Financing Firm Networks

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Overview of joint work with
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CAREFIN and IGIER Research Groups

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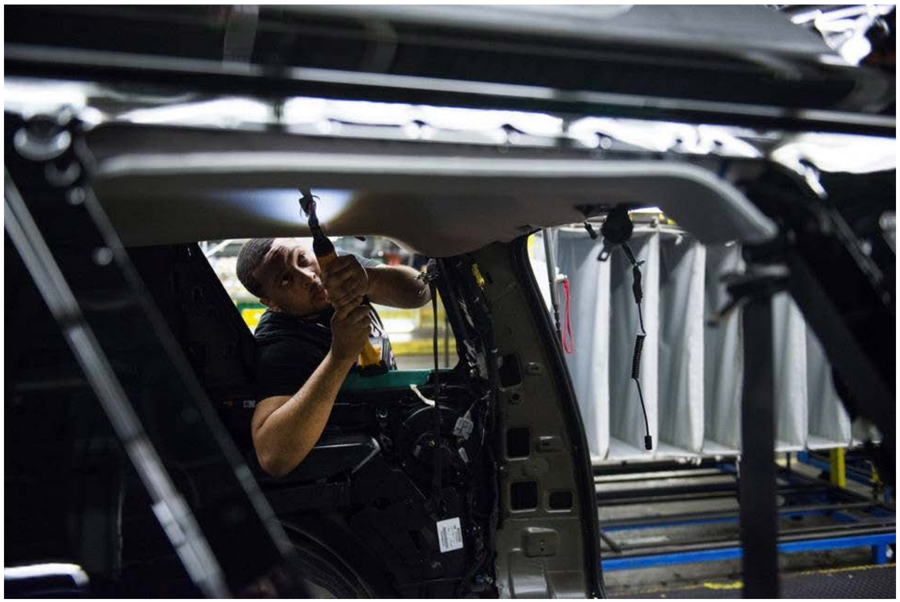
General Motors Seeking to Get Equipment From Supplier in Bankruptcy Case



W.S.J. July 11, 2016 6:31 p.m. ET

General Motors Co. is fighting to get equipment and inventory from a family-owned auto parts supplier that filed for chapter 11 bankruptcy protection last week, saying a contract dispute threatens to shut down 19 GM assembly plants in North American and lead to “tens of millions of dollars in losses.”

- Corporate failures may generate large losses to commercial and industrial partners.
- When exposed to a debtor default, annual failure risk of a non-financial creditor increases by around 53% (Jacobson and von Schvedin 2015)

Network based analysis of credit and distress risk propagation

- Traditional problems of financial economics:

1) Pricing of insurance against corporate failures
2) Optimal portfolio management of a portfolio of assets and liabilities.
3) Equity and Debt Valuation.

- New ingredient …. when firms are part of a network of commercial, financial and industrial relations.

Plan of the talk

- Financial economic formulation of the problem.
- Some theoretical and empirical results.
- Industrial applications: the «necessity» to innovate credit portfolio management by means of Fintech and Big Data solutions.

Traditional model of optimal firm financing policy.

- Basic assumptions:
  - No frictions and perfect separation between financing and investment decisions.
  - Modigliani-Miller capital structure irrelevance in absence of taxes and bankruptcy costs.
  - Opimal tradeoff between tax benefits of debt and bankrupcy costs.
- This is a single firm model and (Merton) pricing of equity and debt is reduced to the pricing of a put on firm assets.
- In this world, firms master their own fates and pricing of default risk depends only on the firm balance sheet and asset risk exposure.

Back to reality

- This modeling approach is realistic (at most) for a big US corporation with relevant cash reserves that does active financial hedging.
- Boundaries of the firm are endogenously selected (Holmstrom Roberts 1998) based on regulation, property rights enforcement and production external conditions.
- In the case of small and medium enterprises that are part of a strongly interconnected and localized production chain, each individual firm can not survive unless the whole production chain is properly working. (Peterson Rajan 1997, Kim Shin 2015)
- The unfolding of the recent financial crises suggests the necessity to introduce a better model of credit linkages among productive entities.

Basic References

- The approach we explore is similar in spirit the physics of collective phenomena. (More is different, P. W. Anderson 1972)
- We abstract from the exact nature of the single firm mechanics and try to explore the effect induced by the collective interaction among connected firms.
- The idea is not new. D. Acemoglu, Carvalho V, Ozdaglar, A. and A. Tahbaz-Salehi (2012) explore the aggregation properties of productive shocks.
- Our analysis builds on the paper: Buraschi and Porchia (2013) Dynamic Networks and Asset Pricing.

Distress propagation and epidemics

- Zero order model: Modify a pure exchange Lucas Tree equilibrium in order to relax the diversification assumption.
- We price a claim on cash flows=dividends=fruits of the tree (No capital structure, all equity firm!!)
- Porchia and Buraschi (2013) model explicitly firm-specific shocks and their transmission, considering a «Lucas orchard».
- Distress of one firm raises the likelihood of transition to distress of connected firms.
- MAIN OBSERVATION (Tebaldi Buraschi 2017) Dividend pure jump dynamics is equivalent to SIS epidemic spreading of disease. (Virus spread on networks Van Mieghem, Omic and Kooij, 2009)

The Buraschi Porchia (2013) economy

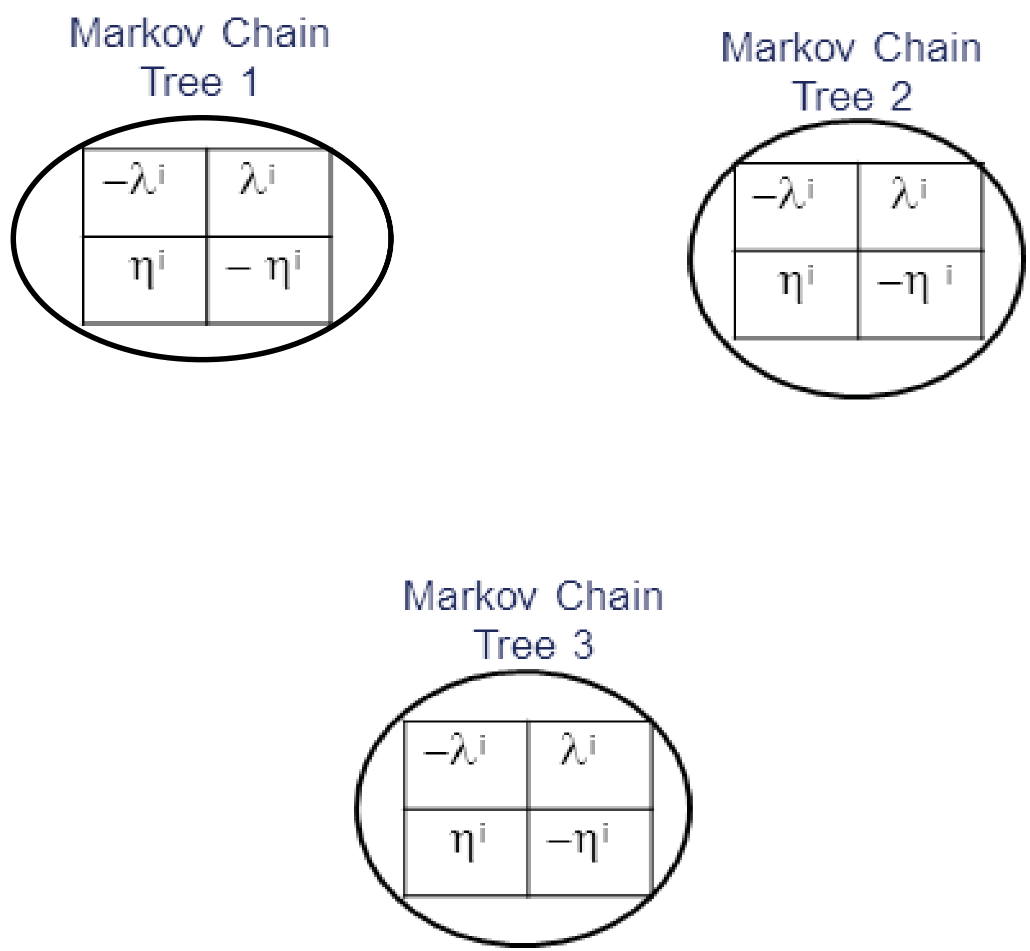
- Power utility representative investor
- N firms paying dividends:

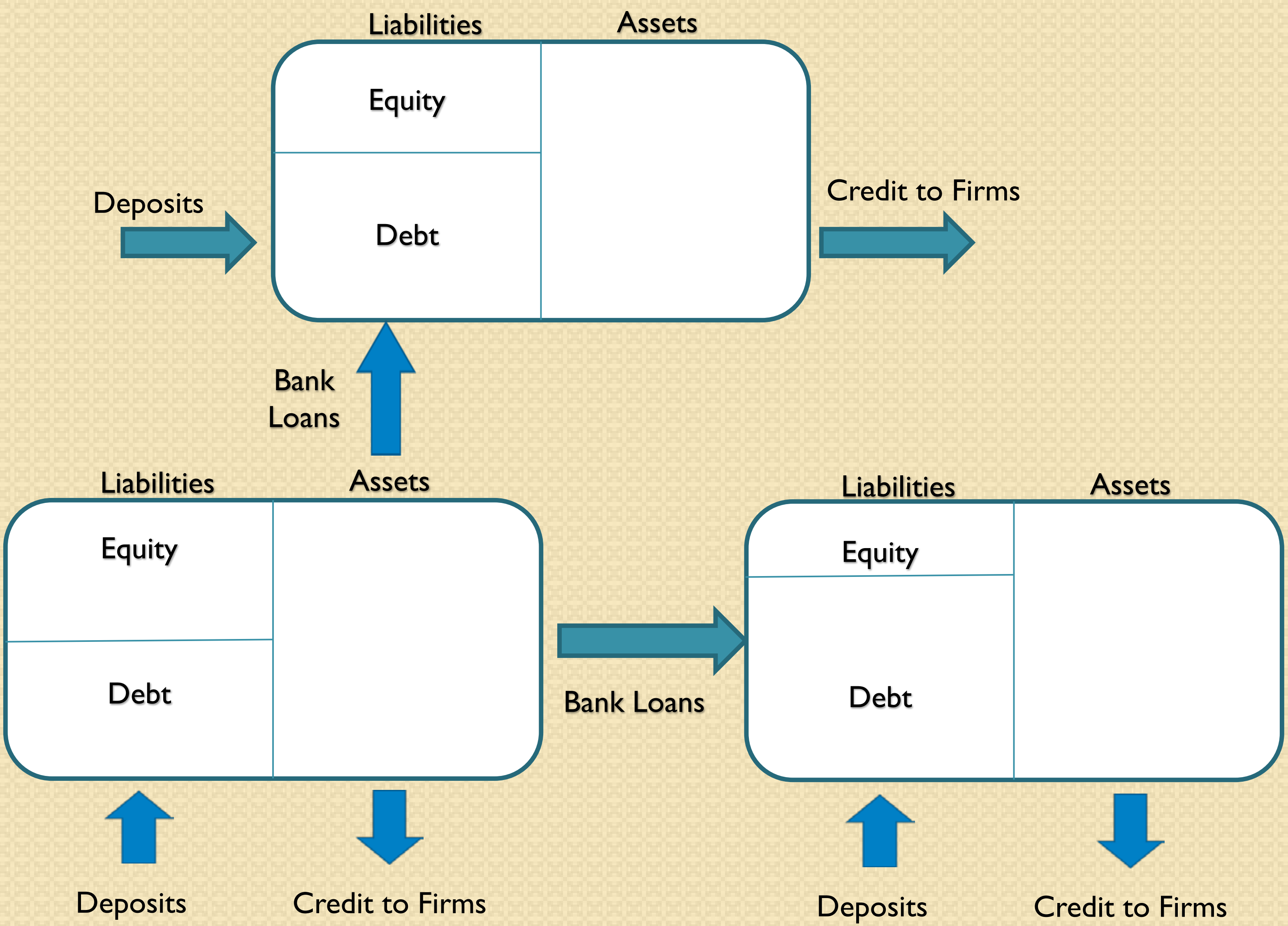
$$D_i = Y_t x_t^i \,, i = 1 \ldots N$$

- Y_t common lognormal shock, x_t^i binary indicator

$$x_t^i = \begin{cases} \overline{x^i} \\ \\ \underline{x^i} \end{cases}$$

Isolated trees




Liabilities
Assets
Equity
Debt
Deposits
Credit to Firms
Bank
Loans
Liabilities
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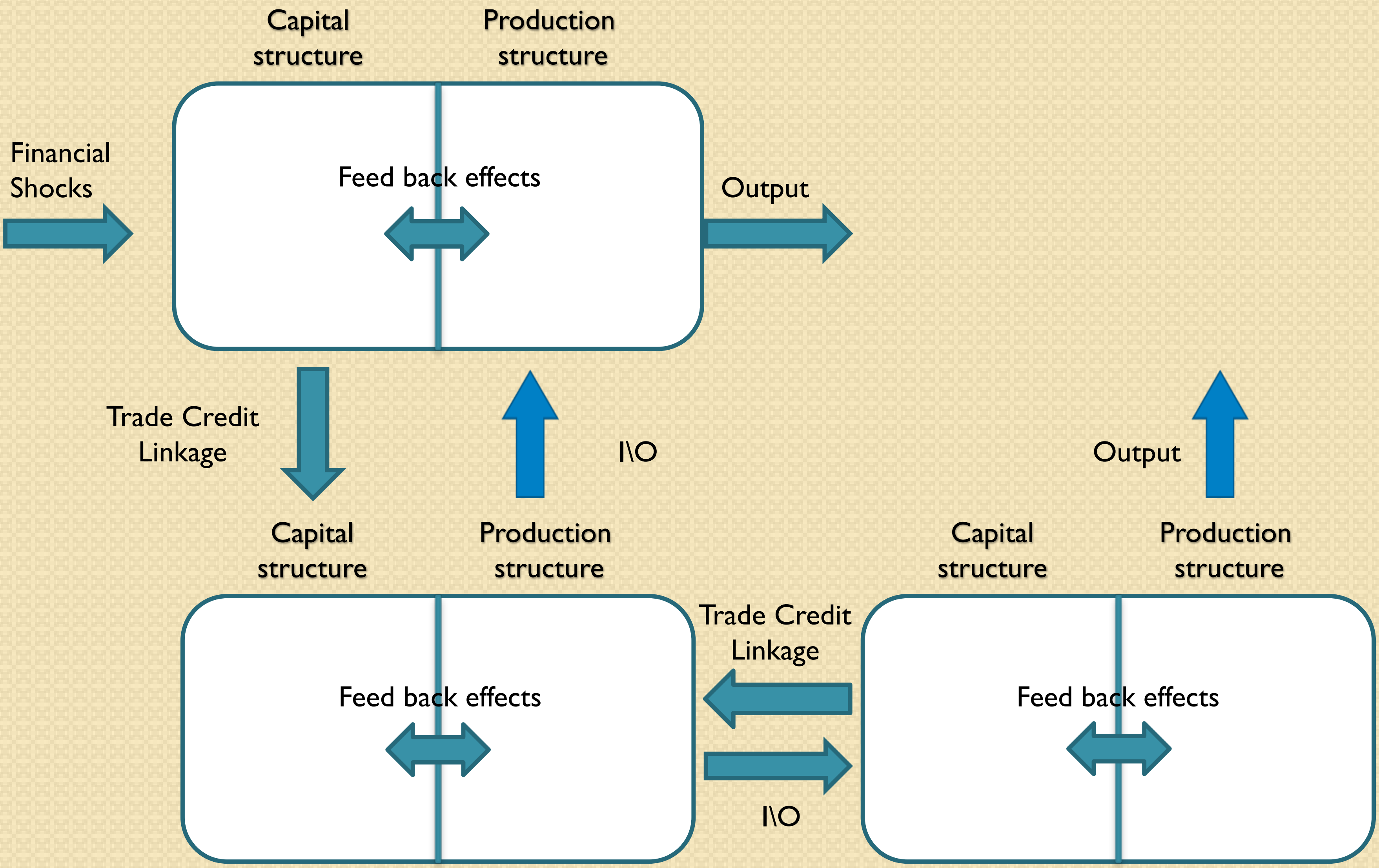
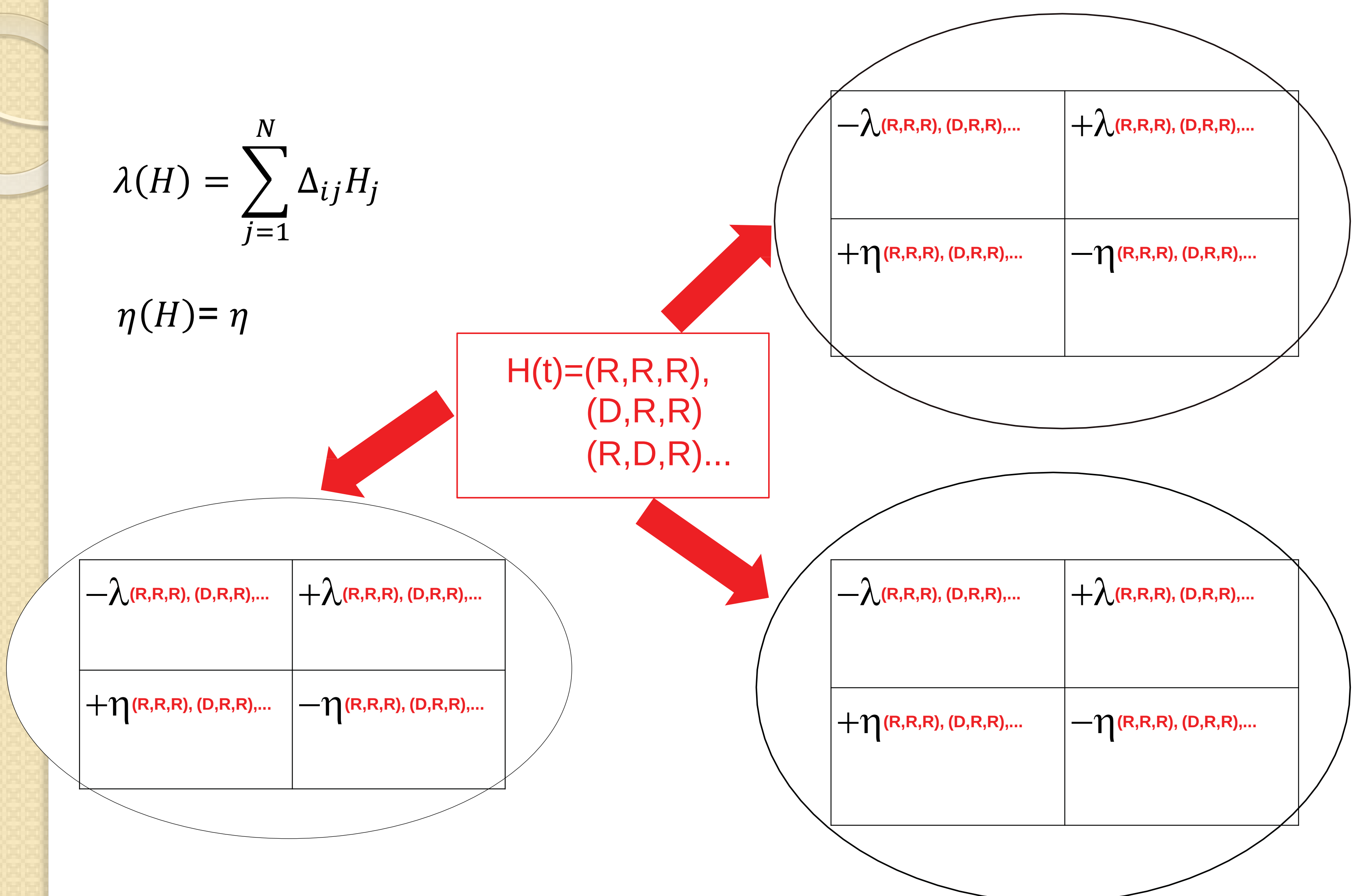

Capital structure
Production structure
Financial Shocks
Feed back effects
Output
Trade Credit Linkage
I\O
Output
Capital structure
Production structure
Capital structure
Production structure
Trade Credit Linkage
Feed back effects
Feed back effects
I\O

Lucas Orchard

$$\lambda(H) = \sum_{j=1}^{N} \Delta_{ij} H_j$$

$$\eta(H) = \eta$$



Long term, large economy limits

- Consider the long term limit $t \to +\infty$ of a large economy $N \to +\infty$.

- Metastable states arise (with exponential in N long life)

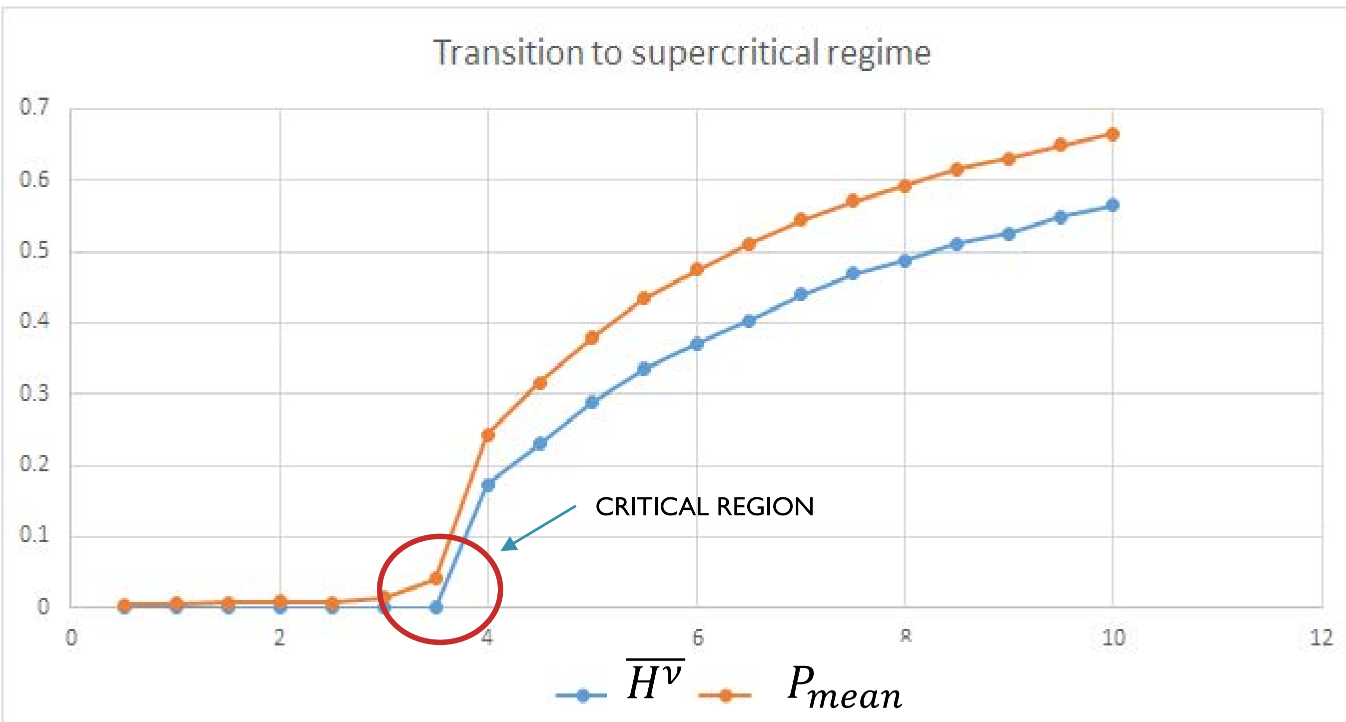
- A critical threshold bounded by the inverse of the principal value of the network matrix separates the supercritical from the subcritical regime:
  - Subcritical regime, $\frac{\lambda}{\eta} < \frac{1}{\alpha}$: firm specific shocks average out
  - Supercritical regime, $\frac{\lambda}{\eta} > \frac{1}{\alpha}$: epidemics is endemic, cascades of idiosyncratic distress shocks do not average out generate aggregate shocks.

- Critical point fluctuations cluster and are intermittent. Bak, Scheinkman and Woodford claim that macrofluctuations are close to critical!

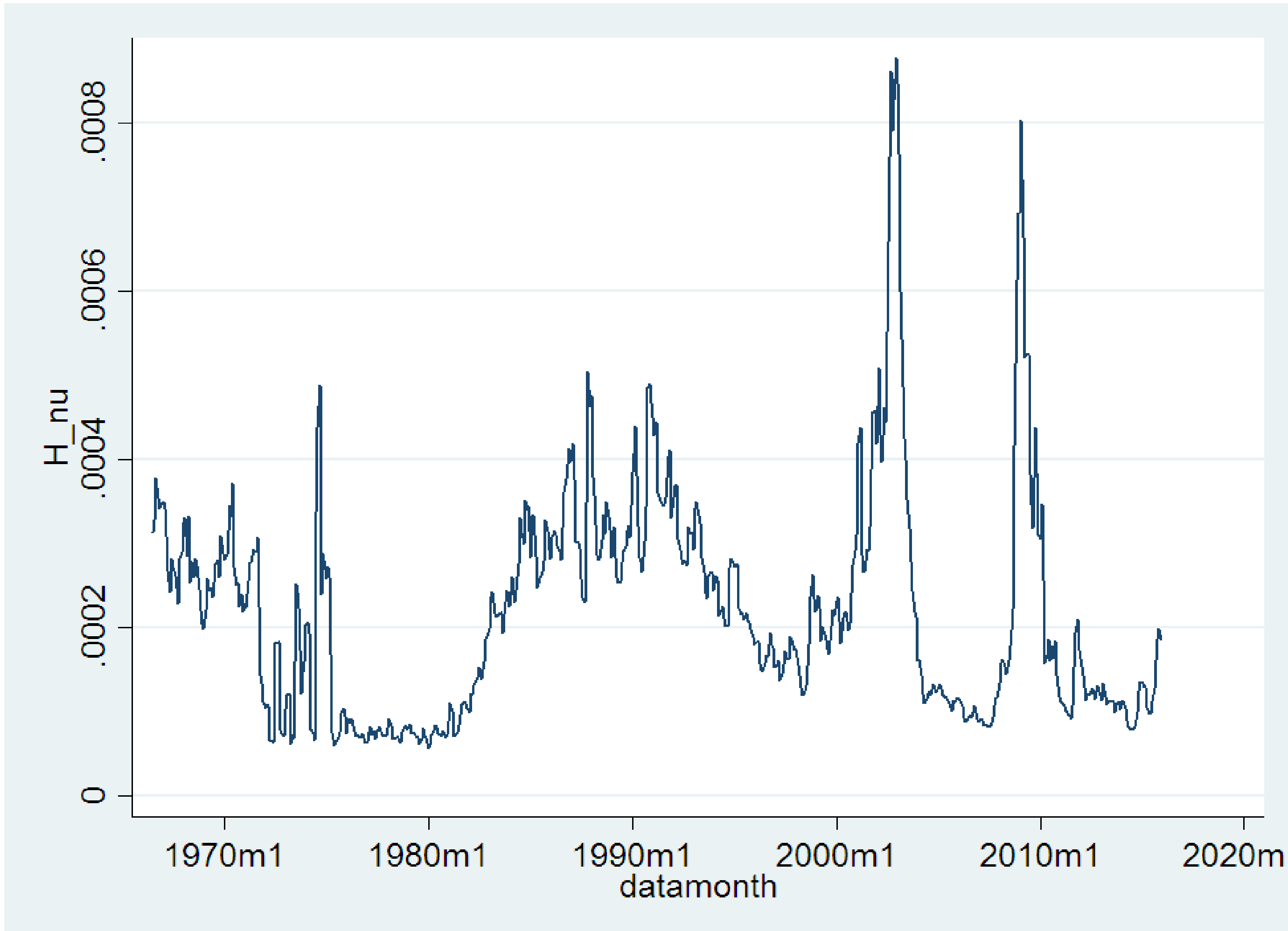
Network distress indicator

$$H^{\nu} = \frac{\sum_{i=1}^{N} \nu_i^L H_i}{\sum_{i=1}^{N} \nu_i^L}$$

ν_i^L systemicness of firm i
(element i of left principal vector)

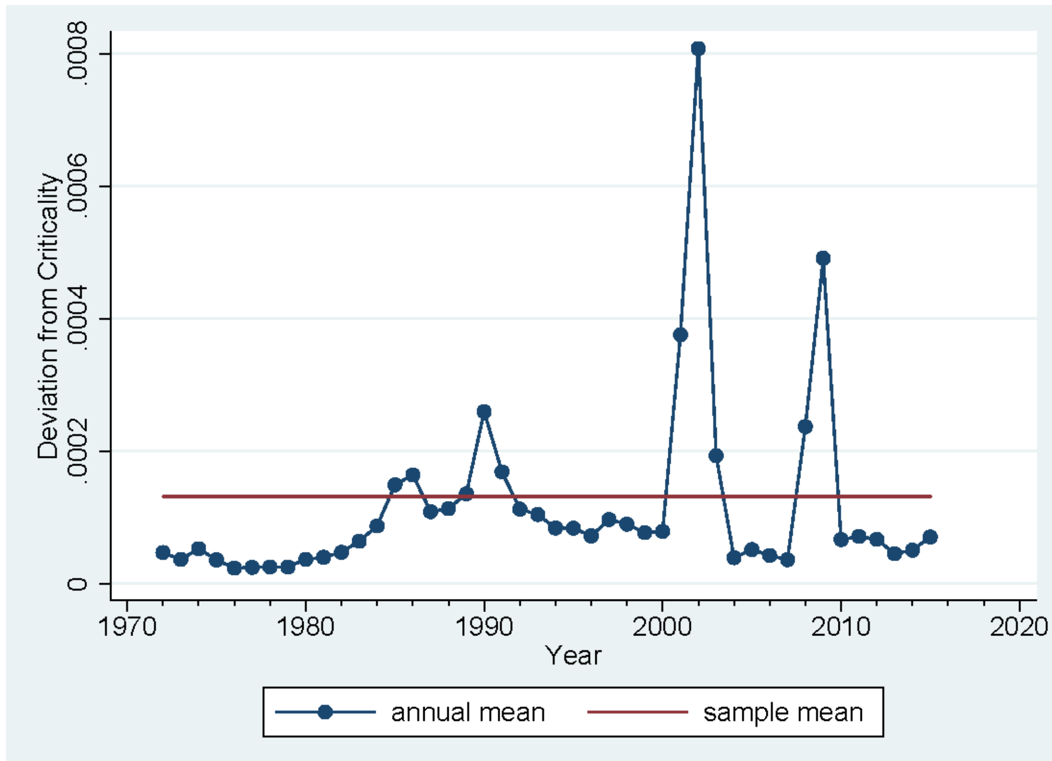


Aggregate distress dynamics



Deviations from criticality:

Intermittent behviour contributes to the explanation of the credit spread puzzle



Valuation in a network economy

- Network based Gordon growth formula:

$$P_i(H) = (A^H - aI)^{-1} C_i(H)$$

- Expected risk premium:

$$\mu_i^\infty = \gamma\kappa + (1 - h_i)E\mu_i^\lambda + h_i E\mu_i^\eta$$
$$E\mu_i^\lambda \propto v_i^R \alpha\lambda/\eta$$

- v_i^R vulnerability (Right singular vector component)

Empirical results

- Expected return decreases with increasing default probability: potential explanation of CHS puzzle.

- Vulnerability is priced by investors: a Long-Short portfolio generates 45 b.p. (vw 71 b.p.) monthly returns.

- Vulnerability (not beta!!) moves one to one with leverage. Higher leverage implies firm more vulnerable to network shocks

Empirical results Compustat-CRSP dataset

Sort on network exposure vs returns

dist_portnu	1	2	3	4	5	6	7	8	9	10
ret	1.356359	1.40745	1.413976	1.473108	1.462563	1.526112	1.628493	1.562108	1.675906	1.808615
vw_ret	0.732943	1.062563	1.109987	1.040034	1.093157	1.255378	1.277536	1.345655	1.361648	1.442325
nu	-0.83214	-0.37192	-0.23802	-0.14514	-0.07176	0.003004	0.070438	0.159611	0.300942	0.768669

Sort on network exposure vs leverage

dist_porttotnu	1	2	3	4	5	6	7	8	9	10
nu_std	-1.36553	-0.58853	-0.34791	-0.1877	-0.05738	0.067959	0.197591	0.346954	0.589221	1.345319
TL2_std	-0.16196	-0.09408	-0.07031	-0.02819	-0.03868	-0.02911	0.02071	0.074864	0.131992	0.19476
mdr_std	-0.31444	-0.16701	-0.11697	-0.01363	-0.03707	-0.00244	0.084285	0.158123	0.187164	0.221989

Optimal portfolio management

- Accounting for network relationships in the formation and pricing of optimal portfolios of firm debt or equity.

- There are many examples of hybrid contracts that rely on an unerlying network:
  - Contratti di Rete (Italy) regulate productive relations among firms but guarantee firm financial independence.
  - Loan Guarantee Networks (China): groups of Small and Medium Enterprises (SME) back each other and form guarantee network to obtain loan from banks (Niu Cheng Yan 2017).

Basic implementation issues

- The traditional diversification approach has limited applicability if contagion and distress propagation are not properly taken into account.

- The most challenging technical problem is the reconstruction of the network relationships. In general network relations are endogenously selected and unobservable.

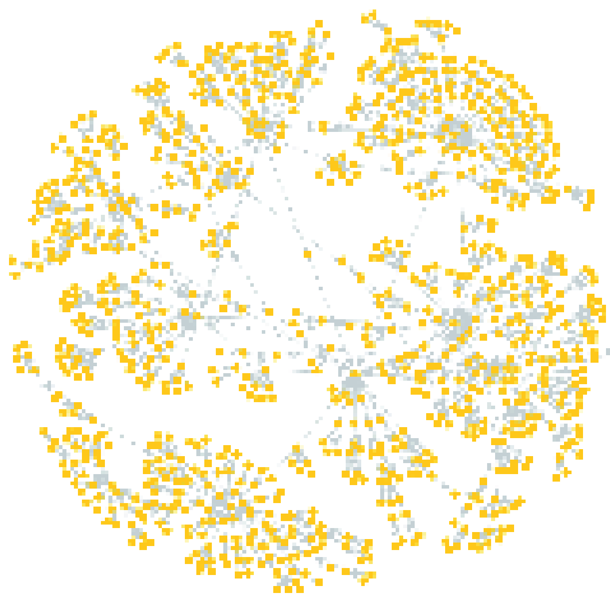
- Improving information accumulation on network connections may require a reduction in diversification. Is there an optimal tradeoff?

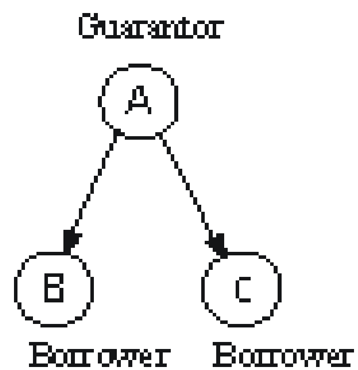
Technological solutions

- Fintech solutions for information accumulation: E-trading, trade-finance, supply-chain finance, peer-to-peer lending platforms play a dual role, they promote the creation of networks, they produce relevant information on firm-to-firm connections.
- Recent acqusitions of lending platforms from Wall Street investment banks are aimed at developing a market-place for sub-prime customers that the bank cannot serve through standard channels.
- Big Data solutions for financial network analytics: the information geometry of the network does influence the pricing of credit and equity claims. Hence high speed and high capacity are required for both risk management and pricing issues.

Loan Guarantees Neetwork

Network of Guarantors SME Loan from: Niu Cheng Yan 2017





Follow up

Important problems to be solved in the near future:

- How to price a loan with a guarantee network?
- How to optimally grow a robust loan guarantee network?
- Italian system: do we know the map of the relevant networks?
- Developing a marketplace for SME lending?