_t)} \frac{c'(d_t)}{c'(d_{t+1})}$$

Euler equation for deposits:

$$\frac{1}{R_t} - ic_D(D_{t+1}, B_{t+1}) = \mathbb{E}_t \Lambda^B_{t,t+1}(1 - \pi^d_{t+1})$$

Euler Equation for assets:

$$p_t + ic_B(D_{t+1}, B_{t+1}) = \mathbb{E}_t \Lambda^B_{t,t+1}[p_{t+1}(1 - \mu) + \mu](1 - \pi^d_{t+1})$$

Calibration

Directly set Parameters

Parameter	Value	Interpretation
β	.99	Discount factor
δ	.0025	Depreciation rate
α	0.3	capital share
δ^d	0.1	dead-weight cost of default (James, 1990)
ξ	0.002	liquidity premium 73bps (Krishnamurthy et al., 2012)
μ	0.06	share of maturing loans (Markart et al. 2017)
ϵ^z	0.007	sd. of prod. shock
ρ^z	.95	autocorrelation of prod. shock
ρ^c	0.75	ac. of bank income shock (Begenau, 2016)

Calibration (ctd.)

Parameters calibrated from simulation

Par	Value	Interpretation	Target
γ	3	Capital adjustment cost parameter	$sd(Investement) = 4.32$
σ	0.029	sd. of idiosyncratic bank shock	$mean(\pi^d)$ = 0.66%
ϵ^c	0.005	sd. of aggregate bank shock	$sd(\pi^d)$ = 0.44%
$p1$	12.8	slope of regulatory cost	mean(Leverage) = 10.37
$p2$	9375.3	convexity of regulatory costs	sd(Leverage) = 0.26

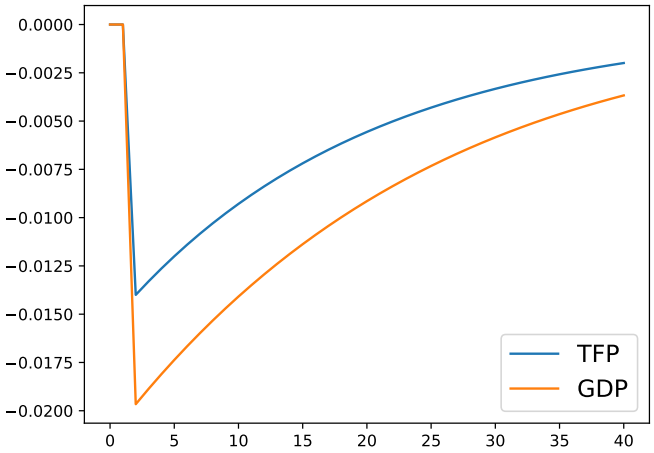
Financial Sector Moments

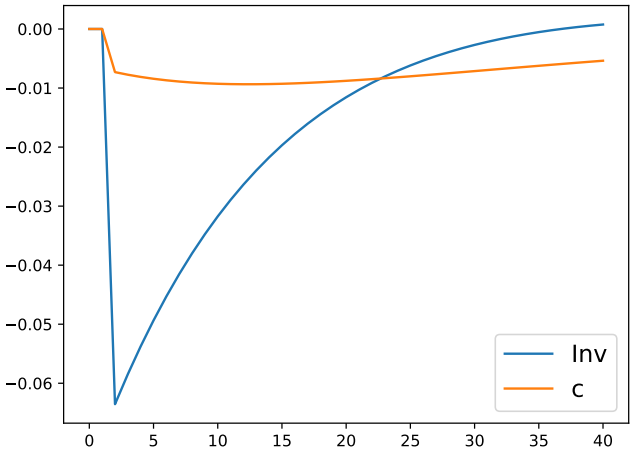
Targeted financial sector moments

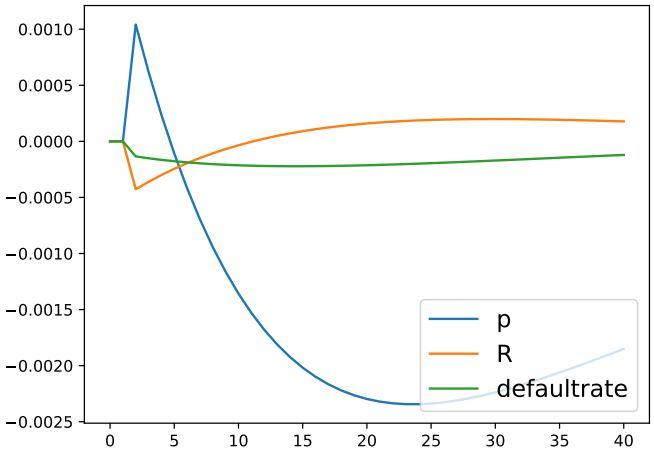
Variable	Model	Data
$mean(Leverage)$	9.81	10.37
$sd(Leverage)$	0.24	0.26
$mean(\pi^d)$*	0.50%	0.66%
$sd(\pi^d)$*	0.43%	0.44%

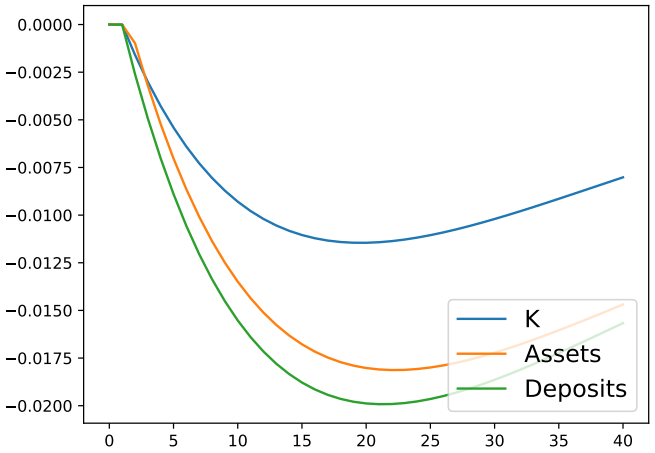
Data: 1990-2015 FDIC Call Reports
*annualized

Impulse Response to Productivity Shock



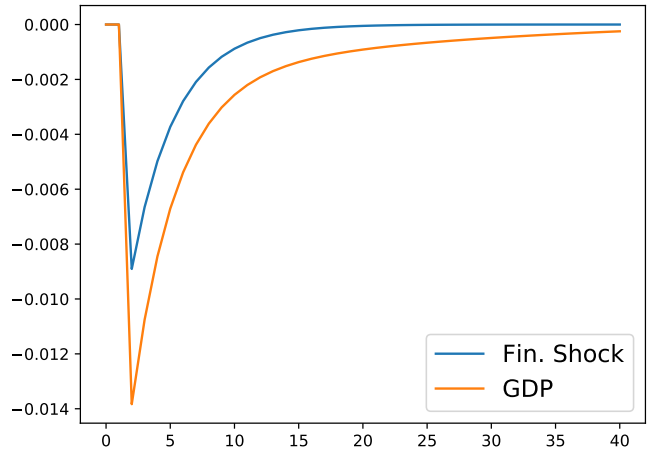


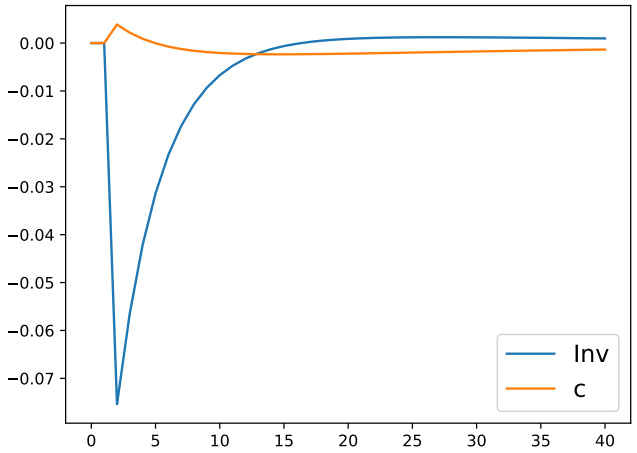


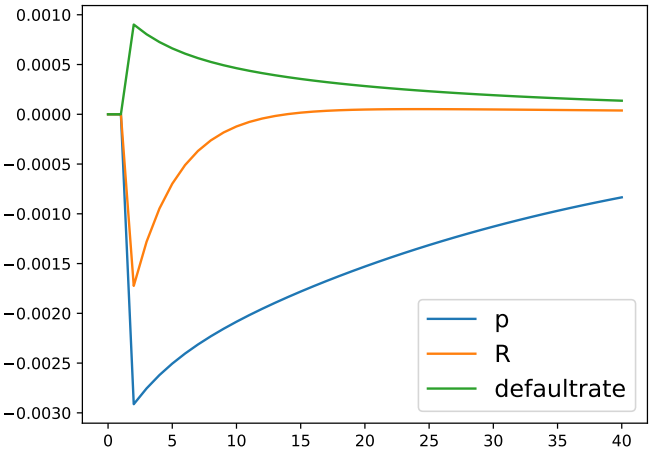


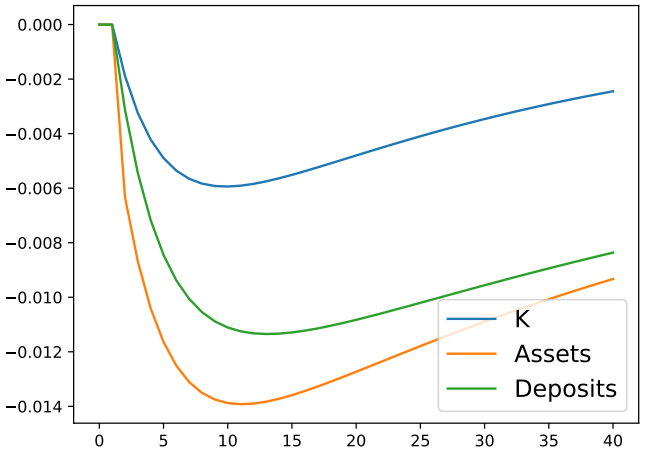
relative deviations from stochastic steady state,
except R and default rate: absolute deviations

Impulse Response to Financial Shock









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Business Cycle Moments

Business Cycle Moments

	St.Dev		Rel St.Dev		AC	
Variable	Data	Model	Data	Model	Data	Model
GDP	1.1	1.5	1	1	0.88	0.70
Consumption	0.9	0.6	0.8	0.4	0.90	0.76
Investment	5.8	5.9	5.3	3.9	0.88	0.66
Interest Rate	1.4	0.40	-	-	0.92	0.60

Data: 1990-2015 FRED and FDIC Call Reports

Business Cycle Correlations

Correlations with Output

Variable	Data	Model
Investment	0.92	0.96
Consumption	0.90	0.60
Interest Rate	0.68	0.70
Bank Assets	0.37	0.30
Bank Liabilities	0.31	0.33
Equity	0.33	0.27
Dividends	0.40	0.24

Data: 1990-2015 FRED and FDIC Call Reports

Policy experiment

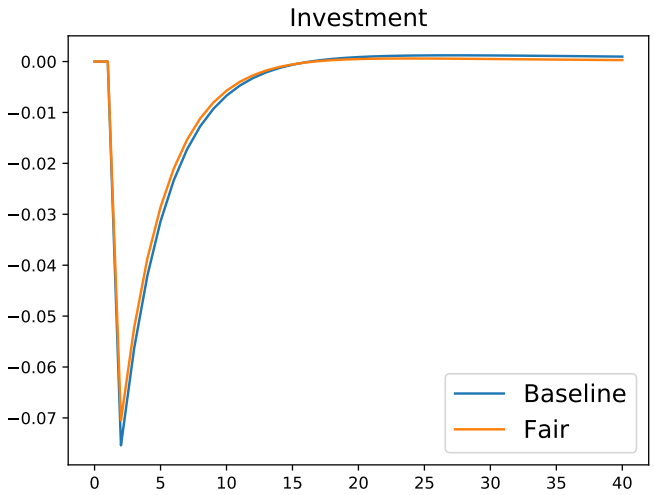
- We consider an alternative regulatory regime:
- Regulatory costs are set to equal expected default costs (fair regulation)
- Compare simulated economies
  - Mean and volatility of defaults fall
  - Mean GDP, Consumption and size of banking sector are higher
  - Volatilities are almost unaffected
  - Financial amplification is still present

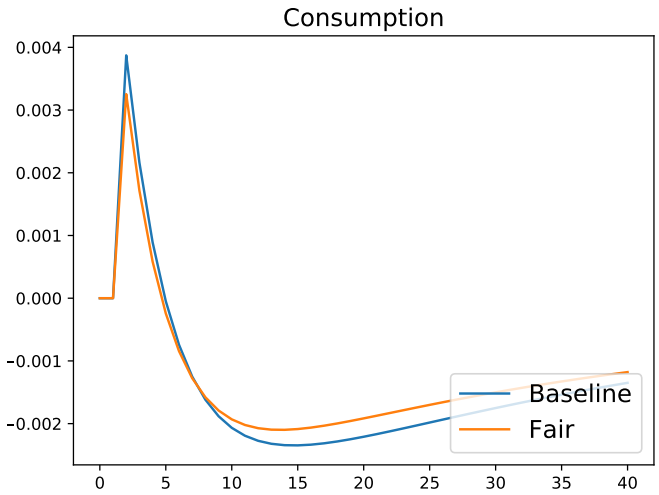
Baseline vs. Economy with fair regulation

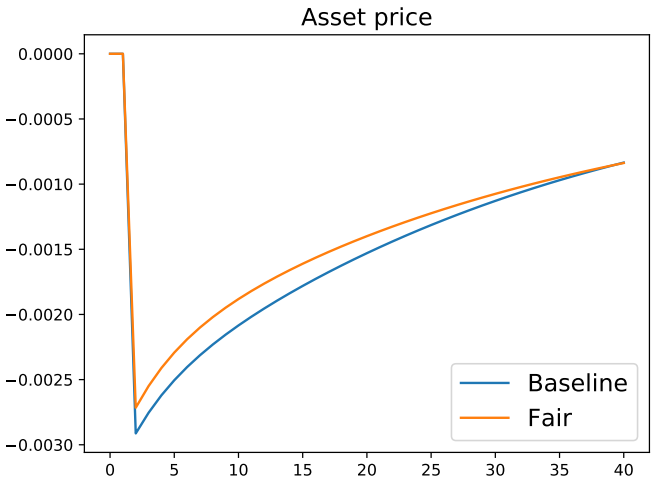
Means in the two economies

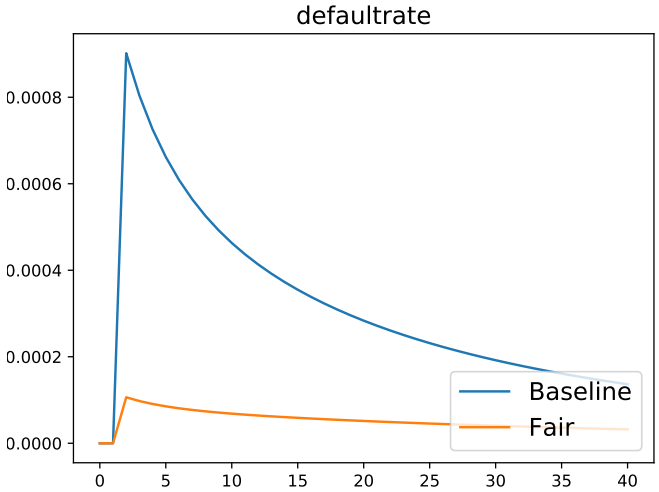
Variable	Baseline	Fair	Difference
Bank Leverage	9.19	7.80	1.4
Bank Assets	3.83	3.95	3.0%
Bank Liabilities	3.41	3.44	0.9%
Default rate	0.50%	0.08%	0.4 pp
Lending Rate	3.45%	3.34%	-10 bps
GDP	0.85	0.86	0.2%
Consumption	0.586	0.588	0.4%
K	7.66	7.71	0.7%

Financial Shocks in Baseline vs. Fair Regulation









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Conclusion

- We incorporate a long-term lending and bank default risk in a macroeconomic model
- Financial shocks are amplified and cause spikes in default rates
- Banks don't internalize their default risk due to regulatory subsidy
- Eliminating the subsidy reduces defaults and increases credit supply...
- ...but financial amplification remains present

Thank you for your attention!

Appendix: Solution Method

- Global non-parametric non-linear solution
- At each state x along the simulation path
  1. Compute deterministic path from x to steady state $\Longrightarrow$ equilibrium of deterministic model at x
  2. Correct for uncertainty: perturbation of deterministic path in the shock variance $\Longrightarrow$ uncertainty correction for equilibrium variables