Firm Dynamics and Aggregate Volatility with Endogenously Segmented Credit Markets

Antonio Falato
Columbia University

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Roadmap

1. Stylized Facts

2. Firm Growth and Investment with Endogenously Segmented Credit Markets

   (a) Setup

   (b) Calibration

3. Numerical Results

4. Conclusions

Facts

- Size patterns of debt mix (Cantillo & Wright (2000), Petersen & Rajan (1995)):
  - the mix of bank and market debt varies over firms' life-cycle;
  - small firms are bank dependent.

- Business cycle patterns of debt mix (Kashyap et al. (1993), Oliner and Rudebusch (1996), Gertler & Gilchrist (1994), Korajczyk & Levy (2002)):
  - aggregate debt mix changes with macroeconomic conditions;
  - size effects: large firms issue debt counter-cyclically, small firms do not change their debt mix.

- Real implications? (Christiano et al. (1999), Heuvel (2002))

Approach

- Develop a theory of endogenous credit market segmentation and study its implications for firm investment and growth.
- Heterogeneous firms make optimal forward looking debt structure and production/investment choices.
- Credit markets are segmented since bank debt and bonds are imperfect substitutes.
- Aggregate uncertainty.
- Quantitative analysis.

Previous literature

- Macro: Financial frictions, financial accelerator, and credit channels

  (Bernanke, Gertler, & Gilchrist (1998), Carlstrom & Fuerst (1997), Kiyotaki & Moore (1998), Cooley, Marimon & Quadrini (2001), Albuquerque & Hopenhayn (2001), Kashyap & Stein (1995), Oliner & Rudebusch (1996))

  $\hookleftarrow$ No banking.

- Micro of banking: Bank regulation; bank lending and the business cycle

  (Freixas & Rochet (1996), Bhattacharya & Thakor (1993), Heuvel (2001), Kim & Santomero (1988), Matutes & Vives (2000), Rajan (1994))

  $\hookleftarrow$ No general equilibrium framework.

- Equilibrium co-existence of bank lending and market financing

  (Holmstrom & Tirole (1997), Repullo & Suarez (1998), Bolton & Freixas (2000, 2001), Besanko & Kanatas (1993))

  $\hookleftarrow$ No aggregate uncertainty.

Setup

- Three types of risk-neutral agents:

  1. Worker-investors (bond holders), infinitely lived.

     Save through bond market.

  2. Banks, infinitely lived.

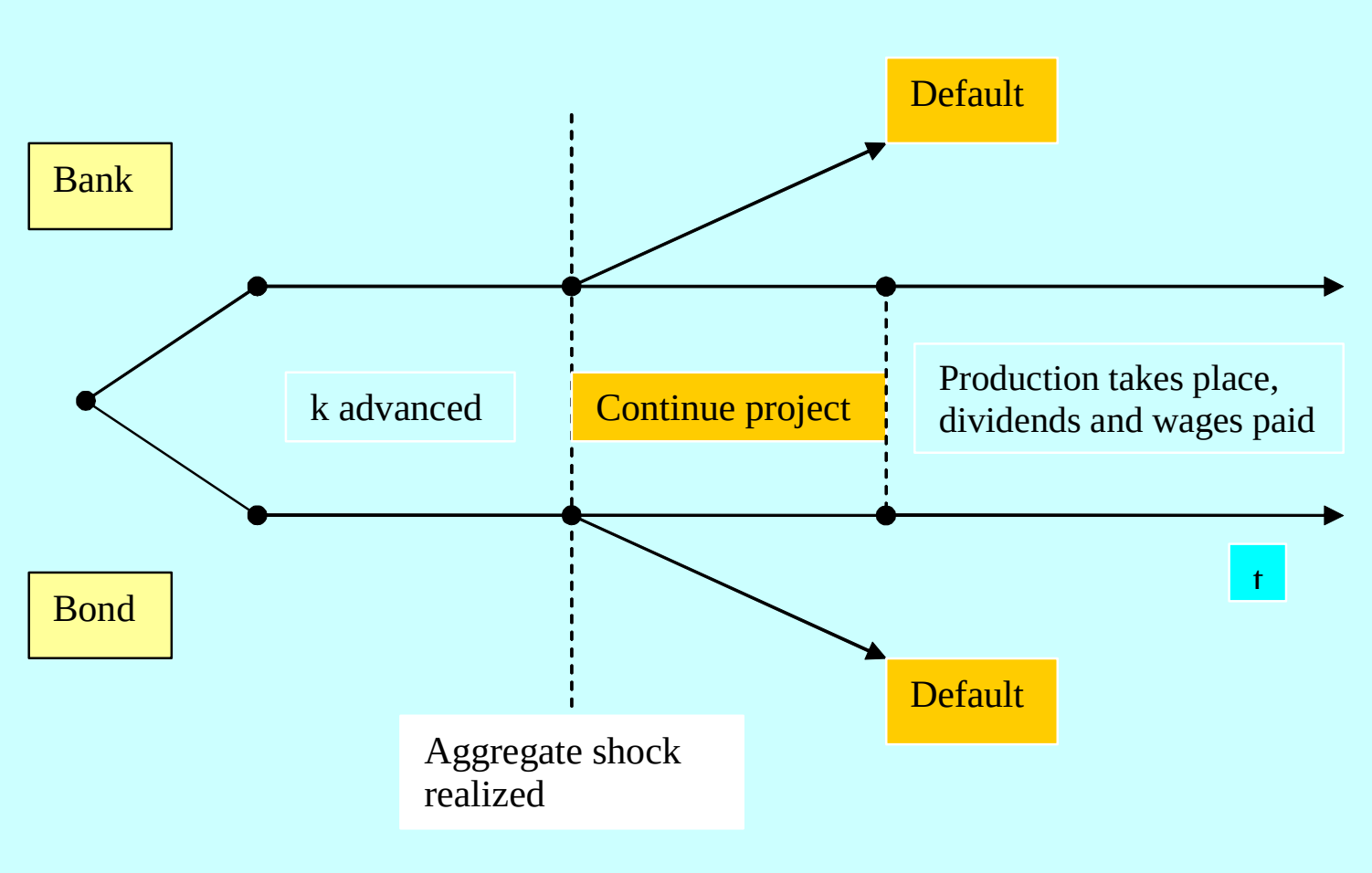
     Raise funds from bond market but cannot operate a technology.

  3. Owner-managers, with finite lives (α).

     Operate own technology and raise funds either from banks or directly from bond market: search problem.

- Aggregate uncertainty (technology or interest rate shocks).

Timing


Default
Bank
k advanced
Continue project
Production takes place,
dividends and wages paid
t
Bond
Default
Aggregate shock
realized

Worker-Investors

- Preferences over consumption c_t and labor l_t :

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(c_t - \varphi \left(l_t \right) \right), \qquad \beta \in (0,1)$$

- Budget constraint:

$$c_t + a_{t+1} = w_t l_t + \left(1 + r_t \right) a_t$$

- Choices given by

$$\begin{aligned} \varphi' \left(l_t \right) &= w_t \\ r &= \frac{1}{\beta} \end{aligned}$$

Technology

- Leontief, $y_t = zF(k_t, l_t) = zF(k_t)$, i.e. constant capital-labor ratio ξ.
  A project requires sunk set-up investment I_0.

- Uncertainty over project productivity $z \in \{z_h, z_l\}$, i.e. probability of finding good projects $p = [0, 1]$.
  Capital and consumption chosen before observing the shock.

- Period discounted expected net firm profits under bond and bank financing:

$$\pi_z(k_t, w_{t+1}) = \beta \left(\alpha k_t + (1-\alpha) \left[y_t - w_{t+1}\frac{k_t}{\xi} + (1-\delta) k_t \right] - k_t \right)$$

Financial Contracts

- Specify:
  - repayment schedule to financier, $\{\tau(\mathsf{s}_t)\}_{t=0}^{\infty}$;
  - stream of transfers to manager, $\{d(\mathsf{s}_t)\}_{t=0}^{\infty}$;
  - stream of capital advancements, $\{k(\mathsf{s}_t)\}_{t=0}^{\infty}$,

  where s is the aggregate state of the economy.

- Manager and bank have preferences over consumption d_t, τ_t :

$$V_0 = E_0 \sum_{t=0}^{\infty} \beta^t d_t,$$
$$B_0 = E_0 \sum_{t=0}^{\infty} \beta^t \tau_t, \qquad \beta \in (0,1)$$

Financial Contracts

- Limited investor protection (enforcement): manager can default and take

$$D_z(\mathsf{s}, k) = zF(k) + V_0(\mathsf{s}) - \kappa$$

$V_0(\mathsf{s})$: value of a "fresh start,"

κ : fixed default penalty.

- Promises kept as far as

$$E_{s+1} \sum_{j=s+1}^{\infty} \beta^{j-s-1} d_j \geq D_z(k_s, \mathsf{s}_{s+1}) \qquad \text{(CPC)}$$

Banks vs. Markets

- Higher protection than bond holders (Shleifer and Vishny (1997)):

$$\hat{D}_z(\mathsf{s}, k) = (1 - \Lambda)(zF(k, l) + V_0(\mathsf{s}) - \kappa) < D_z(\mathsf{s}, k)$$

$\Lambda \in [0, 1]$: proportional default penalty under bank financing.

- Subject to capital regulation (Basel Accord, 1988), can lend capital up to a given constant proportion of their wealth:

$$k_s \leq \frac{1}{1-\gamma} E_s \sum_{j=s}^{\infty} \beta^{j-s} \tau_j \qquad (CAR)$$

Solution Strategy

- Problem 1 - demand of capital: (CPC) makes the problem not recursive
  - Solution: manager's Lagrange multipliers, μ, as state variable (Marcet and Marimon (1999)).
- Problem 2 - supply of capital: (CAR) makes the problem not recursive
  - Solution: bank's Lagrange multipliers, γ_λ, as control variable and manager's relative Lagrange multipliers, $\mu_\lambda = \frac{\mu}{\gamma}$, as state variable.
- Control variables: $d, \tau, k, \gamma_\lambda, \mu'_\lambda$.
- Aggregate state variable: $\mathsf{s} = (p, M)$,

  M : distribution of firms over μ_λ.

Aggregation

- Debt structure decision rule (Lucas & Prescott (1974), Gomes et al. (2001)):

$$\Phi_z(\mathsf{s},\mu_\lambda) = \begin{cases} 1 & \text{if} \quad W_z^I(\mathsf{s},\mu_\lambda) \geq W_z^B(\mathsf{s},\mu_\lambda) \\ 0 & \text{otherwise} \end{cases}$$

  A manager z in state (s,μ_λ) will accumulate capital according to

$$\mu'_\lambda = \mu(\mathsf{s},\mu_\lambda) = \Phi_z(\mathsf{s},\mu_\lambda)\,\mu^I(\mathsf{s},\mu_\lambda) + (1-\Phi_z(\mathsf{s},\mu_\lambda))\,\mu^B(\mathsf{s},\mu_\lambda)$$

- Simple (linear) aggregation:

$$K = \int_{\mu_\lambda} k(\mathsf{s},\mu_\lambda)\,dM$$

  $\rightarrow$ GE: for given sequence of w solve the dynamic program of the individual firm, then use aggregate labor market clearing to solve for w.

Investment

Segmentation affects firm investment

$$E\left[\pi_k\left(s'\right)\right] = 0 \qquad \text{(PO)}$$

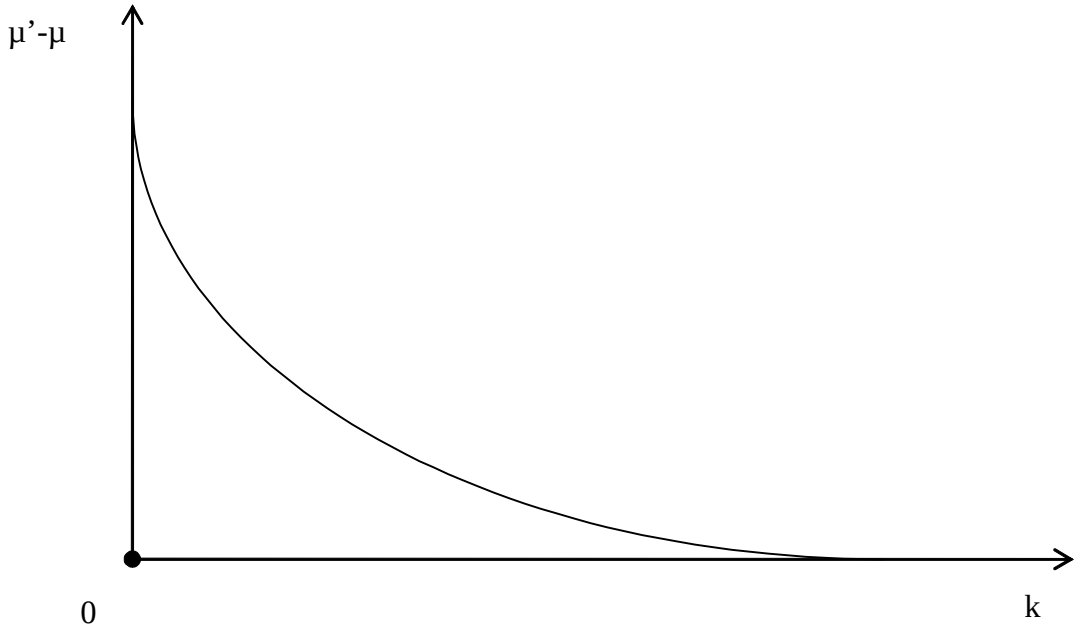
$$E\left[\pi_k\left(s'\right)\right] = \beta E\left[\underbrace{\mu_\lambda\left(s'\right) - \mu_\lambda\left(D_k\left(s'\right)\right)}_{(CPC)}\right] \qquad \text{(Bond)}$$

$$E\left[\pi_k\left(s'\right)\right] = \beta E\left[\underbrace{\mu_\lambda\left(s'\right) - \mu_\lambda\left(\hat{D}_k\left(s'\right)\right)}_{(CPC)}\right] + \beta E\left[\underbrace{\gamma_\lambda\left(s'\right) - 1\left(1-\gamma\right)}_{(CAR)}\right] \qquad \text{(Bank)}$$

Endogenous Segmentation

Small firms are bank dependent

- Decreasing "marginal utility" of banks:
  $\mu_\lambda(s') - \mu_\lambda(\hat{D}_k(s')) - D_k(s')$:



Quantitative Analysis

Parameter	Value
Intertemporal discount rate	$\beta = .96$
Disutility from working	$\nu = 1.1$
	$\pi = .001$
Death probability	$\alpha = .05$
Production function	$\theta = .975$
Capital-labor ratio	$\xi = .003$
Depreciation rate	$\delta = .037$
Set-up cost	$I_0 = 0.2$
Cost of repudiation	$\kappa = .026$
Incentive benefit of bank	$\Lambda = 0.1$
CAR	$1 - \gamma = 0.08$

Calibration

- Period is one year: $\beta = 0.96 \Rightarrow r = 0.04$.
  Disutility from working: $\varphi(l_t) = \pi l^{\nu}$.
  $\nu = 1.1$, standard in BC literature.
  π (and ξ) set to have one third of available time spent working.

- Production function: $F = zk^{\theta}$.
  $\theta = 0.975$ (Atkeson, Khan, & Ohanian (1996)).
  $E(z)$, δ set to have capital-output ratio 2.8 and labor income share 0.6.
  $\alpha = 0.05$ (Evans (1987)).

- κ, I_0 set to have 40% of the firms constrained in the steady state.

- Λ set to match the ratio of bank supplied capital to output in the US, 0.644 (Demirguc-Kunt and Levine (2001)).

Aggregate Debt Mix

Effect of regulatory changes

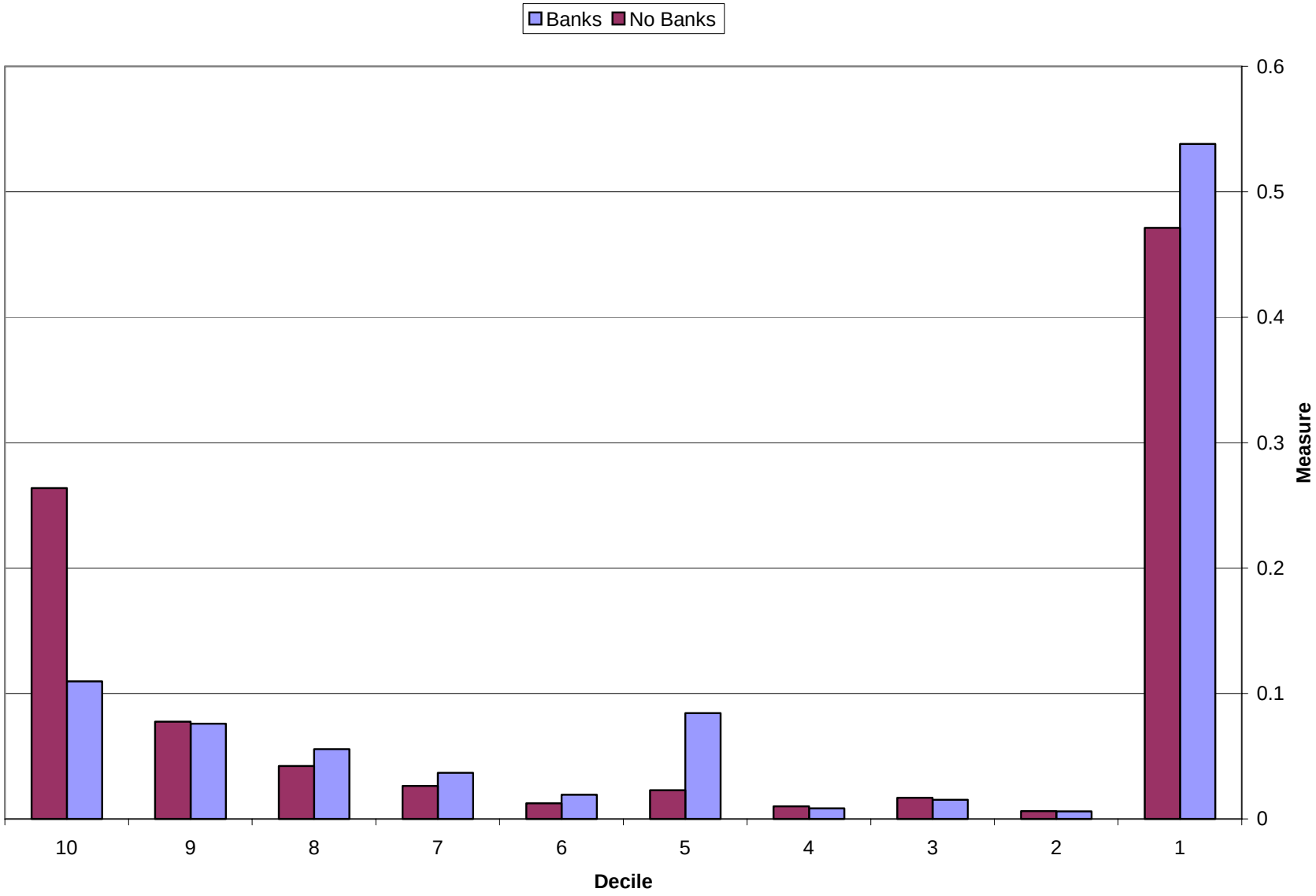
CAR	Share of bank-financed capital	Share of bank-financed firms
2%	29.9	40
4%	20.8	35.7
8%	14.8	27.7

Aggregate Debt Mix

Legal determinants

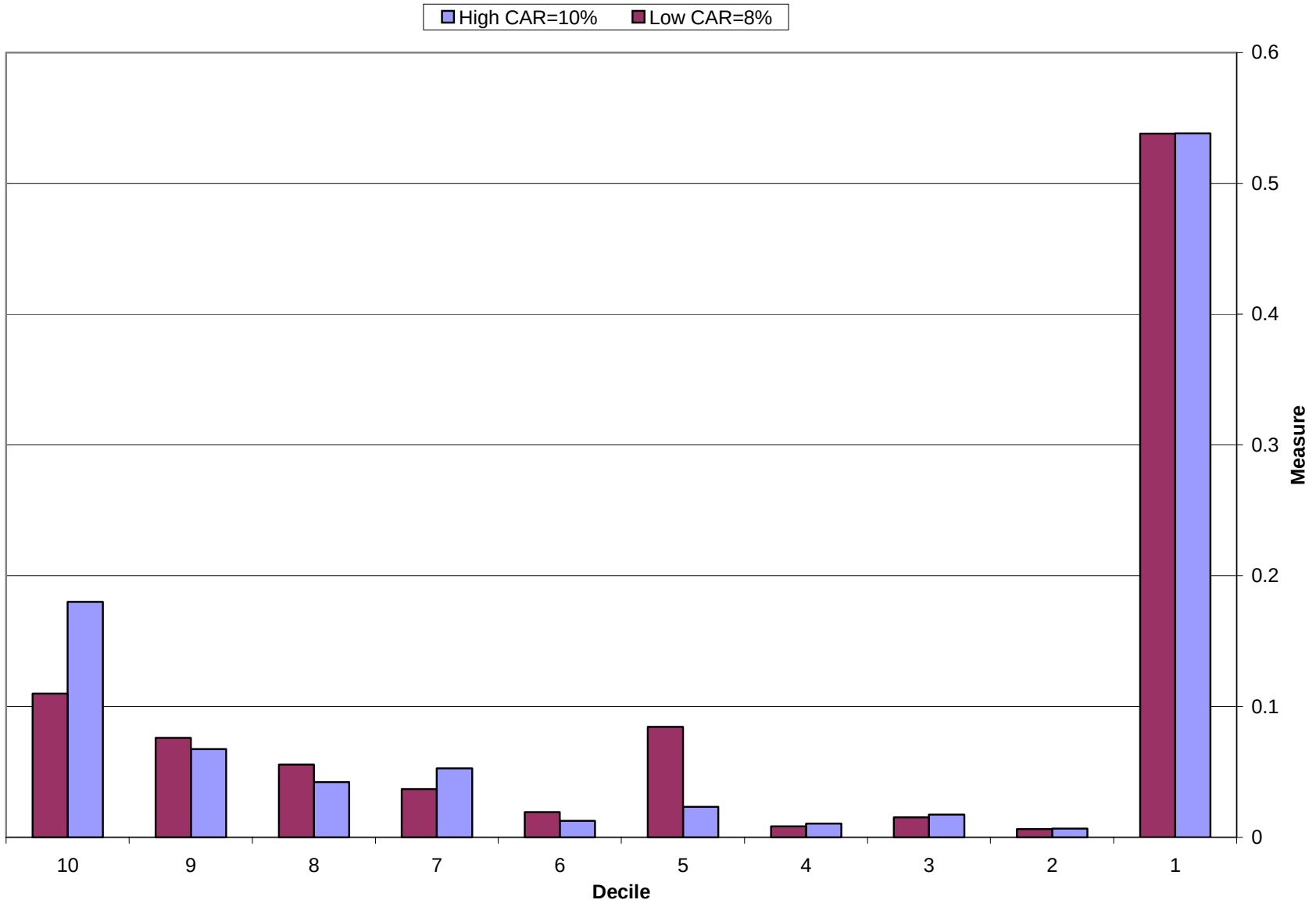
Λ	Share of bank-financed capital	Share of bank-financed firms
0.05	4.7	15.54
0.1	14.8	27.7
0.2	25.6	35.1

Firm Size Distribution



More skewed in market-based financial systems.

Firm Size Distribution



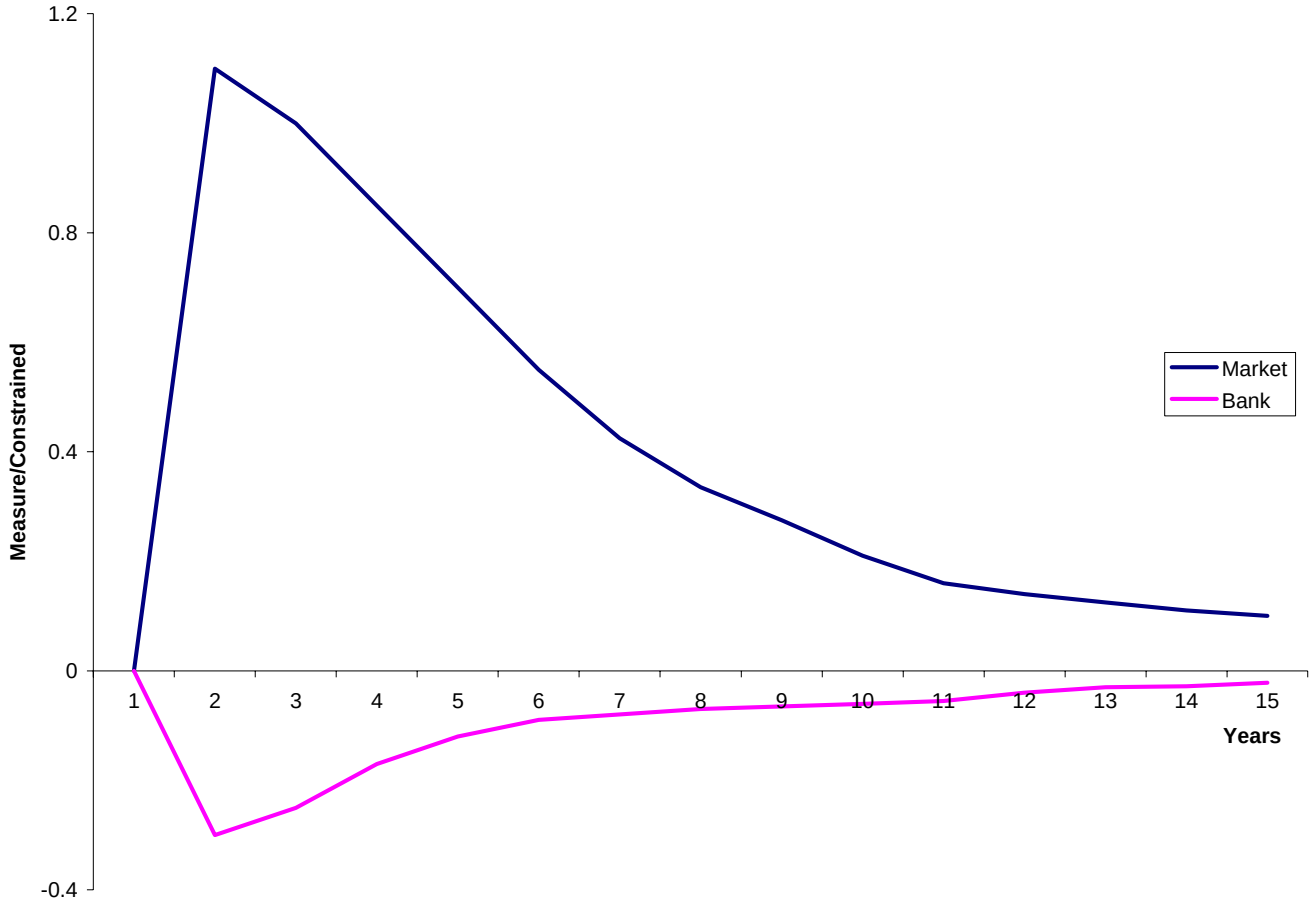
More skewed with higher CAR.

Welfare Costs of Segmentation

Large!

CAR	Welfare Loss	Average Firm Size
0%	2.43	0.68
4%	3.03	0.60
8%	4.45	0.50
10%	5.53	0.40
12%	6.75	0.32

Monetary Tightening and Debt Mix



Impulse response of bond issues and bank loans

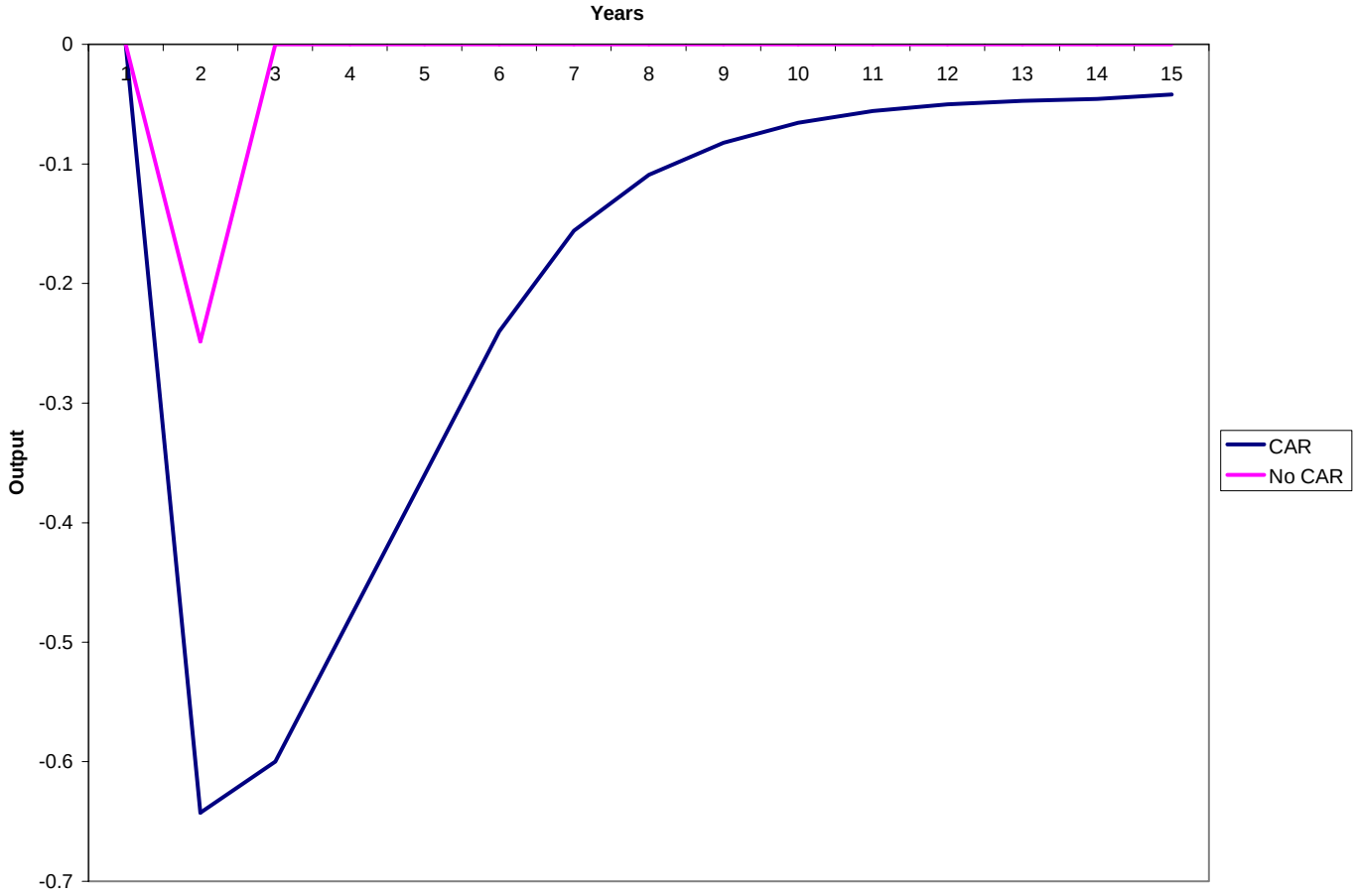
Debt Structure and MP

Debt issues are counter-cyclical for large firms, a-cyclical for small firms

	Expansions	Contractions
Investment growth$_L$	4.66	-1.11
Investment growth$_S$	9.10	-4.41
$\frac{k_L}{k_L+k_S}$	59.34	61.05
Change in debt$_L$	-0.12	0.22
Change in debt$_S$	0.22	-0.11

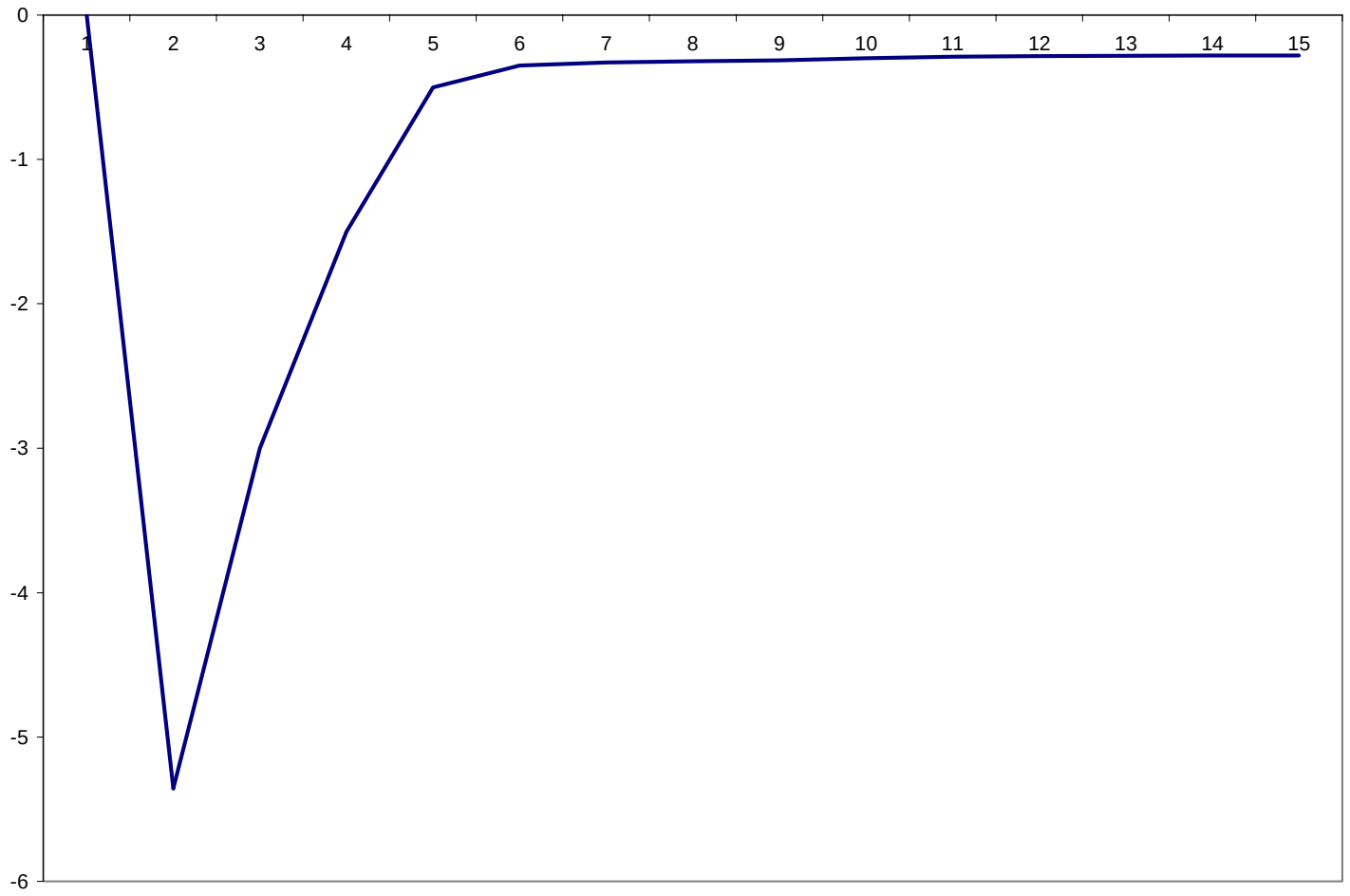
Averages from simulation

Monetary Tightening and Output



Impulse Response of GDP

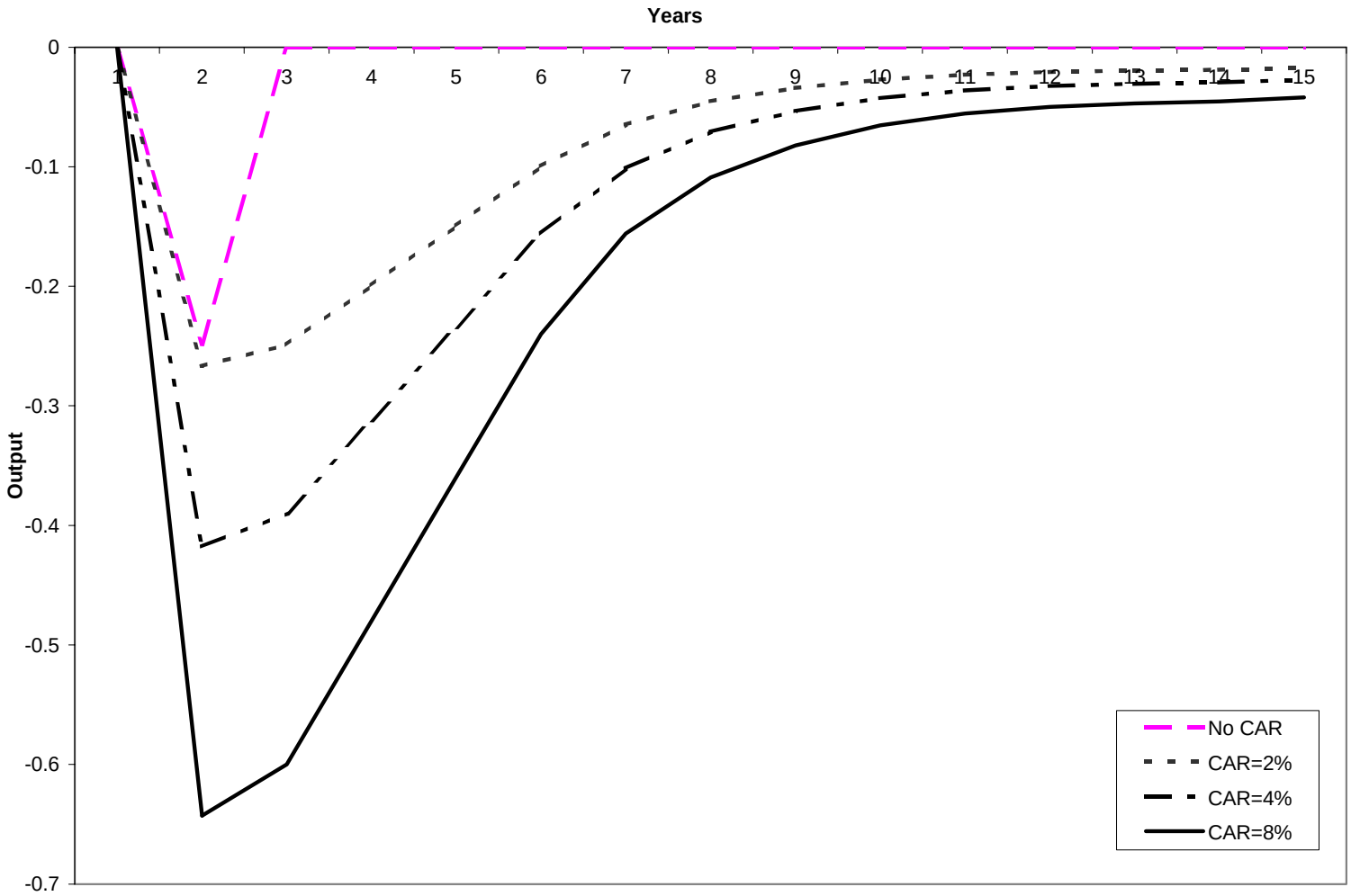
Monetary Tightening and Investment



Impulse Response of Investment

Monetary Tightening and CAR

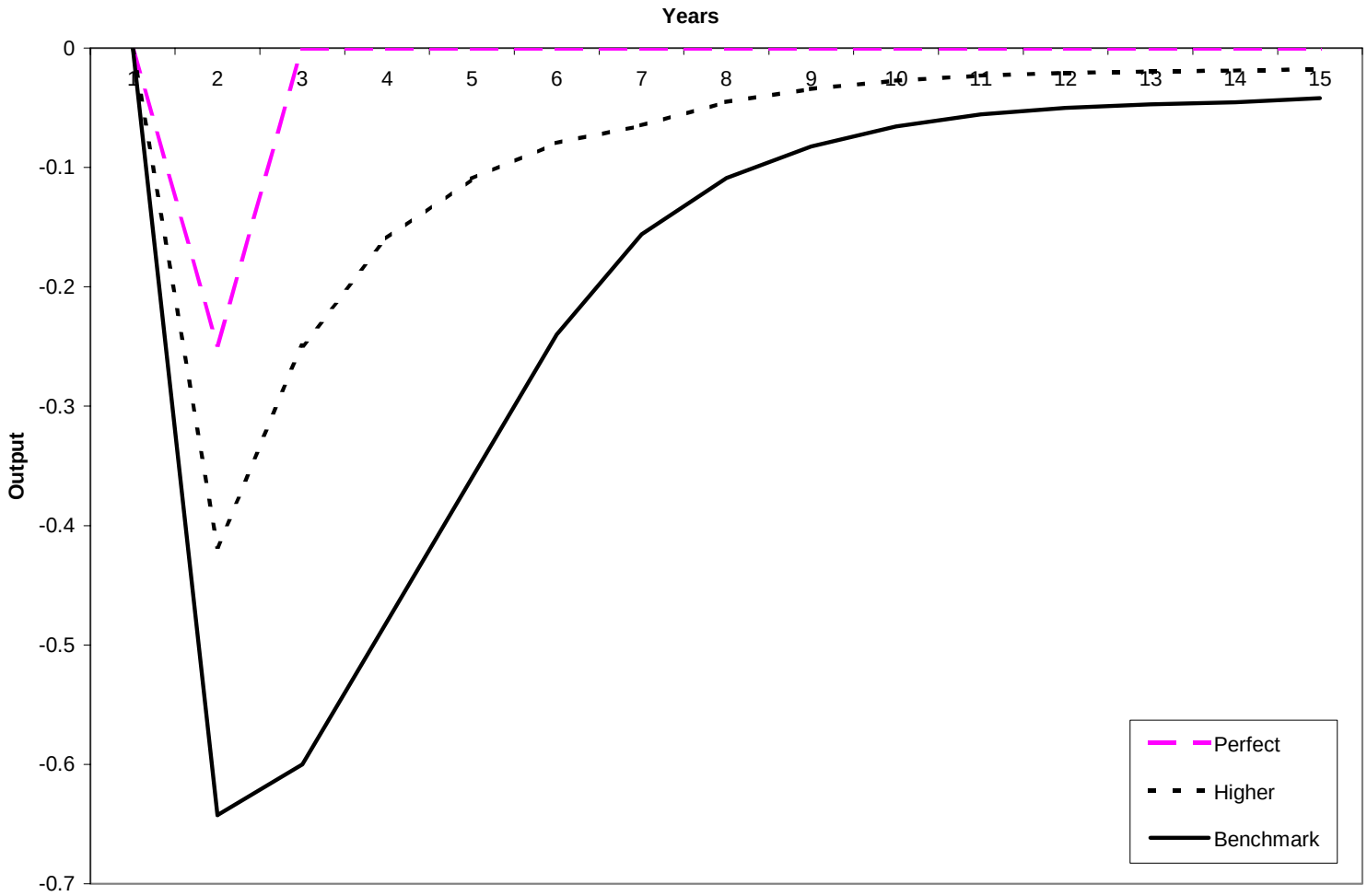
Effects stronger with higher CAR



Impulse Response of GDP

MT and Enforcement

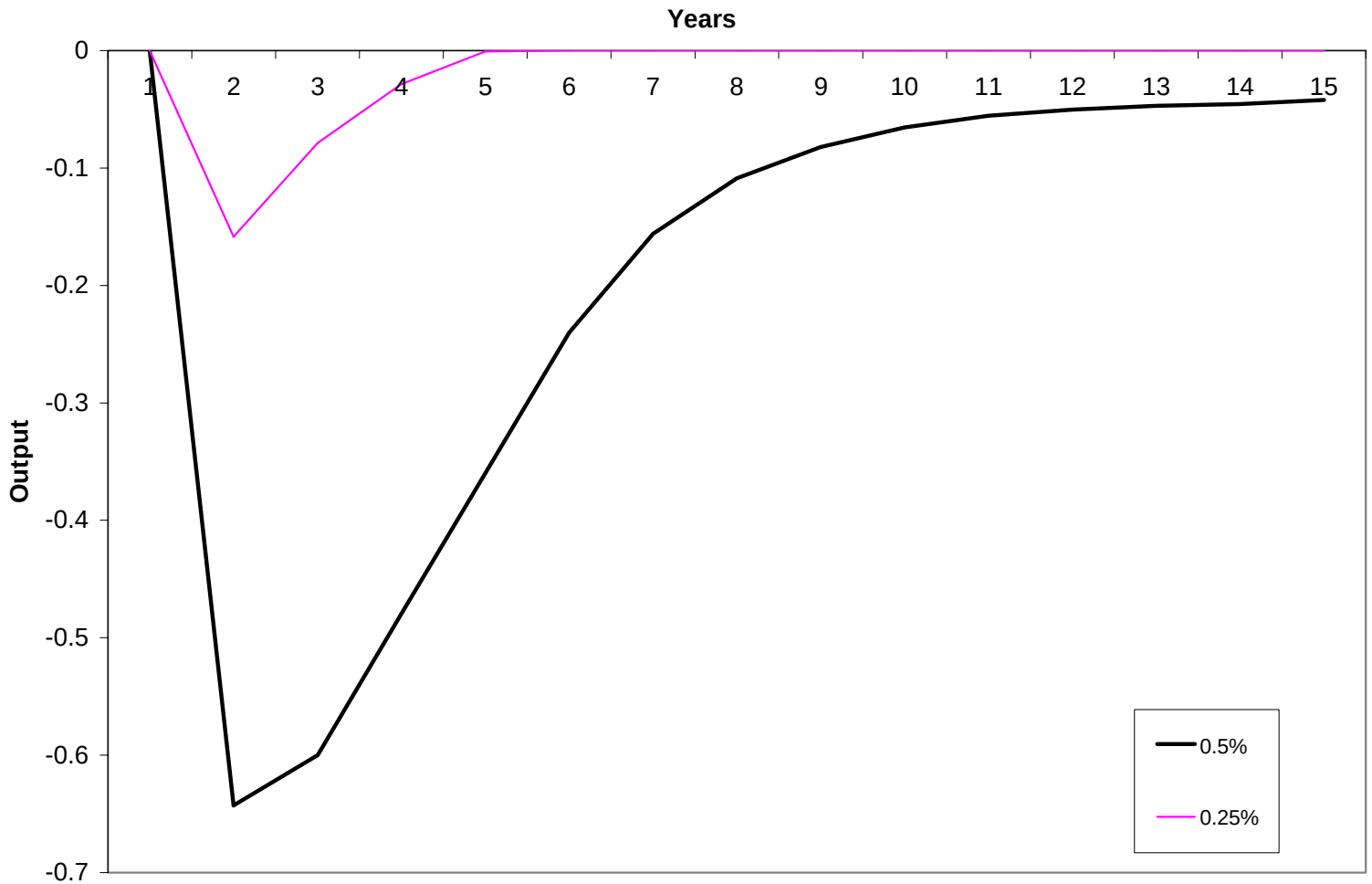
Effects stronger with worse enforcement



Impulse Response of GDP

Size of Monetary Tightening

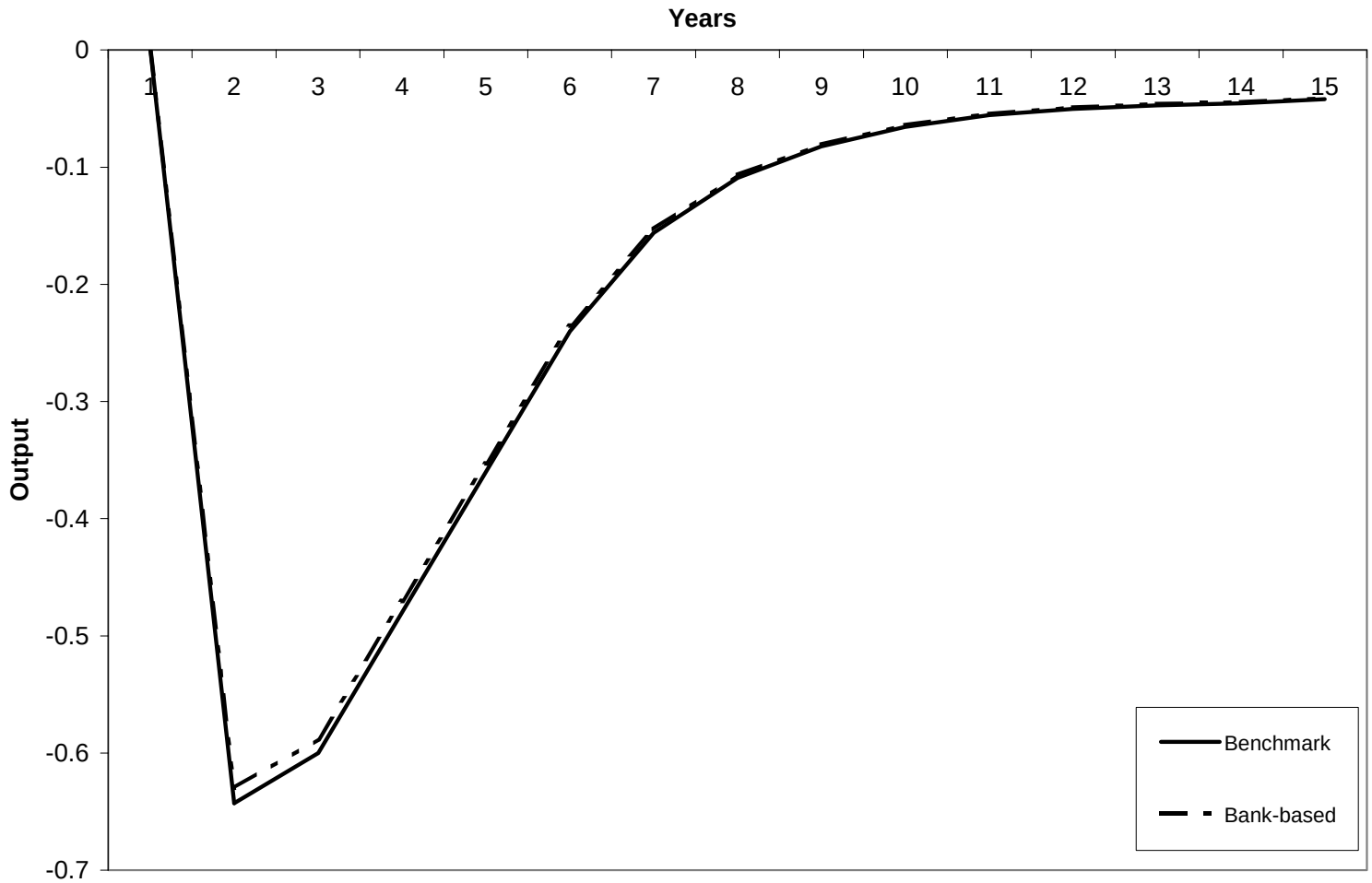
Matters!



Impulse Response of GDP

MT and Segmentation

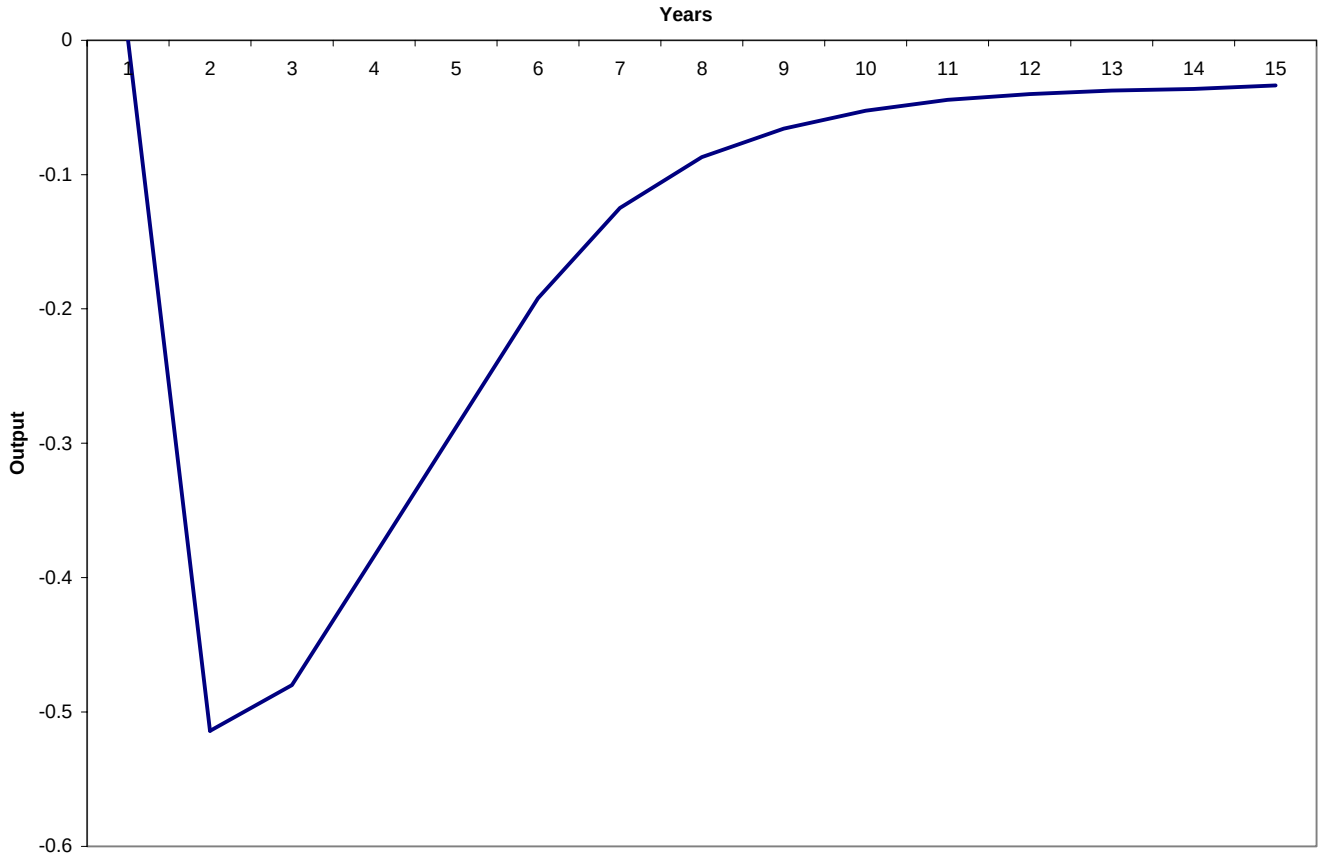
Ambiguous!



Impulse Response of GDP

Cyclicality of CAR

Counter-cyclical bank capital regulation is contractionary



Impulse Response of GDP to CAR Shock

Conclusions

- Microfoundations of credit market segmentation:
  - good fit of documented patterns.
- Quantitative evaluation of implications for firm investment and growth: frictions that limit access to capital markets
  - have sizable welfare costs;
  - affect firm size distribution and aggregate volatility.
- Future work:
  - lotteries and full fledged debt (capital?) structure choice;
  - opaque banks (Japan!);
  - risk aversion and asset pricing implications.