Credit risk evaluation for loan guarantee chain in China

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Outline

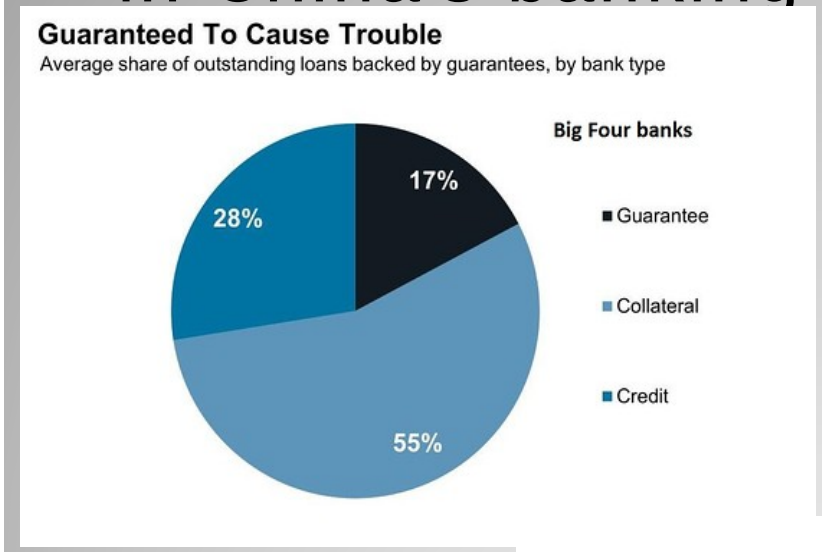
- 1. Introduction
- 2. Related Works
- 3. Our strategy
- 5. Experiments
- 6. Conclusions & discussions

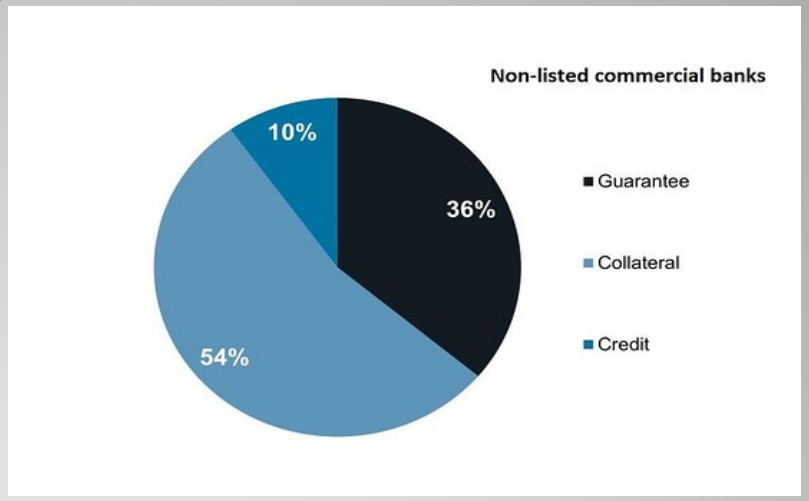
P1 introduction

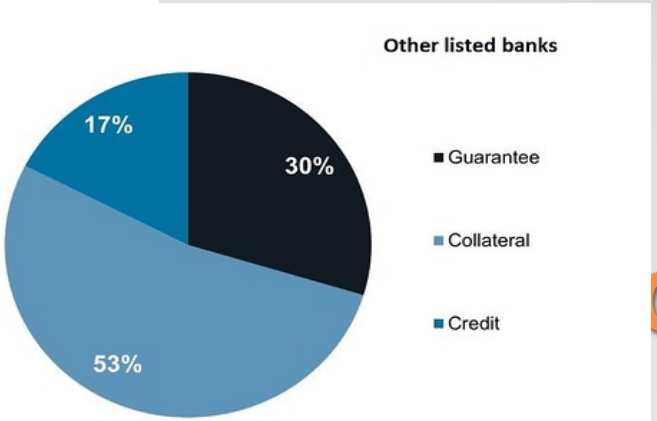
Background

- Bank loan, the most popular approach for Small and Medium Enterprises (SME) to raise money in china.
- However, commercial banks , reluctant to extend loans to these enterprises without explicit backing.
- SME, seeking for other companies to back loans for them, thus forming the loan guarantee chains→ Risk sharing mechanism

- Guaranteed loan: about a quarter of loans in China's banking system



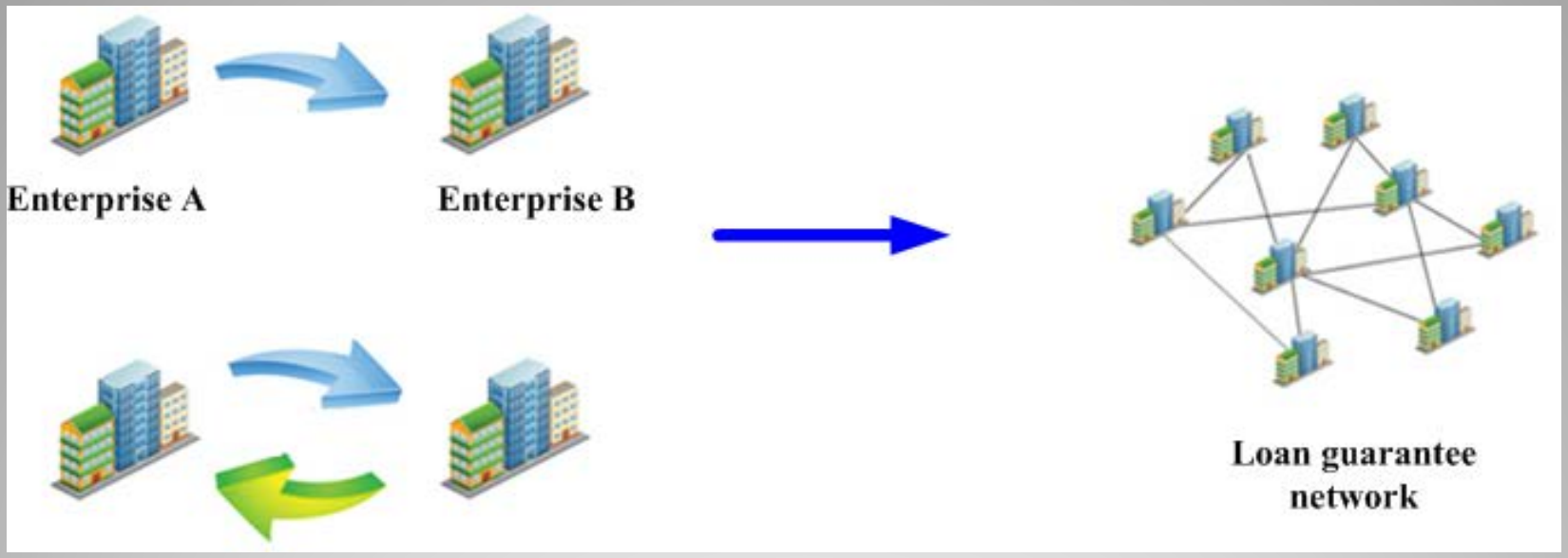




Note: Collateral typically refers to land or government bonds. Credit means the loan is not explicitly backed by anything.
Source: WIND Info. Non-listed commercial bank figures are based on data from a sample of 26 banks

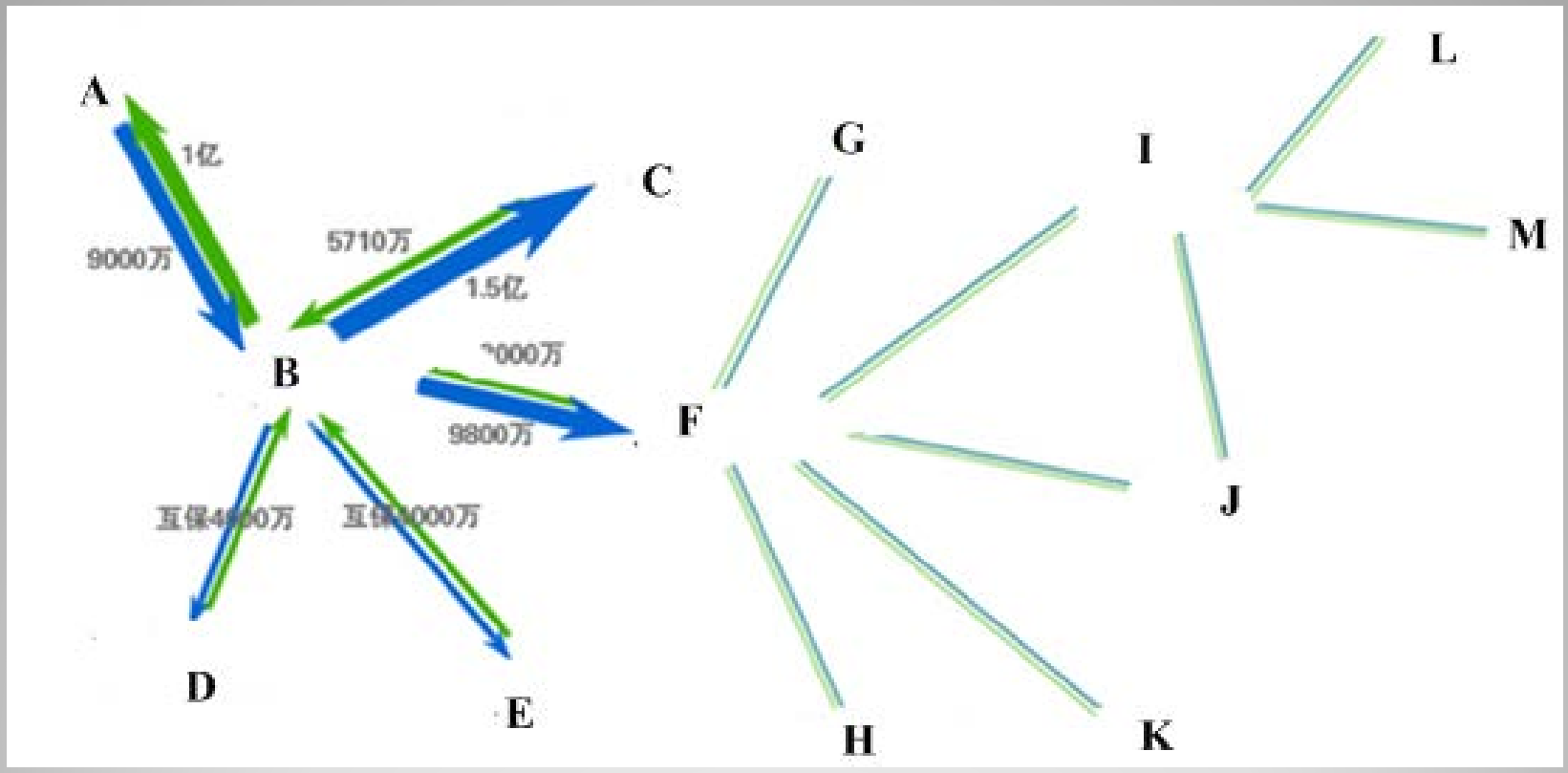
WSJ.com

Real finan China , 2014



The guarantee relationship among enterprises: quite complicated and inter-wined, thus forming a huge financial network

Formation of loan guarantee network



Risk contagion

- Impact of the loan guarantee chain in China
  - With the economy up, development of economy.
  - However, with the economy declining, financial disasters.
    - Wide-spread of default risks within enterprises across different regions and different vocations.
  - threatening to spread financial contagion from struggling firms to more healthy parts of the economy
- Ongoing financial crisis caused by guaranteed loan
  - From Yangteze Delta region to circum-Bohai sea region , some other economic emerging regions
  - Exploding in various industries in China, such as iron and steel business, Textile industry
  - Leading to the increase of loan default rate right now
  - Similar to epidemic disease

Traditional analytic strategy

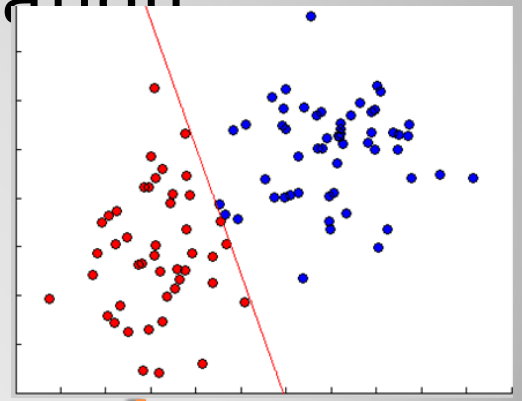
- Vector space model
  - Modeling financial entities described by feature vectors, such as:
    - Character, Capital, Collateral, Capability, Condition and Stability.
  - Credit behaviors of enterprises.

Enterprise	Credit history (year)	Overdue records	Overdue amount (thousand)	Inquire records	Credit amount (million)
A	10	3	1000	0	500
B	5	4	30002	2	10

- Risk prediction model
  - The classical models for quantifying the credit risk are linear regressions.

$$R = k_1 * x_1 + k_2 * x_2 + \ldots + k_n * x_n + b$$

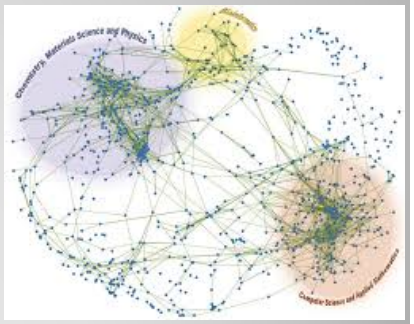
  - More complex models applied:
    - SVM& Neural network
- Hard to interpret financial relation

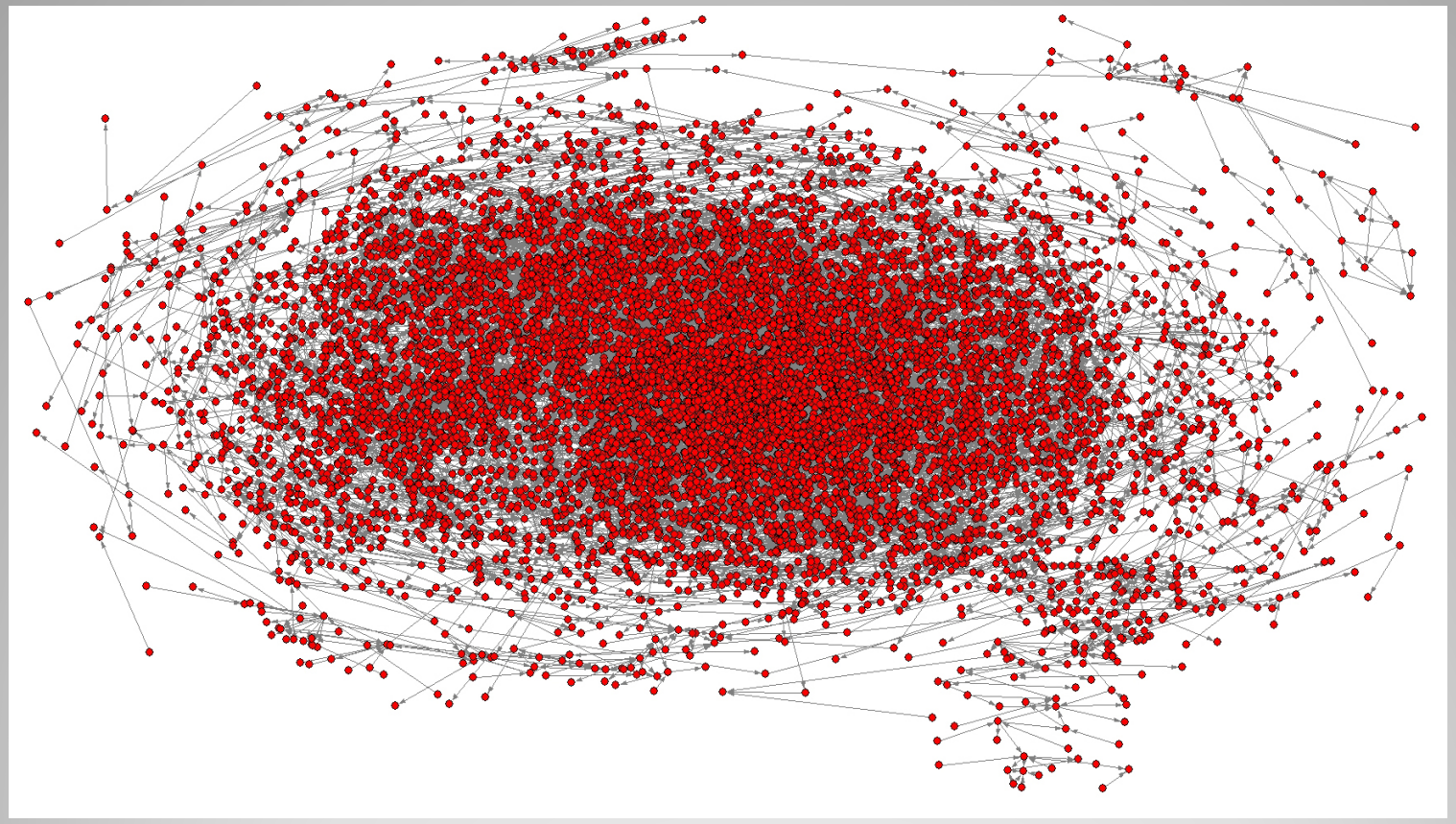


Traditional analytic strategy

Complex network analysis

- Network science
  - A powerful tool to analyze the relations among entities.
  - Successful application in social network and information retrieval
  - Some application of economics & finance, especially for the system risk
- Sometimes, relationship is more reliable than behaviors!





Real example of loan guarantee network

- Modeling the loan guarantee chain by complex network theory
- A novel network based credit rating strategy to measure the credit worthiness of enterprises
- Testing our strategy in the real guarantee loan dataset

1.3 Our contributions

P2 Related work

2. Related Work

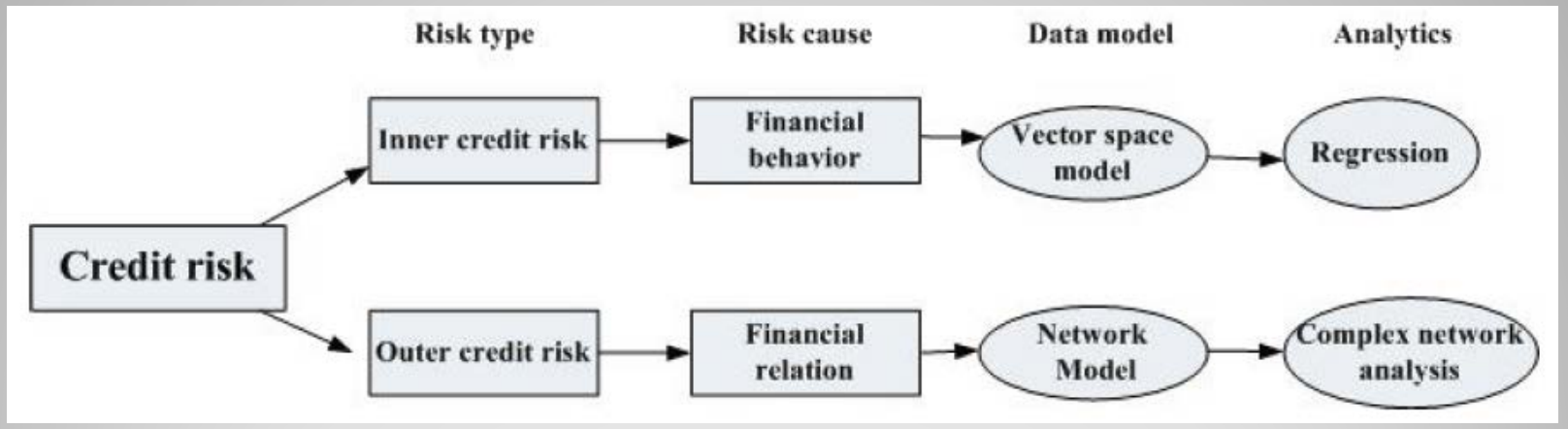
- Researches about credit risk caused by guaranteed loan, mainly in China
  - Zhang, Li, & Guo, 2012
    - Analyzing the guarantee chain's infecting process and modeling the critical condition with infection models.
  - Zhang, 2011
    - A basis analysis about the risk sharing mechanism, the risk reduction mechanism and risk contagions of the guarantee chain
  - Leng, Zhang and Xing, 2014
    - adopting regression models to analyze the transfer of risks to guarantors.
- No complex network analysis work

2. Related Work

- Complex network researches in economics & finance
  - Complex Network in Finance (Nature physics 2013)
  - Vitali et al, 2011
    - DebtRank, a novel measurement of banks w.r.t. their systemic impact;
  - Battison et al, 2012
    - The control network consisting of transnational corporations;
  - Van Vlasselaer et al, 2013
    - Social network analysis to detect the fraud transactions.

P3 : our strategy

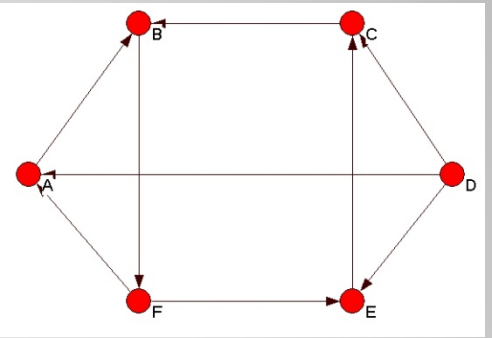
- Two types of credit risk of a financial entity:
  - Inner credit risk: the financial condition of itself
  - Outer credit risk: risk diffusions within the correlated financial entities.



New analytic framework

Complex network modeling

- Enterprise--→Nodes in the network
- Loan guarantee relations among enterprises--> Directed edge
  - Along the edge, the first enterprise backs the second one to get money
  - The weight of the edge



Credit rating

- Providing information about credit quality.
- Classical credit rating by vector space model
- Drawback of the classical credit rating
  - Taking each financial entity individually
  - Neglecting the correlations within different financial entities;
- One related concept: support ratings
  - Financial entitis supported by other entities.
  - The impact of the adjacent financial entities.

New credit rating strategy

- Basic idea:
  - Based on relation among enterprises
  - More central, more risk
    - Easy to default ,
    - threatening the whole system
- K-shell decomposition method
  - A centrality measure of complex network
  - Partitioning a network into sub-structures directly linked to centrality. (Batagelj & Zaversnik, 2011)
  - Assigning an integer index, *ks*, to each node, indicating the location of the node in the network according to its connectivity patterns.
    - The k-shell value of each node : proportional to the central location in the network.

Basic knowledge

- Some definitions
  - Degree: the degree of an enterprise in a loan guarantee network is the number of edges connected to it.

$$k_i = \sum_{j=1}^{n} A_{ij}$$

  - In-degree: the number of ingoing edges connected to an enterprise.

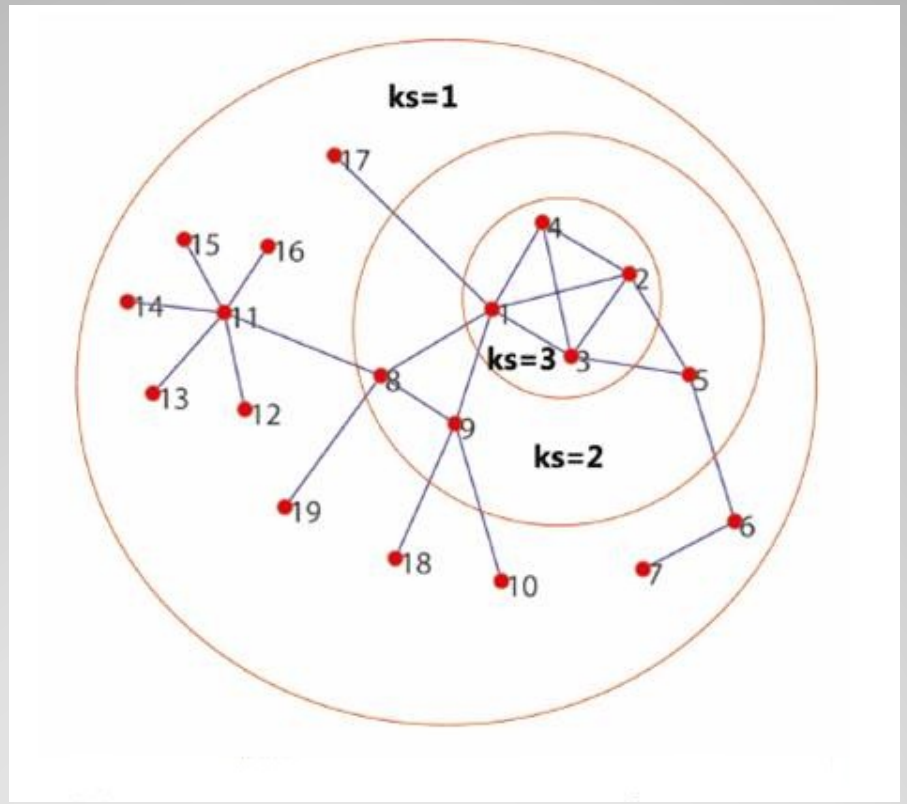
$$k_i^{in} = \sum_{j=1}^{n} A_{ij}$$

  - Out-degree: the number of outgoing edges connected to an enterprise.

$$k_j^{out} = \sum_{i=1}^{n} A_{ij}$$

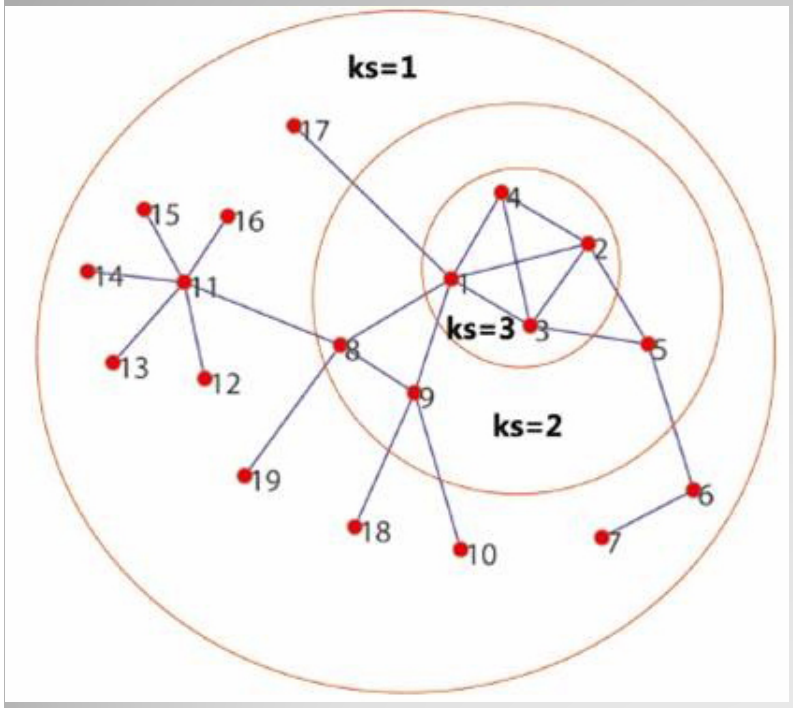
NetRating strategy

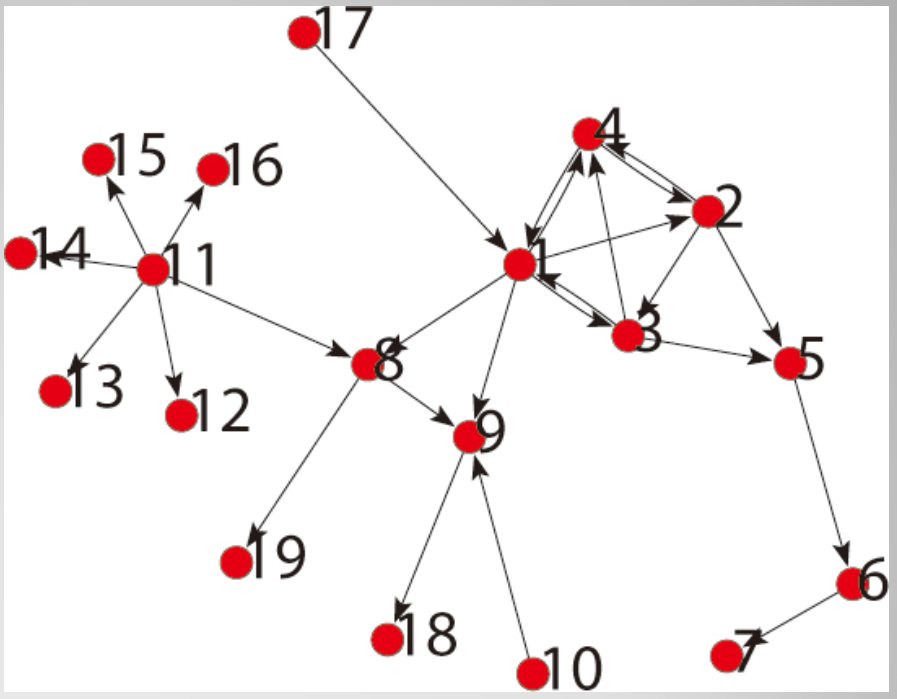
- Undirected guarantee network
- Measuring the outer credit risk of enterprises by their degree
- The outer credit risk of an enterprise by its *ks* values obtained from the standard k-shell decomposition method.
- Enterprises with high ks values -> more susceptible->outer credit risk.
- Automatic strategy without previous parameters setting



Example for NetRating

- The directions of edges: more insights

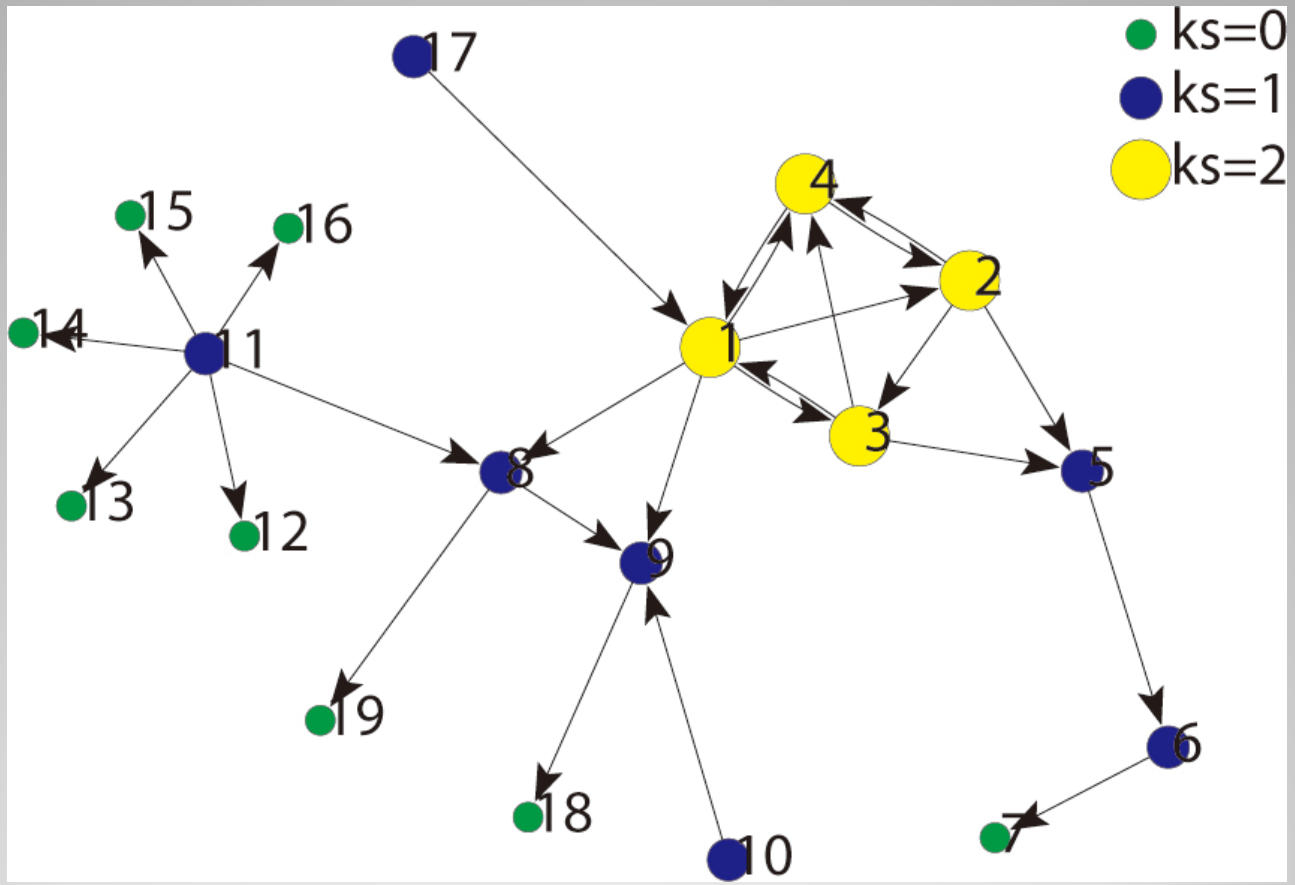




For directed network, work?

Directed NetRating strategy

- The directed k-shell decomposition method
  - similar pruning routine as the standard *k*-shell decomposition method.
  - More information: Direction of edge
- Directed guarantee network.
  - Measuring the outer credit risk of enterprises by considering the out-degrees of the enterprises.
  - The credit rating of an enterprise is smaller with backing loans to multiple other enterprises (more risk)
  - Utilizing more information than NetRating strategy



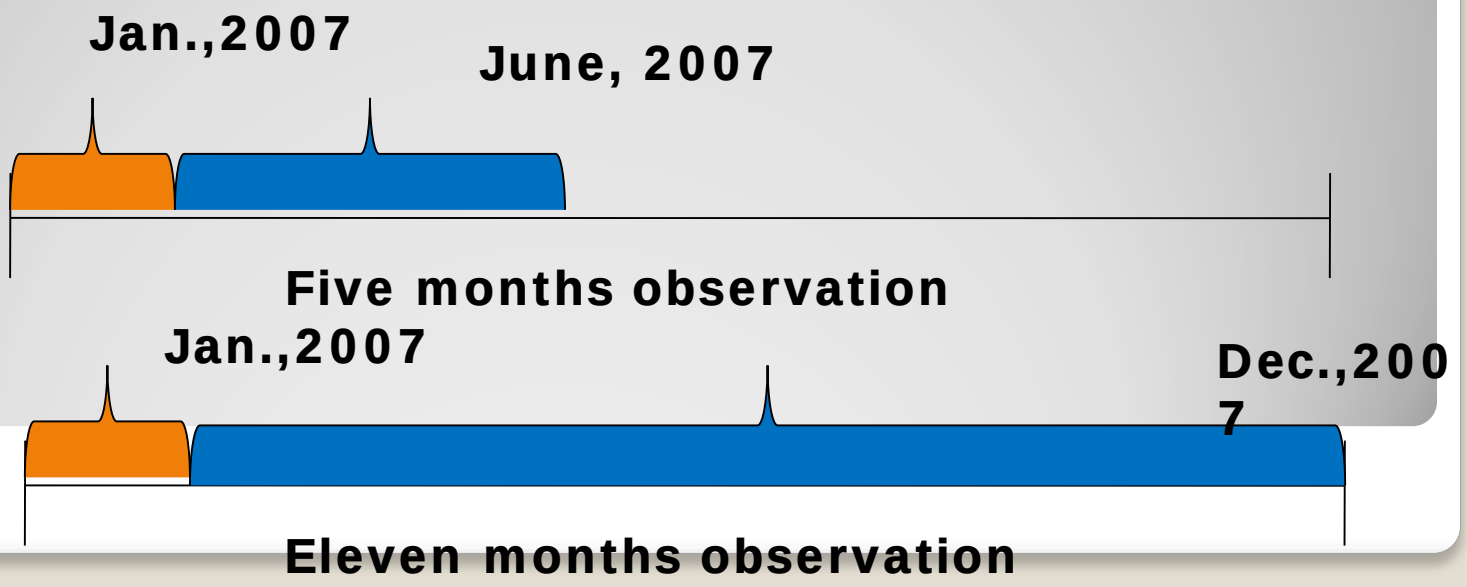
Example of directed NetRating

P4 Experiment

Data introduction

- The data set
  - Credit Reference Center, People's Bank of China
  - 12 months during 2007, with each month corresponding to one snapshot of the guarantee networks.
  - More than 10,000 enterprises
- Guarantee networks
  - The original guarantee networks connected. For simplicity, only considering the maximal connected components

- Only exploring the outer credit risk of enterprises
- Evaluation scheme
  - Credit rating for enterprises from the network in the 1st month
  - Checking the default situation of enterprises with credit rating after certain time period



- With NetRating, four level of ks value over the 1st snapshot network: 1, 2, 3, 4
- The mappings from the ks values of enterprises to their credit ratings: The larger ks value, the lower credit grade

ks	Credit grade	Credit quality
1	A	Strong
2	B	Adequate
3	C	Speculative
4	D	Vulnerable

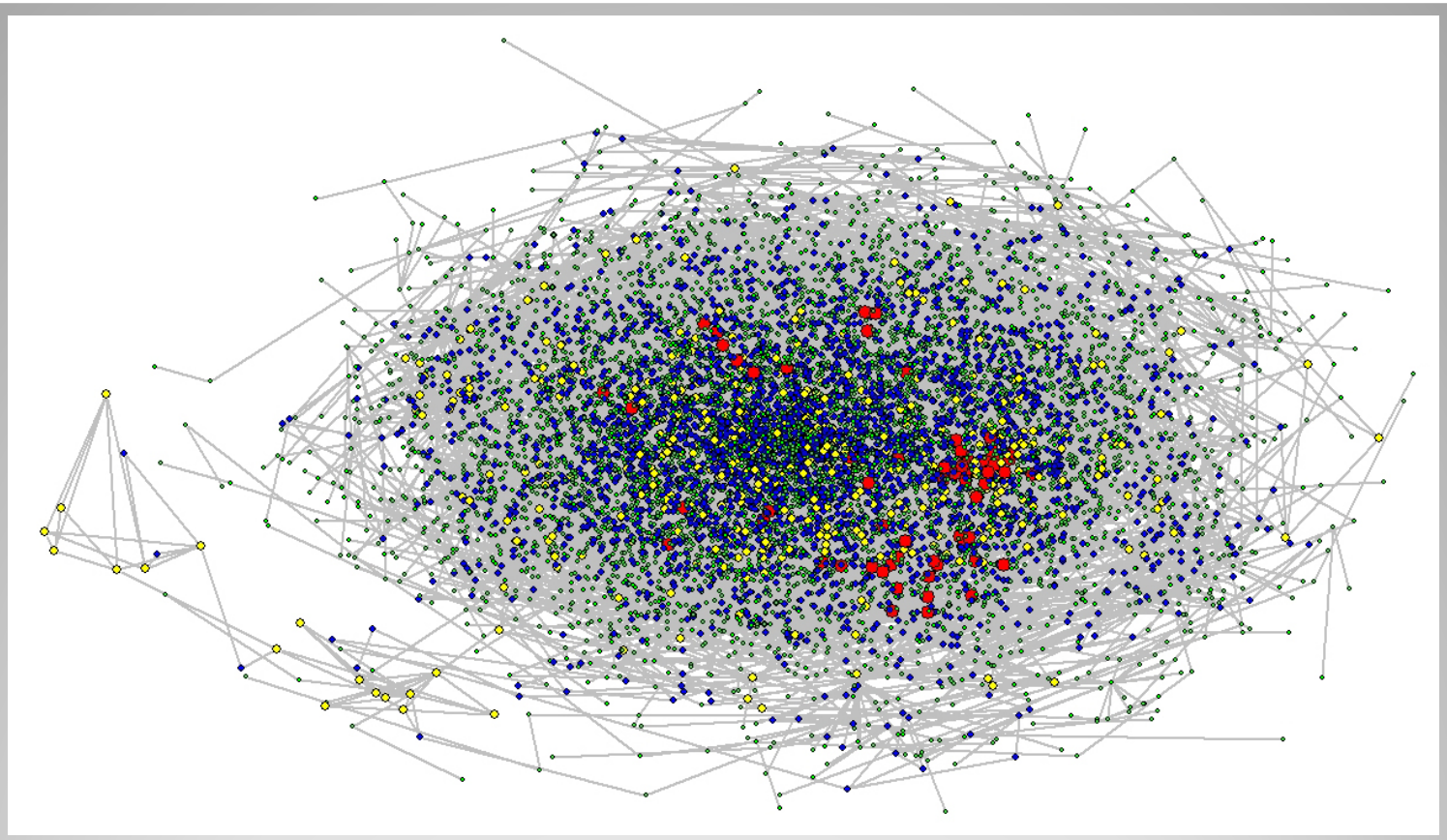
Evaluation of the NetRating strategy

- Comparison of default rate of enterprise with different credit rating

Credit grade	Company number	Default rate (half-year)	Default rate (1-year)
A (ks=0)	3452	0.93%	1.25%
B (ks=1)	2328	2.28%	2.96%
C (ks=2)	428	5.84%	8.41%
D (ks=3)	61	0	0

- In general, the enterprises with larger ks value, the lower credit rating, easier to default
- Why it doesnot work when ks =3? No directed information

Evaluation of the NetRating strategy



Visualization of the NetRating strategy

Evaluation of the directed NetRating

- With directed NetRating, three level of ks value over the 1st snapshot network: 1, 2, 3
- The mappings from the ks values of enterprises to their network based credit ratings: the larger ks value, the lower credit rate

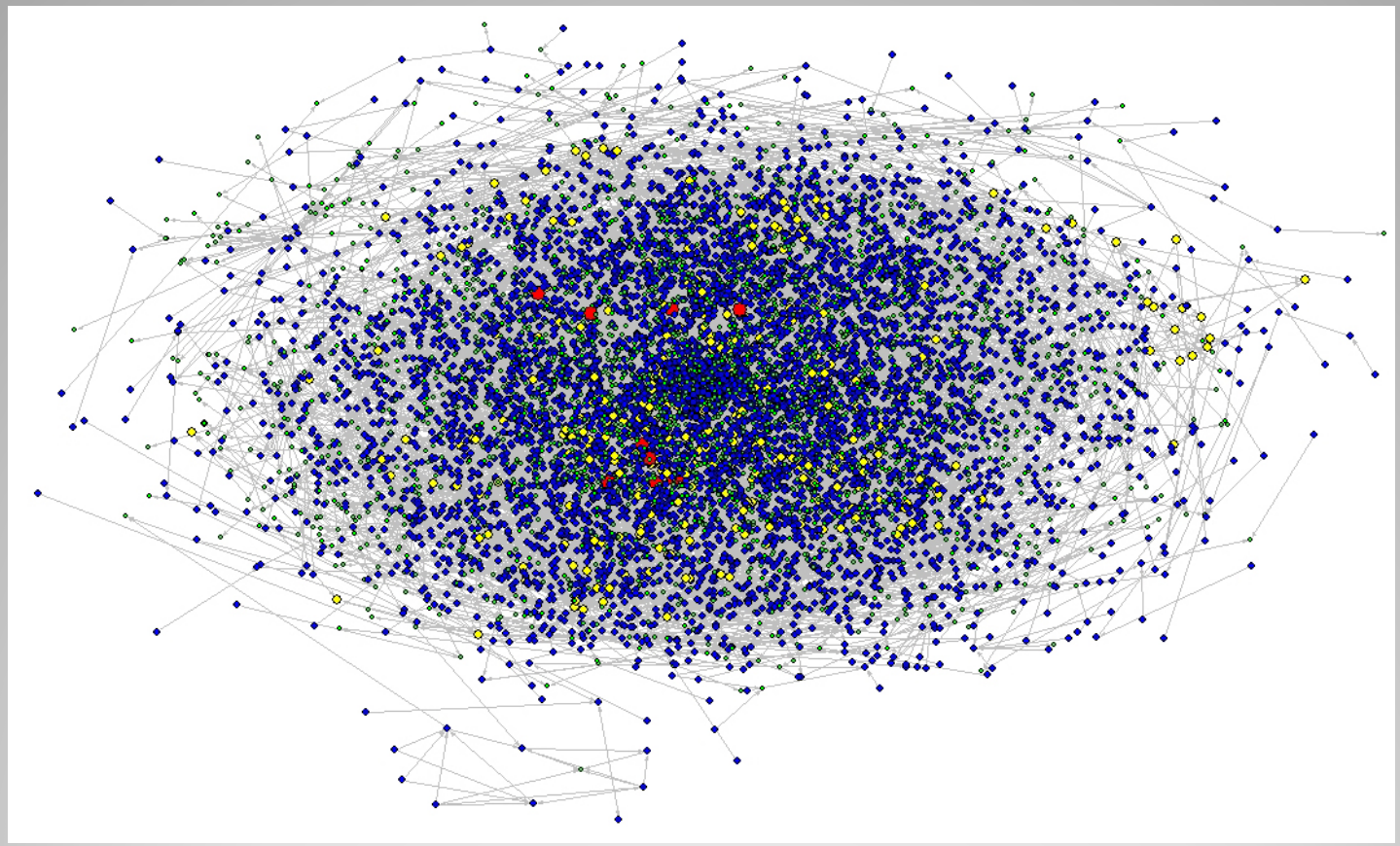
ks	Credit grade	Credit quality
1	A	Strong
2	B	Weak
3	C	Vulnerable

- Comparison of default rate of enterprise with different credit rating

Credit grade	Company number	Default rate (half-year)	Default rate (1-year)
A (ks=0)	5959	1.66%	2.25%
B (ks=1)	299	2.01%	2.68%
C (ks=2)	11	45.45%	54.55%

- The enterprises with larger ks value, the lower credit rating, more central, easier to default
- The enterprises with largest ks value, the highest default rate

Evaluation of the directed NetRating strategy



Visualization of the directed NetRating

P6 Conclusion

Conclusions

- Complex network model for describing the risk of enterprises caused by guarantee relation among them
- With NetRating, managing the financial risk of guaranteed loans in a quantitative way.
- With directed NetRating, the use of direction information
- According to experiments, our strategy makes sense: the more credit rate, the more default risk

Discussions

- Only considering the outer risk of an enterprises involved in the guaranteed loan, integrating our strategy with classical credit rating techniques
- More helpful with the weights of edges taken into consideration
- More valid evaluation measures
- A starting point for credit risk analysis of loan guarantee chain

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Thank you for your attention!

Any questions~