Can We Predict the Next Capital Account Crisis?

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Predicting Crises Is Challenging

- Many possible explanatory variables to consider
- Very hard to get the timing of crises right
- Nature of crises has evolved over time
Predicting Crises with Binary Classification Trees (BCTs)

- BCTs work by successively partitioning the data in order to separate crises from non-crises.
- BCT starts by comparing all variable thresholds to split the data.
  - E.g. Current Account/GDP above or below 3 percent.
- For each candidate split, it computes a measure of how it improves the “purity” of the data.
  - Measure of purity based on product of probabilities of crisis and non-crisis at each node (which depend on relative frequencies, priors and relative misclassification costs).
Benefits of BCTs

- Can consider a large number of competing variables. Variables with low explanatory power do not interfere with results.
- Consider all possible variable*threshold interactions. This is not possible in standard regressions where possible combinations are orders of magnitude higher than number of observations.
- Non-parametric.
- Can consider variables with missing values.
- BCTs unrelated to standard crisis-prediction tools:
  - At the very least, they provide alternative estimates that can complement other predictions.
Missing Crises vs False Alarms

- We want to err on the side of caution.
- Ready to call crisis prone a node where ratio of crisis/non-crisis twice as high as in the sample
  - Two parameters are used to determine conservativeness: priors and relative misclassification costs
  - Set crisis prior to 20%; cost of missing crisis 2x cost of misclassifying non-crisis
  - Alternatively could set prior to sample frequency (6%); cost of missing crisis 7.7x cost of misclassifying non-crisis
Data covers 49 emerging markets:
- Significant access to private international financial markets;
- No substantial net foreign asset position; and
- Are not small (GDP at least 7.5 billion dollars)

Sample covers 1994-2005
Dating Capital Account Crises Episodes

- Dating of crises result of concerted effort of the Working Group on Vulnerability Indicators
- Initial candidate episodes chosen based on:
  - Sudden stop indicators, exchange rate pressure (from EWS), sovereign defaults, banking crises (Demirguc-Kunt and Detragiache 1998) and corporate crises (CVU).
- Final selection of episodes made after comments from IMF country desk economists
- Dating based on inception of crises
- Table 1 lists crisis episodes. Appendix provides detailed information on crisis selection
Vulnerability Indicators

- **External sector:**
  - Reserve coverage (relative to ST/maturing external debt and the current account deficit)
  - Current account balance/GDP
  - External debt/GDP
  - Real exchange rate overvaluation (using only *ex ante* data)
  - Exchange rate regime

- **Fiscal sector:**
  - Overall balance
  - Primary gap (difference between primary balance and debt-stabilizing primary balance)
  - Public debt (in percent of GDP)
  - Short-term debt/total debt
  - Foreign-currency debt in percent of total debt
Vulnerability Indicators (cont’d)

- **Financial sector:**
  - Capital adequacy
  - Return on assets
  - Non-performing loans as a share of total loans
  - Growth in private sector credit/GDP
  - Share of foreign currency loans

- **Corporate sector:**
  - Default probability (implied by Black-Scholes-Merton formula)
  - Interest coverage ratio
  - Debt-to-assets ratio
  - Real return on assets
  - Valuation measure based on the price-to-earnings-ratio.
Vulnerability Indicators (cont’d)

- Macroeconomic Conditions. One-year-ahead WEO forecasts of:
  - Real GDP growth
  - CPI inflation.

- Global Demand Conditions
  - One-year-ahead WEO forecasts of growth in import demand by trading partners
  - Commodity price indices faced by each particular country (constructed by RES Commodities Unit)

- EMBI Spreads
Vulnerability Indicators (cont’d)

- Country-invariant measures of global conditions not used
  - Given nature of BCT, they often acted as proxies for year dummies
- Due to forecasting nature of exercise, all variables are lagged:
  - For example, use current account balance in 2000 when predicting crisis in 2001
Baseline Tree
Out-of-Sample Forecasts
Using Data Up To 2000 To Predict 2001

Sample
320 obs. o/w 7.2% crisis

Current Account Balance (% of GDP) ≤ -2.9

168 obs. o/w 12.5% crisis

ST Ext. Debt/Reserves ≤ 41%

124 obs. o/w 16.1% crisis

Argentina Brazil Costa Rica Czech Republic Dominican Republic Estonia Guatemala Hungary Jamaica Latvia

Lebanon Lithuania Mexico Panama Romania Serbia Slovak Republic Sri Lanka Tunisia Turkey

ST Ext. Debt/Reserves > 41%

152 obs. o/w 1.3% crisis

Algeria Chile China Colombia Croatia Ecuador Egypt El Salvador India Indonesia Israel Jordan Kazakhstan Korea Lebanon Malaysia Morocco Pakistan Peru Philippines Russia Slovenia South Africa Slovakia Sri Lanka Tunisia Ukraine

44 obs. o/w 2.3% crisis

Bosnia Bulgaria Poland

Misses 40% of crises (South Africa and Venezuela)
Misclassifies 33% of non-crises
Using Data Up To 2001 To Predict 2002

Sample
369 obs. o/w 7.6% crisis

Current Account Balance (% of GDP) ≤ -2.9

191 obs. o/w 12.6% crisis

ST Ext. Debt/Reserves ≤ 125%

ST Ext. Debt/Reserves > 125%

158 obs. o/w 8.2% crisis

WEO Forecasted Real GDP Growth ≤ 2.5%

WEO Forecasted Real GDP Growth > 2.5%

33 obs. o/w 33.3% crisis

Estonia

33 obs. o/w 33.3% crisis

178 obs. o/w 2.2% crisis

Algeria
Chile
China
Colombia
Egypt
El Salvador
India
Indonesia
Israel
Jordan
Korea
Malaysia
Mexico
Morocco
Pakistan
Panama
Peru
Philippines
Poland
Russia
Slovenia
Sri Lanka
Thailand
Ukraine
Uruguay

137 obs. o/w 4.4 crisis

Bosnia
Brazil
Bulgaria
Costa Rica
Croatia
Czech Rep.
Dominican Rep.
Ecuador
Guatemala
Hungary
Jamaica
Kazakhstan
Latvia
Lithuania
Romania
Serbia
Slovak Rep.
Tunisia

Misses all crises
Misclassifies 2.5% of non-crises
Using Data Up To 2002 To Predict 2003

- We predict both crises (Dominican Republic and Jamaica), misclassify only 16 percent of non-crisis observations
Using Data Excluding East Asia to Predict East Asia

Sample
487 obs. o/w 6% crisis

Reserve Cover ≤ 82%

152 obs. o/w 12.5% crisis

Deviation of Real Effective Exchange Rate from past average ≤ 11.6%

103 obs. o/w 6.8% crisis
- China 1994
- Indonesia 1996, 1997
- Thailand 1996, 1997

Deviation of Real Effective Exchange Rate from past average > 11.6%

49 obs. o/w 24.5% crisis

WEO Forecasted Real GDP Growth ≤ 3%

49 obs. o/w 14.3% crisis
- Indonesia 1999, 2000
- Korea 1999
- Malaysia 1999
- Thailand 1999

WEO Forecasted Real GDP Growth > 3%

335 obs. o/w 3% crisis

Misses all 5 crises and misclassifies 7.5% of non-crises
Top split alone would have missed only Malaysia 97 and misclassified 13% of non-crises
RandomForests

- Estimates 1000 trees based on bootstrapped samples. In each split, it only considers 3 randomly chosen indicators. Predictions from each tree are averaged out.

- Performance similar to that of forecasting trees:
  - 2001: Predicts the same crises but has more false-alarms
  - 2002: Predicts the crisis in Brazil while still missing others, misclassifies 25% of non-crises
  - 2003: Misses one of the crises and has more false-alarms
  - East Asia: Predicts Korea while still missing others. Misclassifies 29% of non-crises.
Global Conditions vs Country-Specific Indicators

- It would be interesting to get a sense of extent to which benign global environment compensates for country vulnerabilities.

- We include contemporary global condition variables (commodity prices and import demand). No longer a forecasting exercise!
Sample
554 obs. o/w 6.1% crisis

Reserve Cover ≤ 81%

164 obs. o/w 14% crisis
Deviation of Commodity Export Prices from past average ≤ -14%
93 obs. o/w 22.6% crisis
External Debt (% of GDP) ≤ 24
16 obs. o/w 0% crisis
Algeria 1994
Argentina 1995, 2001
Brazil 1998, 2002
Colombia 1999
Ecuador 1999
Indonesia 1997
Jamaica 2003
Lithuania 1999
Mexico 1994

Deviation of Commodity Export Prices from past average > -14%
71 obs. o/w 2.8% crisis
Dominican Republic 2003
Korea 1997
77 obs. o/w 27.3% crisis
Argentina 1995, 2001
Brazil 1998, 2002
Colombia 1999
Ecuador 1999
Indonesia 1997
Jamaica 2003
Lithuania 1999
Mexico 1994

Reserve Cover > 81%

390 obs. o/w 2.8% crisis
WEO Forecasted Real GDP Growth ≤ 3%
54 obs. o/w 13% crisis
Bulgaria 1994
Colombia 2002
Hungary 1996
Lebanon 2001
Ukraine 1994
Venezuela 1998
41 obs. o/w 2.4% crisis
Venezuela 1994

WEO Forecasted Real GDP Growth > 3%
336 obs. o/w 1.2% crisis
Czech Republic 1997
Israel 1997, 2002
Malaysia 1997
13 obs. o/w 46.2% crisis
Algeria 1994
Argentina 1995, 2001
Brazil 1998, 2002
Colombia 1999
Ecuador 1999
Indonesia 1997
Jamaica 2003
Lithuania 1999
Mexico 1994
Pakistan 1998
Philippines 1997
Romania 1999
Russia 1998
South Africa 2001
Thailand 1997
Turkey 1994, 2001
Ukraine 1998
Uruguay 2002
Baseline Tree + Contemporary Global Conditions

- Taken at face-value:
  - Deviation of commodity prices from past average of 14% does as much harm for low reserve cover countries as having external debt above 24% of GDP

- We should also be cautious when trying to separate global and country-specific crisis determinants:
  - If global conditions deteriorate, a number of improvements in country indicators (e.g. more reserves, less short-term debt) could be reversed
Conclusions

- Can we predict the next capital account crises?
  - If it were not for 2002, our performance would have been excellent

- How do our estimates compare with previous Early Warning Systems (EWS)?
  - In-sample we do better
  - Out-of-sample comparison difficult since crises definitions different and EWS uses monthly data
  - But out-of-sample performance comparable (and 2002 aside, our performance seems preferable)
Conclusions

- Traditional macro/external variable seem to have more explanatory power than financial sector variables
  - There are limitations in our methodology and some financial sector variables had limited coverage
  - Maybe macro/external variables are better at explaining whether crisis occurs, but financial indicators may be more relevant for how disruptive crisis will be

- Role of reserve cover identified in our estimates supports view that world is a safer place now
  - Reserve accumulation often higher than threshold in our estimates