Contagion and Risk Sharing on the Inter-bank Market

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- Interbank loans are conducted directly between pairs of banks
- If a bank fails its creditors may not recover their funds
- Counterparty risk -> Systemic risk

The Topology of the Federal Funds Market ECB Working Paper No. 986.(Bech, M.L. and Atalay, E.)

Questions

What is the effect of the structure of the interbank market on the likelihood of contagion

How this varies with the type and degree of shock

How financial regulation may be used to mitigate these effects

Is there an optimal interbank market structure?

Previous Work

- Markets as risk sharing
  - Allen and Gale (2001), Giesecke & Weber (2006)

- Markets as contagion spreading
  - Boss et al. (2004), Vivier-Lirimont (2006)

- Structure
  - Iori et al. (2008) – Italian
  - Muller (2006)* – Swiss
  - Upper and Worms (2004)* – German
  - Boss et al. (2004) – Austrian
  - Angelini et al (1996) – Italian
  - Humphrey (1986) *- USA

Previous models

- Several papers have attempted to understand the effect of market structure
  - Iori (2006)
  - Battiston et al (2009)
  - Gai and Kapadia (2010)
  - Georg (2012)
  - (and others)

Model

- Discrete time, partial equilibrium model of the interaction of:
  - Financial Sector
    - N Banks
  - Non-financial sector
    - M Lenders
    - Q Borrowers
- All agents uniformly distributed on a unit circle

- Depositors – each time step
  - Place all of their deposits, D_j,in a single bank

$$\arg\max_{i \in N} D_j (r_i^{deposit} - g(i, j))$$

  - Where g(i,j) is the distance between i and j on the circle
- Borrowers
  - Receive a single investment opportunity which requires τ and pays μ after two periods with probability θ
  - Approach a single bank to fund that investment

$$\arg\max_{i \in N} \tau \theta_{I_{jt}} (\mu - (1 + r_i^{loan})^2) - g(i, j)$$

- Banks
  - Each has a balance sheet consisting of:
    - Interbank loans I_i
    - Loans to non-financial entities L_i
    - Deposits D_i
    - Equity E_i
    - Reserves R_i
  - Sets too interest rates
    - Loan rate r_i^{loan}
    - Deposit Rate $r_i^{deposit}$

Banks

– Maximise expected return

$$E(r_i) = \left(\sum_{k_i=1}^{K_i} (1 + r_i^{loan})\theta_{k_i}\right) + (1 + r^{interbank}) I_i \theta_i^{interbank} - r_i^{deposit} D_i$$

Funded Loan Request

Interbank Lending and Borrowing

Deposits

– Key aspect is the selection of K_i – the set of funded loan requests

Constraints:

- Balance sheet must balance

$$E_i + D_i = L_i + R_i + I_i$$

- Deposits are equal to the value paid in by households
- The value of loans is the sum of investments funded
- Reserves requirement

$$R_i \geq \alpha_i D_i$$

- Capital requirement

$$E_i \geq \beta_i (L_i + \max(I_i, 0))$$

- Interbank Market
  - Interest rate is determined endogenously
  - Rate at which supply of interbank funds equals demand
- Given an interbank rate a particular bank maximise their expected return and so lend/ borrow a specific amount.
- Over the population of banks this may lead to excess supply or demand
- Equilibrium rate is found numerically

OTC market – direct connection between lenders and borrowers

Connections determined randomly

- Consider each borrower in turn
  - Borrows form each lender with probability λ (probability of connection)
  - Loan proportional to requested funds
  - If insufficient funds are available to meet borrowers demand more borrowers add added in decreasing order of size

If a bank has negative equity or is unable to repay it interbank loans it goes bankrupt

- 100% of available funds are used to repay loans

Dividends

- At the end of each time step banks pay dividends proportional to their equity such that equity over time is constant.

- Bank parameters
  - Reserve Ratio (Reserve requirement)
  - Equity Ratio (Capital requirement)
  - Lending Rate
  - Deposit Rate
  - Probability of repayment of interbank loans
- Initially randomly assigned values
- Each time step two banks are randomly chosen
  - Poorer banks parameters are replaced by perturbed copies of richer banks parameters
  - Perturbation U(0,0.001)

Parameters

Parameter	Meaning	Value
β	Capital Requirement	0.08
α	Reserve Requirement	0.1
N	Banks	100
M	Households	10000
μ	Project Payoff	0.15
θ	Project Success Probability	0.99
τ	Project Size	1.0

Model simulated for 10000 time steps before statistics generated. 25000 repetitions

T-test that parameters no longer change

Results

Model

Type	Value	Std Dev.
Loans	751.5	32.75
Deposits	737.3	31.1
IB Loans	263.3	36.9
Cash Reserves	74.2	3.42
Equity	99.1	5.13
Unused Capital	10.7	6.8

US data (2006)

Type	Norm
Loans	950.2
Deposits	721.8
IB Loans	41.5
Borrowing	221.7
Cash Reserves	36.3
Equity	99.1
Other Assets	94.55
Other Liabilities	71.9

Parameter	Value	Std Dev	Parameter	Value	Std Dev
Loan Rate	0.036	0.01	Bankrupt	0.18	0.84
Deposit Rate	0.012	0.004			
Interbank Rate	0.022	0.01			
Dividend Rate	0.8	0.03	Reserve Ratio	0.03	0.01
Lender Equity	0.83	0.08	Equity Ratio	0.05	0.02
Borrower Equity	1.67	0.61	Interbank Confidence	0.98	0.01

Individual bankruptcy

λ	Interbank Connections	Number of bankruptcies	Contagion %	Size given contagion	Largest Shock
0	179	1.62	22.6	7.16	19.8
0.1	387	1.59	21.3	7.45	24.6
0.2	683	1.43	18.3	7.82	28.9
0.3	986	1.17	14.4	8.10	28.8
0.4	1294	0.96	10.5	9.15	29.8
0.5	1622	0.71	7.4	9.58	27.5
0.6	1929	0.57	5.2	10.89	27.2
0.7	2273	0.43	3.6	11.75	25.8
0.8	2568	0.35	2.6	13.46	26.0
0.9	2957	0.26	1.8	13.93	23.4
1	3270	0.22	1.3	16.79	23.1

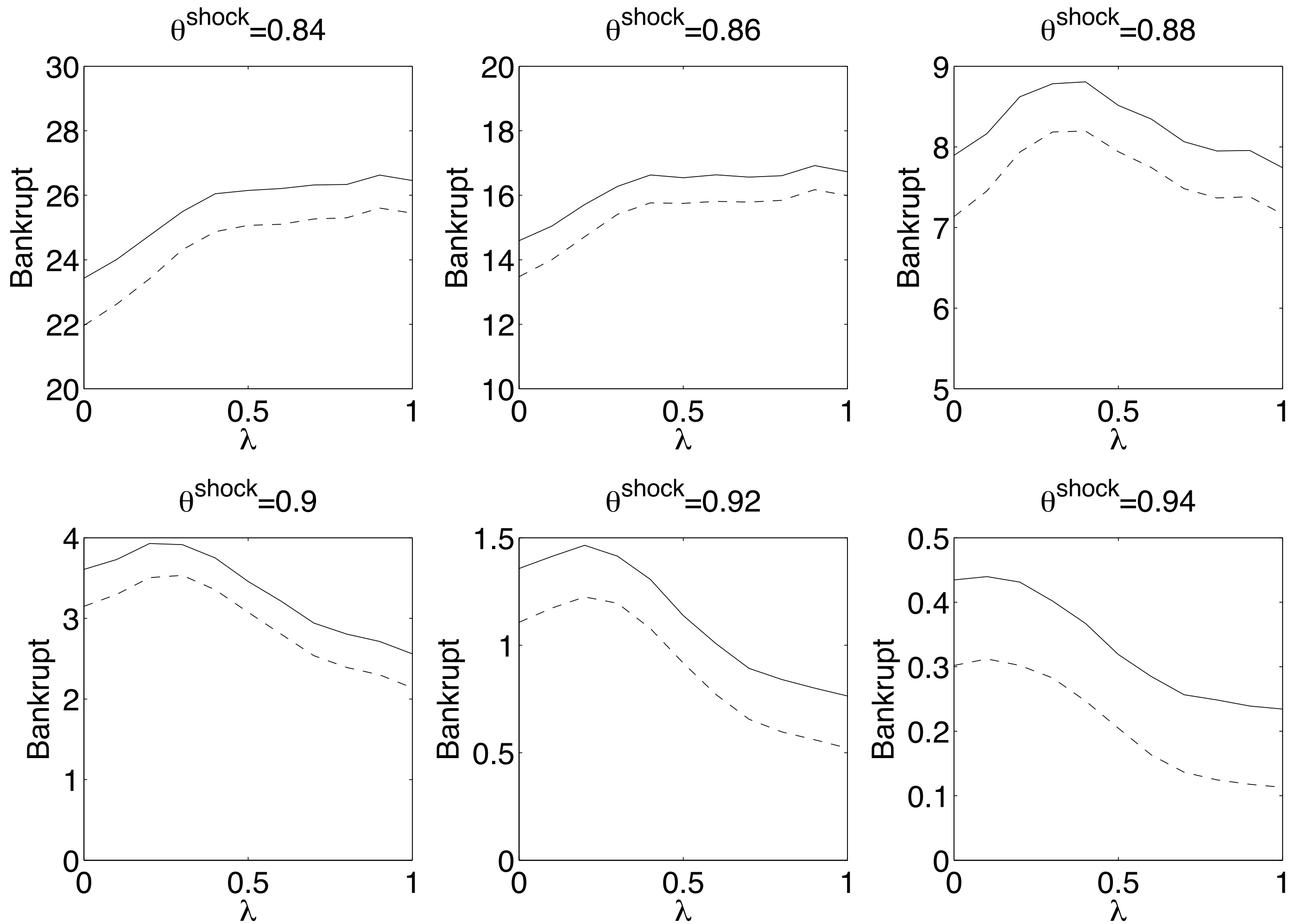
Probability – Angelini et al. (1996) and Boss et al. (2004)

Contagion – Giesecke & Weber (2006) and Freixas et al. (2000)

Size – Upper and Worms (2004) and Humphrey (1986)

Systemic Shock

– Change probability of project success



Systemic component is significant:
- Giesecke and Weber (2006) and Brusco et al. (2007)

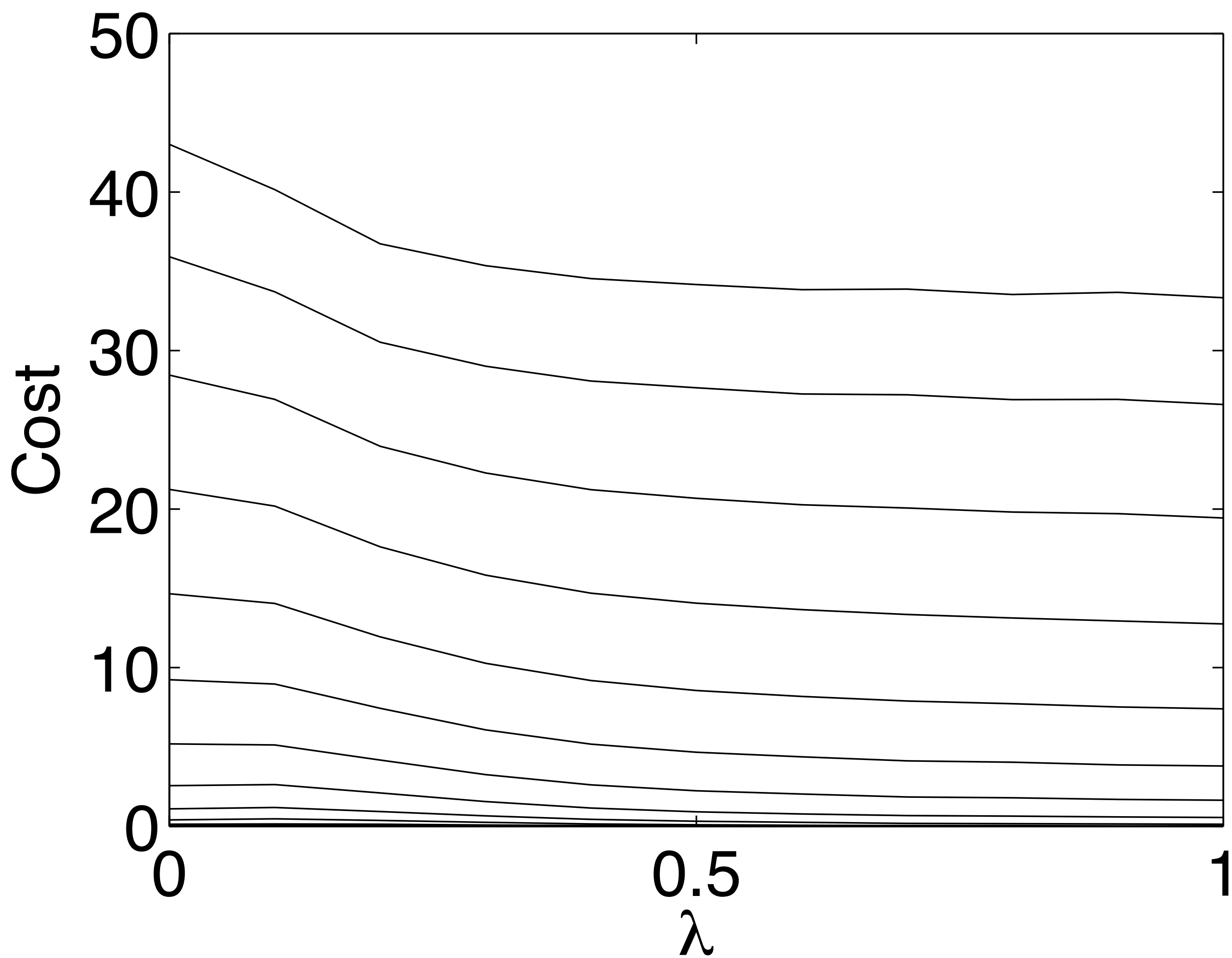
Interbank rate increases
- particularly for unconnected markets

Interbank market confidence heavily reduced
- Brusco & Castiglionesi (2007)

Loans and deposits reduce proportionate to size of the shock

Effects of bankruptcy continue into the future
- Intermediately connected markets particularly badly effected

- Welfare effect – cost of bankruptcies



Market Confidence

- During the financial crisis confidence in the market evaporated

Reduce probability of being repaid by

$$\kappa B_t$$

Where kappa is optimised for each bank and B_t is the number of bankruptcies this period

Credit worthiness

- Banks are more willing to lend to those banks who are more likely to repay
  - In this case those with more equity

- Rate at which banks may borrow at is increased for each bank by

$$|N(0,1/E_j)|\%$$

Credit and Market Confidence

	Market Confidence		Credit Worthiness	
	Number	Max Size of Failure	Number	Max Size of Failure
0	1.39**	20.52	1.3**	21.85**
0.1	1.34**	28.98**	1.39**	25.43
0.2	1.28**	31.00*	1.19**	23.98*8
0.3	1.1	30.59	0.78**	22.3**
0.4	1	34.39**	0.58**	22.76**
0.5	0.84*	33.47**	0.44**	22.74**
0.6	0.68*	32.46**	0.32**	20.81**
0.7	0.67**	35.05**	0.26*	20.56**
0.8	0.49*	32.29**	0.2	20.59*
0.9	0.6**	39.55**	0.19	21.65
1	0.57**	41.9**	0.16	23.16

Conclusions

The market does a good job of replicating stylised facts of real interbank markets, despite its simplicity

For small shocks, more connected markets are less likely to suffer from contagion but when they do it may be more severe

The relationship between systemic shocks, the structure of the interbank market and contagion is complex

No optimal Inter bank market structure

Conditioning on credit worthiness leads to increased stability.

Conditioning on Market confidence has the opposite effect.