

Identifying the Early Warnings of Currency Crisis in India

Mohan Rao
Ph.D. Candidate

Puja Padhi
Associate Professor

Department of Humanities & Social Sciences,
Indian Institute of Technology Bombay

Introduction

- The financial crises have enthused a huge theoretical and empirical debate in recent times due to their recurrent nature in the history of economics
- Academics are interested in an economic crisis as they have had a history of fascination for the crises, policy makers are interested because they want to prevent the crisis and financial market participants are interested as they can make money out of it (Kindleberger, 1978).
- The financial crises can be divided into two broad categories – currency and sudden stop crises, and debt and banking crises
- Argentina (2001), Brazil (1998-99), Latin America (1980s), Russia (1998), Southeast Asia (1997) and UK (1992).
- Currency crisis is a situation in which a country's exchange rate depreciates substantially or foreign exchange reserves deplete on a large scale or a combination of both in a short period of time (Burnside et al., 2008; Glick and Hutchison, 2013; among others)

Introduction (Contd.)

- Three generations of models evolved over a period of time to explain the phenomenon of currency crisis upon the failure of previous model in explaining the subsequent crisis episode
- The previous literature (Cerra and Saxena, 2002) and macroeconomic structure suggest that these three generations of models do not explain the case of India completely despite the presence of some of the elements of these models
- Though there is a plethora of empirical studies on currency crises but there is only one study on India's currency crisis (Cerra and Saxena, 2002)
- The current study emphasizes on India's exposure to currency crisis

Review of Literature

- After the outburst of European Exchange Rate Mechanism (ERM) crisis – mainly in UK – in 1992, there is an abundance of empirical studies on currency crises and selective empirical studies are mentioned below:
- Multi-country analysis – in KLR framework: Kaminsky et al. (1998), Kaminsky and Reinhart (1999) and Edison (2003)
- In Logit/Probit framework: Berg and Pattillo (1999); Bussiere and Fratzscher (2006); Licchetta (2011); Frankel and Saravelos (2012)
- Single-Country Analysis: Alvarez-Plata and Schrooten (2004) and Boinet et al. (2005) on Argentina; Mariano et al. (2004), Feridun (2008), Tamgac (2011) and Ali Ari (2012) on Turkey
- Calvo and Mendoza (1996), Cole and Kehoe (1996), Sachs et al. (1996) and Otker and Pazarbasioglu (1996) on Mexico
- Peng and Bajona (2008) on China; Megersa and Cassimon (2015) on Ethiopia; Cerra and Saxena (2002) on India.

Objective of the Study

- The main objective of this paper is to study the likelihood of a currency crisis in India
- Our other objective is to build the Early Warning System (EWS)
- We also try to find the determinants that are likely to cause currency crisis

Rationale of the Study

- There have been no studies on the India's vulnerability to currency crisis and the determinants of the crisis
- The three generations of the crisis models and the subsequent literature are mostly absent in the case of India

Data and Selection of Variables

- This paper uses monthly data for the period January 1986 to December 2015 with the aim of covering all the major events in the economy
- Financial Sector
 - M3 Multiplier
 - Bank Credit
 - Real Interest Rate
 - Stock Index
 - Excess M1 Balances
 - M3/Reserves
 - Deposits
- External Sector
 - Exports
 - Terms of Trade

Data & Variables (Contd.)

- Real Exchange Rate
- Imports
- Reserves
- Current Account Balance as a Percentage of GDP
- Gold Prices
- Crude Oil Prices
- Real Sector
 - Output
- Fiscal Sector
 - Fiscal Deficit as Percentage of GDP

Methodology

- The objective of this paper is to study the likelihood of a currency crisis in India and the factors contributing to it, and construction of an early warning system (EWS)
- Building of an early warning system involves the following steps: 1. Identification of crisis months. 2. Selection of the variables. 3. Extraction of signals. 4. Calculating the Probabilities. 5. Logit Model has been employed as an alternative
- **Crisis Identification**
- Exchange Market Pressure Index: $I = \frac{\Delta E}{E} - \frac{\sigma_E}{\sigma_R} \frac{\Delta R}{R}$
- $Crisis = 1 \text{ if } I > \mu_I + m\sigma_I$
- $= 0 \text{ otherwise } (I \leq \mu_I + m\sigma_I).$
- In the above index $\frac{\Delta E}{E}$, $\frac{\Delta R}{R}$ are monthly changes in exchange rate and reserves respectively, and $\frac{\sigma_E}{\sigma_R}$ is the variance smoothing weight

Noise-to-Signal Ratio and Probabilities

Table 1 – Performance of each indicator

	Crisis (in the crisis horizon of 12 months)	No Crisis (in the crisis horizon of 12 months)
Signal	A	B
No Signal	C	D

Source: Kaminsky et al. (1998 and 1999)

Methodology (Contd.)

- When $A > 0, B = 0, C = 0$ and $D > 0$, warnings by the variables will be completely accurate. The noise-to-signal ratio can be written as the ratio of bad signals $\left(\frac{B}{B+D}\right)$ to good signals $\left(\frac{A}{A+C}\right)$ and expressed as $\left(\frac{\frac{B}{B+D}}{\frac{A}{A+C}}\right)$. The conditional and unconditional probabilities are as follows: $\left(\frac{A}{A+C}\right)$ and $\left(\frac{A}{A+B+C+D}\right)$. Whereas, Type I and Type II Errors can be written as $\left(\frac{C}{A+C}\right)$ and $\left(\frac{B}{B+D}\right)$ respectively.

- **Composite Indicator**

- Composite Crisis Indicator: $K = \sum_{j=1}^n \frac{S_t^j}{\omega^j}$

- Where, $S_t^j = 1$ if the variable j exceeds the critical region at time t
- $= 0$ otherwise.

- And $\omega^j =$ Noise – to – signal ratio of variable j .

Methodology (Contd.)

➤ Probability of Currency Crisis

- Probability of crisis is calculated for every month given the composite indicator value by identifying how frequently a particular value is followed by a crisis

- $$Pr.(C_{t,t+12}|K_i < K_t < K_j) = \frac{\sum \text{Months with } K_i < K_t < K_j \text{ and crisis within 12 months}}{\text{Months with } K_i < K_t < K_j}$$

➤ Logit Model:

- $$Pr(y_t^*) = \frac{e^{Z_i}}{1+e^{Z_i}} = \Lambda(\beta' X_t + u_t)$$

- Since y_{it}^* is a latent variable, we take a dummy variable Y , which is defined as below:

$$Y_t = 1 \text{ if } y_t^* > 0 \\ = 0 \text{ otherwise}$$

- $$Pr(\text{Crisis}_t = 1|X_t) = \Lambda(\beta' X_t + u_t)$$

Results & Discussion

- Whenever the EMPI crosses the threshold value, that period is considered as currency crisis but all those periods may not turn out to be full-blown crises as the fiscal and/or monetary authorities are most likely to step-in timely to pre-empt the crisis.
- The following months are identified as crisis months (22): June 1988, May 1989, August 1989, September 1990, October 1990, December 1990, February 1991, April 1991, June 1991, July 1991, March 1993, September 1995, October 1995, December 1997, June 1998, May 2008, September 2008, October 2008, September 2011, May 2012, June 2013 and August 2013.
- Among those identified months, only the early periods were consistent with devaluation but not the later periods.

Table 2 – Efficiency of the Indicators

Indicator	Threshold Percentile	Noise to Signal Ratio	Con. Prob. of Crisis	Uncon. Prob. of Crisis	Prob. (Type I Error)	Prob. (Type II Error)
Financial Sector						
M3 Multiplier	>79	1.093	0.197	0.394	0.802	0.216
Bank Credit	>75	1.181	0.225	0.394	0.775	0.266
Real Interest Rate	>95	0.651	0.063	0.394	0.937	0.041
Excess M1 Balances	>92	0.565	0.107	0.394	0.894	0.060
M3/Reserves	>92	0.024	0.190	0.394	0.810	0.005
Deposits	<30	1.861	0.197	0.394	0.803	0.367
Stock Index (BSE)	<24	1.046	0.232	0.394	0.768	0.243

Table 2 – Efficiency of the Indicators (Contd.)

External Sector						
Terms of Trade	<11	0.558	0.148	0.394	0.852	0.083
Exports	<27	1.207	0.240	0.394	0.761	0.289
Real Exchange Rate	<14	0.707	0.169	0.394	0.830	0.119
Imports	>95	0.521	0.070	0.394	0.930	0.037
Reserves	<10	0.186	0.197	0.394	0.803	0.037
Current Account Balance	<10	0.081	0.225	0.394	0.775	0.018
Gold Prices	>95	0.717	0.070	0.394	0.930	0.037
Crude Oil Prices	>94	0.717	0.070	0.394	0.930	0.050
Real Sector						
Output (IIP index)	<18	0.651	0.225	0.394	0.775	0.147
Fiscal Sector						
Fiscal Deficit	>83	0.273	0.303	0.394	0.697	0.083

Table 3 – Performance of the Indicators

Indicator	Percentage of Observations Correctly Called	Prob. (Crisis/Signal)	Average Lead Time	Persistence of Signals
	$(A+D) / (A+B+C+D)$	$A/(A+B)$		
Financial Sector				
M3 Multiplier	0.553	0.373	2	0.59
Bank Credit	0.533	0.356	3	0.55
Real Interest Rate	0.605	0.500	1	1
Excess M1 Balances	0.611	0.536	2	1.15
M3/Reserves	0.681	0.964	4	27
Deposits	0.461	0.259	3	0.35
Stock Index (BSE)	0.550	0.384	2	0.62

Table 3 – Performance of the Indicators (Contd.)

External Sector				
Terms of Trade	0.614	0.538	2	1.17
Exports	0.525	0.351	4	0.54
Real Exchange Rate	0.600	0.480	3	0.92
Imports	0.611	0.556	2	1.25
Reserves	0.661	0.778	4	3.50
Current Account Balance	0.683	0.889	2	8
Gold Prices	0.611	0.556	1	1.25
Crude Oil Prices	0.603	0.476	3	0.91
Real Sector				
Output (IIP index)	0.606	0.500	4	1
Fiscal Sector				
Fiscal Deficit	0.675	0.705	5	2.39

Results & Discussion (Contd.)

- We choose the threshold value (critical region) – depends on the percentile distribution – for each variable separately, by executing a grid-search operation
- The variables whose noise-to-signal ratios below one were the best performing ones
- The pervasiveness of Type I Error and high unconditional probability highlight that there is no single variable that can predict currency crisis in case of India
- We compute the average lead time (column 3), wherein the low average of months shows that there is no single indicator that gives warnings about every impending crisis
- Inverse of unadjusted noise-to-signal ratio is presented to know the persistence of signals in the crisis window relative to normal periods
- All the crisis months prior to and during 1991 were considered as part of 1991 currency crisis, in which Fiscal Deficit, Real Exchange Rate, Reserves and M3/Reserves issued warnings during the crisis months

Results & Discussion (Contd.)

- This crisis started building up from 1988 and unfolded fully in 1991, which resulted in devaluation of rupee followed by large scale financial reforms
- As there was an Exchange Rate Regime shift in 1993 , the economy had seen a currency stress in 1993 due to which there was a decrease in Stock Index, Output and Real Exchange Rate
- There was short spell of currency stress in 1995, and Stock Index and Bank Credit issued signals during this period
- In 1997, South East Asian currency crisis had had an effect on Indian economy too, due to which Exports declined, M3 Multiplier and Real Interest Rate increased
- As a result of sanctions on India after the nuclear tests in 1998 , there was a currency stress in the subsequent month that resulted in a decrease in exports, stock index and an increase in M3 Multiplier

Results & Discussion (Contd.)

- Owing to great recession in 2008, Indian economy also witnessed a short period of currency crisis, in which indicators sent warnings mainly during the crisis as it was of exogenous in nature
- Indicators such as Bank Credit, Excess M1 Balances, Gold Prices, Oil Prices and Imports issued warnings just before the crisis whereas indicators like Stock Index and Real Exchange Rate gave warnings during the crisis
- India's monetary authority Reserve Bank of India (RBI) responded to this crisis by shifting its policy stance by monetary tightening whereas Government has implemented stimulus packages as a fiscal response to the crisis
- In 2013, variables such as Current Account Balance and Deposits issued signals consistently throughout the period, and variables such as Exports, Output, M3 Multiplier, Terms of Trade, Real Exchange Rate and Gold Prices have sent signals well in advance but not consistently

Results & Discussion (Contd.)

- This crisis had its roots from 2011 and started accumulating from then to result in currency crisis in 2013, and reasons for this phenomenon may vary from policy impasse to series of corruption allegations, and thankfully it did not turn out to be a full-blown currency crisis like 1991 though there were comparisons
- To some extent, central bank's intervention in foreign exchange market also helped in preventing further depreciation of rupee
- It can be observed from the above results that the silent nature of the variables and low average lead time indicate no relative importance to the traditional crises models

Table 4 – Probabilities of Currency Crises

Value of Composite Indicator	Probability of Crisis
0-0.5	0.43
0.5-1.0	0.29
1.0-1.5	0.05
1.5-2.0	0.45
2.0-2.5	0.12
2.5-3.0	0.30
3.0-5.0	0.14
5.0-7.0	0.37
7.0-9.0	0.67
Above 9	0.87

Table 5 – Logit Estimation Results

Indicator	Model 1	Model 2	Model 3	Model 4	Model 5
Financial Sector					
M3 Multiplier (M3M)	-0.112* (0.029)		-0.084** (0.042)	-0.104* (0.038)	-0.117** (0.047)
Bank Credit (BC)	-0.037 (0.024)				-0.103* (0.036)
Real Interest Rate (RIR)	0.047 (0.041)				0.372* (.073)
Excess M1 Balances (EM1B)	0.0001 (0.0002)			0.0004 (0.0002)	
M3/Reserves (M3/R)	0.018* (0.006)		0.029** (0.011)	0.003 (0.005)	0.059* (0.018)
Deposits (Dep.)	0.163* (0.046)		0.245* (0.053)	0.255* (0.058)	0.424* (0.078)
Stock Index (BSE) (SI)	-0.002 (0.003)				-0.020* (0.007)
External Sector					
Terms of Trade (ToT)		0.007 (0.008)		0.001 (0.009)	
Exports (Exp.)		0.041* (0.013)	0.028*** (0.014)	0.0217 (0.014)	
Real Exchange Rate (RER)		0.029 (0.019)			0.063** (0.028)

Table 5 – Logit Estimation Results (Contd.)

External Sector					
Imports (Imp.)		0.029*	0.041*	0.038*	0.074*
		(0.010)	(0.011)	(0.011)	(0.013)
Reserves (R)		0.007***	0.018**		0.034*
		(0.004)	(0.008)		(0.012)
Current Account Balance (CAB)		1.439*	1.455*	1.442*	2.342*
		(0.191)	(0.201)	(0.189)	(0.312)
Gold Prices (Gold)		-0.061*	-0.074*	-0.098*	-0.086*
		(0.012)	(0.013)	(0.016)	(0.016)
Crude Oil Prices (Oil)		0.003		0.009***	
		(0.005)		(0.005)	
Real Sector					
Output	-0.092*		-0.063***		-0.084***
	(0.029)		(0.036)		(0.043)
Fiscal Sector					
Fiscal Deficit (FD)	0.026			0.201	
	(0.110)			(0.125)	
Constant	-1.953**	-3.512*	-7.534*	-8.656*	-10.478*
	(0.978)	(0.415)	(1.140)	(1.436)	(1.640)
No. of Observations	360	360	360	360	360
Likelihood Ratio Statistic	55.74*	153.83*	196.78*	190.50*	249.49*
Pseudo R ²	0.115	0.318	0.408	0.395	0.517

Results & Discussion (Contd.)

- We estimate binary logistic regression model – as part of the EWS – as an alternative methodology
- We estimate two separate Logit regressions by dividing the variables into two sub-categories – financial and, real and fiscal sectors – in order to arrive at Model 3
- In Model 3, Imports, Current Account Balance, M3 Multiplier, M3/Reserves and Output are statistically significant and correctly signed
- Model 4 has been estimated taking all the significant variables from running univariate regressions (Frankel and Saravelos, 2012)
- In model 4, M3 Multiplier, Imports, Current Account Balance and Oil are significant and in line with the literature
- In Model 5, Bank Credit, Real Interest Rate, M3/Reserves, Stock Index, Imports, Current Account Balance, M3 Multiplier, Real Exchange Rate and Output have the expected signs and are statistically significant (Stepwise Regression with backward selection)

Table 6 – Performance of the Models

Goodness of Fit	KLR	Model 3	Model 4	Model 5
<i>Cut-off Probability of 25%</i>				
% of Tranquil Periods Correctly Called	50	84	85	87
% of Observations Correctly Called	66	91	91	92
% of Crises Correctly Called	89	100	100	100
% of False Alarms of Total Alarms	46	19	18	16
% Prob. of Crisis Given an Alarm	54	81	82	84
% Prob. of Crisis Given No Alarm	12	0	0	0
<i>Cut-off Probability of 50%</i>				
% of Tranquil Periods Correctly Called	94	99	100	100
% of Observations Correctly Called	77	99	100	100
% of Crises Correctly Called	50	100	100	100

Table 6 – Performance of the Models (Contd.)

Cut-off Probability of 50%

% of False Alarms of Total Alarms	14	1	0	0
% Prob. of Crisis Given an Alarm	86	99	100	100
% Prob. of Crisis Given No Alarm	26	0	0	0

Cut-off Probability of 75%

% of Tranquil Periods Correctly Called	95	100	100	100
% of Observations Correctly Called	76	89	87	91
% of Crises Correctly Called	47	73	67	78
% of False Alarms of Total Alarms	13	0	0	0
% Prob. of Crisis Given an Alarm	87	100	100	100
% Prob. of Crisis Given No Alarm	27	15	18	12

Results & Discussion (Contd.)

- Model 5 was considered in calculating the probability of crisis and in building the early warning system (EWS)
- All Logit models outperform KLR model in terms of goodness-of-fit at all cut-off probability levels – 25%, 50% and 75%
- Whereas KLR model fares better at 75% than other cut-off levels
- However, KLR model can be used as a benchmark methodology in identifying the crisis periods and alternative methodologies can be adopted to strengthen its predictive power
- Irrespective of the exchange rate regimes (as the previous literature suggest) and macroeconomic structure, the Indian economy is still vulnerable to currency crisis
- Building an EWS may not (necessarily) guarantee the prevention of a looming crisis but it can be a useful diagnostic tool.

Conclusion

- In this paper, we focus on the recent history of currency crises and/or stress periods in India.
- The KLR and Logit models have been employed to find out the factors contributing to the crisis.
- Logit model fares better than KLR methodology in terms of the goodness-of-fit measures (and probabilities).
- Both these methodologies indicate that there is no relative importance to the three generations of models.
- We also found that currency crisis in India is due to combination of different macroeconomic imbalances.
- Though Indian economy seems to be more stable for a decade from 1998 to 2008 (until global financial crisis) but it is still not immune to currency crisis as our results suggest.

Thank you!