• To address whether economic research can benefit from concepts, theories and methodologies of other disciplines.
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• Measurement & Internalization of Systemic Risk in Global Banking (& CCP Clearing) Networks

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Objectives

• 1. To measure the systemic risk of each country in the network

• 2. To allocate it to the country that generates it according to the “contribution” made in terms of capital charges.

3. To assess the fragility of the global bank network
Systemic Risk

• Three key elements:

- Domino Effect
- Contagion
- Systemic Important Institutes

Source: Oxford Banking Dictionary, 2010
Two Sources of Literature

• 1. Portfolio Approach versus
• 2. Complex System Approach
1. Portfolio Approach

• 1) Early study: to identify contagion after controlling the fundamental common factors
• 2) Treat banks as asset portfolio using option pricing model
• 3) Recent study: non-parametric estimation, extreme value theory, VAR
Three Problems need to be Addressed

• Emphasis on the magnitude of a bank not so much on the connectivity
• Limited sample
• Limited common factors
2. Complex System Approach

• 1) Early study: complete structure & incomplete structure
   (Allen Franklin & Douglas Gale)

• 2) Identify more complex topology of specific markets

• 3) Extensive research on systemic risk
Two Problems need to be Addressed

- Emphasis on topology without dynamics
- Application of complex theory
Construction of A Global Bank Network

Data: Bankscope

• 30,000 from 2009 to 2011
• consolidated & unconsolidated balance sheet

Information used:

• branches and subsidiaries
• “ownership” category
Yifan Hu algorithm in Gephi
Communities identified (2008 V. Blondel et al algorithm)
Measurement of Systemic Risk

\[
\begin{align*}
\frac{dI_k(t)}{dt} &= -\mu I_k(t) + \lambda k S_k(t) \Theta(\lambda, t) \\
\frac{dS_k(t)}{dt} &= -\lambda k S_k(t) \Theta(\lambda, t) + \mu I_k(t) \\
S_k(t) &= 1 - I_k(t) \\
I_k(0) &= I_k^0
\end{align*}
\]
Different meaning of “Virus” in Banking Network

• Virus = Default
  Default is situation that banks are unable to observe their debt obligations or service their liabilities.

• Major Reason: liquidity shortage

• Link = a transaction between bank A and B
Crisis Outbreak Threshold $\lambda_c$

• A Topology related Threshold:

  $\lambda_c = \langle K \rangle / \langle K^2 \rangle$, for scale free network

  $\lambda_c = 1 / \langle K \rangle$, for regular network
Internalization of Systemic Risk

• Shapley-Value: cooperative game

• A bank network that has n banks will consist of $2^n$ subsystem which are: $\emptyset$, {1},{2}...{n},{1,2},{1,3}...{n-1,n}...{1,2...n}.

A case of 3 banks:

• $SV(bank_1) = \frac{1}{6} \{ 2^*[\Phi\{1\}-0] + [\Phi\{2,1\}-\Phi\{2\}] + [\Phi\{3,1\}-\Phi\{3\}] + 2^*[\Phi\{2,3,1\}-\Phi\{2,3\}] \}$

A general formula:

$$SV_i(\Sigma) = \frac{1}{n} \sum_{n_s=1}^{n} \frac{1}{C(n_s)} \sum_{s \supseteq i, |s|=n_s} [\Phi(s) - \Phi(s-\{i\})]$$
The Challenge

1. The SV of the subsystem
   • Largest component or average

2. The topology of the remaining network may change,
   • Kolmogorov-Smirnov tests
SV
Objectives

• 1. To measure the systemic risk of each country

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Capital Charges

- The Capital Charge is an instrument to curb systemic risk by regulators
- Conversion from SV to the Capital Charge
Holling Type Two Function
Capital Charges

• Holling Type two Function

• Capital Charge =
  \[ SV(\lambda c)^n / (1+SV(\lambda c)^n) \]
• Where \( n=1,2\ldots N \)
Country Level Capital Charges

![Graph showing Capital Charges for various countries]
Comparison
Objectives

1. To measure the systemic risk of each country
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3. To assess the fragility of the global bank network
First Experiment- Sequential Shocks

• **The original shock** which has caused liquidity problem of targeted country and withdrawal of banks from overseas

• **The induced shock** which has caused re-location of banks that link to the original crisis-attacked-banks
The Number of Banks without Shocks: $6+5+1=12$
The Number of Banks with Shocks: $3+3+1=7$

1 Round (original): A is reduced by half;
2 Round (induced): B,C are reduced by half

- A
- B
- C

B

C

0

1

2

1

2

1

2
Withdrawal Strategies

• “Gradualism” versus “Big Bang”

• In this research, “Gradualism” = withdraw half of a bank’s assets in the crisis-shocked country
Rewiring Strategies

• The new targeted country can be chosen by two strategies: new territory development strategy and clustering strategy

• If there are more than one countries that the withdrawal capital can be relocated to, then random strategy is followed
Second Experiment
-Directional Shocks

- Out-degrees versus in-degree
- Why it is important?
  Export or import financial service products
  Two strategies for a nation’s economic development:
  1) “Export promotion”
  2) “Import substitution”
The Impact Factor

\[ I_i^{(1)} \equiv B_i^{(0)} - B_i^{(1)}, \]
\[ I_i^{(2)} \equiv B_i^{(1)} - B_i^{(2)}. \]

• In terms of out-degree (strength) and
• in-degree (strength),
Conclusions

• 1. Constructed a global banking network
• 2. Evaluated the country level systemic risk and suggest capital charges for regulation (Combine individual risk control policy with the systemic risk control policy)
• 3. Sequential shocks have different impacts on countries. Export oriented countries need to prepare more “capital cushion”
Current research

• Optimal Structure of a Financial Clearing System,
• Focus on Interoperability Central Counterparty System
• Basic reproduction number in epidemic spreading model