The Anatomy of Financial Vulnerabilities and Banking Crises

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Road Map

- Background and Literature

- Vulnerabilities and Shocks

- Data, Categorization, and Aggregation Methodology

- Evolution of Vulnerabilities around Banking Crises

- Lee-Posenau-Stebunovs (LPS) Indexes vs. Credit-to-GDP Gap (CGG)
    - Occurrence of Banking Crises
    - Severity of Banking Crises

- Conclusion

Background

- Aikman, Kiley, Lee, Palumbo, and Warusawitharana (AKLPW) (2017)
  - Provided algorithmic approach intended to complement judgmental analysis (the OFR Annual Report, IMF's GFSR, and the Board's QS process) regarding the buildup of risks to the financial system
  - Pulled together a large number of indicators and showed how vulnerabilities evolved in the U.S. and how the aggregate index Granger-causes the credit-to-GDP gap (CGG)
  - Purely a time-series analysis
- Lee, Posenau, and Stebunovs (2017)
  - Extend to 27 countries
  - Our country-level indexes outperform the CGG in predicting the occurrence and severity of banking crises
  - Emphasizes advantages of holistic bottom-up framework

# Vulnerabilities in the U.S. Financial System (from AKLPW)

Literature
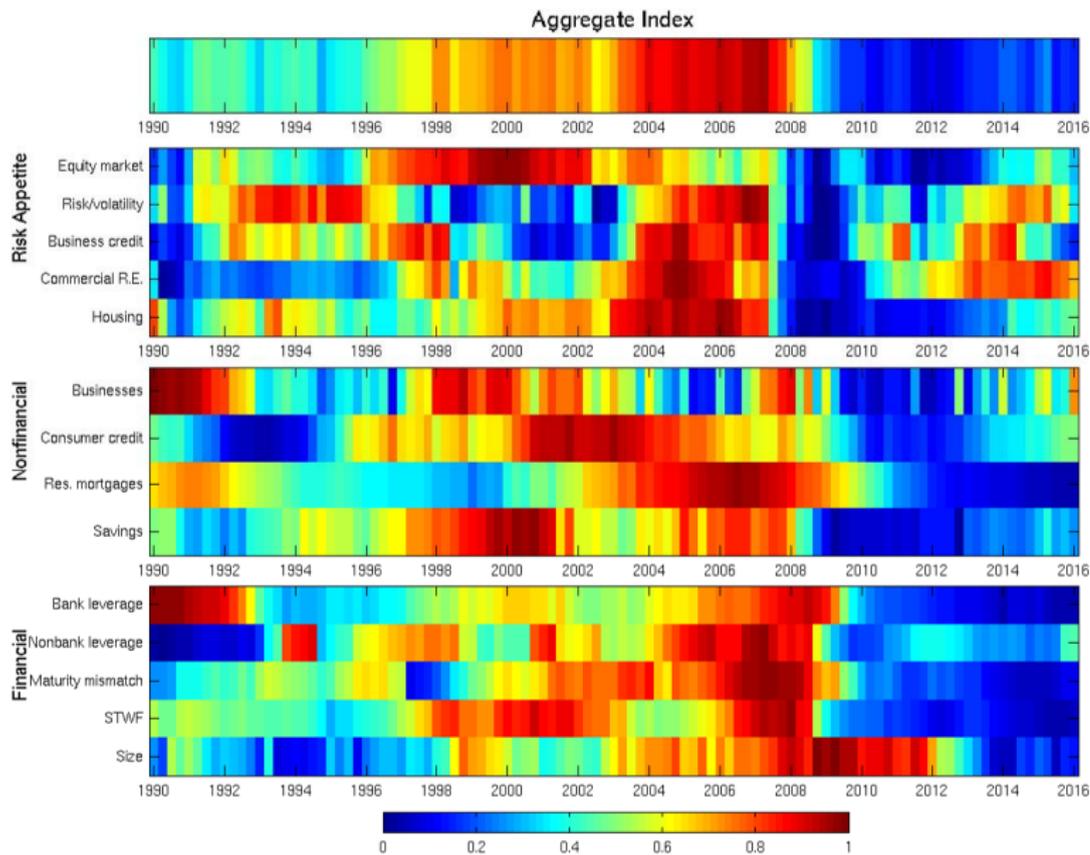
- Financial Crises:
    - *Pre-crisis conditions and early warning indicators:* Claessens and Kose (2014), Laeven and Valencia (2013), Adrian, Covitz, and Lian (2013), Schularick and Taylor (2012), Frankel and Saravelos (2011), Reinhart and Rogoff (2009), Ferguson, Hartmann, Panetta, and Portes (2007), Kaminsky and Reinhart (1999), Eichengreen and Portes (1987), Kindelberger (1978)
    - *Emphasis on particular vulnerabilities:* Borio and Lowe (2002), Demirguc-Kunt and Detragiache (1997), Kaminsky, Lizondo, and Reinhart (1998), Frankel and Rose (1996), Manasse and Roubini (2009), Lee (2009), Manasse, Roubini, Schimmelpfennig (2003), Detragiache and Spilimbergo (2001), Krishnamurthy and Vissing-Jorgenson (2013), Cecchetti (2008)
- Types of Crises and Output Loss
    - Blanchard, Cerutti, and Summers (2014), Howard, Martin, and Wilson (2011), Kroszner, Laeven, and Klingebiel (2007)

Financial Vulnerabilities and Shocks

- Vulnerabilities in the financial system can arise from various sources

  - (AKLPW) Risk appetite, financial sector, nonfinancial sector, (LPS) external sector, and sovereign sector

- Elevated aggregate vulnerabilities amplify economic and financial shocks

  - Given the state of vulnerabilities in the financial system, shocks can amplify and lead to a banking crisis state

- Once in a crisis state . . .

  - As vulnerabilities unravel or unwind, there are detrimental real effects (for example, from financial disintermediation)
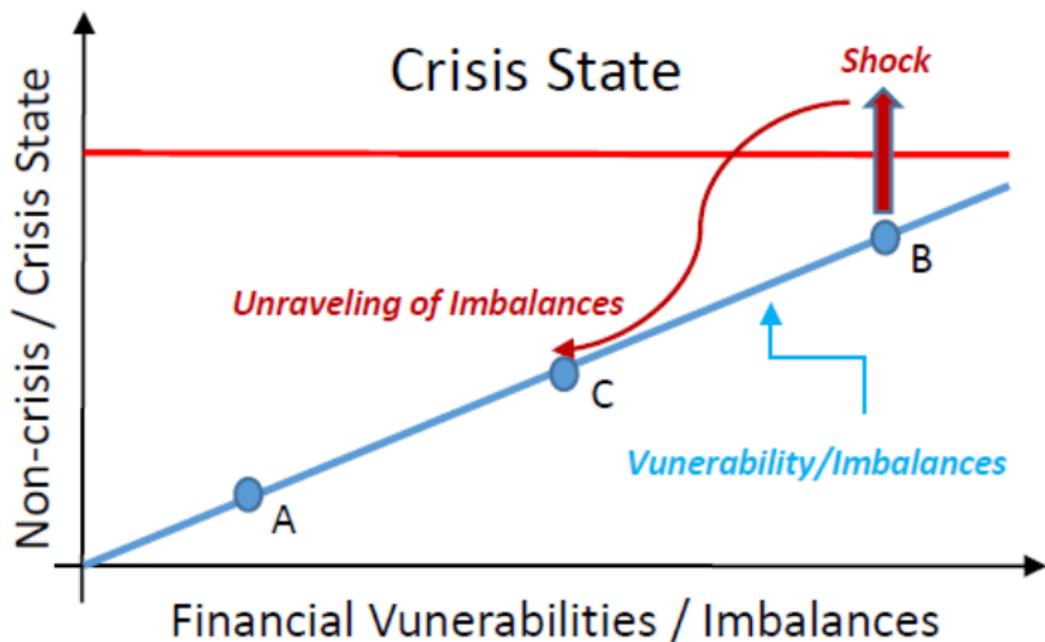
Two Hypotheses

1. Financial crises are more likely to occur in countries with more elevated aggregate vulnerabilities

2. More elevated aggregate vulnerabilities prior to financial crises have more severe consequences (in terms of output loss) after the onset of these crises

Data and Categorization

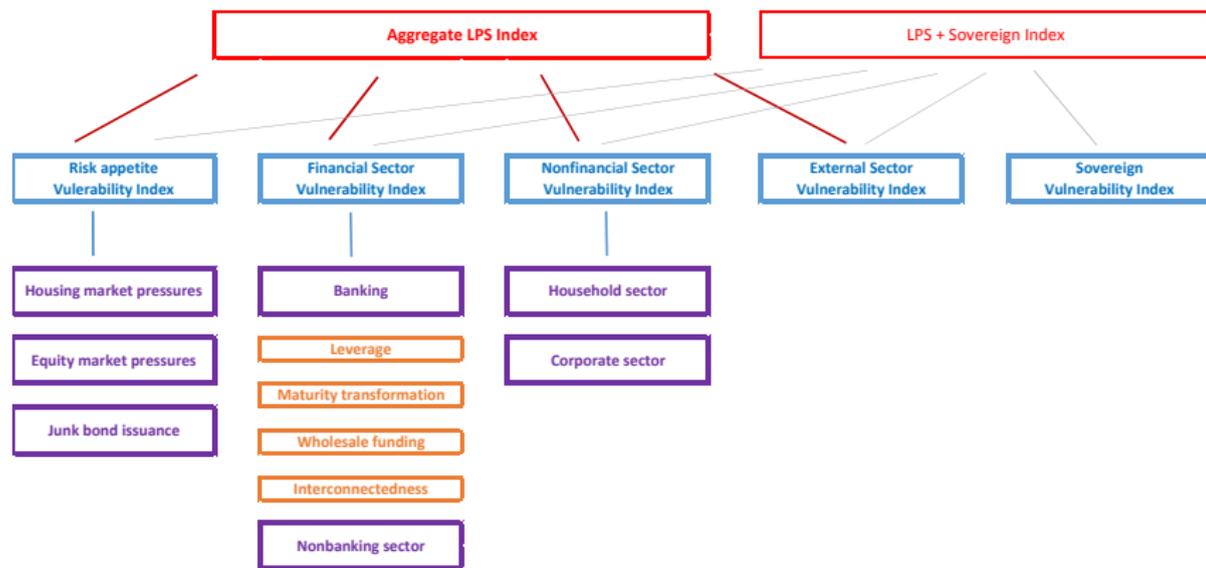We compile over 600 data series for 27 countries from 1986 to 2015

- Risk appetite vulnerabilities
  - Housing market (price-to-rent ratio, price to income/GDP)
  - Equity market (forward P/E ratio, dividend yield ratio)
  - Junk bond market (high-yield junk bond issuance relative to total corporate bond issuance)
- Financial sector vulnerabilities
  - Banking sector - leverage (capital ratios, detrended bank-credit to GDP), maturity transformation (loans to deposits), reliance on wholesale funding (short-term funding ratios), interconnectedness (foreign exposure)
  - Nonbank sector - leverage (detrended nonbank-credit to GDP)

Data and Categorization, continued

- Nonfinancial sector vulnerabilities
  - Household sector - leverage (detrended household credit to GDP and debt service ratios)
  - Business sector - leverage (detrended business credit to GDP and debt service ratios, aggregate corporate debt to equity, 90th percentile debt to equity ratio)
- External sector vulnerabilities
  - Reliance on external debt and reserve adequacy (detrended external debt to GDP, current account deficit to GDP, reserves to GDP, short-term external debt to reserves)
- Sovereign vulnerabilities
  - Leverage and fiscal capacity (detrended government debt to GDP, fiscal deficit to GDP, government revenue to GDP)
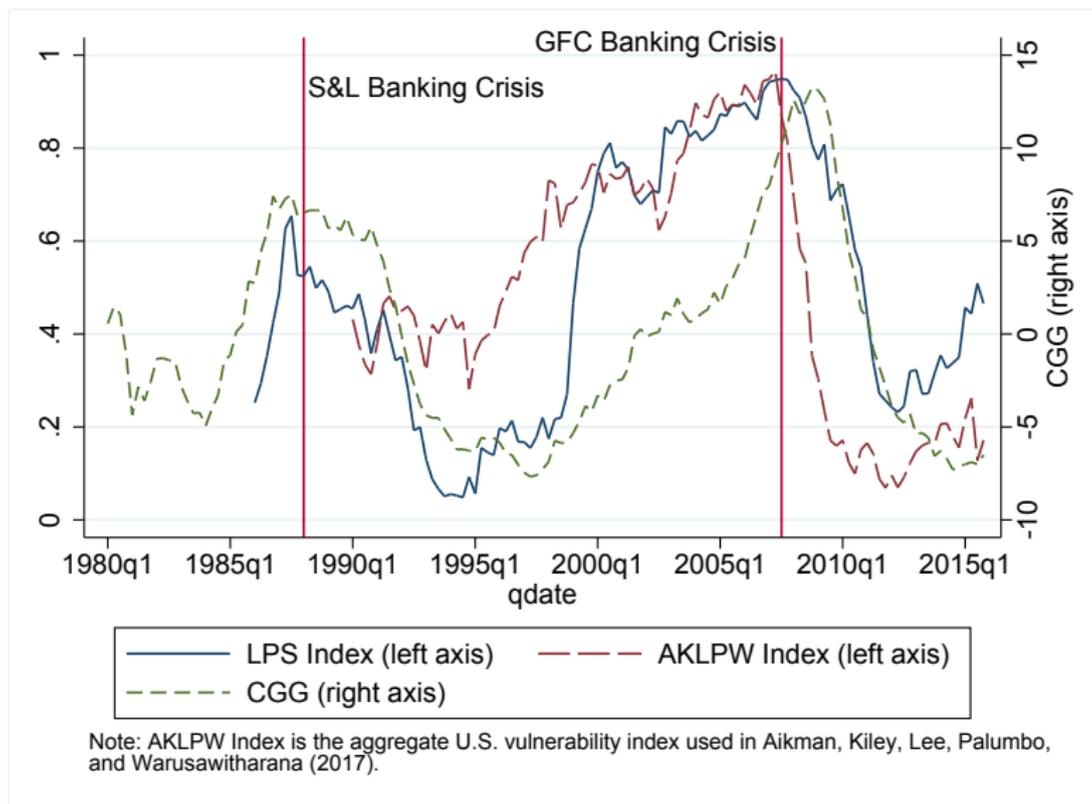
Standardization and Aggregation

1. Standardize each of the variables
   - Remove linear trend, if necessary
   - Create Z-score: subtract sample average values (at most 30 years worth), then divide by full-sample standard deviation
   - Rescale using kernel density estimates to place on [0,1] interval, so median is approximately 0.5
   - Does not consider pooled cross-section of data (only time-series)

2. Aggregate standardized variables to a "category' of vulnerabilities
   - Component index is the un-weighted average of standardized indicators (with the exception of bank vs. nonbank index)
   - Add indicators when data become available
   - Rescale using kernel density estimates to place on [0,1], again

3. Lee-Posenau-Stebunovs (LPS) Index
   - The country-level LPS Index is based on the same aggregation method using the 4 main vulnerability categories
   - We also construct LPS + Sovereign Index that includes sovereign vulnerabilities
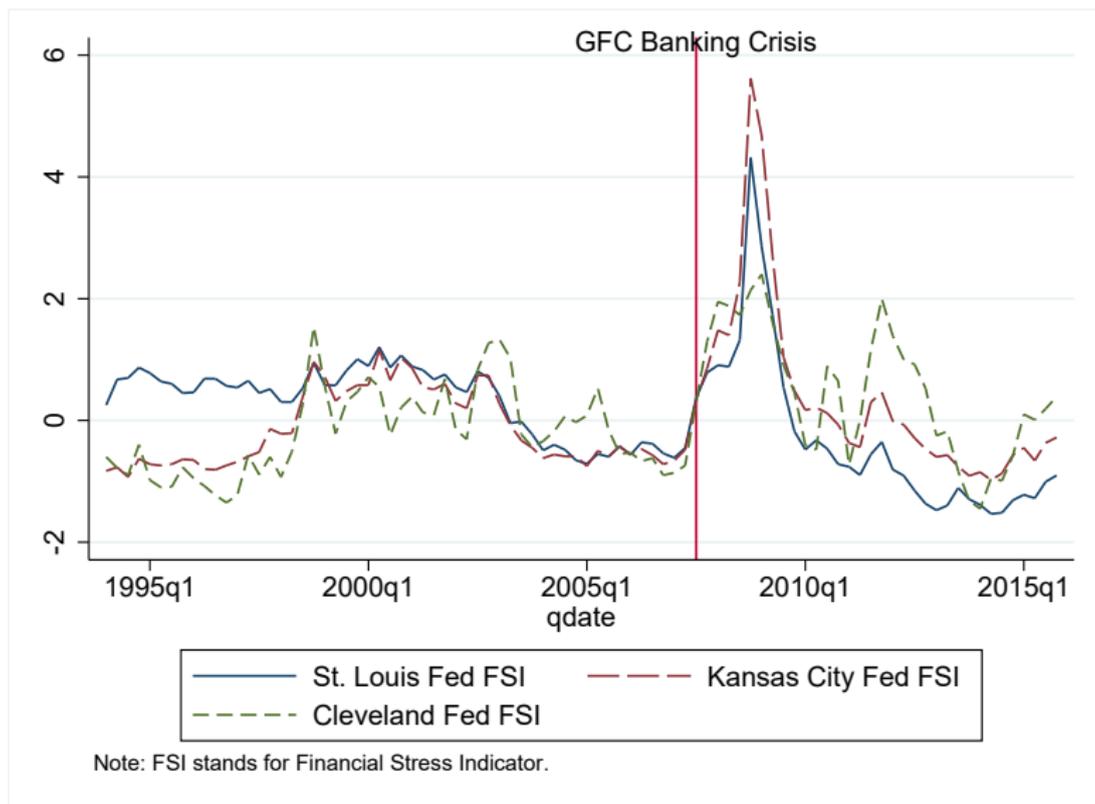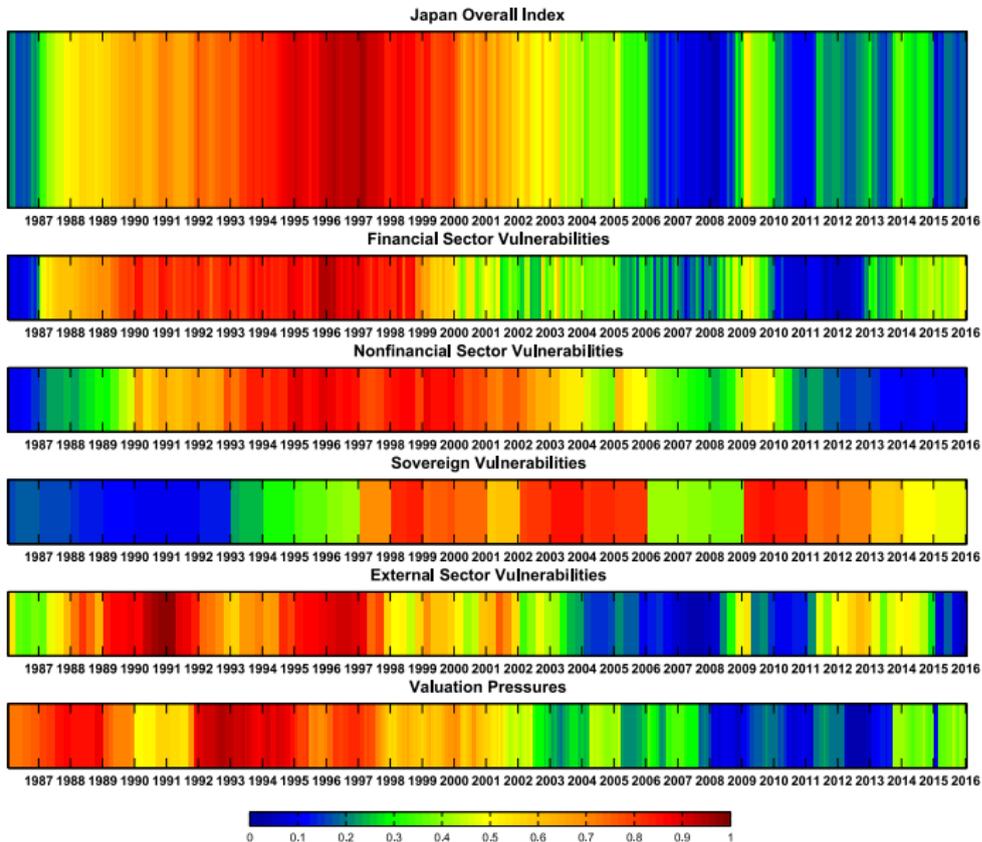
Data and Categorization Schematic

The AKLPW vs. the LPS Index for the U.S.

Note: AKLPW Index is the aggregate U.S. vulnerability index used in Aikman, Kiley, Lee, Palumbo, and Warusawitharana (2017).

Comparison: Financial Stress Indexes for the U.S.

Note: FSI stands for Financial Stress Indicator.

Japan Overall Index

Financial Sector Vulnerabilities

Nonfinancial Sector Vulnerabilities

Sovereign Vulnerabilities
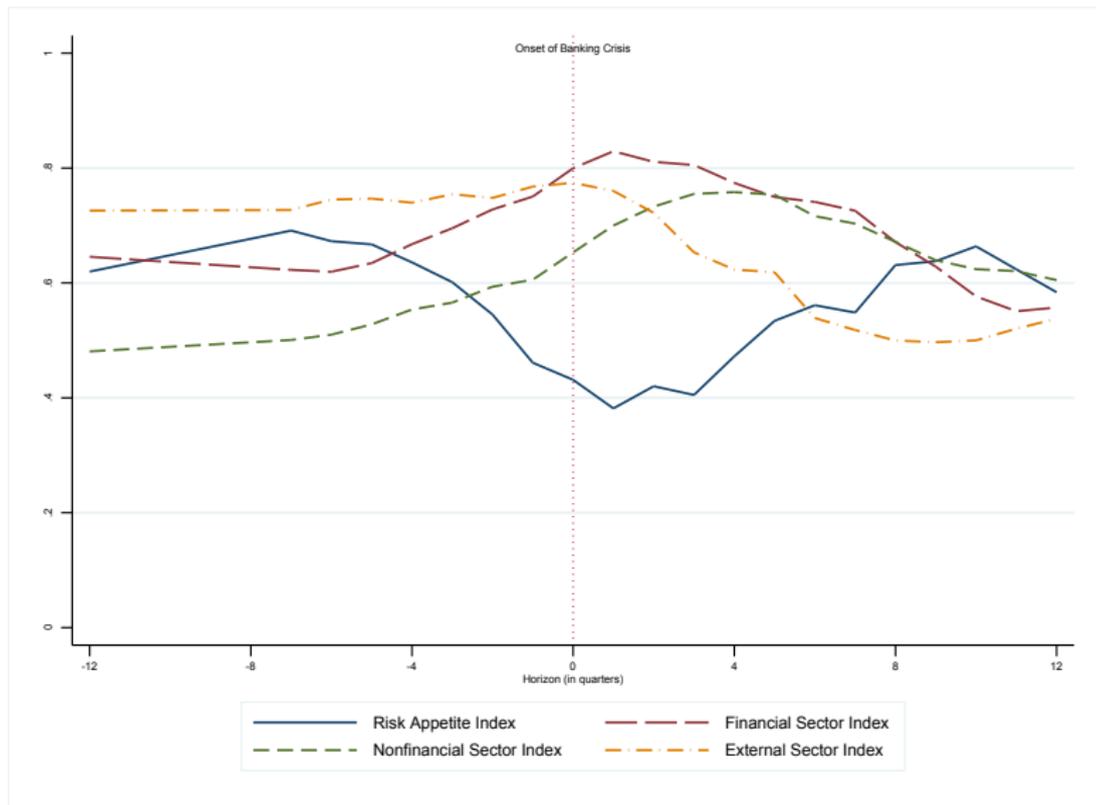
External Sector Vulnerabilities

Valuation Pressures

Difficulty in Pooling Data in the Cross-section

1. Official statistics are measured and reported differently from country to country
   - Examples include bank equity ratios, loans-to-deposit ratios, government debt, etc.
2. Structural and compositional differences remain even when looking at same metric
   - Analogous to a country "fixed effect"
   - Examples include elevated Japanese government debt
   - Another is P/E ratios where significant differences exist in the composition of industries from country to country

Banking Crises / Output Loss—Laeven and Valencia (2013)

Country	Banking Crisis	Output Loss (pct.)	GFC
Austria	2008:Q3	14.0	✓
Belgium	2008:Q3	19.0	✓
Brazil	1990:Q1	62.3	
	1994:Q4	0.0	
China	1998:Q3	19.4	
Denmark	2008:Q3	36.0	✓
Finland	1991:Q3	69.6	
France	2008:Q3	23.0	✓
Germany	2008:Q3	11.0	✓
Greece	2008:Q3	43.0	✓
Ireland	2008:Q3	106.0	✓
Italy	2008:Q3	32.0	✓
Japan	1997:Q4	45.0	
Luxembourg	2008:Q3	36.0	✓
Malaysia	1997:Q3	32.4	
Mexico	1994:Q4	13.7	
Netherlands	2008:Q3	23.0	✓
Norway	1991:Q4	5.2	
Portugal	2008:Q3	37.0	✓
Russia	1998:Q3	N/A	
	2008:Q3	0.0	✓
South Korea	1997:Q3	57.6	
Spain	2008:Q3	39.0	✓
Sweden	1991:Q3	30.6	✓
	2008:Q3	25.0	✓
Switzerland	2008:Q3	0.0	✓
Thailand	1997:Q3	109.3	
Turkey	2000:Q4	37.0	
United Kingdom	2007:Q3	25.0	✓
United States	1988:Q1	0.0	
	2007:Q3	31.0	✓

Vulnerabilities around Banking Crises

Mean Aggregate LPS Indexes
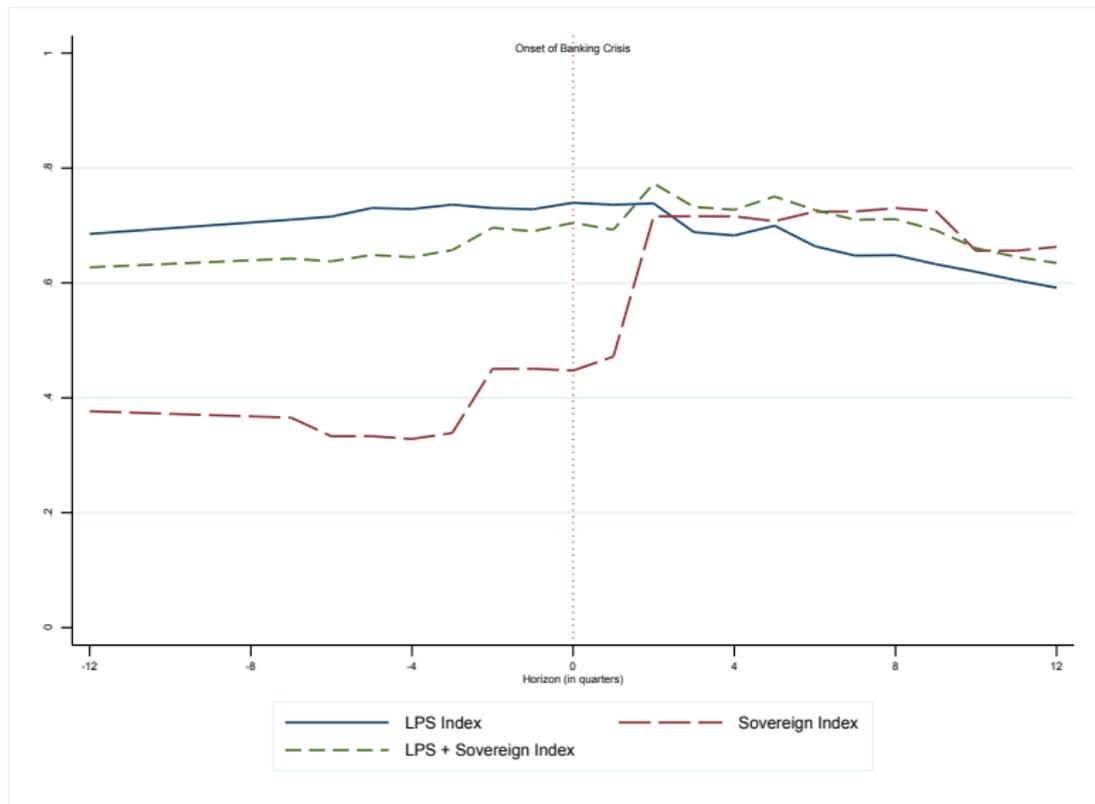
Recap of Vulnerabilities around Banking Crises

- Valuation pressures have already subsided substantially prior to banking crises
- External and financial sector vulnerabilities are elevated prior to banking crises and then subside afterwards
- Nonfinancial sector vulnerabilities lag the other vulnerabilities a bit
- Sovereign sector increases its vulnerabilities after banking crises (due to government intervention and/or weakening fiscal capacity)
- The fact that many of the results are driven by 2007/2008 financial crisis is an important caveat

1. Are banking crises more likely to occur in countries with more elevated aggregate vulnerabilities?

2. Do more elevated aggregate vulnerabilities prior to banking crises lead to more severe consequences (in terms of output loss) after the onset of these crises?
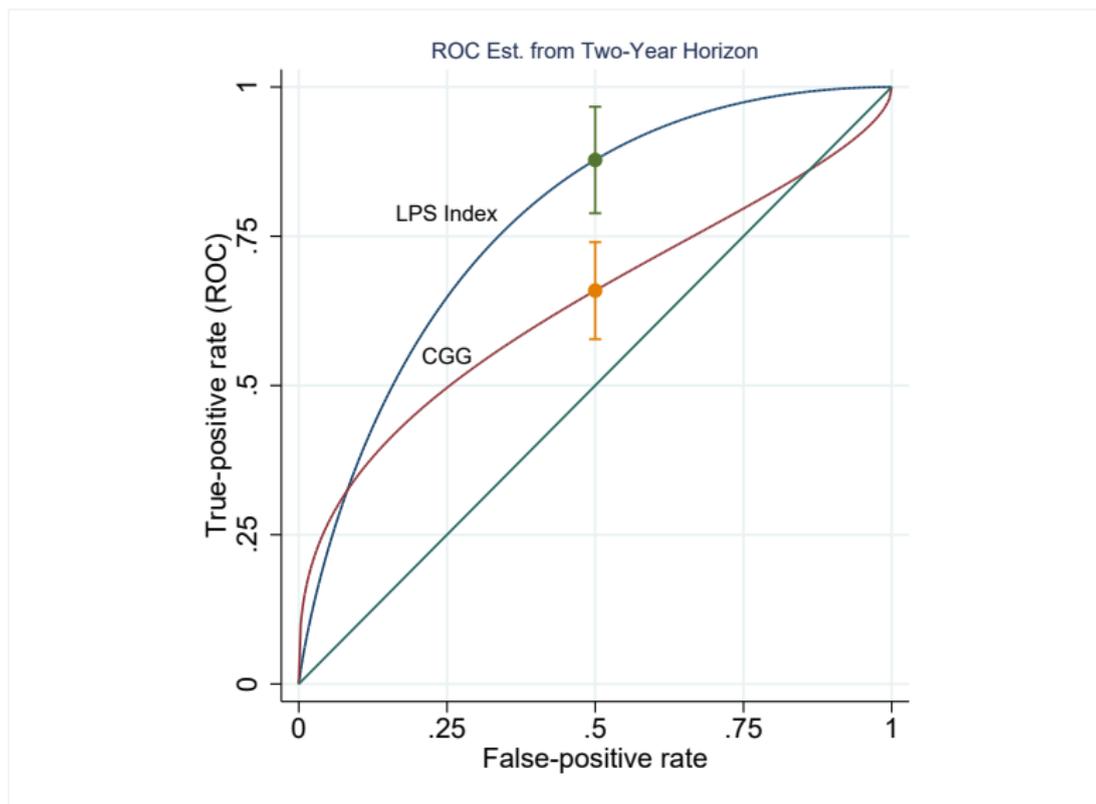
The LPS Index and the Onset of Banking Crises

- Drehmann and Juselius (2014)
  - Use the receiver operating characteristic (ROC) curve and calculate the area under the curve (AUC) as a summary measure to determine predictive power for banking crises
  - Touts the Credit-to-GDP gap (CGG) as one of the better early warning indicators – we use as a benchmark

- Important differences in analysis are
  - Sample period and sample of countries: They use 1980, or the latest, to 2012.
  - They use systemic banking crisis episodes from Laeven and Valencia (2012), but some adjustments are made, and do not consider two years post crisis

- Keep in mind drawbacks to CGG, especially in real-time
  - Edge and Meisenzahl (2012): HP-filter has lots of problems–sensitive to end points, large adjustments in real-time...
  - CGG can also be elevated post-crises because of drawdowns of credit lines and/or large falls in GDP

The LPS Index vs. CGG: Predicting Banking Crises

The Aggregate indexes have higher AUCs 2 to 3 years out

	-12	-11	-10	-9	-8	-7	-6	-5
Full Sample (from 1986)								
Risk App. Index	0.67	0.66	0.74**	0.66	0.63	0.71	0.69	0.70
CGG	0.55	0.56	0.55	0.58	0.64	0.66	0.69	0.74
Fin. Index	0.72	0.74	0.73*	0.75	0.75	0.72	0.71	0.73
CGG	0.60	0.62	0.61	0.63	0.65	0.67	0.69	0.73
Nonfin. Index	0.58	0.61	0.62	0.62	0.62	0.64	0.65	0.66
CGG	0.60	0.62	0.61	0.62	0.63	0.64	0.66	0.71
External Index	0.79 ***	0.80***	0.79***	0.81***	0.79***	0.77**	0.78	0.78
CGG	0.59	0.62	0.61	0.62	0.64	0.65	0.67	0.72
LPS Index	0.74**	0.76**	0.80***	0.79**	0.78**	0.78**	0.79**	0.80
CGG	0.59	0.62	0.61	0.63	0.64	0.65	0.67	0.72
LPS + Sovereign	0.71*	0.74*	0.74**	0.74*	0.72	0.73	0.72	0.73
CGG	0.59	0.62	0.61	0.63	0.64	0.65	0.67	0.72
Real Time (from 1996)								
LPS Index	0.73**	0.71*	0.72**	0.74**	0.69*	0.68	0.64	0.69
CGG	0.60	0.59	0.57	0.58	0.59	0.58	0.58	0.62
LPS + Sovereign	0.73*	0.71*	0.70*	0.71*	0.66	0.66	0.61	0.66
CGG	0.60	0.59	0.57	0.58	0.59	0.58	0.58	0.62

A Closer Look at the ROC Curve

ROC Est. from Two-Year Horizon

LPS Index

CGG

True-positive rate (ROC)

False-positive rate

The LPS Index and the Severity of Banking Crises

- Elevated vulnerabilities in multiple sectors should lead to more detrimental real effects after a shock puts a country into a "crisis" state

- Output loss is measured by the real GDP gap (the cumulative difference in trend GDP and actual as in Laeven and Valencia (2013) three years after a crisis)

- We can also compare the LPS Index to the credit-to-GDP gap, which may have policy implications regarding counter-cyclical capital regulation

Vulnerabilities, CGG, and Output Loss
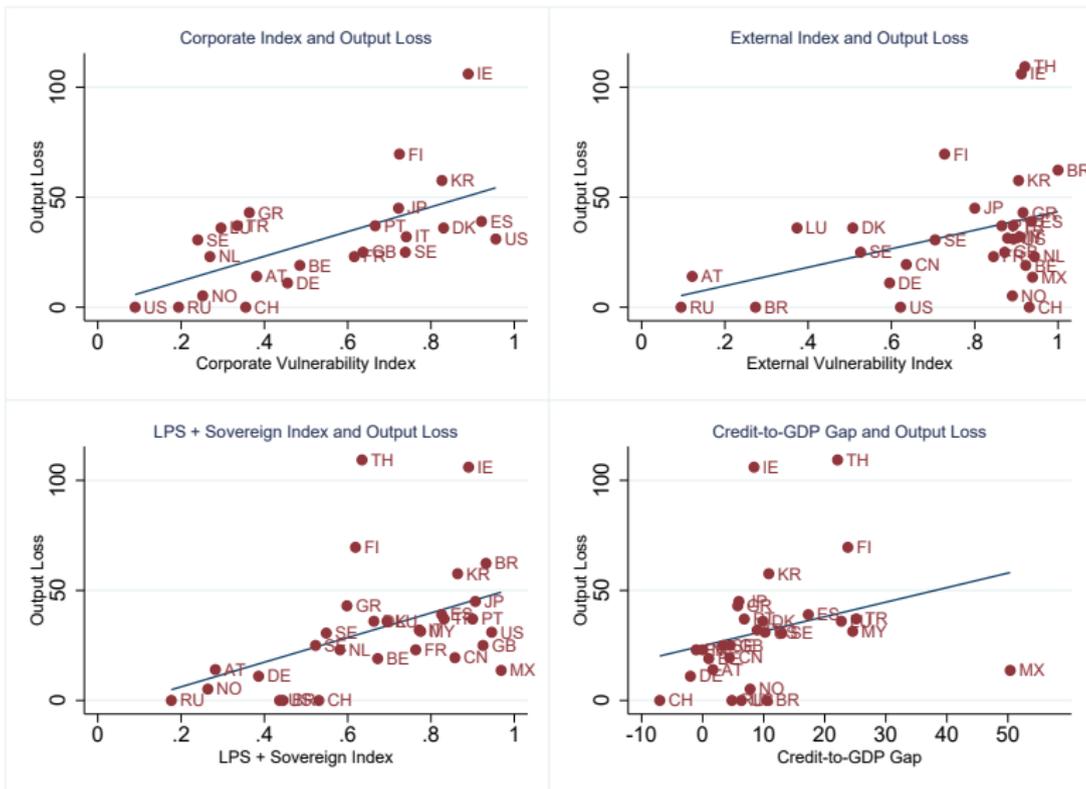
Explaining Output Loss

	(1)	(2)	(3)	(4)	(5)	(6)
Nonfinancial Index	51.9***					
	(2.82)					
Corporate Index		56.1***				
		(3.66)				
External Index			42.2**			
			(2.25)			
LPS Index				58.3**		
				(2.61)		
LPS + Sov. Index					55.9**	
					(2.72)	
CGG						0.66
						(1.51)
Constant	-0.51	0.71	1.28	-8.79	-4.98	24.8***
	(-0.04)	(0.08)	(0.09)	(-0.53)	(-0.34)	(3.72)
Obs.	24	24	30	30	30	29
R-sq. adj.	0.23	0.35	0.12	0.17	0.18	0.04

$^*\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Explaining Length of Recessions

- Sample increases to close to 100 for 27 countries
- Dependent variable is length of the recession defined as the duration between the peak and trough of the relevant economic activity from Howard, Martin, and Wilson (2011)
- The LPS and LPS + Sovereign Indexes (driven by risk appetite) explains more of the variations in the length of recessions than CGG

Alternative Aggregation Methods

- Extreme example is adding Sovereign Vulnerabilities to the LPS Index

- Improves explaining the severity of banking crisis

- May want to think of a loss function to have the optimal weights on different components for the index

Conclusion

- Careful categorization and organization of data allows us to understand the evolution of banking crises via the lense of vulnerabilities

- Our simple aggregate LPS and LPS + Sovereign Indexes perform better in explaining the occurrence and severity of banking crises compared to the CGG—aggregation adds value!

- The LPS and LPS + Sovereign Indexes also seem correlated with the length of recessions

- Real-time analysis has serious limitations given the data

- An index superior at explaining both the onset and severity of financial crises would be useful for policymakers in setting macroprudential policy and with crisis management

Vulnerabilities at AFEs
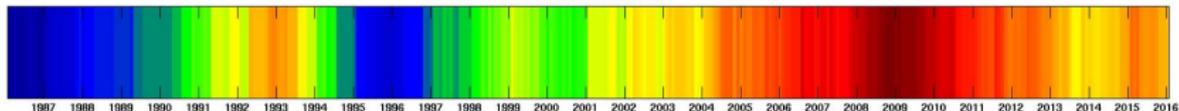
Vulnerabilities at EMEs

EMEs

Financial Sector Vulnerabilities

Nonfinancial Sector Vulnerabilities
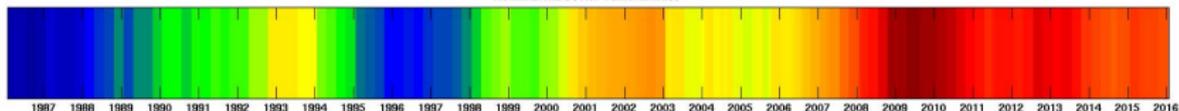
Sovereign Vulnerabilities
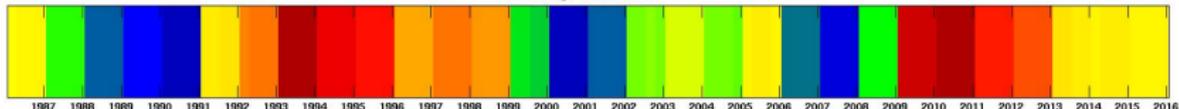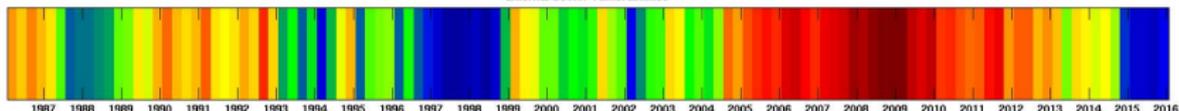
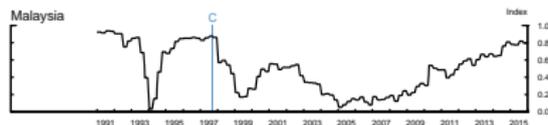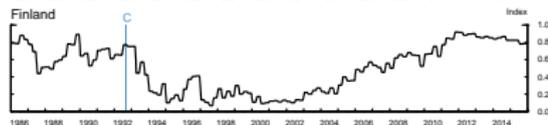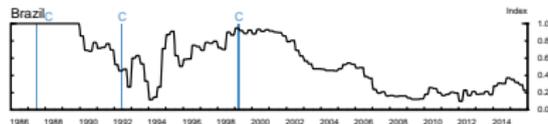External Sector Vulnerabilities

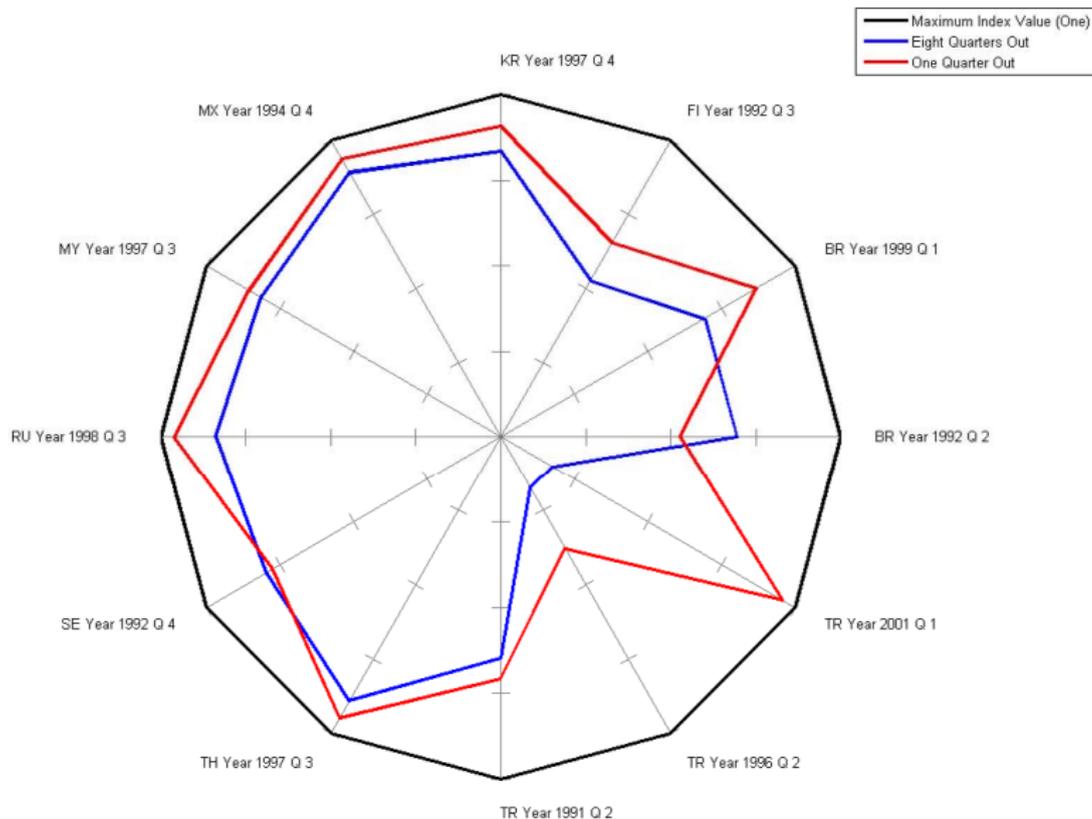Valuation Vulnerabilities
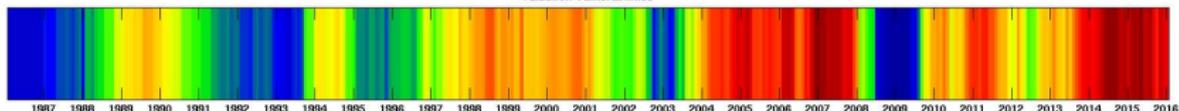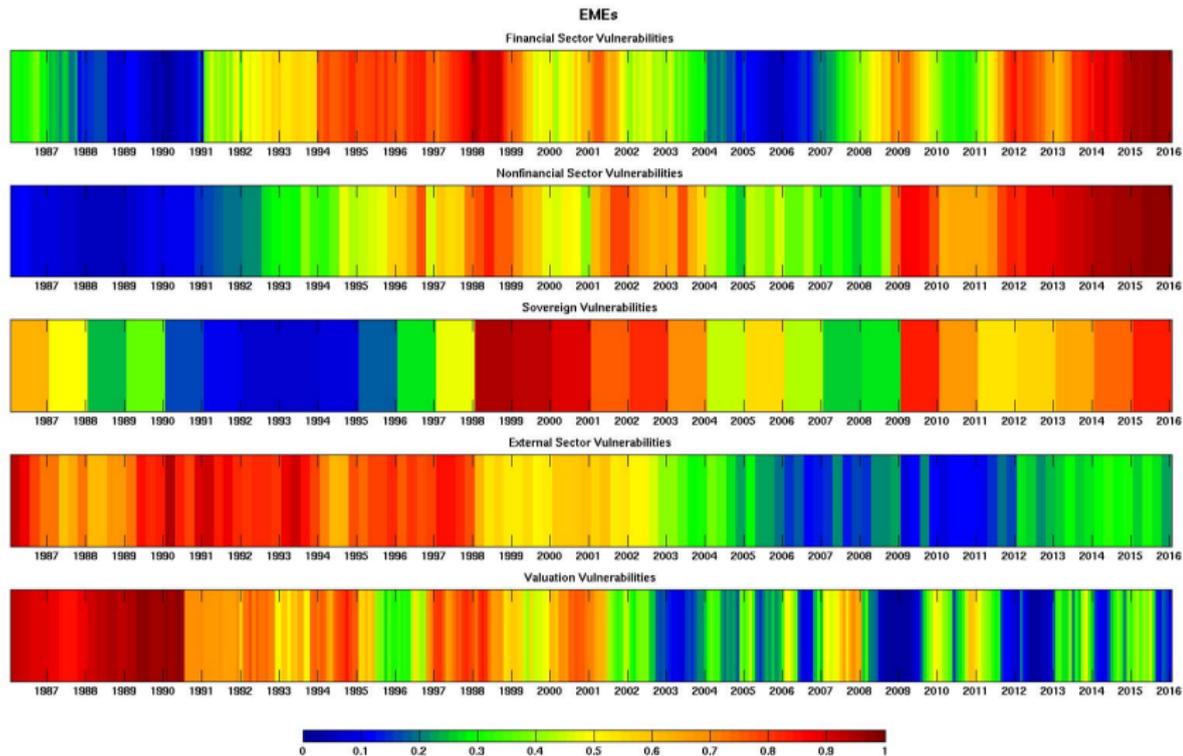
- Currency Crises

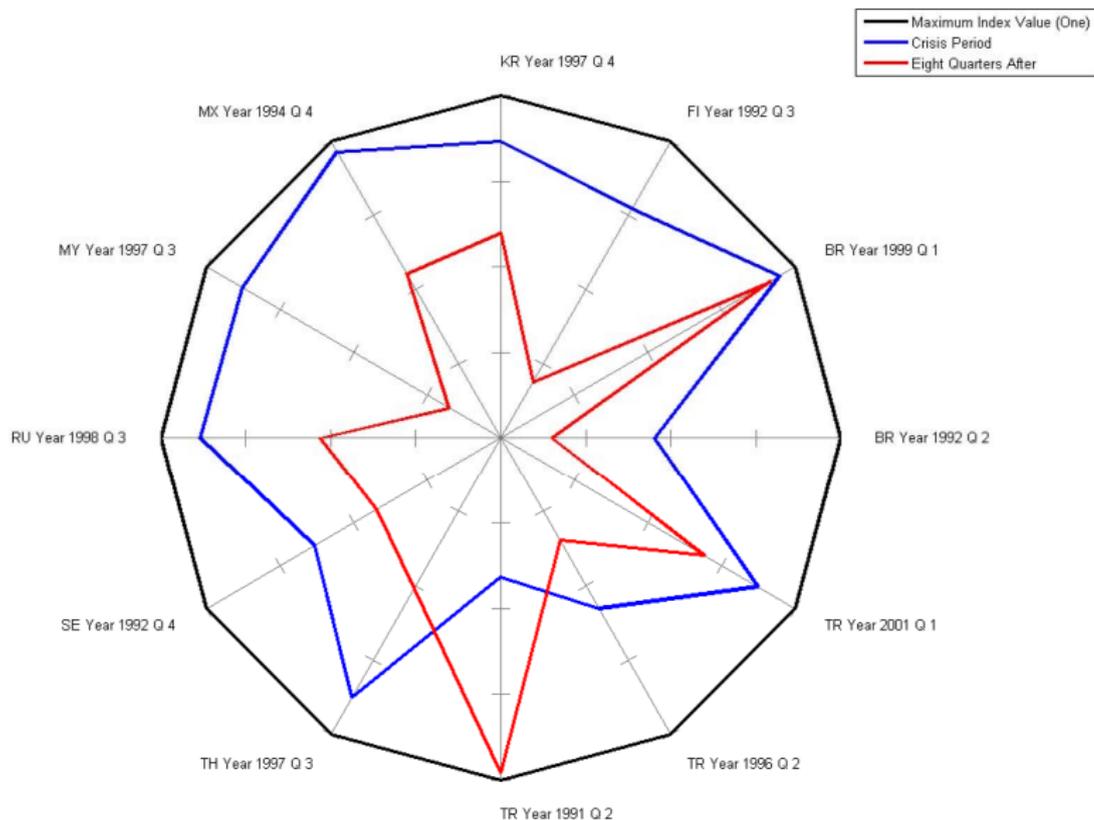# Currency Crises - Histograms of Vulnerabilities (t-1 quarter)
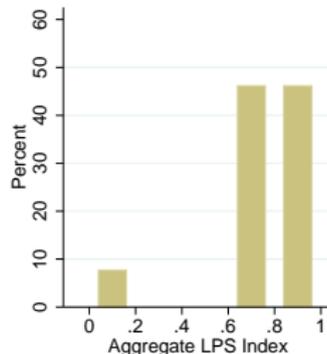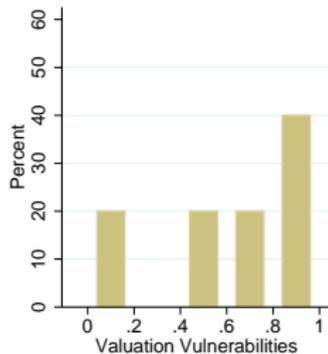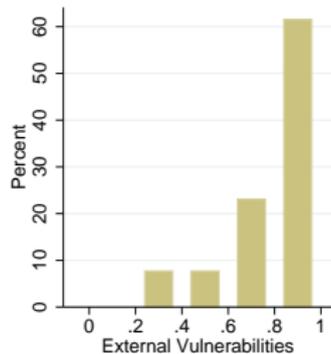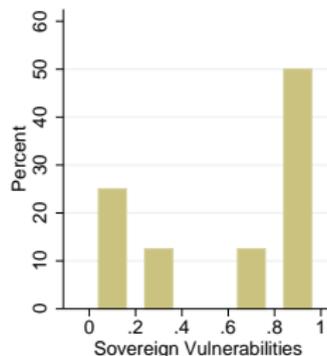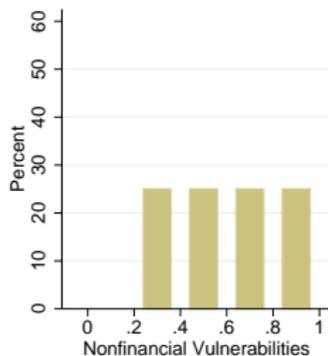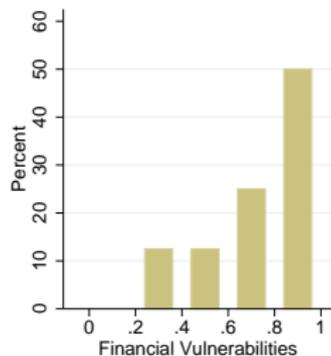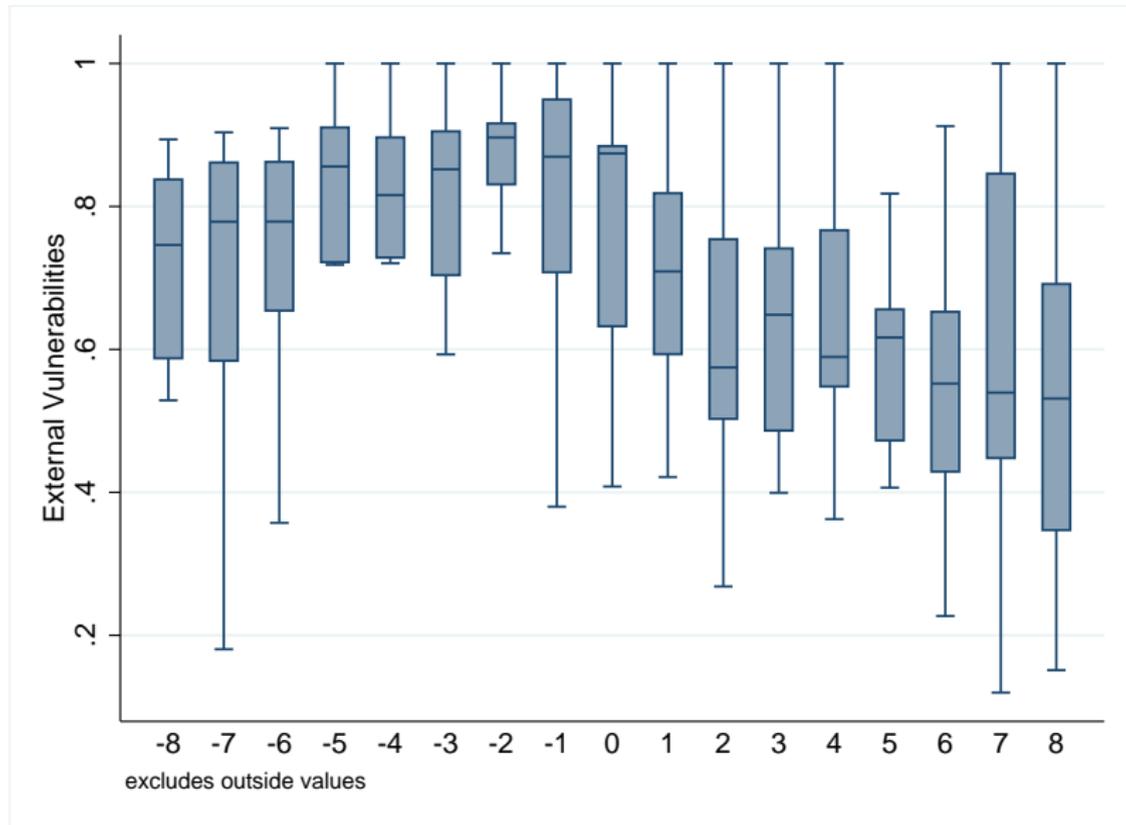
Currency Crises and External Sector Vulnerabilities
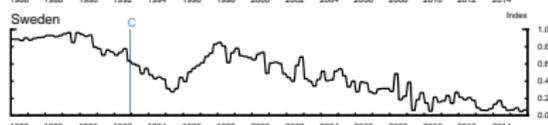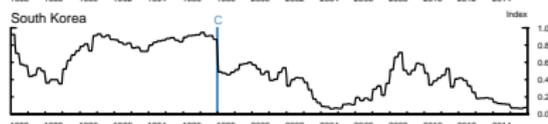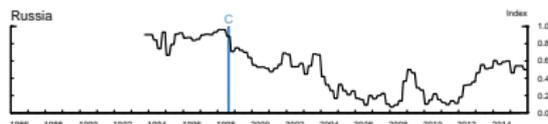
External Sector Vulnerabilities Pre-Currency Crises

Radar chart legend:
- Maximum Index Value (One)
- Eight Quarters Out
- One Quarter Out

Axis labels (clockwise from top):
KR Year 1997 Q 4, FI Year 1992 Q 3, BR Year 1999 Q 1, BR Year 1992 Q 2, TR Year 2001 Q 1, TR Year 1996 Q 2, TR Year 1991 Q 2, TH Year 1997 Q 3, SE Year 1992 Q 4, RU Year 1998 Q 3, MY Year 1997 Q 3, MX Year 1994 Q 4

External Sector Vulnerabilities Post-Currency Crises

Radar chart with the following axis labels (clockwise from top): KR Year 1997 Q 4, FI Year 1992 Q 3, BR Year 1999 Q 1, BR Year 1992 Q 2, TR Year 2001 Q 1, TR Year 1996 Q 2, TR Year 1991 Q 2, TH Year 1997 Q 3, SE Year 1992 Q 4, RU Year 1998 Q 3, MY Year 1997 Q 3, MX Year 1994 Q 4. Legend: Maximum Index Value (One); Crisis Period; Eight Quarters After.
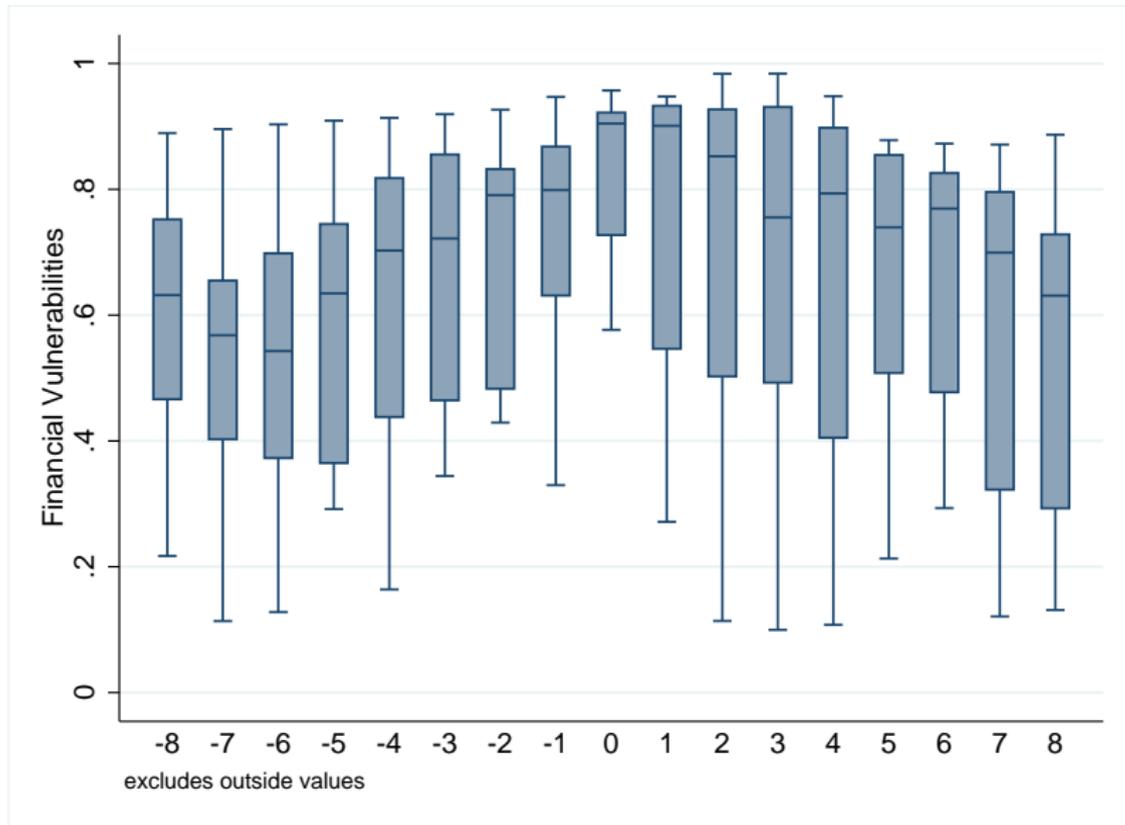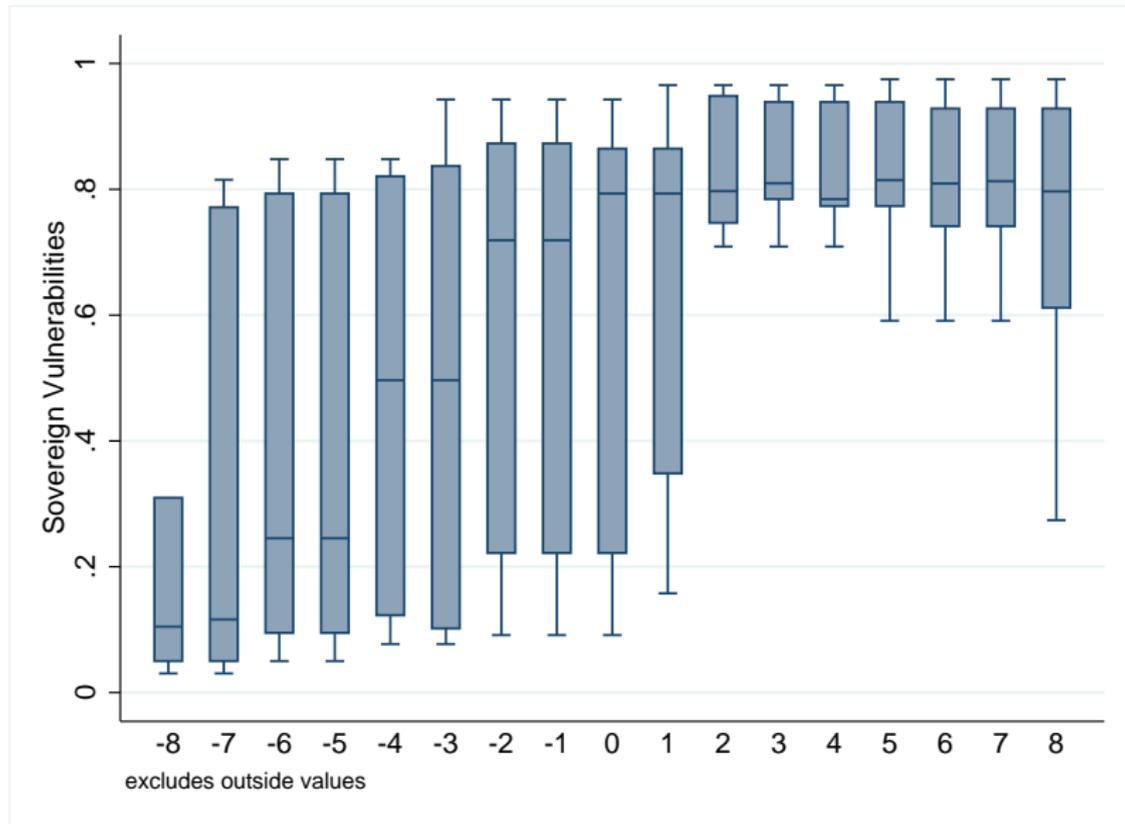
External Sector Vulnerabilities around Currency Crises

Financial Sector Vulnerabilities around Currency Crises

Sovereign Vulnerabilities around Currency Crises

Recap of Vulnerabilities around Currency Crises

- External and financial sector vulnerabilities are elevated prior to currency crises and then subside afterwards

- Sovereign sector increases its vulnerabilities after currency crises (perhaps due to government intervention and/or weakening fiscal capacity)