THE ECONOMICS OF BANK CAPITAL

Edoardo Gaffeo

Department of Economics and Management
University of Trento

OUTLINE

- What we are talking about, and why
- Banks are «special», and their capital is «special» as well
  - Skin in the game
  - Braking distance to avoid a crash
  - Capital requirements as VaR
- Perverse regulation?
  - The drivers of endogenous risk
  - The risk-taking channel of monetary policy
- What have we learned?

CAPITAL WHAT?

Assets	**Liabilities**
Total Assets (A)	Deposits (D)
Low-risk assets (A_1)	Non-core liabilities (B)
High-risk assets (A_2)	
	Capital (C)
	Tier 1 – Equity (E)
	Tier 2 – Hybrid instruments (H)

CAPITAL WHAT?

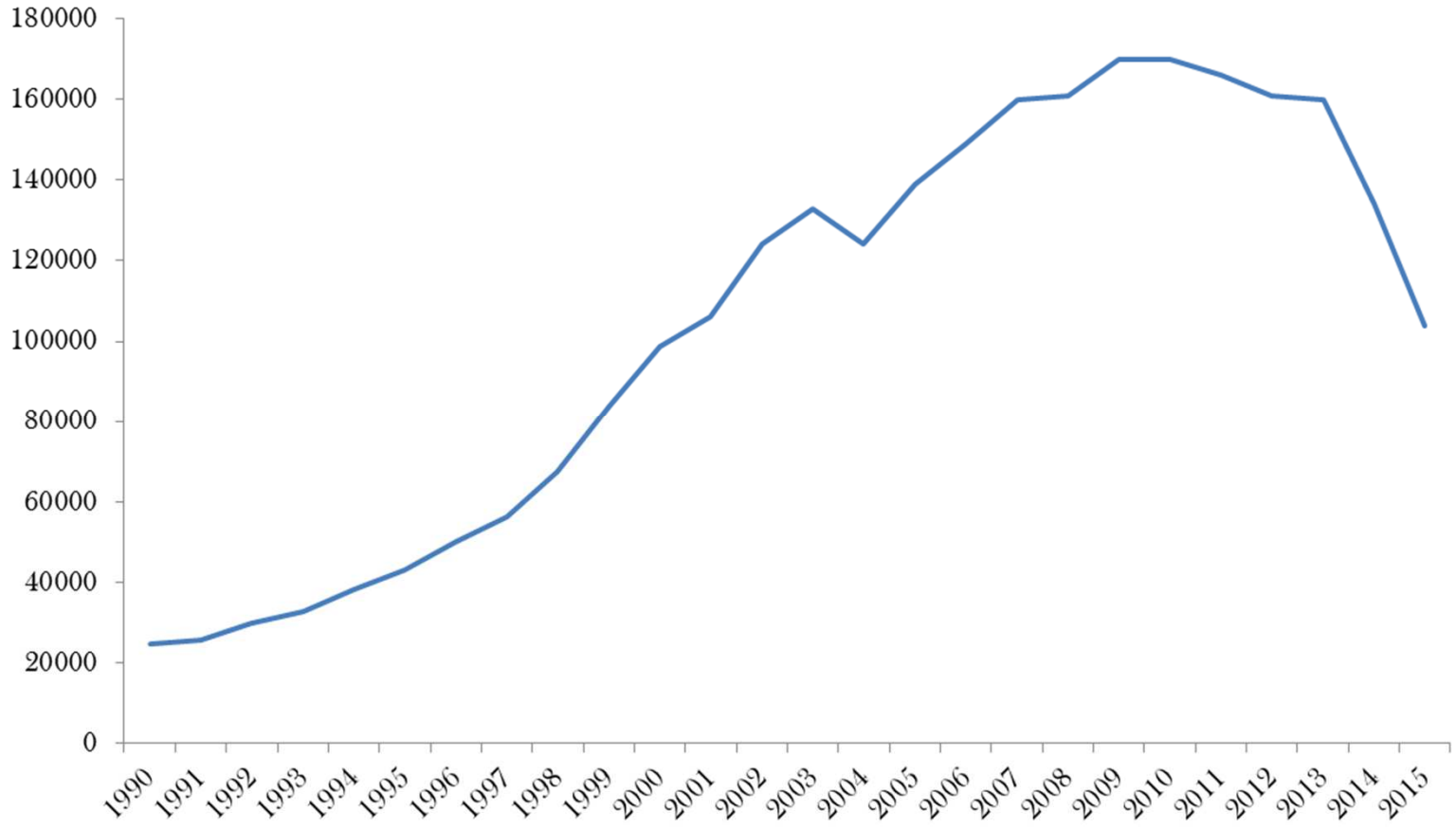
$$\text{Capital adequacy ratio} = \frac{C}{w_1 A_1 + w_2 A_2} \geq \Phi$$

Φ = minimum CAR specified in RW banking regulation

$$\text{Leverage ratio} = \frac{E}{A} \geq \Delta$$

Δ = minimum LR specified in banking regulation (from 2018)

A HOT RESEARCH TOPIC …



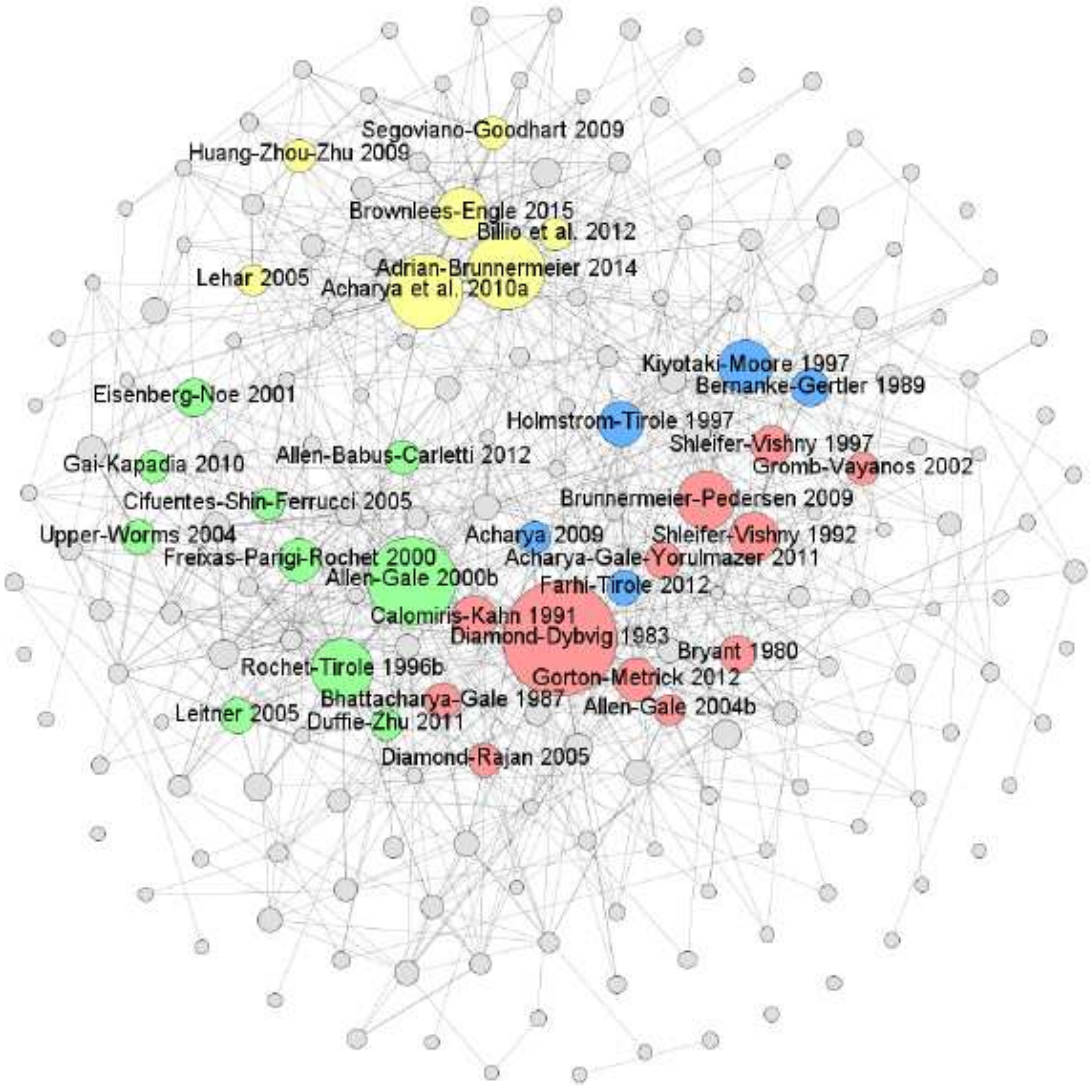
Google Scholar items found per year searching for «bank capital»

… THAT SPURS A LOT OF RESEARCH IN SEVERAL AREAS

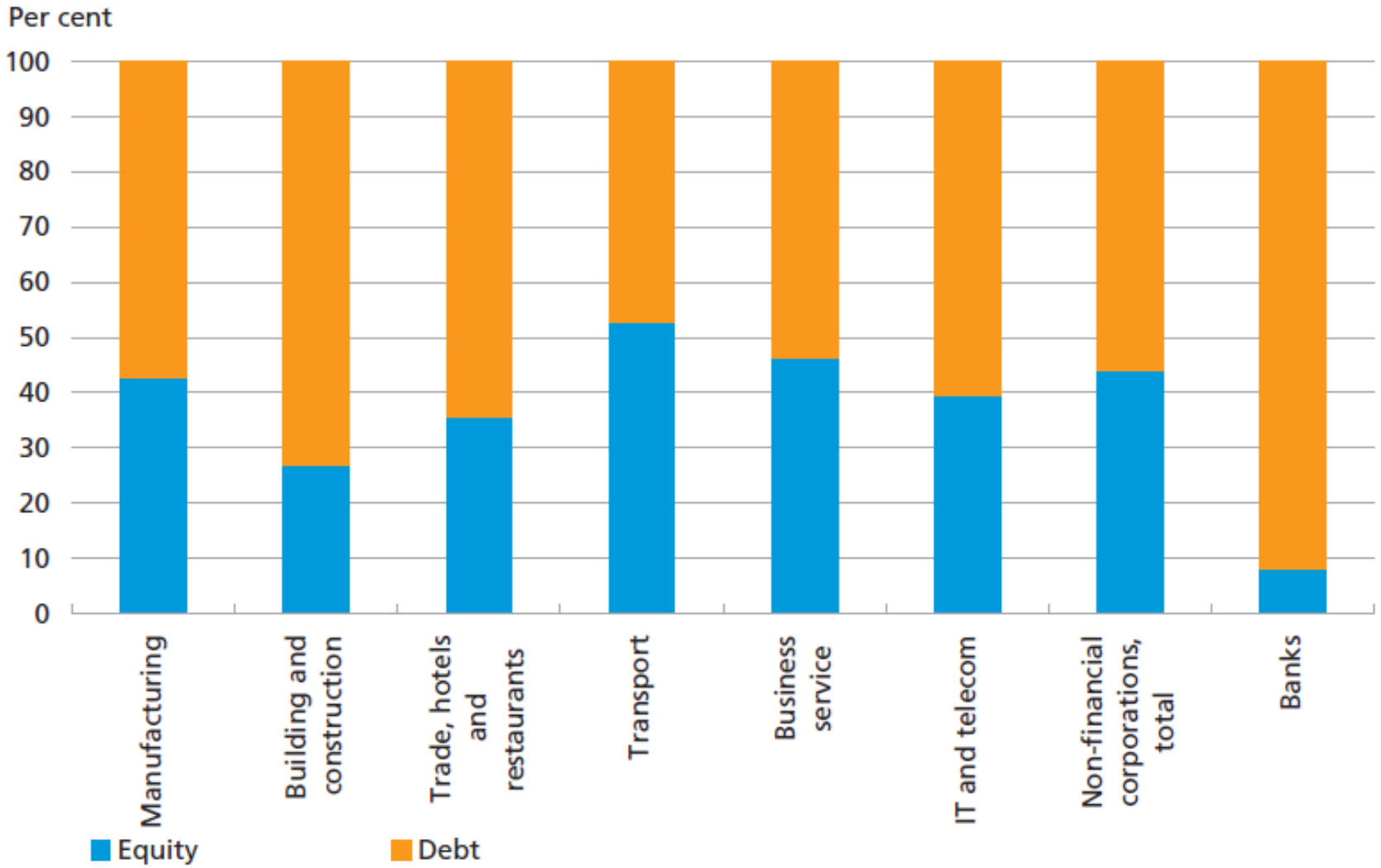
Benoit *et al.* (2017)

Survey of 220 papers on:

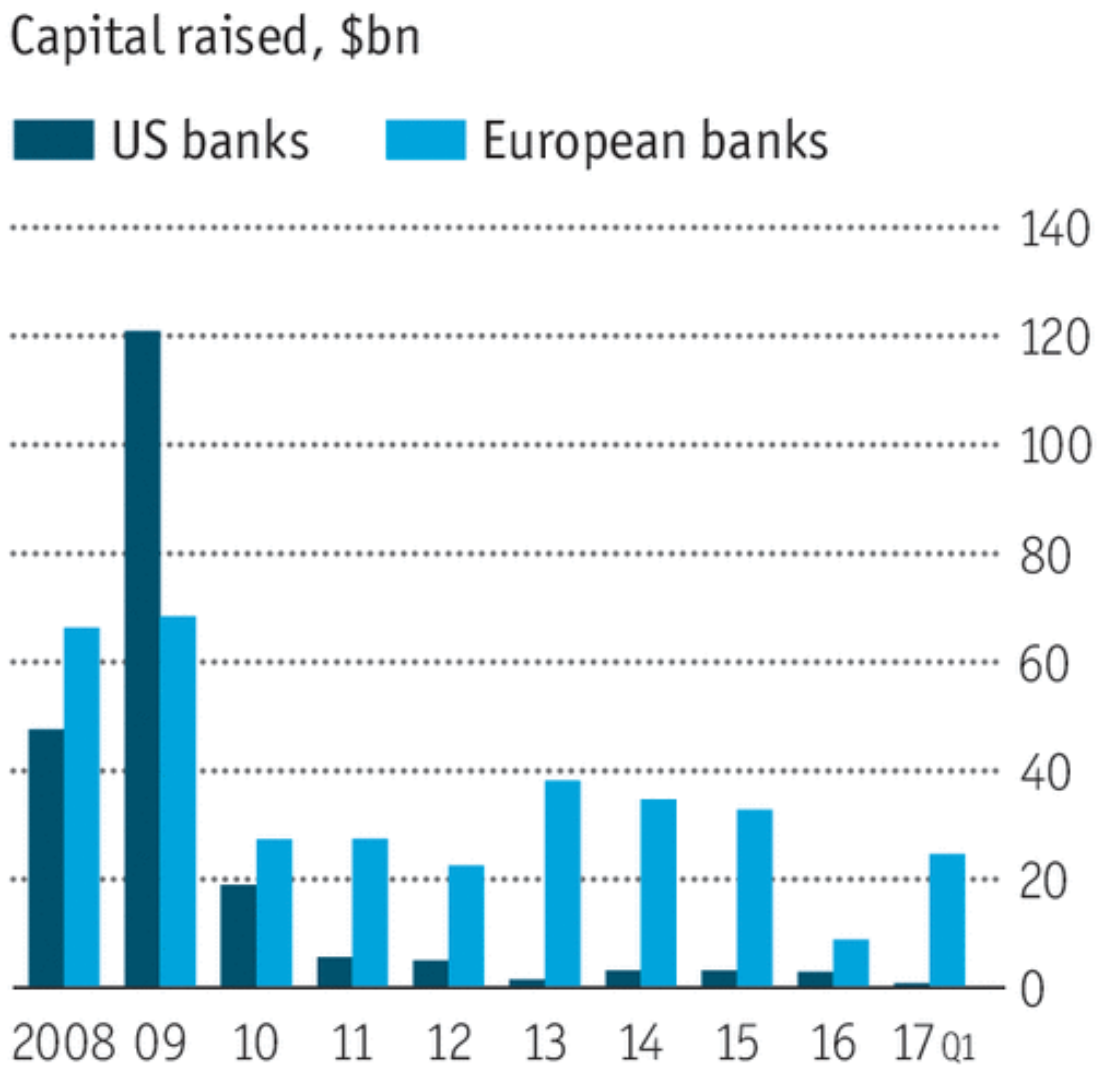
1. Systemic risk-taking (blue)
2. Amplification mechanisms (red)
3. Contagion (green)
4. Systemic risk measures (yellow)



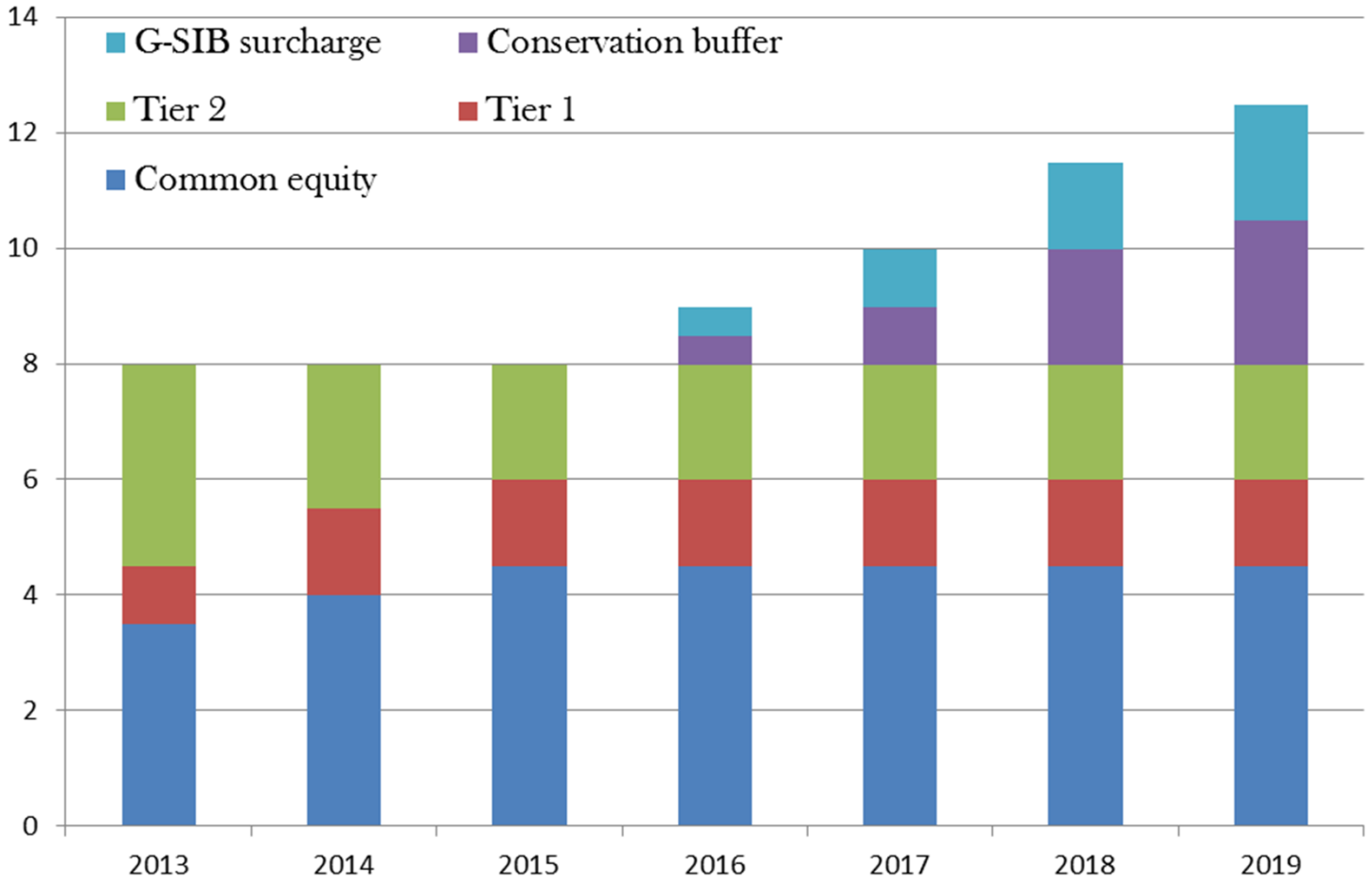
BANKS ARE «SPECIAL»



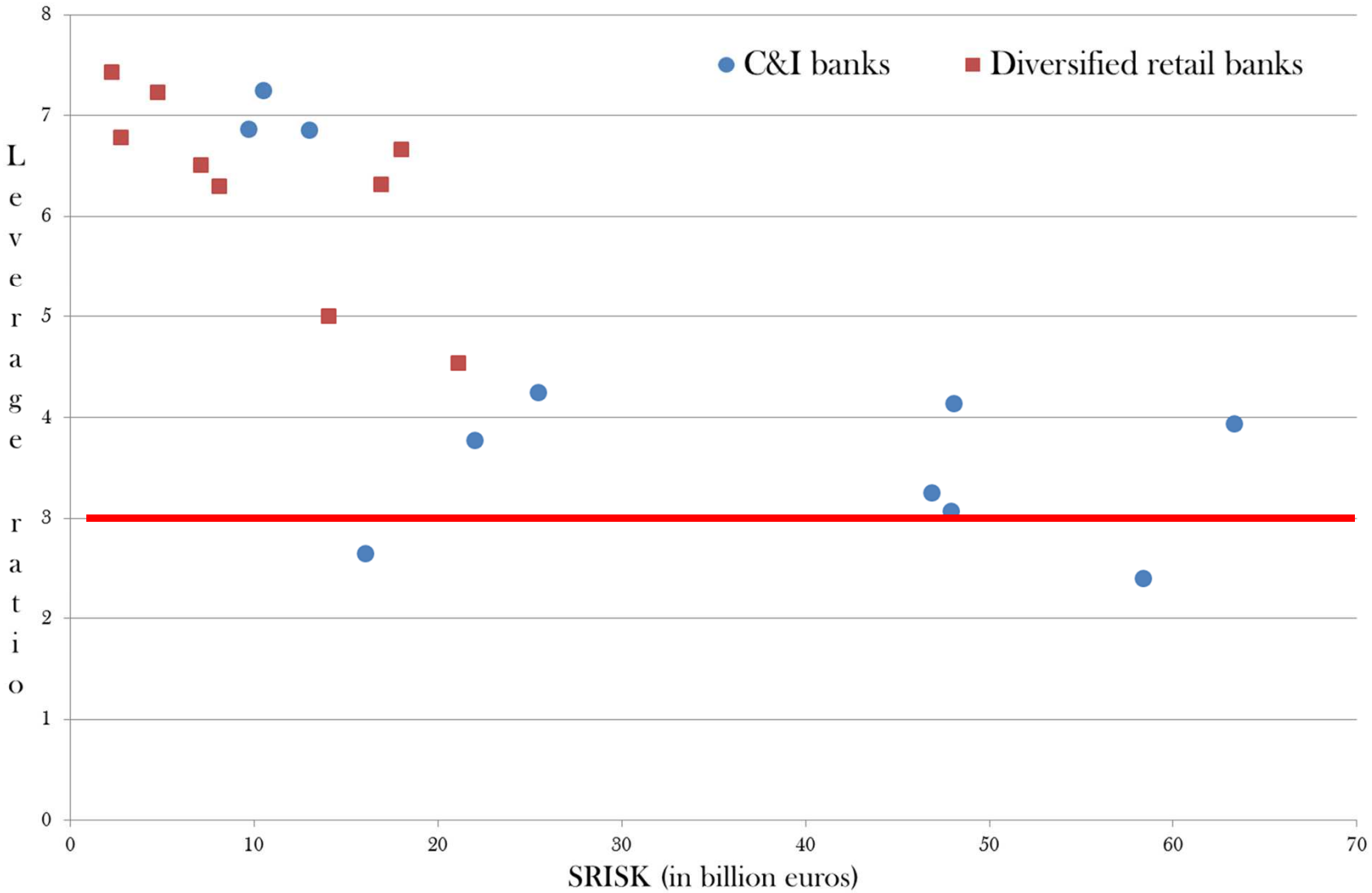
RECAPITALIZATION: A TRANSATLANTIC VIEW



CAPITAL REQUIREMENTS



HOW DOES BANK CAPITAL RELATE TO RISK?



A TOUGH THEORETICAL ISSUE

- **Key point:** banks' optimal capital structure is strictly related to the theory of financial intermediation: Why do banks exists?
- In the presence of transaction costs (e.g., asymmetric information), FIs increase social welfare by providing QAT services:
  - Maturity transformation
  - Liquidity transformation
  - Volume transformation
  - Risk pooling
- In classical theories of FI, none role for capital!

BANKS AS DELEGATED MONITORS

- Diamond (1984): investment projects of a larger scale than individual savings, and project cash flows unobservable to investors.
- Information can be retrieved by costly ex-post auditing (costly state verification), or a pre-commitment to pay a fixed amount (D) with a non-pecuniary penalty (P) in case of default.
- A bank acts a filter: it audits projects on behalf of investors, and pre-commits to repay them a fixed amount D with a penalty P for default. The latter is equivalent to a demand deposit contract.
- Due to the LLN, intermediation is Pareto improving if the bank is large enough, so that its probability of default goes to zero and deposits are riskless.

BANKS AS LIQUIDITY INSURERS

- Diamond and Dybvig (1983): investment projects can be of two types: i) an asset that matures in the long-run, but interim liquidation comes with a cost (illiquidity); ii) a short-run asset.
- Risk-averse investors can be of two types: i) "early" or ii) "late". Type is i.i.d. and private information (shock), while in the aggregate fractions are public information (LLN).
- As long as shocks are not perfectly correlated across individuals, banks may efficiently invest savings on long-term projects, providing depositors with insurance against idiosyncratic consumption shocks.

BANKS AS LIQUIDITY INSURERS

- The game has a second (bad) Nash equilibrium.
- If depositors believe that only early consumers withdraw in $t = 1$, the bank can satisfy both early and late depositors by exploiting the law of large numbers.
- If depositors hold different beliefs, however, the bank can be subject to a run and forced to bankruptcy.
- Remedies: find an institutional arrangement preserving the good equilibrium but suppressing the bad one.
- Example: deposit insurance.

A ROLE FOR CAPITAL

- Why does bank capital play none role in these theories?
  - Delegated monitoring: perfect diversification.
  - Liquidity provision: deposit insurance affects incentives to take risk, but the issue is neglected.
- Different rationales for bank capital.

BANK CAPITAL IN THE MONITORING-THE-MONITOR PROBLEM

- Holstrom and Tirole (1997): moral hazard generates limited pledgeability and borrowing constraints.
- Firms are endowed with net worth N and want to invest I > N. They can choose between direct and bank financing:
  - Direct financing does not monitor: cheap but low pledgeability.
  - Bank financing monitors: increases pledgeability at some cost.
- Each firm can privately choose one of three projects:

	Good	Bad 1	Bad 2	
Private benefits	0	b	B	with $B > b > 0$
Prob. success	p_H	p_L	p_L	with $p_H > p_L$
	socially efficient			

BANK CAPITAL IN THE MONITORING-THE-MONITOR PROBLEM

- Bank monitoring can prevent choice of Bad 1, but not of Bad 2 (social inefficiency).
- Firm capital acts as a signal: skin in the game.
- Firms need to have at least N_{bank} to make it IC to choose Good instead of Bad 1, assuming banks monitor.
- Firms need to have at least $N_{direct} > N_{bank}$ to make it IC to choose Good when approaching direct financing.

- But bank monitoring is only privately observable. Banks must hold enough capital to make it IC for them to monitor.
- Banks exist only if they have equity capital. In this case, they allow a larger amount of investment (Pareto improvement).

BANK CAPITAL IN THE MONITORING-THE-MONITOR PROBLEM

- Several implications:
  - Capital in firms and capital in banks play complementary roles.
  - High enough capital in banks expand firms' debt capacity, as bank loans makes direct financing cheaper (banks and markets are complements).
  - A negative shock to bank capital causes a credit crunch and an increase of the cost of external finance for firms. Poorly capitalized firms are affected the most.

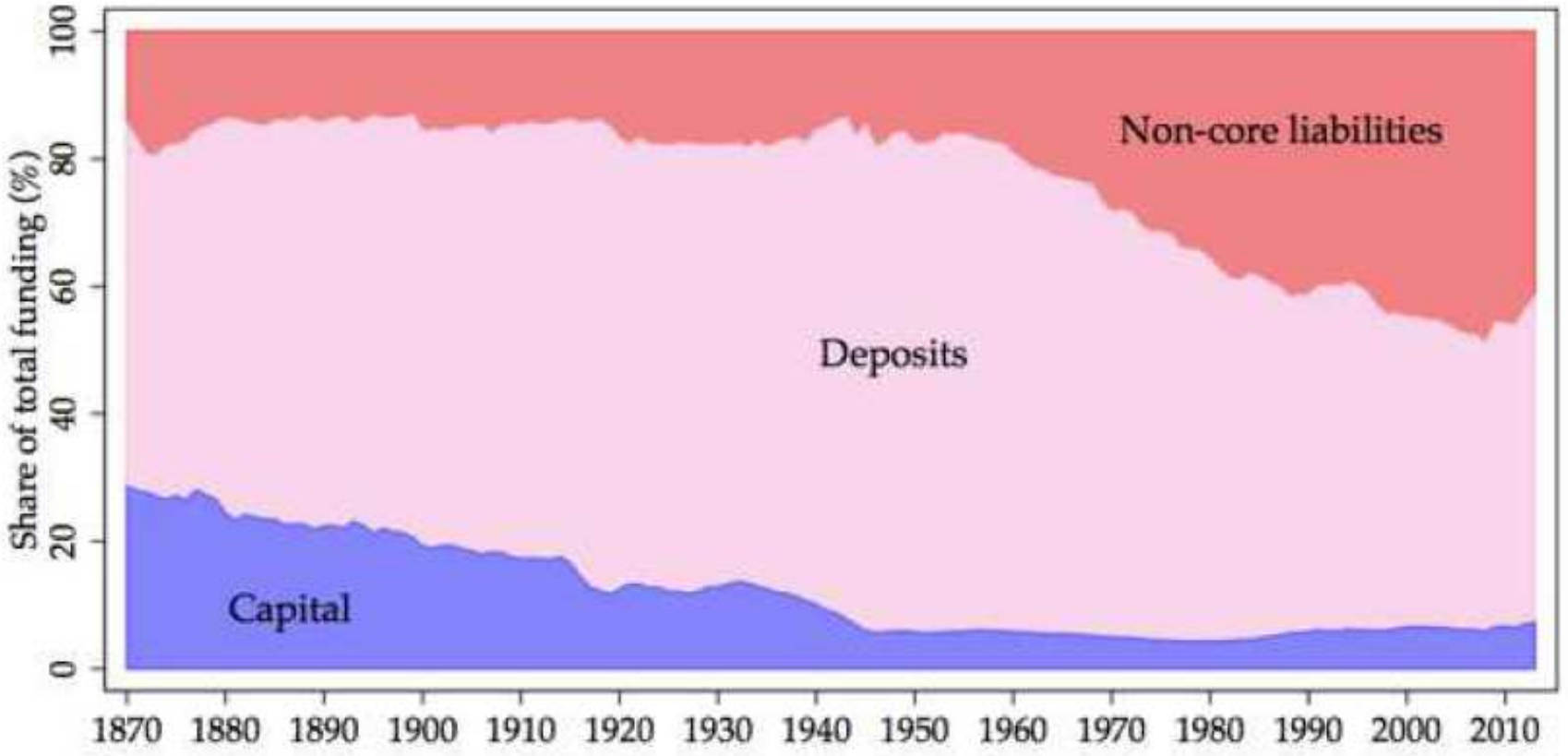
EXCESSIVE RISK TAKING

- Merton (1977): deposit insurance as a put option.
- In DD (1983), the cash flow distribution of investments is given. What if the bank can make unobservable project choices with different riskiness after deposits are received?
- Incentive for banks to take the riskiest project, if this carries higher repayments to the bank.
- Risk-taking can be tamed if depositors discipline bank managers by threatening withdrawal as they receive adverse information on the amount of risk the bank is taking.
- Deposit insurance reduces incentives for information acquisition and control by depositors. Regulatory restrictions is necessary to limit risk taking: capital requirements.

A COMPLEX DANCE

- Bank capital affects the quality of assets, monitoring efforts, distribution of cash flows.
- Capital requirements are needed to restrain the appetite for risk.
- They act as a lower bound: once you bang against it it's too late. Shareholders might be expropriated even if their stake is still positive.
- The (excess-)capital buffer is an endogenous variable.
- Risk management is valuable (Froot and Stein, 1998).
- Bank risk management takes the form of VaR (Adrian and Shin, 2007).

THE HISTORICAL EXPERIENCE



Jorda *et al.* (2017). Composition of liabilities for the banking sector, averages by year for 17 countries.

THE HISTORICAL EXPERIENCE

- The capital ratio provides virtually no information about the probability of a systemic financial crisis.
- Loan growth (asset side of the balance sheet) is the single most useful indicator of financial crisis risk among several other potential predictors (Schularick and Taylor, 2012).
- The amount of bank capital affects the cost of a crisis: a more highly levered financial sector at the start of a financial-crisis recession is associated with slower subsequent output growth and a significantly weaker cyclical recovery.
- Do we have a theory of bank capital explaining these stylized facts?

BASEL-BASED CAPITAL REQUIREMENTS

- The regulator sets a probability of solvency α (ex. $\alpha = 99.9\%$).
- A default occurs whenever the value of losses is larger than equity.
- Let x_i the exposure to obligor i, and u_i the random loss (in excess of that provisioned). Thus, the total portfolio loss of n different assets is $L = \sum_{i=1}^{n} x_i u_i$.
- For given capital K, bankruptcy occurs when $L > K$.

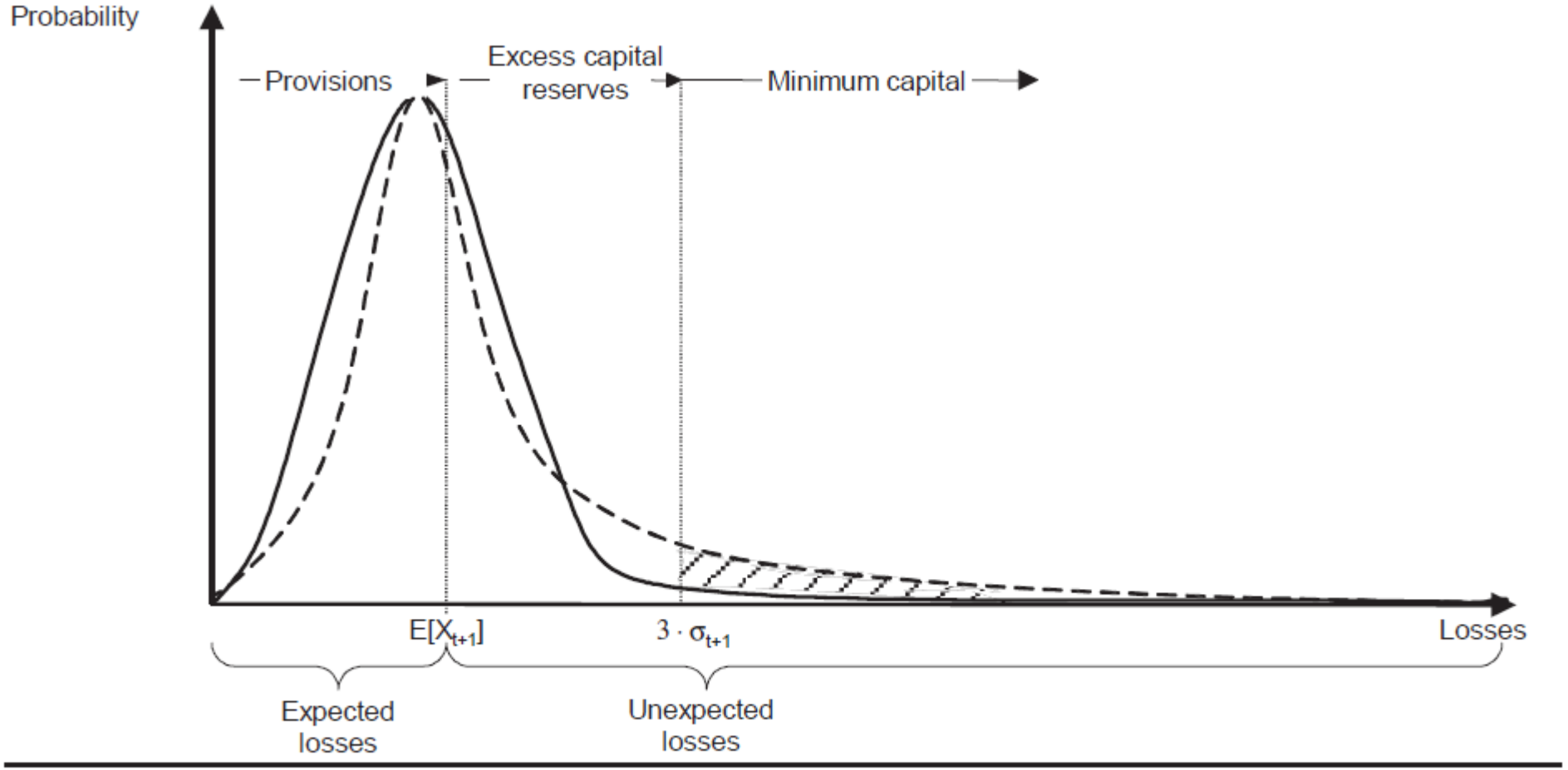
BASEL-BASED CAPITAL REQUIREMENTS

- The same as setting a loss ratio $\ell = \frac{L}{\sum_{i=1}^{n} x_i}$ larger than $k = \frac{K}{\sum_{i=1}^{n} x_i}$.
- Prudential regulation imposes a level of capital K such that

$$Prob(\ell \geq k) = 1 - \alpha.$$

- In a perfectly diversified portfolio with uncorrelated credit risk, the LLN implies that the required capital is zero.
- Capital requirements are concerned with correlated risks and imperfect diversification.

MANAGING RISK IN BANKS



Note: The unbroken curve shows the assumed distribution of losses, while the broken curve illustrates an actual distribution of losses. $E[X_{t+1}]$ and σ_{t+1} are the mean value and standard deviation, respectively.

BANK CAPITAL AS A VAR PROBLEM

- Banks assess the risk to which they are exposed by recurring to statistical calculations measuring the Value-at-Risk (VaR) of their assets as returns vary.
- The urge to action coming from price movements generates an externality: in an attempt to mitigate its own risk exposure, a bank contributes to spread the risk all over the financial system.
- Systemic risk is endogenous: price changes and balance-sheet adjustments reinforce each other to amplify small shocks.

BANK CAPITAL UNDER A VAR CONSTRAINT

- A two-period economy, $(t, t+1)$
- An investor decides an asset allocation by choosing between:
  - an amount y_t of risky security, which costs p_t
  - cash, c_t

- The price of the risky security at time $(t+1)$ is

$$p_{t+1} = (1 + \tilde{r}_{t+1})p_t$$

- where $\tilde{r}_{t+1}$ is the outcome of a stochastic process, with
  - $\tilde{r}_{t+1} \sim iid\ \Omega(\mu, \sigma^2), \qquad \mu > 0$

BANK CAPITAL AS A VAR PROBLEM

- The investor has an initial capital endowment e_t.
- The time t balance sheet is $p_t y_t + c_t = e_t$, and it is consistent with either short or long positions on the risky security.

- For a Leveraged investor (i.e., a financial intermediary)

Assets		Liabilities	
Securities	$p_t y_t$	Equity	e_t
		Debt	$- c_t$

The leverage is $L_t = \frac{p_t y_t}{e_t}$.

BANK CAPITAL UNDER A VAR CONSTRAINT

- Let α be the VaR confidence level, so that (1 - α) represents the maximum probability to go bankrupt the following period.
- Bankruptcy occurs whenever $e_{t+1} \leq 0$, occurring if:

$$\tilde{r}_{t+1} p_t y_t + e_t \leq 0$$

that is

$$\tilde{r}_{t+1} \leq -\frac{e_t}{p_t y_t}$$

BANK CAPITAL UNDER A VAR CONSTRAINT

- Define ϕ as a constant such that

$$Prob(\tilde{r}_{t+1} \leq \mu - \phi\sigma) = 1 - \alpha$$

- $\phi\sigma$ is the VaR associated to the stochastic return $\tilde{r}_{t+1}$ at the confidence level α, when the expected return is μ.
- The problem is that of choosing an asset allocation with an amount of risky asset y such that the probability to become insolvent at time $(t+1)$ is not higher that $(1 - \alpha)$.

BANK CAPITAL UNDER A VAR CONSTRAINT

- The probability of insolvency is exactly equal to (1 - α) when:

$$-\frac{e_t}{p_t y_t} = \mu - \phi\sigma$$

that is

$$\mu + \frac{e_t}{p_t y_t} = \phi\sigma$$

- Given the initial position in equity (e_t), the expected return on the risky asset (μ), its riskiness (σ) and the acceptable threshold for risk (ϕ), this identifies the total amount of risky asset to be held in the portfolio.

BANK CAPITAL UNDER A VAR CONSTRAINT

- Interesting implication. Desired leverage is equal to:

$$L = \frac{p_t y_t}{e_t} = \frac{e_t}{\phi\sigma - \mu}\frac{1}{e_t} = \frac{1}{\phi\sigma - \mu}$$

that is a constant

$$L = L(\phi, \sigma, \mu)$$
$$\quad - \quad - \quad +$$

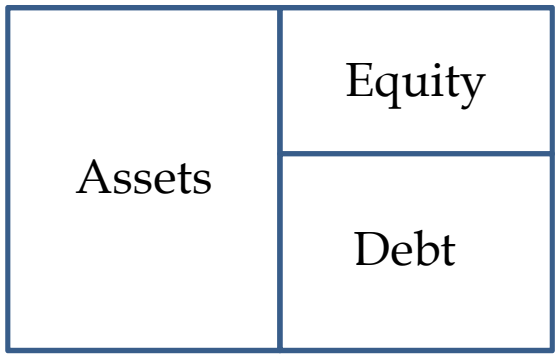
BANK CAPITAL UNDER A VAR CONSTRAINT

- Adrian and Shin (2010): If the price of the risky asset varies, a bank using a VaR approach in asset allocation wants to keep the leverage constant («leverage targeting»).
- The demand curve for a risky asset has a positive slope (demand more asset when its price increases), while the supply curve has a negative slope (sell assets if the price decreases).
- This is a precondition for the amplification of shocks at a systemic level.

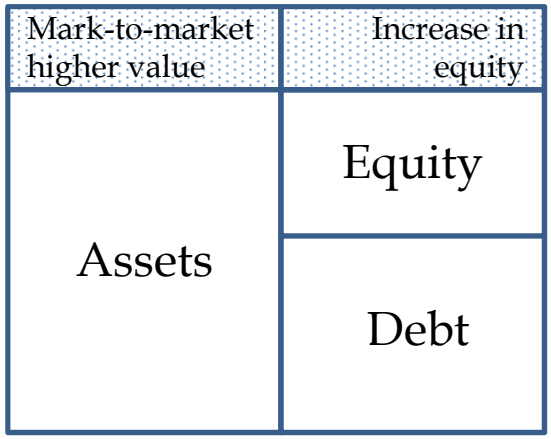
BANK CAPITAL UNDER A VAR CONSTRAINT

Assets		Liabilities	
Securities	py	Equity	e
		Debt	$py - e$

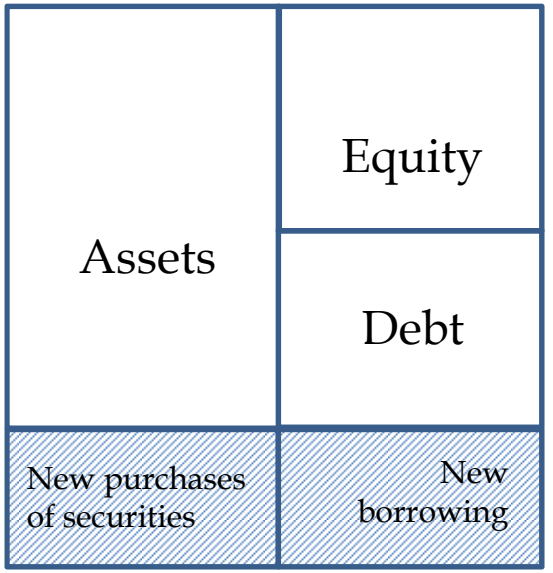
i) Initial balance-sheet



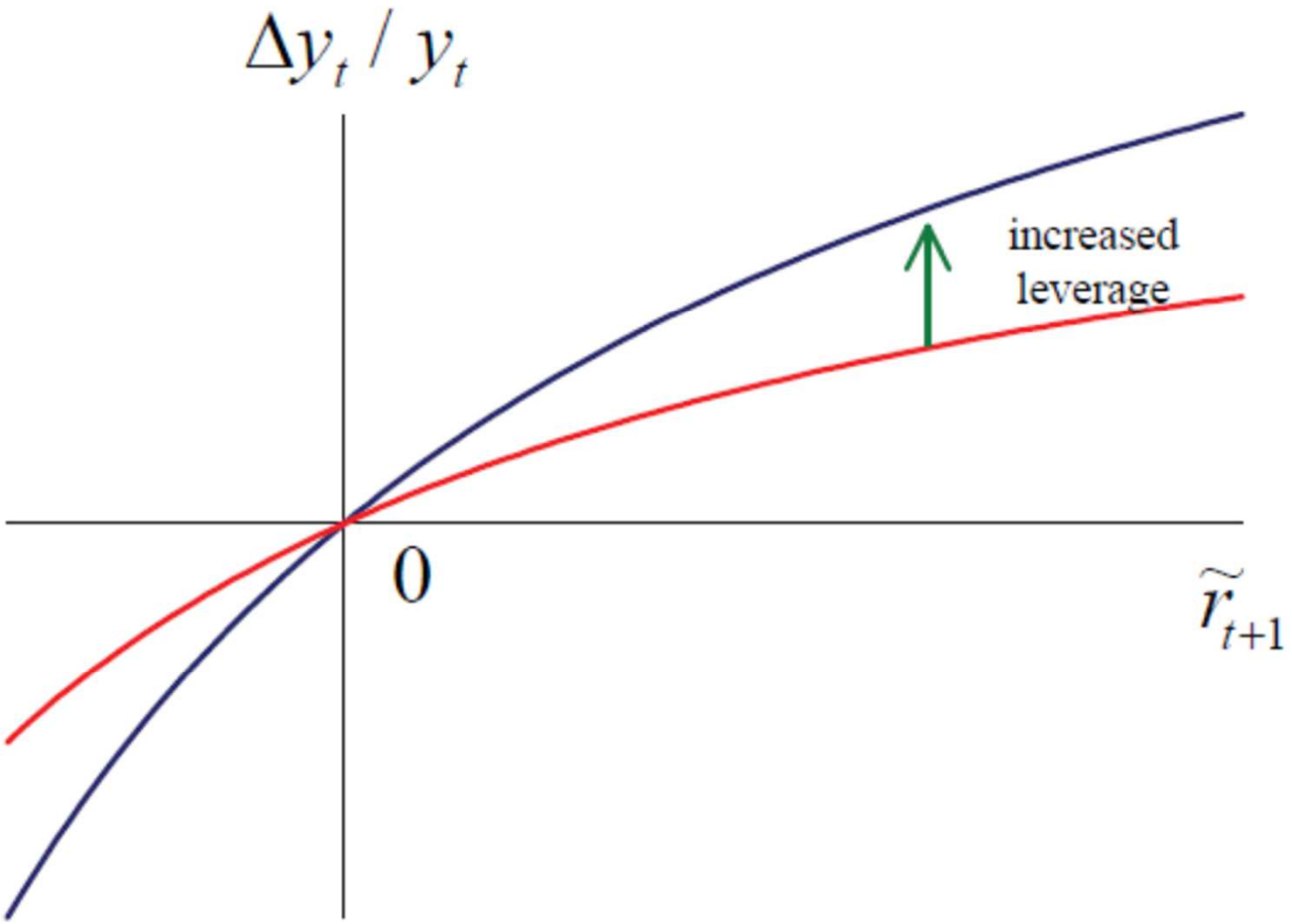
ii) After a price increase



iii) After the adjustment



BANK CAPITAL UNDER A VAR CONSTRAINT



PRO-CYCLICAL LEVERAGE?

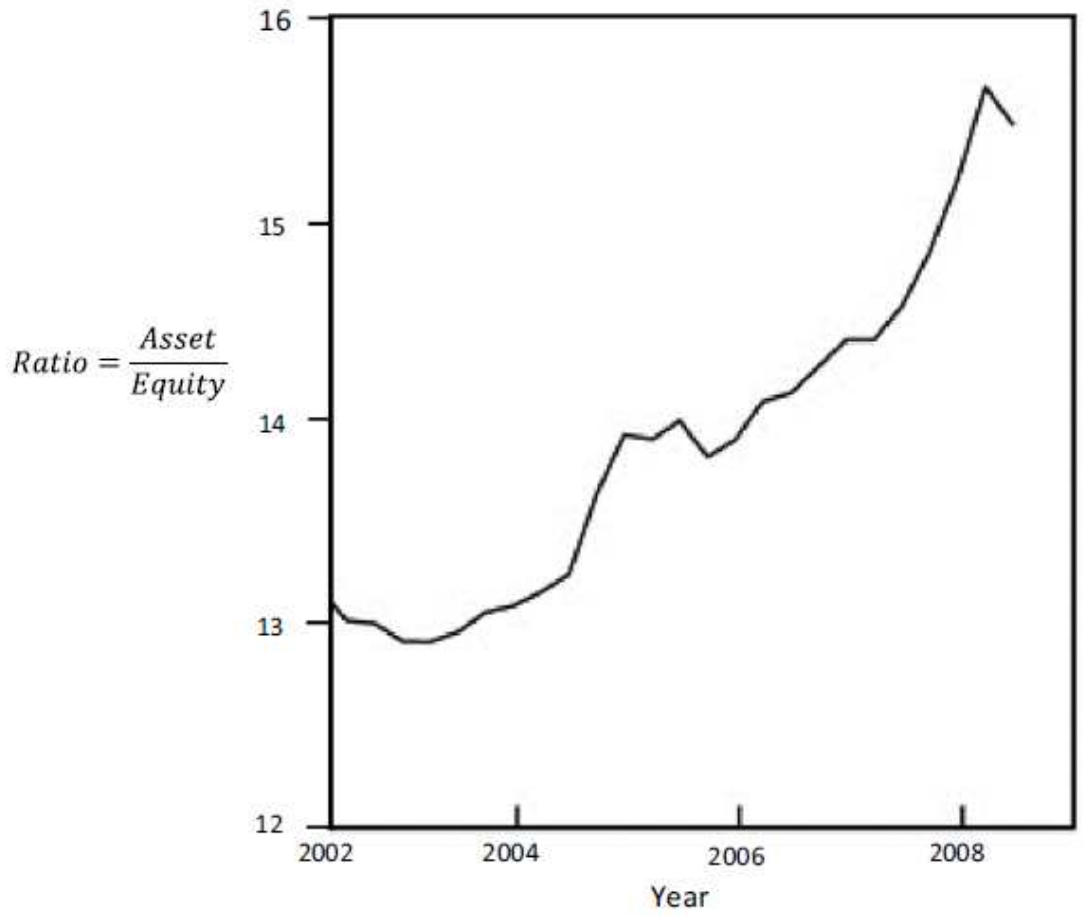
- Recall that leverage is:

$$L = \frac{p_t y_t}{e_t} = \frac{1}{\phi\sigma - \mu}$$

where $\phi\sigma$ is the value at risk per euro of assets (unit VaR).

- Leverage is pro-cyclical if the unit VaR is counter-cyclical (Adrian and Shin, 2014).

THE RECENT EXPERIENCE



Goel *et al.* (2014). Leverage for U.S. commercial and investment banks.

SYSTEMIC LEVERAGE – MARK I

- Banks engage in highly correlated high leverage choices due to strategic complementarities (Aikman *et al.*, 2015; Vives, 2014).
    - Acharya and Yorumalzer (2007): when the number of bank failures is large, the regulator finds it ex-post optimal to bail them out ("too many to fail"). This gives banks incentives to herd and increases the risk that many banks may fail together.
    - Farhi and Tirole (2012): private leverage choices depend on the anticipated policy reaction to the overall maturity mismatch. Since policy instruments are only imperfectly targeted to the institutions they try to rescue, it is profitable for a bank to adopt a risky balance sheet when others are doing the same.

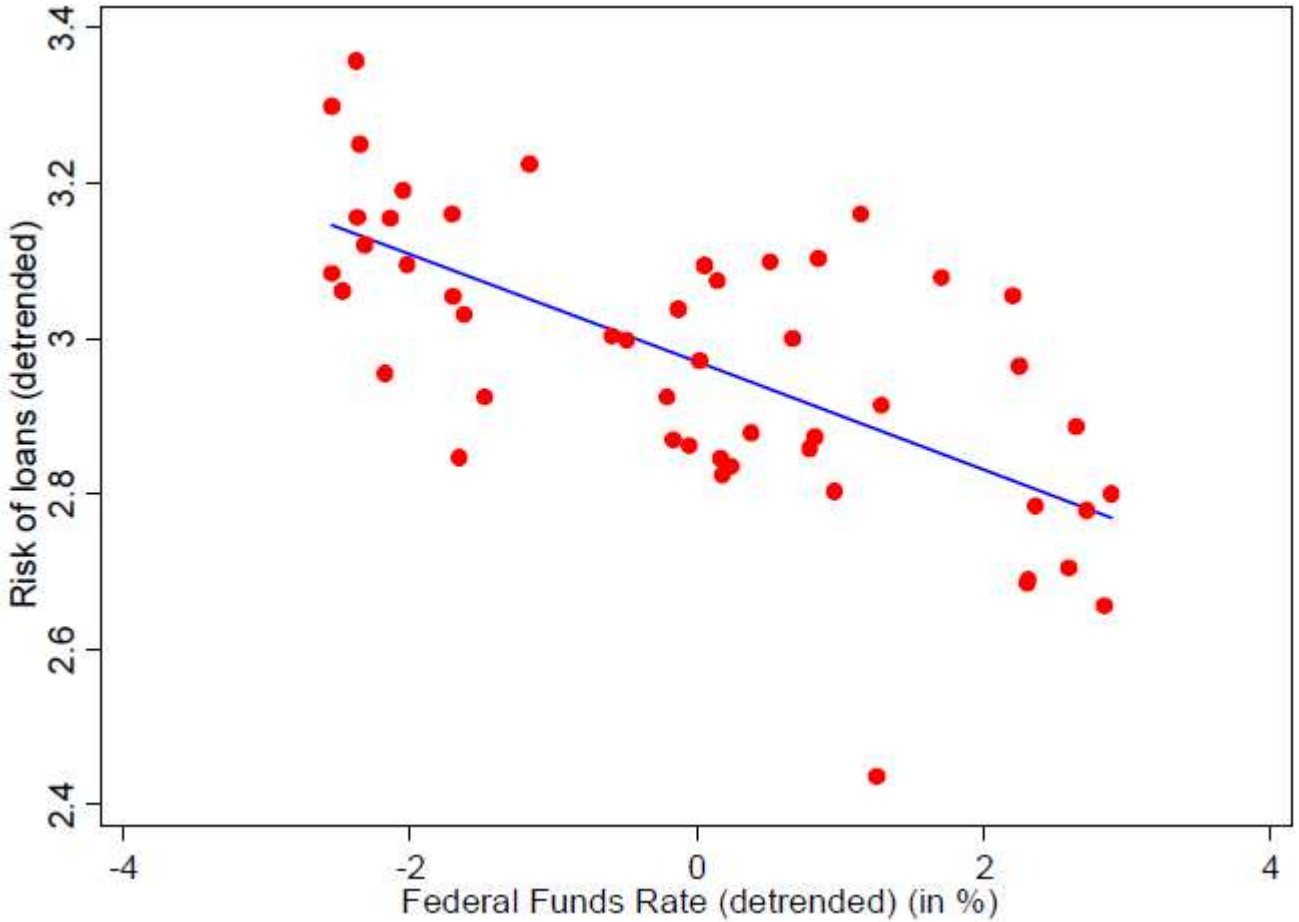
SYSTEMIC LEVERAGE – MARK II

- Systemic leverage increases as a response to monetary policy: bank risk-based channel of monetary transmission (Borio and Zhu, 2008; Dell'Ariccia *et al.*, 2014).
- Policy (risk-free) rates affect bank risk taking depending on how banks are able to pass policy changes onto lending rates (pass-through effect), and on how they optimally adjust their capital structure in response to such changes (leverage effect).

SYSTEMIC LEVERAGE – MARK II

- Lower risk-free real interest rates imply a reduction of interest rates on bank loans. This reduces the bank's gross return conditional on its portfolio repaying, reducing its incentive to monitor.
- The risk-shifting effect works the other way round. Due to agency problems and limited liability, the amount of risk shareholders want to transfer to debtholders falls as deposit rates drop.
- The strength of the risk-shifting effect is a function of leverage, however. If banks can adjust optimally their capital structure, equilibrium leverage increases in a low interest rate environment since the benefit from holding capital (as a signal) falls.

RISK-TAKING CHANNEL



Dell'Ariccia *et al.* (2013). Interest rates (Fed Funds) and bank risk taking (Survey of Terms of Business Lending) for U.S. banks.

WHAT HAVE WE LEARNED?

- Tension between micro- and macro-prudential regulation.
- In a banking system, both systemic risk and individual bank's contribution are endogenous and depend on banks' equity capital.
- Capital requirements should be set to properly capture this co-evolution.
- Ex. Gauthier *et al.* (2012): properly-designed capital requirements could reduce the probability of a systemic crisis by 25%.

WHAT HAVE WE LEARNED?

- Leaning-against-the-wind: how should monetary respond to financial imbalances?
- For demand shocks, prices and risk-taking (leverage) move in sync. A monetary restriction is effective in restraining both.
- For supply shocks, the policy rate cannot deal with both objectives at the same time.
- In any case, a lot of additional research is needed!

THANK YOU ALL

Edoardo Gaffeo
Department of Economics and Management
University of Trento
edoardo.gaffeo@unitn.it