Asset fire-sales, contagion and systemic risk - Evidence from the South African banking sector

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Motivation

- Growing interconnectedness in the banking sector
  - Upside: Diversification and risk sharing
  - Downside: Intensifying amplification of shocks and contribution to systemic risk
- How to measure and quantify systemic risk?
  - Which bank contributes most?
  - Which assets?

Outline

- Systemic risk and fire-sale spillovers - a model of asset fire-sale propagation for South African financial system
  - Model framework
  - Results
- BlackRhino
- Data on Capital flows
  - Morning Star & ASISA

Literature on systemic risk

- Systemicness: Size? Leverage? Connectedness?
  1. Infer bank linkages from correlations in market prices.
     CDS spread and bonds (Ang and Longstaff (2011), Giglio (2011))
     Comovement in equity returns (Adrian and Brunnermeier (2010), Acharya, Pedersen, Philippon and Richardson (2010), Billio, Getmansky, Lo, and Pelizzon (2010), Diebold and Yilmaz (2011) of financial intermediaries
  2. Study amplification from balance sheet linkages
     De Haas and van Horen (2011),
  3. Simulations and scenario analysis (Arvai et al. (2009))

$\rightarrow$ Implementation of asset fire-sales propagation model for the South African banking sector.

Model overview

- Banking sector model - Shock propagation via fire-sales

Framework from Greenwood et al. (2015)

- Initial shock: An initial exogenous shock hits the banking system. This can be a shock to one or several asset classes, or to equity capital.
- Direct losses: Banks holding the shocked assets suffer direct losses which lead to an increase in their leverage.
- Asset sales: In response to the losses, banks sell assets and pay off debt.
- Price impact: The asset sales have a price impact that depends on each assets liquidity and the amount sold.
- Spillover losses: Banks holding the fire-sold assets suffer losses from spillovers

Fire-sale spillovers: Model set up

- Banks $i = 1, ..., N$ and asset classes $k, ...K$
- Bank i has total assets a_i with portfolio weight m_{ik} on asset k such that $\sum_k m_{ik} = 1$. On the liability side, bank i has debt d_i and equity capital e_i, resulting in leverage $b_i = e_i/d_i$.

1. Vector of asset returns $F = [f_1, ..., f_k]$ leads to direct losses:

   $a_i \sum_k m_{ik} f_k$ for bank i; AMF for the whole system $(\mathcal{I} \times \mathbf{1})$
2. What's the shortfall?

   $b_i a_i \sum_k m_{ik} f_k$ for bank i; $BAMF$ for the whole system $(\mathcal{I} \times \mathbf{1})$
3. Banks raise this shortfall by selling assets proportionally to their weights m_{ik} which leads to asset sales:

   $\sum_i m_{ik'} b_i a_i \sum_k m_{ik} f_k$ for asset k';

   $M'BAMF$ for the whole system$(\mathcal{K} \times \mathbf{1})$

Fire-sale spillovers: Model (2)

- These asset sales have price impacts that depend on each assets illiquidity l_k. The illiquidity is measured in units of percentage points of price change per dollar amount sold which is standard in the empirical literature. Placing these illiquidity measures into a diagonal matrix L, the fire-sale price impacts are:

$$l_k \sum_i m_{ik'} b_i a_i \sum_k m_{ik} f_k \text{ for asset k'}$$

$$LM'BAMF \text{ for the whole system} (\mathcal{K} \times \mathbf{1})$$

Price impacts cause spillover losses to all banks holding the assets that were fire-sold which we can calculate as 1):

$$a_{i'} \sum_{k'} m_{i'k'} l_k \sum_i m_{ik'} b_i a_i \sum_k m_{ik} f_k \text{ for bank i'}$$

$$AMLM'BAMF \text{ for the whole system} (\mathcal{I} \times \mathbf{1})$$

Fire-sale spillovers: Model (3)

- Summing the losses over all banks i, total spillover losses suffered by the system A, M, B, L for a given initial shock F :

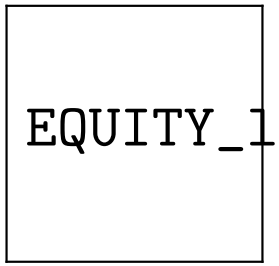
$$\mathcal{L} = \sum_{i'} a_{i'} \sum_k m_{i'k'} l_k \sum_i m_{ik'} b_i a_i \sum_k m_{ik} f_k$$

$\mathcal{L}$ captures indirect losses suffered through spillovers, while direct losses are given by 1'AMF $(\sum_i a_i \sum_k m_{ik} f_k)$

$\Rightarrow$ from this we can derive measures of financial system vulnerability

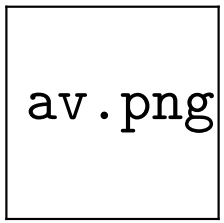
1. Aggregate Vulnerability, is the fraction of system equity capital lost due to spillovers. $\mathcal{L}/e$ captures the aggregate vulnerability of the system to fire-sale spillovers
2. Systemicness of bank i: $AV = \sum_i S(i)$.
3. $S(i)$ is higher: the higher the leverage b_i, the higher connectedness (i owns illiquid and large assets hold by other banks), the bigger the bank and the larger the shock

Fire-sale spillovers: Implementation



- 29 banks, 97% of total assets of the banking system
- Shock scenarios:
  1. -30% Household unsecured lending
  2. -30% Household mortgage lending
  3. - 40% Government bonds

Fire-sale spillovers: Implementation



Agent-based Modeling

ABM - novel approach which builds simulation models consisting of many agents which engage with one another:

- computational models of complex systems
- use an individualistic approach (bottom-up)
- simulate the systemic (emergent) effects caused by the actions and interactions between autonomous agents

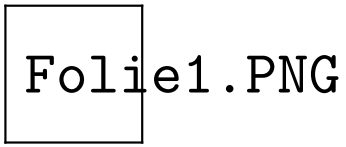
For example: banks buy and sell securities/assets, take in deposits, take an investment strategy etc.

Methodology

How does this work?

1. Initialize a population of autonomous agents (objects) capable of making simple decisions in a domain. Agents can follow different (heterogeneous) or the same (homogeneous) strategy.
2. Create an environment in which the agents may interact with one another.
3. Feed new information to the model, allowing the agents to operate autonomously, and observe for emergent complex phenomena (e.g. bubbles, market crash).
4. Allow the agents to self-adapt to their changing environment through mechanisms such as machine learning or optimization algorithms.

Methodology



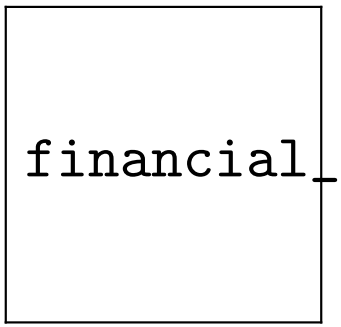
Next steps:

- Introduce agent interactions and endogenous responses from market participants.
- Finding an adequate agent based model to model systemic risk
- Fire-sale model: calibration on SA data

South African Data

DATA on capital flows

- Current account deficit of -4.4% (Q3 2016) financed by foreigners acquiring South African assets



DATA on capital flows

Association for Savings and Investments in South Africa ASISA

ASISA is an industry body that publishes quarterly reports on the Collective Investment Schemes Industry in South Africa.

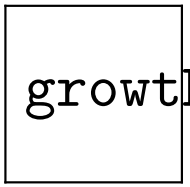
- CISs that are registered domestically
- CISs that are marketed domestically (domiciled abroad)

Morningstar

Morningstar is an investment research and investment management firm headquartered in the United States.

- CISs that are domiciled and registered domestically
- All other CISs globally

DATA



THANK YOU!