

Understanding Financial Crises - a statistical perspective

M. R. Grasselli

This time is different

The signals approach

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A joint project by McMaster - Mitacs - EDF

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The ghost of crises past...

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Ioday you need not guess.

HISTORY sometimes repeats itself—but not invariably. In 1719 there was practically no way of finding out the *facts* about the Mississippi venture. How different the position of the investor in 1929!

Today, it is inexcusable to buy a "bubble" —inexcusable because unnecessary. For now every investor—whether his capital consists of a few thousands or mounts into the millions —has at his disposal facilities for obtaining the facts. Facts which—as far as is humanly possible—eliminate the hazards of speculation and substitute in their place sound principles of investment.



STANDARD STATISTICS

200 VARICK ST. New York, New York (now the home of Chipotle Mexican Grill)

Saturday Evening Post, September 14, 1929



Overview

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- Based mostly on the book This time is different: eight centuries of financial folly by Reinhart and Rogoff (2009).
- Systematic search and compilation of all publicly available data mentioned in the book.
- Independent reproduction of the main statistical findings described in the book, updated to 2011.
- Implementation of the "signals approach" for early warning indicators suggested at the end of the book.
- Additional interpretation based on *Panics, manias and crashes* by Kindelberger and Aliber (2011, 1st edition 1978) and *Can 'it' happen again* by Minsky (1982).



A Global Database

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- This time is different
- Datasets and crises
- External Default Domestic Default Banking Crises Inflation and Currency Crises Crises Index
- The signals approach

- 66 countries (expanded to 70), 800 years.
- Fully downloaded and compiled:
 - inflation
 - real GDP
 - exports
 - public debt
 - exchange rates
- Datasets found and partially compiled:
 - public finances
 - national accounts
 - commodity prices
 - real estate and equity indices



Crises and Dates

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• Thresholds (mark both start and duration)

- Inflation: 20% per annum of higher. Median values were
 - 0.5% for 1500-1799
 - 0.7% for 1800-1913
 - 5.0% for 1914-2006
- Currency: annual depreciation of 15% or more
- Debasement: currency conversion rate of 5% or more
- Asset price crashes (equity and real estate): not done !

2 Events

- Banking crises: closure, merger, government assistance with or without runs (start only, duration is harder to measure)
- External debt crises: default on government external debt obligations (start and duration)
- Domestic debt crises: default on government debt under a country's own jurisdiction (scarcer dataset, duration also hard to measure)



Theory of External Debt Crises

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- Datasets and crises
- External Default Domestic Default Banking Crises Inflation and Currency Crises
- Crises Index
- The signals approach

- Payment depends on ability and willingness
- Lack of super-national legal framework for enforcing debt contracts across borders
- Benefits of access to capital markets in uncertain times leads to repayment to maintain reputation
- Reputation argument can be extended to include trade and broader international relations
- Difference between illiquidity and insolvency
- Subject to multiple equilibria similar to bank runs
- Partial defaults and rescheduling should also be taken into account
- Domestic public debt is an important but neglected component of crises



Debt Intolerance

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- Currency Crises Crises Index
- The signals approach

- Duress experienced by emerging countries at levels of debt that would be manageable by advanced countries
- $\bullet\,$ Maastricht treaty specifies a 60% of GNP maximum debt
- More than half of the 36 default episodes of default in developing countries from 1970 to 2008 occur at less than 60% debt to GNP.
- More than half (54.2%) of yearly observations for developing nondefaulters show less than 35% debt to GNP.
- Defaulters borrow more than nondefaulters.
- Most capital flow cycles end in default.



External debt to GNP ratios for emerging countries



Figure: Updated Figure 2.1 in RR



External default through history

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The signals

- Early history (1300-1799): France (8), Spain (6), England (3), Austria (1), Portugal (1), Prussia (1).
- After 1800: international capital markets and new nation-states led to explosion in sovereign default
 - Napoleonic wars (1812-1814)
 - Latin America Independence (1820-1840)
 - Argentinian crisis, Baring Brothers collapse (1870-1890)
 - Great Depression (1930-1950)
 - Emerging markets crises (1990s)
- Average percentage of independent life of a country in state of default:
 - Asia: 10%
 - Africa: 50%
 - Latin America: 40%
 - Europe: 20% (except Greece = 51%)
 - North America: 0%



Cycles of external default

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- Datasets and crises External Default
- Domestic Default Banking Crises Inflation and Currency Crises Crises Index
- The signals approach

- Five big external default cycles from 1800 to 2008
- Coincide with high incidence of global banking crises
- Increasing co-dependence with inflation crises (correlation nearly doubles after 1940s)
- Drops in commodity prices precipitates periods of external default
- Marked correlation between capital flow peaks and new defaults on sovereign debt
- Median duration of a default episode is getting shorter (6 years for 1800-1945 versus 3 years for 1945-2007).



Share of countries in external default



Figure: Reinhart and Rogoff (2009) - Figure 5.1 (updated)



Share of countries in external default weighted by GDP



Figure: Reinhart and Rogoff (2009) Figure 5.2 (updated)



Banking Crises and External Defaults



Figure: Reinhart and Rogoff (2009) - Figure 5.3 (updated)



Inflation Crises and External Defaults



Figure: Reinhart and Rogoff (2009) - Figure 5.4 (updated)



Commodity prices and External Defaults

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Crises Index

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Figure: Reinhart and Rogoff (2009) - Figure 5.5 (modified, different time coverage)



Net Capital Flows from Financial Centres and External Default



Figure: Reinhart and Rogoff (2009) - Figure 5.6



Net Capital Flows from US and External Default



Figure: Reinhart and Rogoff (2009) - Figure 5.6 (modified, different time coverage)



Duration of External Default Episodes



Figure: Reinhart and Rogoff (2009) - Figure 5.7 (updated)



Domestic Debt: missing link explaining external default and high inflation

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- Government domestic debt ranges from 40% to 80% of total public debt (traditionally more for advanced countries, less for emerging but changing).
- Duress at time of external default is quite severe when domestic debt is included (more than half of total debt at a year of default)
- Both domestic and external debt increase in the 5-year period leading to external default (pro-cyclical fiscal policy)
- Domestic public debt build-up continues *after* external default
- Domestic public debt is orders of magnitude higher than base money
- Might explain why observed inflation rates are higher than rate implied by maximum seignorage revenue.



Domestic Debt as a Share of Total Public Debt



Figure: Reinhart and Rogoff (2009) - Figures 7.1, 7.2 and 7.3 (combined)



Ratio of public debt to GDP at time of external default (89 episodes, 1827-2003)



Figure: Reinhart and Rogoff (2009) - Figure 8.1



Run-up in domestic and external public debt prior to external default (89 episodes, 1827-2003)



Figure: Reinhart and Rogoff (2009) - Figure 8.4



Total debt, external default and inflation: world aggregate (1826-2010)



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Figure: Reinhart and Rogoff (2011) - Figure 3



External debt, default, banking crises and inflation in Brazil (1824-2009)



Figure: Reinhart and Rogoff (2011) - Figure 5



Summary of crises in Brazil (1824-2009)

Domestic

default

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External

default

Duration

(in years)

WI. R. Grasselli	Dates	dates	(first year)	dates	external default	inflation crisis
This time is different	1828-1834 7	1986- 1987	1890	1988-1990	26.6	26.1
crises	1898-1901 4	1990	1897	1992-1994		
External Default	1902-1910 9		1900	or		
Domestic Default	1914-1919 6		1914	single		
Banking Crises	1931-1933 3		1923	episode		
Inflation and	1937-1943 7		1926	1988-1994		
Currency Crises	1961 1		1929			
Crises index	1964 1		1963			
The signals	1983-1990 8		1985			
approach			1990			
			1994			
	Number of episodes:					
	9	2	11	2(1)		

Figure: Reinhart and Rogoff (2011)

Domestic and External Default, Banking Crises, and Hyperinflation: Brazil, 1822-2009

Hyper-

inflation

Share of

vears in

Share of

vears in

Banking

crisis dates



Domestic versus external default

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The signals approach

- Around 70 cases of overt default in domestic debt since 1800 (compared to around 250 cases of external default).
- De facto default (not counted) include high inflation and financial repression.
- Output decline prior to domestic default is worse than prior to external default
- Inflation rates increase significantly more during domestic default than external default
- Overt domestic default occurs only in times of severe macroeconomic distress
- For 1800-1939 the probability of domestic default was lower than external
- No statistical difference over the whole sample (1800-2007)



Share of Countries in Domestic Default



Figure: Reinhart and Rogoff (2009)- Figure 7.5



Real GDP around domestic and external default events (1800-2008)





Figure: Reinhart and Rogoff (2009) - Figure 9.1



Consumer prices around domestic and external default events (1800-2008)



Figure: Reinhart and Rogoff (2009) - Figure 9.3



Share of countries in domestic and external default (1800-2006)



Figure: Reinhart and Rogoff (2009) - Figure 9.5



Theory of Banking Crises

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The signals approach

- Bank runs: self-fulfilling prophecies (similar to short-term creditors of a country)
- Increase in withdraws forces liquidation of long-term assets, depressed prices, reduce asset values of other banks as well (indirect contagion)
- Other banks are also exposed through interbank market and derivatives (direct contagion)
- Deposit insurance can prevent bank runs, but in the absence of regulation it induces riskier behaviour (moral hazard)
- Effects on real economy: negative shocks are amplified by the financial sector through reduced lending and therefore investment



Episodes of Banking Crises

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- Inflation and Currency Crises Crises Index
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- Both advanced and emerging countries had serial banking crises since 1800 with strikingly comparable features.
- We consider 18 post-WWII episodes in advanced economies, including the "big five":
 - Spain (1977)
 - One of the second se
 - Sinland (1991)
 - Sweden (1991)
 - Japan (1992)
- Consider also 40 emerging countries episodes (36 post and 4 pre-WWII).
- Also the US in 2008 for comparison.



Understanding

Incidence of banking crises

Region or group	Share of years in banking crises since independence or 1800	Number of banking crises
Africa	12.5	1.7
Asia	11.2	3.6
Europe	6.3	5.9
Latin America	4.4	3.6
North America	11.2	10.5
Oceania	4.8	2.0
Advanced economies Emerging economies	7.2 8.3	7.2 2.8
	Region or group Africa Asia Europe Latin America North America Oceania Advanced economies Emerging economies	Region or groupShare of years in banking crises since independence or 1800Africa12.5 AsiaAsia11.2 EuropeEurope6.3 4.4 North AmericaNorth America11.2 0ceaniaAdvanced economies7.2 8.3

Table: Reinhart and Rogoff (2009) - Table 10.5



Aftermath of banking crises

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- Inflation and Currency Crises Crises Index
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- High correlation between capital mobility (financial liberalization) and banking crises
- Current account deficits/GDP increases prior to the crises
- Drop in real housing prices has 4 to 6 years duration.
- Drop in real equity prices has shorter duration (V-shaped recovery)
- Real GDP growth slows in years t 3, t 2, t 1, stays near zero in t, t + 1, t + 2 and positive again by t + 3
- Real public debt increases on average by 86% by t + 3



Capital mobility and banking crises



Figure: Reinhart and Rogoff (2009) - Figure 10.1



Current account balance/GDP and banking crises in advanced economies (1945-2008)

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Figure: Reinhart and Rogoff (2009) - Figure 13.5



Real housing prices and banking crises in advanced economies (1945-2008)



Figure: Reinhart and Rogoff (2009) - Figure 13.3



Real housing prices in US around the 2007 crisis



Figure: Case-Shiller Composite 20



Equity prices and banking crises in advanced economies (1945-2008)



Figure: Reinhart and Rogoff (2009) - Figure 13.4



Equity prices in the US around the 2007 crisis



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Figure: S&P 500



Equity prices and banking crises in emerging economies (1921-2008)



Figure: Figure 10.2 in RR



Growth in real GDP per capita and baking crises in advanced economies (1945-2008)



Figure: Figure 13.6 in RR



Growth in real GDP per capita in the US around the 2007 crisis



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Figure: Percentage change in real GDP per capita in the US.



Growth in real GDP per capita and baking crises in emerging economies (1921-2008)

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Crises Index

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Figure: Reinhart and Rogoff (2009) - Figure 10.5



Central government debt and banking crises in advanced economies (1945-2008)



Figure: Reinhart and Rogoff (2009)- Figure 13.7



Central government debt in the US around the 2007 crisis

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- The signals approach



Figure: Public debt in the US



Central government debt and banking crises for all countries (1921-2008)

Understanding Cumulative increase in public debt in the three years following Financial Crises - a the banking crisis statistical perspective Malasia M R Grasselli Mexico Index=100 in year of crisis Japan This time is different Norway Philippines Datasets and crises Korea Average is 186.3 External Default Sweden Domestic Default Thailand Banking Crises Average Inflation and Currency Crises Spain Crises Index Indonesia The signals Chile approach Finland Colombia 100 150 200 250 300

Figure: Figure 10.10 in RR



Debasement

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- First de facto default in history: Dionysius of Syracuse, IV century B.C.
- Henry VIII: 83% reduction of silver content in pound during 1542–1547
- March toward fiat money: 8.5g to 1g silver content from 1400 to 1850
- Lessons:
 - inflation and default are nothing new
 - financial innovation does not necessarily create new crises, but can magnify its effects
 - advanced economies once experienced the same traumas that plague emerging countries today



Debasement throughout history (1400-1850)



Figure: Reinhart and Rogoff (2009) - Figure 11.2



Inflation and Modern Currency Crises

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- Clear inflationary bias through history (1500-2007)
- Inflation spikes considerably in the 20th century
- Low inflation period post 2001 might not extend indefinitely
- Currency crises go hand in hand with inflation
- Currency crises spike during Napoleonic Wars and then again in the post Breton Woods period
- Sustained high inflation leads to dollarization
- Dollarization persists even after successful disinflation



Inflation throughout history (1500-2006)



Figure: Reinhart and Rogoff (2009) - Figure 12.1



Currency crises throughout history (1800-2007)



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Currency Crashes: Share of Countries with an Annual Depreciation Greater than 15 Percent: 1800-2006



Figure: Reinhart and Rogoff (2009) - Figure 12.3



Median annual currency depreciation (1800-2007)



Figure: Reinhart and Rogoff (2009) - Figure 12.4



Inflation and currency crises in emerging markets (1865-2009)



Figure: Reinhart and Rogoff (2011)- Figure 1



Composite Measures of Turmoil

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The signals approach

- The BCDEI index: sum of the number of crises a country experiences in a given year.
- Ranges from 0 to 5 for each country (or 0 to 6 if we include stock market crashes BCDEIS).
- Could be extended to measure severity more accurately.
- Across history: frequent and severe crises in the prewar period followed by bouts of turbulence in the postwar.
- After 1980s most advanced countries experienced low macroeconomic volatility (Great Moderation) until the 2007 crisis.
- For Africa, index jumps in the 1950s (independence), slows down and then picks up again in the 1980s.
- Asia experiences several periods of instability, especially between the two world wars.
- Latin America does relatively well until the 1970s, when the index peaks at 3 crises per country per year in the



BDCEI index for 66 countries weighted by share of GDP (1900-2010)



Figure: Reinhart and Rogoff (2009) - Figure 16.2



Global Financial Crises

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Defining criteria

- one or more global financial centre involved
- two or more distinct regions
- 3 or more countries in each region
- weighted BCDI index is at least one standard deviation above normal
- Examples
 - The crisis of 1825 -1826
 - The panic of 1907
 - The Great Depression 1929-1938
 - The Global Contraction of 2008
- Main difficult with a global crises is the absence of export-led growth



Sequencing of Crises

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- Datasets and crises External Default Domestic Default Banking Crises Inflation and Currency Crises Crises Index
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- Financial liberalization
- Stock and real estate market crashes
- Beginning of banking crisis
- Currency crash (inconsistency between central bank roles in support of exchange rate and lender of last resort)
- Inflation crisis
- Peak of banking crisis (if no default)
- Default on external and/or external debt
- Acute inflation and banking crisis following default



Early warnings, graduation, policy responses

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- Data needed: cross country data on debt over long time span (including state and provincial debt); consumer, bank and corporate debt; housing prices
- Early warnings: signal approach (best indicators have lowest noise-to-signal ratio)
- Biggest challenge is 'this-time-is-different' syndrome.
- Criteria for graduation:
 - attain and maintain investment grade status
 - minimum threshold of income per capita
 - reduction of macroeconomic volatility
 - capacity to conduct countercyclical fiscal/monetary policy
- Policy responses: (i) need to consider complete debt scenario (including consequences on growth and inflation), (ii) stimulus worked when tried, (iii) premature self-congratulation leads to complacency.



Signals methodology

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- Methodology Banking Crises

- Choose a set of indicators for a given type of crisis based on theoretical considerations and/or historical evidence.
- Compute year-to-year change of each indicator for each country in the dataset on a specified frequency (e.g monthly, quarterly, etc).
- Obtain a histogram of changes for the entire period under consideration (e.g past 200 years) and select a country-specific threshold for each indicator.
- At each time step (e.g month), determine whether the change in the indicator is above the threshold (signal).
- Observe the occurrence of a crisis within the next forecast window (e.g 24 months).



Noise-to-signal ratio

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The signals approach Methodology Banking Crises • For each indicator, we compute the following table:

CrisisNo Crisis(within 24 months)(within 24 months)Signal IssuedABNo Signal IssuedCD

- Then A is a *good* signal, B is a *bad* signal, C is a *fail* and D is a *refrain* from issuing a bad signal.
- Ideally, B = C = 0 and A > 0, D > 0, but in general we compute

Adjusted Noise-To-Signal Ratio : $\frac{B/(B+D)}{A/(A+C)}$



Data, indicators and performance

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- We used data for 70 countries from 1960 to 2010.
- We use the following indicators:
 - Ourrent Account Balance
 - 2 Net Domestic Credit
 - **③** Domestic Credit Provided by Banking Sector (% of GDP)
 - Obmestic Credit to Private Sector (% of GDP)
 - Solution Net Flow of Foreign Direct Investment
- We measure the performance of each indicator using both the noise-to-signal ratio and a comparison between the probability of a crisis given a signal and the unconditional probability of a crisis.



Results: current account and net flow

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		Crisis	No Crisis
This time is different	Signal Issued	48	281
The signals	No Signal Issued	410	2223
Methodology Banking Crises			
	Indicator: Data Freque	Net Fleency: Ar	ow Inual
	,	Crisis	No Crisis
	Signal Issued	59	182
	No Signal Issued	455	1681



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Results: net domestic credit and credit to private sector

Financial						
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R. Grasselli	Data	Data Frequency: Annual				
			Crisis	No Crisis		
is time is ferent	Signal Is	sued	96	308		
e signals proach	No Signal	lssued	367	1937		
ethodology						
anking Crises						
	Indicator: Dome	estic Cr	edit To	Private Se	ctor	
	Data	Data Frequency: Annual				
		Crisis		No Crisis		
	Signal Issued	113		393		
	No Signal Issued	342		1870		



Results: credit provided by banking sector

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This time is							
different	Indicator: Dome	Indicator: Domestic Credit Provided By Banking Sector					
The signals			j g				
approach	Data Frequency: Annual						
Methodology		Cricic	No Crisis				
Banking Crises		CHSIS					
	Signal Issued	69	260				
	No Signal Issued	396	2009				



Summary of results

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Banking Crises Performance Analysis Annual Frequency Data

	Adjusted			
Indicator	Noise/	P(crisis	P(crisis)	Percentile
	Signal	signal)		Used
Current				
Account	1.071	0.146	0.155	80
Domestic	0.755	0.207	0.171	84
Credit				
Credit by	0.772	0.210	0.170	89
Banking				
Credit To				
Private	0.699	0.223	0.167	82
Net				
Inflow	0.851	0.245	0.216	90