Theoretical and Applied Economics
Volume XXIV (2017), No. 3(612), Autumn, pp. 97-114

Evaluating Indian economy's vulnerability to currency crisis

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Abstract. *This paper examines India's exposure to currency crisis for the period 1986 to 2015 using KLR (Kaminsky, Lizondo and Reinhart) methodology. Focus of the study is on evaluating currency crises and building an Early Warning System (EWS) to anticipate future crises. Using KLR methodology we explain the phenomenon of currency crises over three stages – identification of the crises periods, selection of the variables causing the crisis based on previous literature and economic structure, and estimating indicators' ability to forecast the crisis. The following are identified as crisis periods: 1991, 2008-2009 and 2012. Among these crises, 1991 crisis was attributed to fiscal mismanagement, global financial crisis caused the 2008 currency slump whereas 2012 crisis occurred due to domestic macroeconomic imbalances. A surprising finding is that there were no common indicators issuing signals in these three spells of crises.*

Keywords: currency crisis; three generations of currency crises models; signal extraction: early warning system; noise-to-signal ratio.

JEL Classification: F31, F47, G01.

1. Introduction

In the recent past, the world economy has seen many crises and gone through major transformations post World War II such as Bretton Woods collapse in 1971, shifting to flexible exchange rate system, globalization, stagflation in 1970s, Latin American currency crises in 1980s, European currency crisis in 1992, Asian currency crisis in 1997 and global financial crisis in 2007-2008 (Glick and Hutchison, 2013). Indian economy has also witnessed major changes in its macroeconomic structure during this period, especially after 1991 currency crisis, though it was relatively stable till 2007-2008 global financial crisis but the economy has seen financial and exchange rate instabilities afterwards. This study focuses on evaluating currency crisis and Early Warning System (EWS) in anticipating the future crises.

A general description of currency crisis, in the absence of a widely accepted definition, is as follows: currency crisis is a situation where there is a rapid depreciation of country's currency or a sudden depletion of foreign reserves or combination of both and/or a sharp increase in domestic interest rates as a result of *speculative attack*(1) on the currency or exodus of investments in fear of devaluation (Edison, 2003; Glick and Hutchison, 2013). There are three generations of models to analyze the phenomenon of currency crisis. In the context of first wave of Latin American Currency Crises, Krugman (1979) developed a theory, which later on came be to referred to as "first-generation model" (Stijn and Kose, 2013), and it was further refined by Flood and Garber (1984). The source of crisis is the mismatch between domestic macroeconomic policies and exchange rate policy. The principal reasons for speculative attack on the currency are fear of 'monetization of debt' through *seigniorage revenue*(2) and investors' anticipation of financial collapse.

The second generation models were developed by Obstfeld (1996) and Eichengreen et al. (1996) among others in the wake of UK's devaluation in Exchange Rate Mechanism (ERM) crisis in 1992. This was a classic example of *self-fulfilling prophecy*(3). The crisis would be aggravated by contagion and herd behavior if the economies are competitors in international markets (currency war) or if the countries share common macroeconomic policies (Asian Crises 1997) or inter-dependent on each other or share common culture (Tequila Crisis in Latin America). The third-generation models were brought out by Krugman (1998 and 1999), Corsetti et al. (1999), Chang and Velasco (1998) and Aghion et al. (2000 and 2001) in the event of East Asian Currency Crisis of 1997 upon the failure of first two generations of models in explaining it. This crisis was ascribed to *moral hazard*(4) problems, asset bubbles, loss of confidence, *international illiquidity*(5) and credit crunch as most important causes. Apart from the above mentioned reasons, unsound macroeconomic policies, self-fulfilling and contagion elements added fuel to the existing ailing economies.

We argue that the above mentioned three generations of models do not fully explain the 1991 currency crisis in India and also the currency slumps of 2008-2009 and 2012. Reasons for these above phenomena could be the time of their developments. The first generation models were developed to explain the first wave of Latin American currency crises, and second and third generations of models were developed much later in the wake of other crises. The 1991 currency crisis does not fit in the first generation of models as there was no monetization of debt (Cerra and Saxena, 2002) and 2008-2009 and 2012

currency slumps cannot be explained by any of the three generations of models since their features – monetization of debt, self-fulfilling expectations, moral hazard problems and contagion effects – were largely absent.

The reasons for 1991 currency crisis are as follows: the collapse of USSR (with whom India had Rupee Trade System) (Sachdeva, 2011), withdrawal of NRI deposits and reduction in NRI remittances, overvaluation of rupee, high current account deficit (CAD), political confidence (Cerra and Saxena, 2002), buying oil in panic at $30 a barrel, which was $10 above the market price due to Gulf war and decrease in domestic oil production due to supply side problems (Weinraub, 1991). However, India has shifted from fixed exchange rate system to managed floating exchange rate system in 1993 (Dua and Rajeev, 2010). But surprisingly, during *global financial crisis* (Reinhart and Rogoff, 2008; Richard, 2011) and again in 2012 due to domestic macroeconomic factors, India had to face currency slumps. The reasons for this slump in 2012 can be attributed to following factors: a series of allegations of corruption scandals, tapering news and recovery signs in USA (Aizenman et al., 2016, p. 319), high CAD, low output (IIP), rise in gold imports, and decline in exports.

It would be interesting to examine an economy with significant differences in economic structure – pre and post reforms (Ahluwalia, 2002) – but facing similar problems in a different fashion. The purpose of our study is to re-look into the 1991 currency crisis and study the economy's *vulnerability*(6) to currency crisis in the recent past. We would also look into the possibilities of forecasting the crisis if an EWS had been available. To best of our knowledge, this is the first India specific ex-post study to employ an EWS to forecast the currency crisis.

Rest of the paper is organized as follows: Section 2 provides review of literature, Section 3 discusses data and variables, Section 4 presents methodology, Section 5 describes the estimation of results and Section 6 concludes the study.

2. Empirical literature on currency crisis

Since the first wave of Latin American Currency Crisis in 1970s, there have been several studies on currency crisis – both multi and single country studies. Initial studies were mainly of theoretical models, and after the outbreak of ERM crisis in 1992, empirical research been happening on currency crisis to a great extent. Selected empirical works are discussed below.

In an ex-post study, Kaminsky et al. (KLR) (1998) developed an EWS to forecast the currency crisis using signal extraction method for the period 1970-95 from a sample of 20 countries, and upon the successful prediction of crisis, Kaminsky and Reinhart (1999) extended the same methodology to study the twin crises – currency and banking crises. The study found that there was no link between these two crises in 1970s but there was a close association between them post liberalization of the financial markets in 1980s. Berg and Pattillo (1999) and Edison (2003) replicated the study of KLR (1998) for the same period using the same data set with minor changes, and obtained results that were almost similar but not same.

In 28 countries for the period 1970-98, Edison (2003) examined the currency crisis and the same methodology as an EWS was successfully applied to Mexico. However, Berg and Pattillo (1999) employed Probit model using the same sample as KLR and found that Probit methodology performs slightly better than the signal extraction method. In an ex-post study, Bussiere and Fratzscher (2006) used multinomial logit model contrary to traditional binary logit models to overcome *post crisis bias* with a sample of 20 emerging economies for the period 1993-2001. While investigating the role of monetary policy in a sample of 32 emerging economies for the period 1960-2001, Erler et al. (2015) say that central bank should refrain from intervention, whereas Nakatani (2016) in the analysis of role of monetary policy in twin crises states that policy interest rates should be reduced and interest rate on reserves should be increased contrary to conventional policy measures.

Following the currency crisis of 2002 in Argentina, Alvarez-Plata and Schrooten (2004) studied it using KLR method for the period Jan. 1992 – Dec. 2001 and found that this approach has not issued signals prior enough to take any policy action to prevent the crisis and the issued warnings were too late, and in addition to this, it issued more wrong signals. To examine the self-fulfilling nature of Argentina's currency crisis, Boinet et al. (2005) used Markov Switching Model for the period 1992Q1 – 2001Q4, and reasoned that economic agents' expectations about the devaluation and economy's unsuitability precipitated the currency crisis in already ailing economy and led to devaluation of currency and collapse of fixed exchange rate system.

Peng and Bajona (2008) successfully conducted an ex-post study using the same methodology in case of China for the period 1991-2004. Since the China's macroeconomic fundamentals were weak enough to experience a currency crisis, it was recommended that there should be modern banking system with supervision and reforms were needed in state-owned enterprises as they've accumulated huge non-performing loans, and before further reforms in capital market and exchange rate system, the financial sector should be revamped. In recent times, Megersa and Cassimon (2015) successfully used KLR method in case of Ethiopian currency crisis for the period Jan. 1970 – Dec. 2008. The crises in Ethiopia were attributed to domestic economic and political factors in addition to border conflicts with its neighbouring nations. The 2008 currency crisis in Ethiopia was ascribed to global economic crisis.

In the analysis of history of currency crises in Turkey, Ali Ari (2012) used Logit model for the period 1990-2008. Crises in Turkey were attributed to various combinations of macroeconomic imbalances, banking sector weaknesses and external shocks. In another study, Ari and Cergibozan (2016) studied twin crisis in Turkey for the period 1990-2013. Their results showed that currency crisis was due to large budget deficits, excess money supply, overvaluation of lira, rise in short term external deficits, external shocks and banking sector weakness. The study found that banking crisis was due to excess money supply and bank short positions, and it was also found that banking crisis leads to currency crisis and vice versa. In a study of India's devastating currency crisis in 1991, Cerra and Saxena (2002) used Error Correction Model for the period 1979-1997. It was found that there was no monetization of debt before or during the crisis and it was also found that current account deficits played a significant role in this crisis and that the exogenous shocks led to loss of investor confidence.

3. Data and selection of variables

In this study, we use the monthly data spanning from January 1985 to December 2015 covering 372 months so as to make sure that this period covers important events both in economic and political spectra. We use monthly data instead of quarterly or annual data since it captures the sudden changes in the economy and nature of the crisis. The data we use starts from 1986 since we take 12 month change(s) in the variable(s) except for Real Exchange Rate (deviation from trend), Excess M1 balances (Excess M1 Balances is defined as real M1 balances less *estimated demand for money*(7)) and the variables which are already in percentage terms. Whenever the monthly data is not available for any variable, we interpolated using cubic spline method. The choice of the variables is based on the previous literature and the availability of data, which are assumed to represent the three generations of currency crisis models and beyond. The list of the variables is as follows:

Financial sector: M3 Multiplier, Bank Credit, Real Interest Rate, Stock Prices (proxy BSE Stock Index), Lending-Deposit Ratio, Excess M1 Balances, M3/Reserves and Deposits.

External sector: Exports, Terms of Trade, Real Exchange Rate, Imports, Reserves, Current Account Deficit, Gold Prices and Crude Oil Prices.

Real sector: Output (Index of Industrial Production (IIP) is taken as a proxy).

Fiscal sector: Fiscal Deficit (as percentage of GDP).

A detailed list of variables can be found in the Appendix I.

4. Methodology

The purpose of this study is thus to explore India's exposure to currency crisis, and to identify the indicators. In our ex-post study, we use Indicators Approach to assess the currency crisis and use EWS (which all variables are able to issue signals) to see the possibilities of forecasting it, which could be helpful in (policy) decision making in order to mitigate the severity of or prevent the currency crisis. This is a three stage methodology and they are as follows: First, we estimate the crisis index and then identify the crisis months. Two, based on the previous literature and macroeconomic structure of the economy, we select the variables. Third, using Kaminsky, Lizondo and Reinhart (KLR 1998) (EWS) approach, we estimate each indicator's ability to forecast the crisis.

The first step is to construct crisis index, which is popularly known as *Exchange Market Pressure Index* (EMPI). There are two methods available to construct EMPI: KLR method and Eichengreen et al. method [$I = \frac{\%\Delta E}{\sigma \mathrm{E}} + \frac{\Delta i}{\sigma \mathrm{i}} - \frac{\%\Delta R}{\sigma \mathrm{R}}$]. However, we choose the former method as the later includes interest rates also, which is not determined in the market in India. In addition to it, excluding interest rate from Eichengreen et al. method gives the same results as KLR method.

4.1. Construction of *EMPI* (I) using KLR Method

$$I = \frac{\Delta E}{E} - \frac{\sigma E}{\sigma R}\frac{\Delta R}{R}$$

Crisis = 1 if $I > \mu_I + \mathrm{m}\sigma_I$

= 0 otherwise ($I \leq \mu_I + \mathrm{m}\sigma_I$)

The index is measured as "the weighted average of percentage change in the bilateral nominal exchange rate and percentage change in foreign reserves, with weights such that the two components of the index have equal sample volatility" (Kaminsky et al., 1998 and 1999). In the *EMPI* equation, $\frac{\Delta E}{E}$, $\frac{\Delta R}{R}$ and $\frac{\sigma E}{\sigma R}$ are percentage changes in exchange rates and foreign reserves, and ratio of standard deviations of percentage changes in exchange rate and reserves respectively. The percentage change in the respective variables is of twelve months so as to ensure that units are stationary and free from seasonal effects.

In crisis determination, '1' has been assigned if the EMPI exceeds its mean (μ) by '*m*' standard deviations (σ) of the index (I) i.e., threshold value, and '0' has been assigned if the index is less than or equal to the threshold value. Here, we choose '*m*' as 1.5 but KLR (1998 and 1999) have taken '*m*' as 3 while Eichengreen et al. (1996) have chosen 1.5 for '*m*' and Edison (2003) has selected 2.5 as the '*m*' value. However, there is no theory but arbitrary selection behind the selection of this value(s). The reason we've chosen the value so as to include any kind of financial pressure or currency stress.

4.2. Signals approach

In this approach, an indicator is said to have issued a signal within the window of 24 months prior to crisis (KLR have chosen this somewhat arbitrarily). Above mentioned signal is issued whenever the indicator crosses the threshold. Here, the threshold depends on the percentile of the distribution of the observations of the indicator. The percentile usually ranges between 0.10 and 0.30 (where a decrease in the variable causes crisis) depending on the value that minimizes the noise-to-signal ratio (which will be discussed soon) and opposite will be the case if the increase in the variable (indictor) is causing currency crisis. In that case percentiles for threshold levels or critical regions will be, for instance, ranging from 0.75 to 0.95. Edison (2003) defines the threshold (*t*) as the mean of the indicator plus 1.5 of its standard deviations with its equational form as follows: $t = \mu_i \pm 1.5\sigma_i$. The sign indicates the nature of the indicator i.e., depending on whether the increase or the decrease causes the crisis. As an alternative, we choose the method proposed by Edison (2003). (Kaminsky et al., 1998 and 1999; Edison, 2003).

4.3 Calculation of noise-to-signal ratio and probabilities

The following 2X2 matrix is useful to study the effectiveness of each variable separately:

Table 1. *Performance of each indicator*

	Crisis (in the following 24 months)	No crisis (in the following 24 months)
Signal was issued	A	B (Type II Error)
Signal was not issued	C (Type I Error)	D

Source: Kaminsky et al. (1998 and 1999).

In the above matrix, cell A indicates the number of months followed by a crisis within the crisis window of 24 months when a variable issues a signal (good signals), cell B designates the number of months when there is no crisis but variable issues a bad signal, cell C shows the number of months that the indicator failed to issue a signal when there is a crisis and cell D is the number of months in which the indicator refrained from issuing a (wrong) signal. The signals that cell C consist are of Type I Error as they will have severe repercussions on the economy, while cell B consists of Type II Error as their impact on economy and policy making is less severe.

Signals will be 100% perfect when the indicator issues only good ones and doesn't miss any when there is a crisis within the window of 24 months i.e., A > 0 and C = 0, and when the indicator refrain from issuing the signal when there is no crisis and doesn't issue any wrong signals (*noise*) i.e., D > 0 and B = 0. In these cases, the 'noise-to-signal ratio' is '0' and in contrast to these cases 'noise-to-signal ratio' will be infinity when A = 0 and C > 0, and D = 0 and B > 0. The percentage of good signals can be expressed as $\frac{A}{A+C}$ and it is also known as conditional probability of crisis, and the percentage of bad signals can be expressed as $\frac{B}{B+D}$. The noise-to-signal is the ratio of percentage of bad signals to parentage of good signals and it can be expressed as $\frac{\frac{B}{B+D}}{\frac{A}{A+C}}$. The unconditional probability of currency crisis is as follows: $\frac{A+C}{A+B+C+D}$. Probabilities of Type I Error and Type II Error are as follows: $\frac{C}{A+C}$ and $\frac{B}{B+D}$ (Kaminsky et al., 1998 and 1999; Edison, 2003 among others).

5. Results and discussion

This section deals with results obtained from the above methodology. Figure 1 shows the EMPI from January 1986 to December 2015. The horizontal line is the threshold value and whenever the EMPI exceeds the horizontal line, it is considered as currency crisis; however not all of them would turn out to be severe financial crises since the government might intervene and take policy measures to prevent the crisis from its severest form. The following months are identified as crisis episodes and they can be classified into three periods: I. May 1989, April – November 1991 and January 1992, II. November 2008 – April 2009 and III. June – July 2012. The first episode is consistent with devaluation of rupee on July 1 and July 3, 1991. However, the second and third episodes did not see the devaluation of rupee as it would have its own negative effects on the economy in the context of India's interdependence on global economy post-reforms.

Figure 1. *Exchange Market Pressure Index*

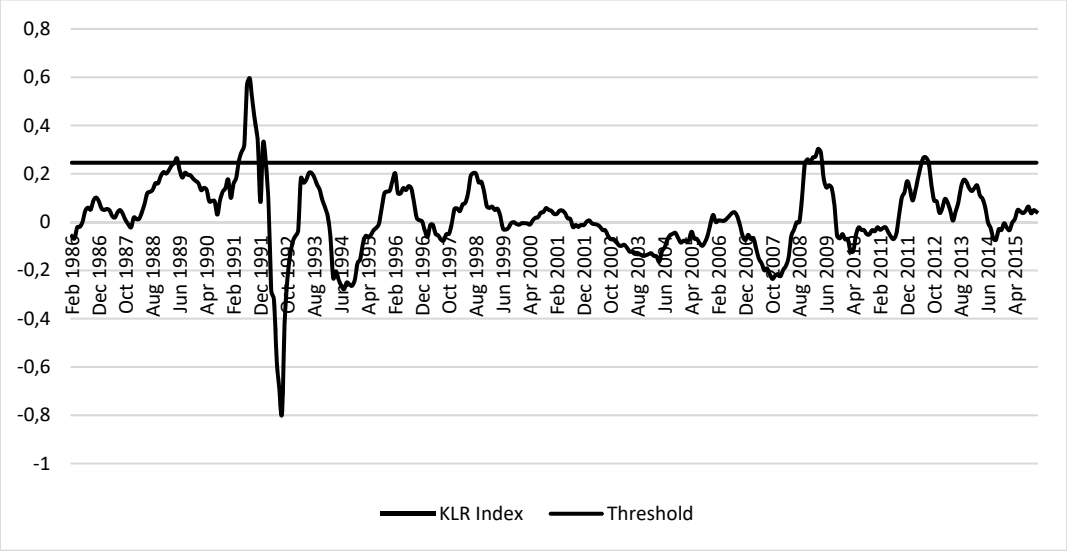


Figure 2 to Figure 19 display the movements of variables, which are assumed to have caused and precipitated currency crisis in India. These variables are expected to represent the three generations of crisis models and beyond. The variables used in this model are for the period January 1986 to December 2015 except for the variable Fiscal Deficit as it is available only from 1988. In these following figures, horizontal lines represent the threshold values of the respective variables. When the indicator exceeds the threshold line, it is considered as a warning, however these warnings include both good and bad signals. As an alternative, we employed Edison's method as an EWS to arrive at the results which do not indicate any warnings or are largely absent from issuing the warnings about the impending crisis.

Movements in variables:

Figure 2. *Bank Deposits*

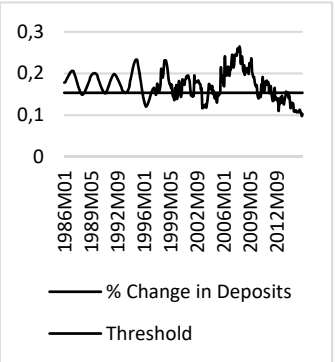


Figure 3. *Bank Credit*

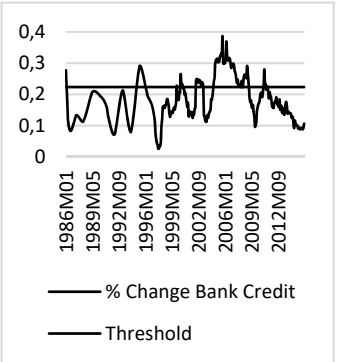


Figure 4. *Stock Index*

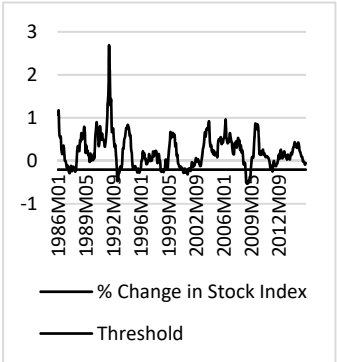


Figure 5. *Oil Prices*

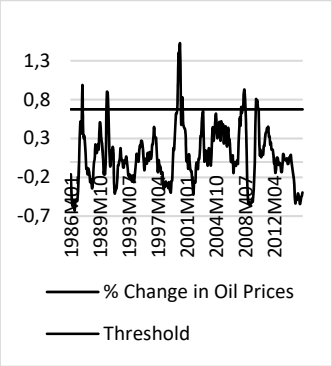


Figure 6. *CA as % of GDP*

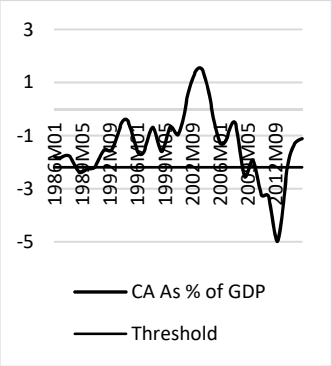


Figure 7. *Excess M1 Balances*

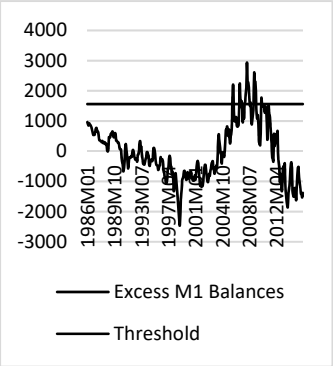


Figure 8. *Exports*

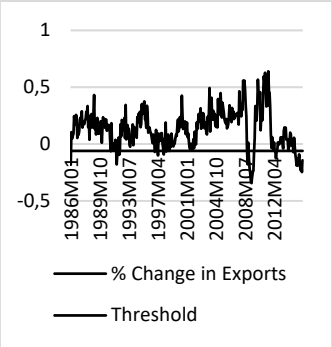


Figure 9. *FD as % of GDP*

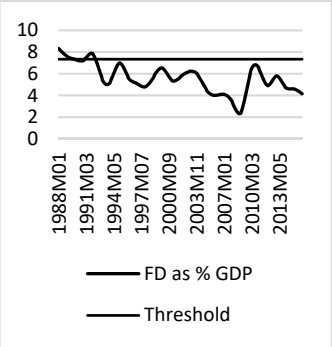


Figure 10. *Gold Prices*

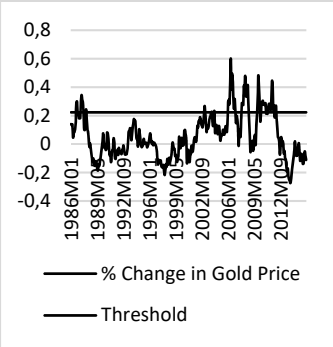


Figure 11. *Imports*

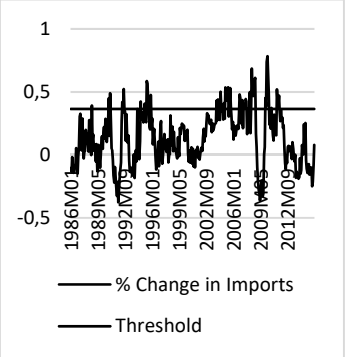


Figure 12. *Lending-Deposit Ratio*

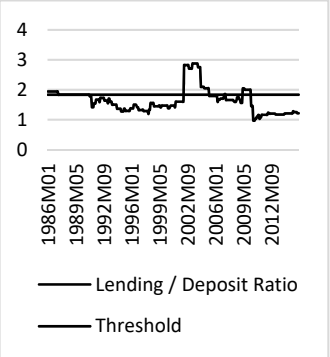


Figure 13. *M3 Multiplier*

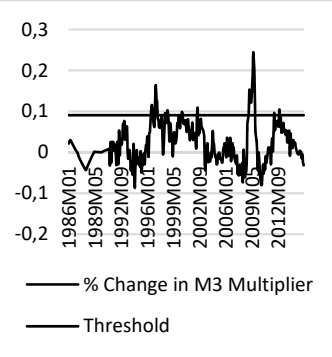


Figure 14. *M3/Reserves*

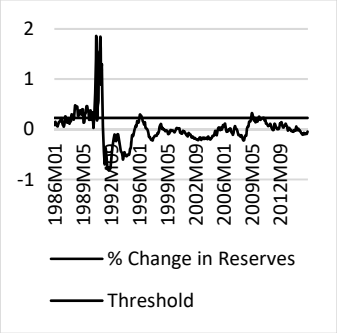


Figure 15. *Output*

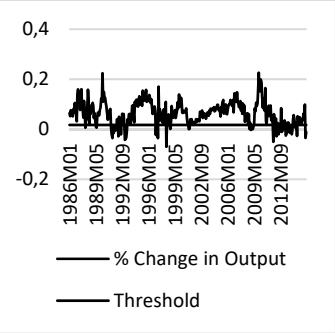


Figure 16. *Real Interest Rate*

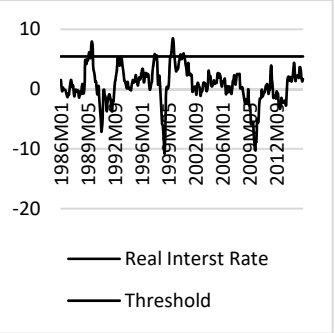


Figure 17. *Real Exchange rate*

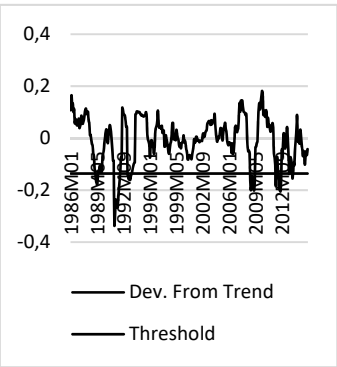


Figure 18. *Reserves*

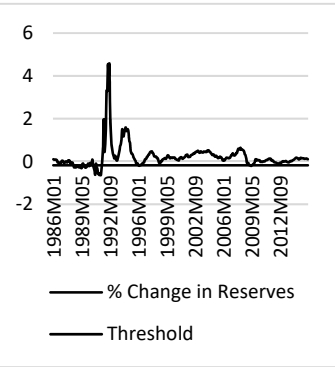
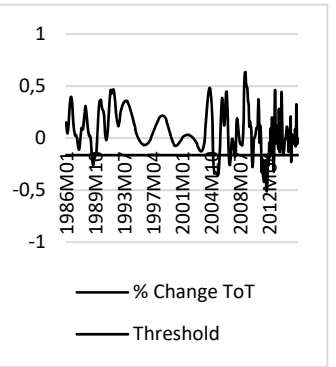


Figure 19. *Terms of Trade*



The following Table 2(A) illustrates threshold values for 18 indicators as well as location of critical region along with their noise-to-signal ratios. For a currency crisis, for instance, a large decline in reserves signals a crisis, so the "<" sign symbolizes that the rejection region is positioned at the bottom tail of the distribution whereas the ">" sign denotes that the critical region is located at the top tail of the distribution and based on the expected sign of the variable, grid search operation has been conducted. It can be said that lower the value of noise-to-signal ratio better the indicator. The noise-to-signal ratio can be used as a condition to decide which variables are more reliable in considering their warnings to act on to prevent or to take policy measures to mitigate the effects. When the value of noise-to-signal ratio for any variable is more than unity/one, it can be said that the indicator issues warnings at random times i.e., that indicator has no inherent predictive power. The best performed indicators based on the noise-to-signal ratios are as follows: lending-deposit ratio, excess M1 balances, terms of trade, real exchange rate, imports, reserves, current account balance, gold prices, crude oil prices, output, fiscal deficit, bank credit, real interest rate and stock index. Whereas the worst performing variables are: M3 multiplier, deposits and exports.

Table 2(A). *Threshold values and noise-to-signal ratios*

Indicator	Threshold percentile	Noise to signal ratio
Financial sector		
M3 Multiplier	>93	1.393
Bank Credit	>75	0.926
Real Interest Rate	>95	0.880
Lending-Deposit Ratio	>81	0.612
Excess M1 Balances	>94	0.138
M3/Reserves	>86	0.097
Deposits	<30	2.355
Stock Prices (Stock Index)	<10	0.691
External sector		
Terms of Trade	<11	0.275
Exports	<10	1.000
Real Exchange Rate	<10	0.247
Imports	>85	0.550
Reserves	<10	0.026
Current Account Balance	<23	0.179
Gold Prices	>84	0.344
Crude Oil Prices	>94	0.484
Real sector		
Output (IIP index)	<16	0.563
Fiscal sector		
Fiscal Deficit	>89	0.023

Source: Authors' calculations.

Another way to interpret the results is by comparing conditional and unconditional probabilities of the crisis (from Table 2(B)). This information is useful in checking the effectiveness of the individual variable in forecasting the crisis and if the indicator is effective then the conditional probability will be higher than unconditional probability of crisis. From these estimates, it can be said that when conditional probability is lower than unconditional probability, this is almost similar to that of noise-to-signal ratio being greater than one.

However, when we look at performance of each indicator, the following indicators perform relatively better in terms of conditional probability: reserves, current account balance, fiscal deficit, lending-deposit ratio and M3/reserves. The unconditional probability (0.306) is same for all the indicators as 'its calculation includes good and missed signals in proportion to all months' and 'the number of months in the crisis horizon are same for all variables'. From column 5 and 6, it can be said that the indicators are not issuing wrong signals but they are refraining from issuing signals when there is an impending crisis in next 24 months. The prevalence of Type I Error in the variables point out that crisis occurrence in Indian context is due to combination of various macroeconomic inconsistencies.

Table 2(B) *Performance of individual indicators*

Indicator	Conditional probability of crisis	Unconditional probability of crisis	Probability of Type I error	Probability of Type II error
Financial sector				
M3 Multiplier	0.055	0.306	0.945	0.076
Bank Credit	0.264	0.306	0.736	0.244
Real Interest Rate	0.055	0.306	0.945	0.048
Lending-Deposit Ratio	0.418	0.306	0.582	0.256
Excess M1 Balances	0.145	0.306	0.855	0.020

Indicator	Conditional probability of crisis	Unconditional probability of crisis	Probability of Type I error	Probability of Type II error
M3/Reserves	0.360	0.306	0.627	0.036
Deposits	0.155	0.306	0.845	0.364
Stock Index (BSE)	0.127	0.306	0.873	0.088
External sector				
Terms of Trade	0.218	0.306	0.782	0.060
Exports	0.100	0.306	0.900	0.100
Real Exchange Rate	0.209	0.306	0.791	0.052
Imports	0.218	0.306	0.782	0.120
Reserves	0.309	0.306	0.691	0.008
Current Account Balance	0.536	0.306	0.463	0.096
Gold Prices	0.291	0.306	0.709	0.100
Crude Oil Prices	0.091	0.306	0.909	0.044
Real sector				
Output (IIP index)	0.227	0.306	0.773	0.128
Fiscal sector				
Fiscal Deficit	0.340	0.286	0.660	0.008

Source: Authors' calculations.

In 1991 currency crisis, fiscal deficit, reserves, current account balance and M3/Reserves were consistently issuing signals throughout the crisis horizon and lending-deposit ratio issued signals prior to crisis but refrained from issuing signals during the crisis period. Decisive variables like Real Exchange Rate issued signals only during the crisis but not fully. Whereas other important variable like Excess M1 Balances was largely absent from issuing any signals along with other variables. These results show that there was a fiscal mismanagement apart from external shocks.

In 2008-2009, real exchange rate, stock index, reserves, M3 multiplier, exports, output and current account balance were issuing signals only during the crisis period but did not issue signals prior to the crisis whereas Bank Credit issued signals prior to crisis but stopped half the way during the crisis. However, Excess M1 Balances was the only variable consistently issuing signals throughout the crisis horizon. It shows that, in the absence of early warnings, the currency stress in 2008-2009 happened all of a sudden and this could be due to global economic crisis of 2007-2008. In 2012, current account balance was the only variable that issued warnings throughout the period whereas other variables – reserves, real exchange rate, output, M3 multiplier, gold prices, exports, terms of trade and bank deposits – also issued prior warnings but not at a very consistent level. Given the high probability throughout the crisis horizon and early warnings from the important macroeconomic variables, this currency slump can be attributed to macroeconomic inconsistencies.

The periods identified with more number of signals are as follows: from 1988 to 1991 and from early 2007 to 2012, however, these periods do not cover all the months. It is noticeable that the first period mentioned above was followed by devaluation in 1991 but the later periods were not followed by any devaluation. However, central bank had to intervene in foreign exchange market and the then Prime Minister Manmohan Singh had to announce in the parliament that the economy was not heading to 1991 like crisis[(8)], and there were a series of statements and indications from various quarters of the government before this event[(9)]. The crisis tremors were felt (politically) only in 2013 but it started building up from 2012, and the 2008-2009 currency slump was due to global economic factors rather than domestic macroeconomic factors.

During 2008-2009, rupee depreciated around 25% w.r.t. its previous year's value and reserves depleted around 15-20%, and in 2012 rupee depreciated around 25% and reserves depleted around 10%. However, these currency crises periods did not turn out to be a full-blown currency crisis like 1991 due to both government and central bank intervention apart from its relative openness and managed floating exchange rate system. However, there were no common indicators that issued warnings prior to the crisis in these three spells of currency crises. The results, we obtained in this study, suggest that India has been vulnerable to currency crisis both pre and post reforms periods.

We end this section by comparing all the crises periods. The 1991 currency crisis ended with large scale financial reforms, devaluation of the rupee and abandonment of fixed exchange rate system (in 1993), and in 2008-2009 currency stress did not lead to any devaluation of the currency whereas the 2012 currency slump ended with the intervention of fiscal and monetary authorities. Is the Indian economy immune to currency crisis in later periods (post reforms)? The answer is 'No' as it is clear from our results. The reasons, why others crises did not turn out to be severe financial crisis like 1991, are relatively better position of reserves and managed floating exchange rate system apart from intervention by fiscal and monetary authorities.

6. Conclusion

The present study is aimed at explaining India's vulnerability to currency crisis in last three decades. In this ex-post study, we used KLR indicators approach to examine the probabilities of currency crisis for the period of 30 years spanning from January 1986 to December 2015 covering major events both globally and domestically. The probabilities obtained in this paper, based on the information provided by individual indicators, support the signals extraction approach. This method identified and forecasted currency crises of 1991, 2008-2009 and 2012, and it shows that developing an EWS helps in forecasting the currency crisis in India. However, only 1991 crisis was followed by devaluation among these economic instabilities. While the 1991 crisis was a result of fiscal mismanagement, 2012 can be largely attributed to domestic macroeconomic imbalances and the 2008-2009 financial stress can be ascribed to global financial crisis of that time.

Findings of the study say that crises in the Indian context are due to amalgamation of different macroeconomic inconsistencies i.e., there is no single indicator that gives the complete picture of the crisis. The economy seems more stable post reforms but as our results suggest, it is still vulnerable to currency crisis as the economy witnessed the short spells of currency crises in recent times. Given the economy's vulnerability to both domestic and global macroeconomic factors, fiscal and monetary authorities may take note of any unusual behavior in the macroeconomic variables in order to take precautionary measures to mitigate or prevent crisis and its aftermath effects.

However, major limitation to this methodology is that marginal effects are not known as it is a non-parametric method apart from issuing wrong signals and not being able to identify the exact timing of the crisis. A new theoretical model can be built to understand

the relationship among exchange rate regimes, macroeconomic structure and the economy's vulnerability to currency crisis. The present work can be extended further by including variables such as political factors, institutional or governance related variables and contagion effects etc. Other methods like Logit/Probit Regression, Artificial Neural Networks (ANN) and Markov Switching Model can also be used to explain the phenomenon.

Notes

(1) A speculative attack in foreign exchange market is massive selling of country's currency assets by both domestic and foreign investors. Currency/Paper Money not only functions as a widely accepted record for payments and repayments but also works as a modern day asset/wealth.

(2) In monetary economics, revenue earned by creation of money (Neumann, 1992).

(3) It refers to a situation where currency crisis is not caused by weak economic fundamentals or improper government policies, instead they're the consequence of pessimistic expectations of investors about the economy.

(4) "Moral hazard problem may arise when individuals engage in risk sharing under conditions such that their privately taken actions affect the probability distribution of the outcome" (Hölmstrom, 1979).

(5) A situation in which the financial system's potential short term obligations exceed the liquidation of its assets (Chang and Velasco, 1998).

(6) In this context, economy's inability to cope with macroeconomic shocks – both domestic and external – and deterioration of economic fundamentals, and as a result economy eventually leads to a crisis.

(7) Estimated demand for money is a function of real GDP, inflation rate and linear time trend.

(8) PM's Statement on the Current Economic Situation in the Country, PIB, Govt. of India, August 30, 2013; "India's Economy: A Five Star Problem" by The Economist, August 30, 2013; "A Speculative Attack on the Rupee" by C.P. Chandrasekhar, The Hindu, August 27, 2013 and "Rupee Gains on RBI Intervention, Global Clues" by Dinesh Unnikrishnan, Live Mint, August 30, 2013.

(9) Crisis in Our Skies, The Hindu, April 9, 2012; Chidambaram defends tough measures, The Hindu, December, 27, 2012; "Your Love, FM's Fear" by Dhiraj Nayyar and Shravya Jain, India Today, January 18, 2013; Chidambaram's appeal: Don't buy so much gold, Business Standard, March 1, 2013; RBI asked banks not to sell gold coins: Chidambaram, DNA, June 6, 2013; Chidambaram to Indians: Please, don't buy gold, Times of India, June 13, 2013; Chidambaram again asks Indians to lower appetite for gold. Here's why, First Post, July 16, 2013.

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Appendix I

List of variables

Variable/Indicator	Purpose of the inclusion	Data source
M3/Reserves	Captures to what extent the liabilities of the banking system are backed by international reserves	Handbook of Statistics on Indian Economy and IMF IFS Database
Excess Real M1 Balances	Loose monetary policy	Handbook of Statistics on Indian Economy and IMF IFS Database
Fiscal Deficit as % of GDP	Loose fiscal policy	Bloomberg Database
Deviation of Real Exchange Rate from Trend	Overvaluation of the currency	IMF IFS Database (Recalculate)
M3 Multiplier (M3/M0)	Rapid growth of money supply	Handbook of Statistics on Indian Economy and IMF IFS Database
Domestic Credit	Credit expansion	Handbook of Statistics on Indian Economy
Deposits	Loss of deposits as crisis unfolds	Handbook of Statistics on Indian Economy
Oil Prices	High oil prices associated with recessions	IMF IFS Database
Real Interest Rate	Its increase indicates credit crunch / Higher interest rate indicates higher risk premium and default expectations	Handbook of Statistics on Indian Economy
Lending Deposit Ratio	Decline in loan quality	IMF IFS Database
Terms of Trade	A decrease in TOT indicates the crisis	World Bank Data Indicators
Gold Prices	Effects reserves through exchange rate	World Gold Council
Output	A rapid decline in output indicates the recession	IMF IFS Database
Stock Index	Burst of asset prices	BSE Index
Reserves	Rapid depletion of reserves is a strong indication of a crisis	IMF IFS Database
Current Account Balance Exports Imports	Current Account Deficit strongly effects reserves through exchange rate whereas rapid increase in imports and decrease in exports are strong indicators of a crisis	Bloomberg Database IMF IFS Database IMF IFS Database