### Data visualization

- **Radar charts**—good for simultaneously plotting readings on all 14 component measures at particular points in time
- **Coxcomb charts**—feasible for ordering of components and can make area proportional to the index of each component
- **Heat maps**—good for placing the 14 components in a historical context and identifying correlations and lead-lag relationships
- **Risk Appetite**
  - Housing, Commercial Real Estate, Business Debt and Finance
  - Financial—Bank Leverage, Nonbank Leverage, Maturity Transformation, Short-Term Funding, Size/Concentration
- **Overall Vulnerability**
  - Riskier firms, filters, leverage, deposits, money at BHCs

### Literature on indicators of financial vulnerabilities

- Early warning indicators for banking and currency crises
  - Agarwal, Gorton, and Saurer (2013)
- Credit booms
- Funding of credit booms
  - Diamond and Rajan (2001), Adrian and Shin (2010), Kirshnamurthy and Vissing-Jorgensen (2013), Concentration
- Inflated asset prices
  - Surveyed in Gyourko, Sinkey, and Skabara (2004), Adrian and Shin (2010), financial sector vulnerabilities
- Concentration
  - Duration (2000)
- Variety of potential vulnerabilities

### Goal and challenges

- Our goal is to construct quantitative measures of vulnerabilities to provide "an algorithmic" and transparent complement to judgmental assessments of financial vulnerabilities for the U.S. financial system which can discipline judgment and potentially help with macroprudential policy such as the countercyclical capital buffer
- Challenges due to large amounts of data
  1. Data categorization
  2. Data processing and aggregation
  3. Data visualization

### Data categorization

- Focus on aggregating information from a wide span of indicators, economic and financial vulnerabilities
- Gather 44 indicators that are mainly based on variables or vulnerabilities emphasized in the literature—group into 14 "same components"
- Risk Appetite—leasing, commercial real estate, business debt and finance, nonfinancial sector vulnerabilities
- Nonfinancial Business, Consumer Credit, Home Mortgage, Nonbank Leverage, Maturity Transformation, Short-Term Funding, Size/Concentration
- Note tables as given that a variety of factors have been shown to have predictive power over the build-up of financial system vulnerabilities

### Aggregate index and the U.S. credit-to-GDP gap

- **Aggregate index Granger-causes CGG (about two years)**
  - Credit-to-GDP gap (CGG) is popular
  - May be useful for determining macroprudential policies
- **Comparison with the U.S. credit-to-GDP gap**
  - Clock to credit-to-GDP gap
  - Used widely in the academic/policy financial cycle literature as a financial stability monitoring tool and is considered a good early warning indicator (EWI) of systemic banking crises, especially for advanced economies
  - Proposed as a guide for setting the countercyclical capital buffer (CCyB) by the Basel Committee on Banking Supervision (2010)
  - But it has some drawbacks
    - Difficulty in estimating and interpreting the trend of the credit-to-GDP gap
    - More recent literature shows that vulnerabilities may also depend on other variables, the relationship is not linear, and not holistic approach that may detect financial vulnerabilities earlier
  - Both credit and GDP can contribute to elevated CCyBs even after financial crises

### Conclusion

- **Main results**
  - Mechanical and transparent algorithm captures the last two decades
  - We provide visualization tools to track U.S. financial vulnerabilities
- **Policy implications**
  - Our vulnerability measures lead the credit-to-GDP gap by two years
  - We provide visualization tools to track U.S. financial vulnerabilities
  - Results change depending on normalization and aggregation
  - More generally, can be applied to different sectors and different countries

- **Practical uses**
  - Can test a variety of lead-lag relationships in cross-correlation functions and in a VAR framework
  - May be useful for determining macroprudential policies
- **Examples**
  - Counter cyclical capital buffers (CCyBs) at banks
  - Early detection of increased vulnerabilities is useful because activation of buffer may potentially require significant lags
  - Early signal of financial disintermediation (in a crisis) is useful because may not need to depend on yet another index/variable for release of the buffer
  - Some quantitative examples (but have to remember the Lucas critique)