Early warning for currency crises:
What is the role of financial openness?

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The views expressed in this presentation are those of the authors and do not necessarily reflect the position of De Nederlandsche Bank.

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Outline

- Motivation and literature
- Model and data
- Main results
- Robustness checks, out-of-sample performance
- Conclusions and extensions

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Motivation

- Currency crises are both an old and current challenge:
  - e.g. many emerging market economies (EMEs) in 1980's, EMS (1992), Mexico (1994), Turkey (1995, 2001), Asian tigers (1997), Russia (1998), Argentina (2002)
  - e.g. EMEs (2008)
- Visible correction of external imbalances, can trigger large balance sheet and output losses
- New: role of capital account openness and gross capital flows

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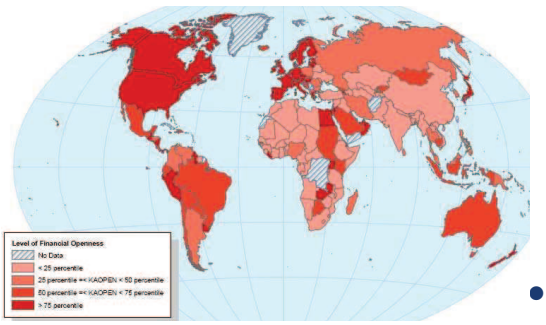
Financial Openness

Chinn-Ito Index by country, 2005



Source: Chinn and Ito, 2007

- Capital account openness
  - Does it actually lead to growth and stability, or the opposite?
  - Pros: can support institutional development, market discipline
  - Cons: exposure to foreign shocks, trilemma (dilemma?)
- Gross capital flows
  - Net flows may hide relevant dynamics
  - Balance sheet approach: importance of both foreign liabilities and assets

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Literature on EWI

- Massive literature on early warning indicators (EWI) since late 1990s:
  - Kaminsky, Lizondo and Reinhart (1998): exports, real exchange rate, reserve coverage matter in "signal extraction" model
  - Eichengreen, Rose and Wyplosz (1997): role of contagion, crises spread between major trading partners
  - (NB: EWI for economic, financial and currency crises)
- Renewed interest in EWI since global financial crisis (GFC):
  - Obstfeld, Shambaugh and Taylor (2009), Rose and Spiegel (2009): few reliable indicators for cross-country vulnerability in GFC
  - Frankel and Saravelos (2010): meta-study on EWI; many were reliable in GFC

Controversies of EWI

- Even with good in-sample results, out-of-sample performance can be shaky:
  - Borensztein, Patillo and Berg (2004): long-term models superior to short-term models, and better than guesswork – but results mixed
  - Cumperayot and Kouwenberg (2010): extreme values of one variable generally not associated with actual crashes
- Take-aways:
  - Generally better at identifying relative vulnerability in cross-section than the timing of crises
  - Multivariate parametric approaches appear more reliable than univariate signal extraction
  - Reinhart and Rogoff (2009): biggest risk is that policymakers discard the results, because "this time is different"

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Model

- Multivariate probit model; dependent variable: crisis dummy
- Various macroeconomic (control) variables found to be significant in the past: reserve adequacy, real effective exchange rate (REER) developments, GDP growth, credit growth – all lagged by 4 quarters
- New variables:
  i. "surges" in gross capital flows (inflows plus outflows over GDP, deviation of 4-quarter value from 5-year mean)
  ii. capital account openness (Chinn-Ito Index)

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Dataset

- 43 countries – both emerging market economies (EMEs) and advanced economies (AEs)
- Quarterly data between 1975Q1 to 2011Q4 (unbalanced)
  - up to Q2 2007 is in sample
- Data sources: mostly IMF IFS, Chinn and Ito (2007); others for capital account openness and ICRG for quality of institutions (robustness checks)

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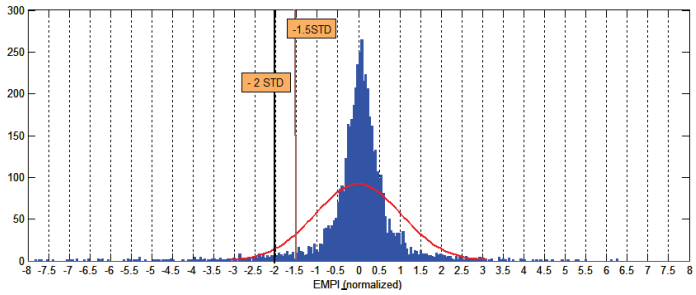
Crisis definition

- Exchange market pressure index (EMPI):

$$EMPI_{i,t} = \frac{\Delta E_{i,t}}{E_{i,t-1}} - \frac{\sigma_{E,i}}{\sigma_{R,i}} \frac{\Delta R_{i,t}}{R_{i,t-1}}$$

- Crisis when EMPI is <-1.5 standard deviations below mean; exclusion window of 4q for "recurrent crises"
- 130 currency crisis episodes (2.4% of observations)



The red line denotes a normal distribution. Properties of the distribution are as follows: Kurtosis=23.92, Skewness=-1.89, Test statistics for fat tails= 0.79, Test for Leptokurtosis -= -3.41.

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Descriptive statistics

Entire Period

	Mean	Stdev	Min	Max
Reserve Adequacy	1.95	2.56	0.00	22.38
REER Dev 10yr	0.00	0.13	-0.49	0.64
GDP Growth 2yr	0.03	0.03	-0.22	0.14
CreditGrowth2yr	0.07	0.18	-1.00	1.81
Grossall_1yrDev	-0.01	0.71	-20.89	5.41
GrossallFDI_1yrDev	0.01	0.11	-1.68	2.99
GrossallPort_1yrDev	-0.01	0.41	-12.69	1.89
GrossallOthers_1yrDev	-0.01	0.38	-10.29	4.48
KAOPEN	0.77	1.57	-1.86	2.46

For currency crisis episodes:

	4 quarters before the crisis				During the crisis				4 quarters After the crisis			
	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max	Mean	Stdev	Min	Max
Reserve Adequacy	1.59	1.53	0.08	7.06	1.35	1.29	0.00	6.30	1.58	1.44	0.02	7.33
REER Dev 10yr	0.05	0.18	-0.43	0.52	-0.05	0.18	-0.41	0.50	-0.02	0.20	-0.49	0.59
GDP Growth 2yr	0.03	0.05	-0.22	0.10	0.02	0.04	-0.19	0.12	0.01	0.04	-0.11	0.13
CreditGrowth2yr	0.15	0.22	-0.18	0.76	0.22	0.28	-0.15	1.08	0.15	0.20	-0.16	0.63
Grossall_1yrDev	0.09	0.35	-0.20	1.97	0.03	0.24	-0.14	1.69	-0.04	0.46	-2.66	1.97
GrossallFDI_1yrDev	0.02	0.11	-0.03	0.70	0.01	0.05	-0.07	0.32	0.00	0.14	-0.69	0.70
GrossallPort_1yrDev	0.04	0.13	-0.05	0.75	-0.02	0.16	-0.85	0.61	-0.02	0.21	-1.41	0.33
GrossallOthers_1yrDev	0.04	0.16	-0.16	0.94	0.04	0.19	-0.11	1.08	-0.01	0.16	-0.56	0.94
KAOPEN	-0.36	1.32	-1.86	2.46	-0.40	1.27	-1.86	2.46	-0.33	1.29	-1.86	2.46

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Baseline regressions

	All countries					Advanced		Emerging	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
KAOPEN	-0.380***	-0.375***	-0.391***	-0.447***	-0.367***	-0.401***	-0.406***	-0.186*	-0.161
	[-3.494]	[-3.424]	[-3.483]	[-4.573]	[-3.358]	[-3.524]	[-3.522]	[-1.818]	[-1.388]
EME	-0.0628	-0.0632	-0.152	-0.389*	-0.122				
	[-.2554]	[-.2052]	[-.5918]	[-1.774]	[-.4894]				
KAOPEN*EME	0.199	0.197	0.206	0.391***	0.193				
	[1.379]	[1.364]	[1.277]	[2.745]	[1.301]				
REER Dev 10Years	1.350**	1.305**	1.482**	1.353**	1.381**	1.008	1.160	1.403**	1.427**
	[2.449]	[2.344]	[2.465]	[2.2]	[2.421]	[.7858]	[.8638]	[2.296]	[2.123]
D(ReserveAdequacy)	-0.187	-0.186	-0.212	-0.219	-0.235	-0.950*	-0.925*	-0.0839	-0.0545
	[-.9804]	[-.9739]	[-1.06]	[-1.418]	[-1.159]	[-1.953]	[-1.91]	[-.4054]	[-.2633]
Inflation	-0.396	-0.394	-0.394	-0.0998	-0.256	-0.325	-0.337	2.175***	2.491***
	[-.2485]	[-.2467]	[-.2492]	[-.1174]	[-.1743]	[-.206]	[-.2201]	[3.736]	[3.976]
Inflation*EME	2.605	2.602	2.766	2.007*	2.677*				
	[1.54]	[1.537]	[1.637]	[1.875]	[1.694]				
d(GDPGrowth2yr)	2.317	2.362	0.314	8.629	4.998	4.799	-3.508	1.534	0.718
	[.2158]	[.2197]	[.0268]	[.7025]	[.4382]	[.1964]	[-.1352]	[.1269]	[.0521]
Government Quality		-0.00421							
		[-.007]							
GrossFlow1yrDev	1.180***	1.218***			1.160***	1.252***		1.119	
	[3.72]	[3.727]			[3.611]	[3.597]		[1.15]	
GrossFDI1yrDev			0.761				2.420		-1.223
			[.683]				[1.42]		[-.6018]
GrossPortfolio1yrDev			1.604**				1.482*		4.047
			[2.143]				[1.868]		[.7155]
GrossOther1yrDev			1.005				0.428		4.511
			[1.327]				[.4629]		[1.485]
GreditGrowth2yr				0.750***					
				[2.619]					
Trade Contagion					0.103***				
					[5.387]				
Lnsig2u	-2.074***	-2.069***	-2.055***	-1.809***	-2.241***	-2.098***	-2.073***	-2.134***	-2.261***
	[-9.637]	[-3.953]	[-9.456]	[-10.03]	[-10.41]	[-9.344]	[-9.237]	[-15.2]	[-13.34]
# of obs	1941	1914	1789	1875	1941	1302	1243	639	546
BIC	377.7	384.6	348.5	342.8	360.5	161.1	164.8	239.9	215.1

Lnsig2u: The panel-level variance component
BIS: Bayes Infomration Criteria
All the explanatory variables are lagged by 4 quarters except Trade Contagion, which is not lagged.

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Baseline regressions

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
	All countries					Advanced			Emerging	
Openness	-0.380***	-0.375***	-0.391***	-0.447***		-0.367***	-0.401***	-0.406***	-0.186*	-0.161
	[-3.494]	[-3.424]	[-3.483]	[-4.573]		[-3.358]	[-3.524]	[-3.522]	[-1.818]	[-1.388]
EME*Openness	0.199	0.197	0.206	0.391***		0.193				
	[1.379]	[1.364]	[1.277]	[2.745]		[1.301]				
EME dummy	-0.0628	-0.0632	-0.152	-0.389*	0.387*	-0.122				
	[-.2554]	[-.2052]	[-.5918]	[-1.774]	[1.865]	[-.4894]				
Gross flow surges	1.180***	1.218***				1.160***	1.252***		1.119	
	[3.72]	[3.727]				[3.611]	[3.597]		[1.15]	
Gross FDI surges			0.761		0.433			2.420		-1.223
			[.683]		[1.086]			[1.42]		[-.6018]
Gross Portfolio surges			1.604**		0.926**			1.482*		4.047
			[2.143]		[1.972]			[1.868]		[.7155]
Gross Other Surges			1.005		0.159			0.428		4.511
			[1.327]		[.7947]			[.4629]		[1.485]
Credit Growth (2yr)				0.750***						
				[2.619]						
Contagion Index						0.103***				
						[5.387]				

Macroeconomic controls, such as REER deviation (+), reserves to short-term debt (-), inflation (+ for EMEs) and GDP growth (+) have the expected sign.

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Baseline results

- More open capital accounts are associated with lower probability of crisis; the result is the strongest for AEs
- Surges in gross capital flows are associated with a heightened vulnerability to crisis; among components, portfolio flows matter most for AEs, and other for EMEs
- Macroeconomic control variables have the expected sign, not always significant
- Credit growth and a contagion index have a large effect, but do not change the results materially

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Alternative definitions/specifications

Results hold up to alternative definitions…

	[1] EMPI<-2 Stdev		[1] 2Q Excl Window		[1] 4Q Excl Window		[2] Net inflows	
KAOpen	-0.418*** [-2.821]	-0.417*** [-2.732]	-0.350*** [-3.632]	-0.356*** [-3.588]	-0.350*** [-3.632]	-0.356*** [-3.588]	-0.336*** [-3.335]	-0.376*** [-3.513]
EME*KAOpen	0.336* [1.95]	0.317* [1.721]	0.260** [2.073]	0.256* [1.866]	0.260** [2.073]	0.256* [1.866]	0.173 [1.225]	0.191 [1.243]
EME	0.00755 [.0235]	-0.0272 [-.079]	0.0406 [.1965]	-0.0473 [-.2157]	0.0406 [.1965]	-0.0473 [-.2157]	-0.131 [-.5407]	-0.192 [-.7625]
ReerDev10Yr	1.881*** [3.694]	1.971*** [3.704]	1.424*** [3.13]	1.569*** [3.224]	1.424*** [3.13]	1.569*** [3.224]	1.425*** [2.619]	1.506** [2.519]
dReserveAdequacy	-0.344** [-2.063]	-0.327* [-1.946]	-0.317** [-2.093]	-0.318** [-2.037]	-0.317** [-2.093]	-0.318** [-2.037]	-0.218 [-1.12]	-0.255 [-1.252]
Inflation	-1.035 [-.3869]	-1.538 [-.4948]	-0.322 [-.2977]	-0.307 [-.2971]	-0.322 [-.2977]	-0.307 [-.2971]	-0.371 [-.2324]	-0.289 [-.191]
EME*Inflation	2.260 [.84]	2.775 [.8883]	1.878* [1.669]	1.961* [1.814]	1.878* [1.669]	1.961* [1.814]	2.620 [1.545]	2.728* [1.674]
d.(GDPgrowthAVG 2yr)	6.049 [.5783]	5.203 [.4753]	6.113 [.6784]	7.941 [.8229]	6.113 [.6784]	7.941 [.8229]	1.867 [.1771]	-0.529 [-.046]
GrossFlow1yrDev	1.060*** [4.174]		0.970*** [4.131]		0.970*** [4.131]			
GrossFDIflow1yrDev		0.626 [.576]		0.492 [.4752]		0.492 [.4752]		
GrossPortfolio1yrDev		0.563 [.7551]		0.836 [1.248]		0.836 [1.248]		
GrossOtherflow1yrDev		1.513*** [2.673]		1.229** [2.374]		1.229** [2.374]		
NetInflow1yrDev							3083.4** [1.976]	
NetFlow1yrDev								-3450.9 [-1.195]
NetPortfolio1yrDev								2729.7* [1.738]
NetOthers1yrDev								3617.9** [2.219]
Insig2u	-2.259*** [-7.502]	-2.230*** [-6.996]	-2.108*** [-11.91]	-2.092*** [-11.55]	-2.108*** [-11.91]	-2.092*** [-11.55]	-2.004*** [-9.581]	-2.026*** [-9.636]
# of obs	2109	1937	2090	1921	2090	1921	1941	1789
BIC	349.7	333.4	442.5	405.3	442.5	405.3	387.6	353.4

…and net capital flows perform reasonably – but not as well as gross flows

Alternative measures of capital account openness

	[1] Chinn-Ito	[2] Quinn's measure	[3] Trade openness	[4] LMF openness	[5] eGlobe openness
Openness	-0.380*** [-3.494]	-0.0202*** [-3.054]	-0.0247** [-2.383]	-0.273** [-2.302]	-0.0348*** [-3.304]
EME*Openness	0.199 [1.379]	0.0187** [2.068]	0.0153 [1.199]	-0.303 [-1.095]	0.0264* [1.86]

Other control variables (including EME dummy) are the same as the main specification. ([1] in table 3).

- **Chinn-Ito measure** is based on principal component of analysis of AREAER. Reference: Chinn and Ito (2007). It is a *de jure* measure of capital account openness.
- **Quinn's measure** is based on coding of AREAER. It is *de jure* measure of capital account openness.
- **Trade** denotes trade openness, which is measured as export plus import divided by GDP (Data: IMF-IFS). It is a *de facto* measure of *current account* openness.
- **LMF** is calculated by Lane and Milesi-Ferretti (2007) as external assets and liabilities divided by GDP. It is a *de facto* measure of *capital account* openness.
- **eGlobe** is calculated by Dreher et al (2008). It is based on trade and capital flows plus coding of AREAER. It is a hybrid measure of general *economic openness*.

Out-of-sample performance

Potential classification of signals and noise

	Crisis in following 4q	No crisis in following 4q
Signal	A	B (Type I error)
No signal	C (Type II error)	D

Signals and noise in predicting currency crises in 2008 (out-of-sample)

	Crisis in 2008	No crisis in 2008
Signal	7	15
No Signal	1	18

# of countries: 41; signal when fitted value>1%
Noise-to-signal ratio = 0.52

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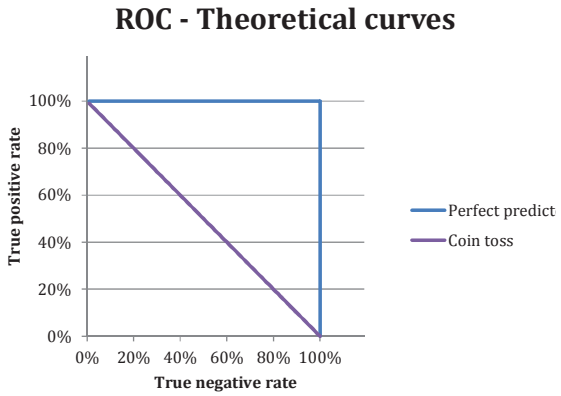
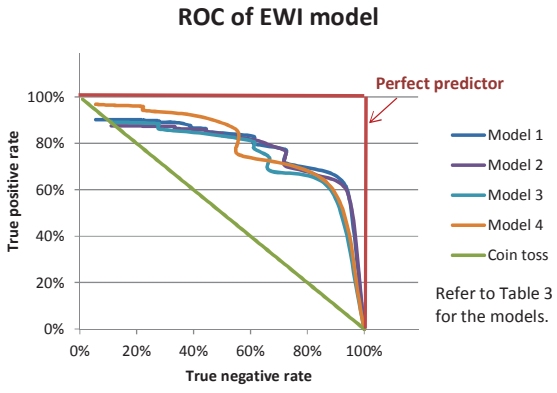
Out-of-sample performance





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Out-of-sample performance

Fitted values as of Q4 2011

Venezuela	36.5%	Finland	0.2%
Philippines	5.3%	Germany	0.1%
India	5.1%	Italy	0.1%
Colombia	5.0%	Switzerland	0.1%
South Africa	4.8%	Israel	0.1%
Ukraine	4.4%	Norway	0.1%
Thailand	3.6%	Sweden	0.1%
Argentina	2.6%	United States	0.1%
Poland	1.9%	Netherlands	0.1%
Brazil	1.9%	United Kingdom	0.1%
Australia	1.4%	Portugal	0.1%
Mexico	1.1%	France	0.1%
Saudi Arabia	1.1%	Spain	0.1%
Indonesia	0.8%	Belgium	0.0%
Peru	0.6%	Austria	0.0%
Korea	0.5%	Greece	0.0%
Czech Republic	0.4%	Hungary	0.0%
Canada	0.3%	Ireland	0.0%
Japan	0.2%		

- Moderately effective at identifying "fragile 5" countries hit by Summer 2013 market stress around tapering of US QE

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Conclusions

- Overall results:
  - Capital account openness associated with lower chance of crises – which we attribute to the role of institutions (see Kose, Prasad and Taylor, 2011)
  - Surges in gross capital flows can increase risks
  - Results robust to alternative specifications
  - Moderate performance out-of-sample
- EWI remain a policy-relevant if not infallible tool

Potential extensions

- Currency regimes: so far, results hold up for fixed/managed versus floating
- Role of macroprudential policies: recent anecdotal examples (limits on bank's open FX positions, bank borrowing levies), but little long-term cross-country data; difficult to use in quantitative analysis
- Specific case of euro area: no nominal adjustment mechanism; fundamental factors even more important?

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Thank you!

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