Model for Systemic Risk Propagation in Financial Networks

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Outline

• Introduction
• Bubbles and cascading financial crisis
• Systemic risk implications
• Financial networks as complex systems
• Summary
• Discussion
Introduction

• Economic systems are globally interconnected
• Exogenous or endogenous shocks can provoke cascading failures
• Financial systems are susceptible to sharp transitions from seemingly stable to irreversibly unstable states
• Sound policies are necessary to halt cascading failures or soften their impact
Market Capitalization of exchange-listed companies – EU candidates

- Euro Zone
- Croatia
- Iceland
- Macedonia
- Montenegro
- Serbia
- Turkey
What happened to Iceland?

- In 2001 banks were deregulated
- By 2007, three major banks in Iceland held foreign debt of over €50 billion compared to Iceland’s GDP of €8.5 billion
- The crisis contributed to the collapse of all three of the country's major banks following difficulties in debt refinancing and a run on foreign deposits
- In 2007, The Economist ranked the Icelandic krona as the most overvalued currency in the world
- The 2008–2012 financial crisis is characterized as a major economic and political crisis in Iceland
- Relative to the size of its economy, Iceland’s banking collapse is the largest suffered by any country in economic history

Systemic Risk

- Global financial crisis of 2007-2012
- Considered to be the worst crisis since the Great Depression of the 1930s
- Propagated value deterioration of most financial markets around the world
- Contributed to potential complete collapse of major financial institutions
- Involved national governments in bailing out too-big-to-fail banks
Systemic Risk

- Adversely affected the housing market and real estate prices globally
- Contributed to increased unemployment rates and prolonged workforce unemployment
- Significantly reduced consumer wealth and quenched appetite for spending
- **Contributed to the European sovereign-debt crisis**
Systemic Risk

• In light of the sovereign debt challenges faced by the Eurozone countries:
  – In December 2011, the European Central Bank committed to provide €1 trillion of funds for the European banks for up to three years in attempt to stem the effects of the most recent financial crisis
  – This injection of liquidity intends to give the European governments three years to make necessary fiscal adjustments
  – Only time could tell whether this added liquidity into the European banking system will end the European sovereign debt crisis
Sovereign Debt Crisis

• Selected Eurozone countries considerably increased their borrowing to unsustainable central government debt to GDP ratios:
  – The Greek and the Irish debt crisis only a wake-up call for the EU
    • Greek GDP - $300 billion
    • Irish GDP - $200 billion
    • Combined, smaller that the GDP of Pennsylvania.
  – Italy and Spain – much larger economies -> bigger problems
    • Italy has close to €2 trillion debt outstanding with 50 percent financed externally
    • Spain has over €700 billion of public debt outstanding and unemployment rate of 22 percent (Federal Reserve Bank of St. Louis, 2011).
Government Debt for the PIIGS countries, Germany, France and the United States

Data Source: IMF Historical Public Debt Database.
Financial Institution Network

• Two channels of bank risk contagion
  – Direct *interbank liability linkages* (focus is on credit risk and loss propagation via the complex network of direct counterpart exposures)
  – Contagion via *reduction in bank asset value* (focus is on financial shocks to specific bank assets that contribute to asset value deterioration which adversely affect other banks with similar asset structures)
Definitions, parameters and data

- Initial shock to the banking system by reducing \((1-p)\) of the value for specific asset
- Magnitude \((\alpha)\) of overall market value damage for specific asset that spreads throughout the banking network
- Distress barrier \((\text{total assets/total liabilities})\)
- Randomness factor \((r)\) – uniformly distributed random number in range \([0, \eta]\) used to adjust the distress barrier \((\text{assets/liabilities} < 1-r)\)
- US CB-BS database from 1976 to 2008
- US FBL-FDIC database from 2008 to 2011
Bipartite network model for systemic risk propagation

• Analyze the properties of the defaulted vs. survived banks during the 2007-12 financial crisis

• Study cascading failure of banks to show that the complex network method captures important features of the financial system

• Examine banks’ balance sheets to assess current stability of the financial system and attempt to forecast future network behavior

• Test the model using 2007 data from the FDIC failed bank list
Bank-Asset Bipartite Network

\[ w_{i,m} = \frac{B_{i,m}}{B_i} \]

\[ s_{i,m} = \frac{B_{i,m}}{A_m} \]
Distributions of typical bank assets

- Weight of Loans for construction and land development
- Weight of Loans Secured by 1-4 family resid. properties
- Weight of Loans Secured by nonfarm nonresidential properties
- Weight of Agricultural Loans

Graphs show the probability density function (PDF) for all banks and failed banks.
Distribution of leverage (equity/assets) ratios

Probability Density Function (PDF)

(value of equity)/(value of total assets)

- all banks
- failed banks
Fraction of survived banks after cascading failures

Loans for construction and land development

Loans secured by 1-4 fam. resid. properties

Loans secured by nonfarm nonresid. properties

Agricultural loans
ROC curves of bank failure prediction

Loans for construction and land development

2007, asset:0;allsteps

2007, asset:0;firststeps

2007, asset:0;othersteps

totally 287 banks fail since 2007

(number of banks identified through the first step)
(number of failed banks identified through other steps)

(0.14, 0.26, 0.6)
(0.38, 0.02, 0.65)
(0.24, 0.02, 0.55)
(0.2, 0.02, 0.45)

(α, η, p)
ROC curves of bank failure prediction

Loans secured by nonfarm nonresid. properties

2007, asset:4;allsteps

2007, asset:4;firststeps

2007, asset:4;othersteps

(0.65, 0.8) (0.25, 0.25, 0.7) (0.15, 0.2, 0.65) (0.05, 0, 0.6)

num of failed banks identified through the first step
num of failed banks identified through the other steps
ROC curves of bank failure prediction for assets that do not have major contribution in bank failures

Loans secured by 1-4 fam. resid. properties

Agricultural loans
Survival rate of banks when specific asset is initially shocked as function of one parameter

Test asset - Loans for construction and land development

Bank survival rate as function of one parameter while the other two parameters are kept constant
Summary

- Financial and economic systems are highly interdependent and fragile
- Bank network (banks own sovereign debt)
- Sovereign debt levels (value affects bank worth)
- Financial markets (banks and national debt are traded on securities markets)
- Currency dynamics (responds to economic dynamics by appreciating or depreciating)
Discussion

• We study systemic risk propagation through interdependent financial networks
• Focus on the challenges of financial and economic system dynamics as strongly related networks

• How to transform global economic networks into more resilient systems to shocks?
• Do crisis have common ingredients?
• Can we apply proposed methods and models universally?
Questions?

Thank You!