

“Early Warning Signal System for Economic Crisis: A Threshold and Indicators Approach”

Dr. Yamini Karmarkar*
Surbhi Vani**

*Reader
International Institute of
Professional Studies, DAVV, Indore

**Student, MBA (MS)
International Institute of
Professional Studies, DAVV, Indore

Abstract

This study deals with creating an early warning signal system for the economic crisis using various macroeconomic indicators and their threshold values. Starting with seventeen economic variables, it shortlisted few variables that are informative for signaling crisis in USA, India and European Union. The study considered 6 major crises that occurred during the period 1991 to 2011. The threshold levels of change for each of the informative indicators are calculated by KLR signaling approach and a Probit Model is applied to study the significant informative variables and their threshold levels. The results of probit regression states that out of 17 indicators five variables were significant for USA, 4 for India and 2 for European union.

One of the major findings of probit model is the goods exports is only a common significant variable which is able to define crisis for all the three sample economies. Also the wholesale price index works for both the USA and India in defining the crisis and inflation (consumer prices) works common for USA and European Union in explaining crisis. Also, it is very important to note that broad money growth, one of the significant indicators of India is providing signals in 2011 (calculation part) which shows that there can be a crisis event in 2013. This study contributes in creating useful information for economic policy makers for predicting economic crisis and for taking suitable policy measures to lessen the impact of economic crisis on an economy.

Keywords:

Economic Crisis, Early Warning, Economy Etc.

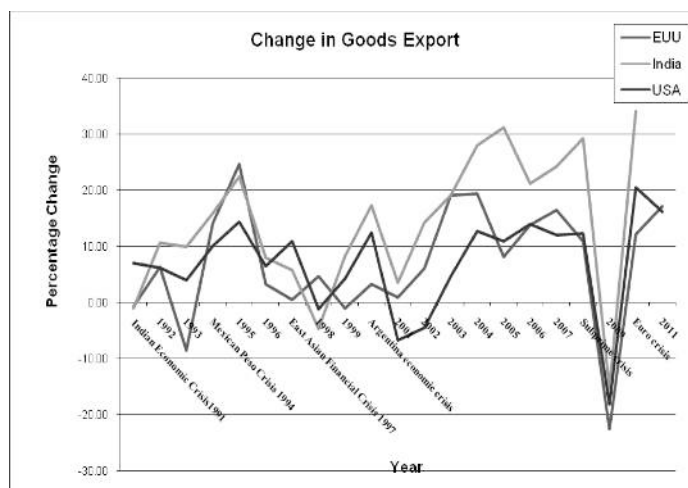
Introduction

Since the break down of various economic, financial, and currency crisis in the world economy from 1990's till the current era, there are number of researchers who had worked attempting to build an early warning system for the crisis. A large number of studies were also conducted to recognize and analyze various macroeconomic and financial indicators that might predict an economic crisis. Although there are various researchers who were not able to give proper results in forecasting the crisis but were able to give signaling model for the crisis.

All that these warning indicators can do is to signal that a crisis is possible. Reasonably the most remarkable and sophisticated model defined and proposed for predicting crisis given in 1990's is the indicators approach of **Kaminsky–Lizondo–Reinhart (1997)** (hereafter KLR), who monitor a large set of indicators that signal a crisis whenever they cross a certain threshold. (Berg and Pattillo, 1999). Since 1990, there were various crises which had

created miserable situations and damaged the world economic scenario. In order to prevent or at least to manage better such damage to the world economy, finding an effective early warning system has become an important issue (Chang, et, al, 2008). There were many empirical studies accessed focused on forecasting the probability of currency crisis. Although currency plays a vital role in the systematic working of the international trade and maintains global stability, it is also necessary to understand and predict the financial and economic crisis which includes currency as well.

If we look into the last two decade, we will find an increased number of crises had occurred in several parts of the world which had created disturbance and had given harsh impacts on the global integrated markets, majorly on the emerging and underdeveloped economies, resulting in real shocks. It has been evident from the very last US subprime mortgage crisis which has clearly elucidate that the impacts of these crisis are not only confined to the global economies but it also challenges the various agencies and authorities works for designing economic policies and maintaining the financial stability.



From this loophole, this research got the gap to study the overall economic crisis. This study deals with developing an early warning signal for indicating economic crisis. Although this paper follows the same approach used by other researchers in their papers for predicting currency crisis i.e., the KLR signaling approach. This paper has also introduced some macroeconomic variables like broad money growth, Inflation, lending interest rate, foreign direct investment, real effective exchange rate and gross domestic savings, other than indicators used in other researches.

For analyzing the upcoming economic crisis three economies were studied namely US, Europe Union and India for the period 1990-2011 using 17 macroeconomic variables. The study aims to identify role of informative indicators and to anticipate their role in signaling of crisis in coming period. For developing more sophisticated and reliable results we have also used probit regression analysis model so as to develop more significant signals for the crisis.

Literature Review

The empirical and theoretical literature is full of studies based on economic crisis, financial crisis and efforts for developing methods for predicting such crisis. Some studies have identified the effects of crisis while others have tried to identify those factors, which have caused crisis. While some others have tried to identify methods for forecasting crisis, i.e., determining the early warning indicators of crisis and the level of significance of these indicators in the crisis.

The post liberalization period in the global economy has brought various economic problems and the understanding cause and effect relationship between these economic problems and the economic variables become necessary. Karmarkar, Y., Karamchandani, M., & Mantri, A (2012), elucidate the long run causal relationships between the exchange rates and other key macroeconomic indicators of the economy using various statistical techniques. There have been several other studies exploring these relationships.

Another category of researches have studied the different crisis that have occurred over time and have tried to identify the similarities and differences. Although Pablo BusteloU,(2000), found some similarities in financial crises in the 1990s, they observed that these crisis have featured substantial differences between them: the ERM crisis of 1992-1993 was mainly due to stringent monetary policies; the Mexican crisis of 1994-1995 was associated to private overconsumption; and the East Asian crisis of 1997-1999 were basically the result of private overinvestment. In order to create a new set of early-warning indicators, economists should focus on non-conventional deficiencies, such as those related to financial fragility associated with financial deregulation and with capital inflows, to a declining efficiency of investment, and to a high short-term external debt especially as a proportion of foreign exchange reserves.

Oliver Burkarta, Virginie Coudert,(2002), also identified common features of currency crises in 15 emerging countries using quarterly data over the period 1980_1998. They used Fisher's

linear discriminant analysis in order to build an early-warning system. Capital control and contagion dummies, as well as an indicator for problems in the banking sector, are included in the set of explanatory variables; the overvaluation of currencies is assessed by real effective exchange rates. It proposed a 'balancing' approach to deal with the trade-off between good classifications and false alarms. The model yields a relatively good and unbiased ratio of correct predictions: four out of five crises are correctly predicted and only one out of five non-crises is predicted as a crisis. The model improves on the indicators of overvaluation with respect to the literature and introduces indicators for contagion, capital controls and problems in the banking sector.

A prominent literature revolves around predicting crisis with several indicators. An attempt was made by Umit Ozkan, Kivilm Metin-Ozkan,(2007), to measure the likelihood of a financial crisis in an emerging market economy. They introduce a methodology, where they can both obtain a likelihood series and analyze the time-varying effects of several macroeconomic variables on this likelihood. Since the issue is analyzed in a non-linear state space framework, the extended Kalman filter emerges as the optimal estimation algorithm. Chin-Shien Lin, Haider A. Khan, Rwei-Yuan Chang, Ying-Chieh Wang ,(2008), used a hybrid causal model for predicting the occurrence of currency crises by using the neuro fuzzy modeling approach. The model integrated the learning ability of the neural network with the inference mechanism of fuzzy logic.

Sarda, V., Karmarkar, Y. et al. (2010), follow another approach for predicting crash, i.e. a stock market crisis using log periodicity. The log periodic power law, which involves oscillating movements of market was found to predict crisis in stock markets with some limitations.

The prominent work in identifying indicators of crisis was done by Kaminsky, G., Lizondo, S., Reinhart (1998). They examined the empirical literature on currency crises and proposed a specific early warning system. This system involves monitoring the evolution of several indicators that tend to exhibit unusual behavior in the periods preceding a crisis. When an indicator exceeds a certain threshold value, this is interpreted as a warning "signal" that a currency crisis may take place within the following 24 months. The variables that have the best track record within this approach include exports, deviations of the real exchange rate from trend, the ratio of broad money to international reserves, output, and equity prices.

In another study, Andrew Berg, Catherine Pattillo (1999) evaluated the KLR approach to anticipating currency crises. The study focused on the implementation of the KLR model in predicting the Asian crisis. Goldstein, M., Kaminsky, L., Reinhart, (2000), provided empirical tests of early warning indicators of banking and currency crises in emerging economies. They identified key empirical regularities in the run-up to banking and currency crises that would enable officials and private market participants to recognize vulnerability to financial crises at an earlier stage.

In spite of some work done on creating indicators for predicting crisis, there is much that needs to be explored. There are several economic indicators, which behave in a particular manner while a crisis is approaching. The modeling of these indicators may provide essential clues for predicting crisis. Further, it is yet to be

explored whether, these indicators are similar for all economies and all crisis or they vary with time and geography?

This paper is an attempt in this direction. It tries to identify the indicators, which are significant in predicting a crisis in India, USA and Europe. The context of these economies is specific as they represent a mix of emerging as well as developed economies.

Objectives

The basic objective of this research is to create a signaling system for generating a pre intimation of economic crisis. For this, it identifies the indicators that are capable of generating signals and then it identifies a threshold level of change for each indicator. This study is done for a series of economic crisis that have occurred from 1991 to 2011 in the global economies and their effect on three economies –The USA, India and the European Union(Considered as one economy). The specific objectives are stated as follows:

- To identify the most informative economic indicators for signaling economic crisis in USA, India and European Union over the period 1990 - 2012. The economic indicators considered for the study are:
 - *Indicators showing economic output* - GDP annual growth rate, Gross domestic Savings, Inflation(consumer prices and percentage of GDP deflator), wholesale price index, consumer price index,
 - *Indicators Reflecting External Sector* – foreign direct investment, Real effective Exchange rate, Current account balance, Imports and Exports
 - *Indicators reflecting Money Market* - Domestic credit provided by banking sector (% of GDP), Broad money growth, Total reserves, Money and quasi money (M2) to total reserve ratio, Cash surplus/deficit, Lending interest rate and
- To identify threshold levels of change for each of the informative indicators for USA, India and European Union.
- To identifying the most significant signaling indicator in case of economic crisis for each of the countries USA, India and European Union.

Research Methodology

In recent years, a number of researchers have claimed success in methodically predicting which countries are more likely to suffer currency crises. Perhaps the most prominent model proposed before 1997 for predicting currency crises is the indicators approach of Kaminsky et al. (1998) (hereafter KLR), who monitor a large set of monthly indicators that signal a crisis whenever they cross a certain threshold. The same approach is been utilized to develop signaling model for economic crisis. This paper follows the same signaling approach for developing threshold levels for various indicators used.

KAMINSKY–LIZONDO–REINHART (1997) Signals Approach

The basic idea behind this approach is that the economy behaves differently on the eve of financial crises as compared with a more relatively 'normal' period Each indicator selected for the model is macroeconomic in nature which is directly affected by the crisis.

The signal approach uses indicators to detect crises in advance. Since economic crises are extreme events, they usually are preceded by extreme developments or imbalances. So they might be detected by leading indicators like decreasing GDP growth rate, balance of payment problems etc, showing exceptional values before the crises starts.

For the purpose we have chosen 17 indicator variables based on theoretical priors and on the availability of yearly data for all the three sample economies for the period 1991-2011. These are GDP annual growth rate, Imports, Exports, Real effective Exchange rate, Gross domestic Savings, Domestic credit provided by banking sector (% of GDP), Broad money growth, Total reserves, Money and quasi money (M2) to total reserve ratio, Current account balance, Inflation (consumer prices and percentage of GDP deflator), wholesale price index, consumer price index, Cash surplus/deficit, Lending interest rate and foreign direct investment.

For applying KLR approach, percentage change for each indicators value is been taken out to bring them on the common

platform. An indicator issues a signal whenever it moves beyond a given optimal threshold level. For generating optimal threshold level for each indicator minimized noise to signal ratio was calculated using matrix below.

We can consider the performance of each indicator in terms of the matrix below. The cell A represents the number of months in which the indicator issued a good signal, B is the number of months in which the indicator issued a bad signal or 'noise,' C is the number of months in which the indicator failed to issue a signal which would have been a good signal, and D is the number of months in which the indicator did not issue a signal that would have been a bad signal.

For dividing the whole data available in the A/B/C/D format we have given a binary code to each data. Whenever any indicator shows a negative flow or decline in its value, it is considered to be a signal and no signal otherwise. By given this signal and no signal code to the indicators data further classification in A/B/C/D becomes more easy and prominent.

	Crisis within 24 months	No crisis within 24 months
Signal was issued	A	B
No signal was issued	C	D

$$\text{Noise} = B / (B+D) \quad ; \quad \text{Signal} = A / (A+C)$$

For each indicator, KLR find the 'optimal' threshold, defined as that threshold which minimizes the noise-to-signal ratio. The thresholds are calculated in terms of the percentiles of each country's distribution for the variable in question.

A more sophisticated approach is to choose a specific percentile of frequency distribution. The threshold level can be derived by taking the distribution of the predicted values and by number of events taking into account. The α percentile might be calculated using the maximum possible numbers of correct signals given in relation with the total number of observations (Klaus.A,et,al,2009). Subtracting this value from 1 will put the threshold in the frequency distribution with high values.

$$\alpha = 1 - (A+B) / n$$

where,

α = threshold percentile for the indicator

A+B = maximum possible correct signals

n = total number of observations

Thus, minimizing the noise-to-signal ratio for the sample of countries yields an optimal threshold percentile for each indicator that is the same for all countries. Formally, an indicator is said to issue a warning signal if it exceeds a critical threshold level. For all calculations a 2 year crisis window is used.

PROBIT Model

In statistics, a probit model is a type of regression where the dependent variable can take only two values, for example crisis or no crisis. The purpose of the model is to estimate the probability that an observation with particular characteristics will fall into a specific one of the categories, the probit model is a type of binary classification model. In this section, we have applied probit regression model to the original data. In this we embed the KLR approach with the binary probit model in which the dependent variable takes a value of one when there is a crisis in 2 years and zero otherwise. This technique is helpful in testing the usefulness of thresholds calculated in KLR approach. To run the probit model, we estimate following equation for each indicator given by Andrew Berg and Catherine Pattillo in 1999 using KLR approach :-

$$\text{Prob} (c = 1) = f (0 + \alpha_1 P(x) + \alpha_2 I + \alpha_3 I^* (p(x) - T))$$

Where, C=1 when there is a crisis in 24 months otherwise zero.

α_1 = coefficients for crisis

P(x) = the percentile of the variable x (jump below the threshold)

α_2 = coefficients for significance level,

I = 1 if the percentile is above some threshold T and zero otherwise (jump at the threshold)

α_3 = coefficients of slope of threshold

Sample Selection And Data Description

Lots of theoretical and empirical studies had suggested number of warning indicators that can be used for indicating or signaling economic crisis. This study also deals with various indicators that are implemented by the most important empirical studies of predicting financial crisis. For the purpose following early warning indicators were used. These are GDP annual growth rate, Imports, Exports ,Real effective Exchange rate, Gross domestic Savings, Domestic credit provided by banking sector (% of GDP),Broad money growth , Total reserves, Money and quasi money (M2) to total reserve ratio, Current account balance ,Inflation(consumer prices and percentage of GDP deflator) ,wholesale price index, consumer price index, Cash surplus/deficit, Lending interest rate and foreign direct investment

All these indicators were studied for all the three sample economies for the period 1991-2011.For checking the influence of these warning indicators on the crisis so as to understand their respective role in the occurrence of crisis we have used six major crisis occurred from 1991-2011.These are 1991 Indian economic crisis, 1994 Mexican economic crisis, 1997 Asian financial crisis,

1999-02 Argentina economic crisis, 2008 Subprime crisis and 2010 Euro crisis.

Findings And Discussions

This study is focused on determining warning indicators that can help in forecasting the economic crisis. This study deals with creating a threshold level for generating signals indicating a possible occurrence of economic crisis using the KLR signaling approach, which can provide a warning signal for the upcoming crisis whenever any indicator crosses the threshold level. For analyzing the upcoming economic crisis three economies were studied namely US, Europe Union and India for the period 1991-2011.

KLR Signal Approach And Its Results

For the purpose of generating noise to signal ratio for each country KLR approach is been deploys which has been shown in matrix above in the methodology. By applying minimization on the noise to signal ratio of each country we are able to get a common noise to signal ratio for each indicator.

TABLE 1 : Noise To Signal Ratio

COUNTRY	INDICATORS	Bad signal as percentage of possible bad signals $B/(B+D)$	Good signal as percentage of possible good signals $A/(A+C)$	Noise to signal ratio
USA		0.17	0.44	0.38
INDIA	Total reserves (includes gold, current US\$)	0.14	0.13	1.07
EUU		0.14	0.33	0.43
USA		0.17	0.38	0.44
INDIA	Current account balance (BOP, current US\$)	0.67	0.50	1.33
EUU		0.67	0.38	1.78
USA		0.83	0.56	1.48
INDIA	Real effective exchange rate index (2005 = 100)	0.17	0.50	0.33
EUU		0.17	0.42	0.40
USA		0.33	0.67	0.50
INDIA	Inflation, consumer Prices (annual %)	0.50	0.47	1.07
EUU		0.50	0.60	0.83
USA		0.50	0.53	0.94
INDIA	Broad money growth (annual %)	0.67	0.53	1.25
USA			0.17	0.27
INDIA	Domestic credit provided by banking sector (% of GDP)	0.17	0.40	0.42
EUU		0.00	0.00	0.00
USA		0.50	0.67	0.75
INDIA		0.50	0.47	1.07
EUU	GDP growth (annual %)	0.50	0.67	0.75
USA		0.33	0.13	2.50
INDIA	Goods exports (BOP, current US\$)	0.17	0.20	0.83
EUU		0.00	0.27	0.00
USA		0.17	0.13	1.25
INDIA	Goods imports (BOP, current US\$)	0.33	0.20	1.67
EUU		0.17	0.13	1.25
USA		0.33	0.13	2.50

INDIA	Gross domestic savings (current US\$)	0.00	0.40	0.00
EUU		0.00	0.33	0.00
USA	Lending interest rate (%)	0.50	0.53	0.94
INDIA		0.83	0.53	1.56
USA	Money and quasi money (M2) to total reserves ratio	0.50	0.40	1.25
INDIA		0.67	0.73	0.91
USA	Cash surplus/deficit (% of GDP)	0.80	0.40	2.00
INDIA		0.67	0.53	1.25
EUU		0.67	0.73	0.92
USA	Consumer price index (2005 = 100)	0.00	0.07	0.00
INDIA		0.00	0.00	0.00
USA	Foreign direct investment, net (BOP, current US\$)	0.50	0.40	1.25
INDIA		0.50	0.27	1.88
EUU		0.83	0.40	2.08
USA	Inflation, GDP deflator (annual %)	0.17	0.67	0.25
INDIA		0.50	0.47	1.07
EUU		0.67	0.60	1.11
USA	Wholesale price index (2005 = 100)	0.17	0.20	0.83
INDIA		0.00	0.00	0.00

Above Table Shows The Noise To Signal Ratio Calculated For Each Country And For Each Indicator. When The Noise-To-Signal Ratio Is Less Than 1, This Number Is Positive, Implying That

Crises Are More Likely When The Indicator Signals Than When It Does Not. Indicators With Noise-To-Signal Ratios Equal To Or Above Unity Are Not Useful In Anticipating Crises.

TABLE 2 : Classification Of Indicators

Indicators	Noise To Signal Ratio	Type	Threshold percentile
Inflation, GDP Deflator (Annual %)	0.25	Informative	54.55
Real Effective Exchange Rate Index (2005 – 100)	0.33	Informative	72.73
Total Reserves (Includes Gold, Current Us\$)	0.38	Informative	68.18
Domestic Credit Provided By Banking Sector (% Of GDP)	0.42	Informative	72.73
Current Account Balance (BOP, Current Us\$)	0.44	Informative	72.73
Inflation, Consumer Prices (Annual %)	0.5	Informative	54.55
GDP Growth (Annual %)	0.75	Informative	54.55
Goods Exports (BOP, Current Us\$)	0.83	Informative	86.36
Wholesale Price Index (2005 = 100)	0.83	Informative	86.36
Money And Quasi Money (M2) To Total Reserves Ratio	0.91	Informative	50
Cash Surplus/Deficit (% Of GDP)	0.92	Informative	63.64
Broad Money Growth (Annual %)	0.94	Informative	63.64
Lending Interest Rate (%)	0.94	Informative	77.27
Goods Imports (BOP, Current Us\$)	1.25	Non-Informative	90.91
Foreign Direct Investment, Net (BOP, Current Us\$)	1.25	Non-Informative	72.73
Gross Domestic Savings (Current Us\$)	0	Nil	77.27
Consumer Price Index (2005 = 100)	0	Nil	95.45

The above table fulfills the objective of the study that is to identify number of informative warning indicators out of all. As it is known that ratio above unity are not useful in predicting crisis they are non informative. Column 1 of this table shows the indicators and column 2 shows the minimized noise to signal ratio for each indicators. Column 3 shows the type of indicator i.e., whether informative or not. We found 13 indicators are informative out of 17 indicators.

After the minimization of noise to signal ratio the optimal threshold level for each indicator is been taken which is derived in the terms of percentiles. Above table shows the various threshold levels for each indicator. KLR approach states that whenever any indicator crosses its threshold levels it will generate a signal. This signal can be a good signal or a bad signal.

PROBIT Model Results and Analysis

In statistics, a probit model is a type of regression where the dependent variable can take only two values, for example crisis or no crisis. The purpose of the model is to estimate the probability that an observation with particular characteristics will fall into a specific one of the categories; the probit model is a type of binary classification model. In this section, we have applied probit regression model to the original data. In this we embed the KLR approach with the binary probit model in which the dependent variable takes a value of one when there is a crisis in 2 years and zero otherwise. We had run binary probit regression only on informative variables as only these 13 informative variables are useful in predicting crisis.

Table 3 shows the results of probit regression technique of the sample economy USA. Each indicator has three parameters on the basis of which we will evaluate its significance on predicting crisis.

Indicators	USA			India			European Union		
	Coeffici	Chi	Sig.	Coefficien	Chi	Sig.	Coeffici	Chi	Sig.
Inflation, GDP deflator (annual %)	$\alpha 1$ 0.012	2.174	0.14	0.023	3.659	0.056	0.012	2.174	0.14
	$\alpha 2$ 20.174	0	1	-0.121	0.013	0.908	20.174	0	1
	$\alpha 3$ -0.611	0	1	-0.099	2.161	0.142	-0.611	0	1
Real effective exchange rate index (2005 = 100)	$\alpha 1$ 0	0	0.988	0.038	0.179	0.672	0	0	0.988
	$\alpha 2$ 0.624	0.241	0.624	-2.865	0.123	0.726	0.624	0.241	0.624
	$\alpha 3$ 0.002	0.001	0.969	0	0	0.00***	0.002	0.001	0.969
Total reserves (includes gold, current US\$)	$\alpha 1$ 0.012	3.321	0.068	0.053	3.319	0.068	0.012	3.321	0.068
	$\alpha 2$ -0.045	0.179	0.672	-4.837	1.863	0.172	-0.045	0.179	0.672
	$\alpha 3$ 0.361	0.017	0.895	0.003	0.001	0.976	0.361	0.017	0.895
Domestic credit provided by banking sector (% of GDP)	$\alpha 1$ 0.007	1.068	0.302	0.005	0.763	0.383	0.007	1.068	0.302
	$\alpha 2$ 0.543	0.455	0.5	1.878	1.906	0.167	0.543	0.455	0.5
	$\alpha 3$ -0.034	0.741	0.389	-0.097	2.216	0.137	-0.034	0.741	0.389
Current account balance (BoP, current US\$)	$\alpha 1$ 0.002	0.418	0.518	0	0.06	0.807	0.002	0.418	0.518
	$\alpha 2$ 14.928	0	1	6.514	0	1	14.928	0	1
	$\alpha 3$ -0.795	0	1	0	0	1	-0.795	0	1
Inflation, consumer prices (annual %)	$\alpha 1$ 0.025	5.148	0.023**	0.021	3.504	0.061	0.025	5.148	0.023**
	$\alpha 2$ -0.784	0.615	0.433	-0.63	0.361	0.548	-0.784	0.615	0.433
	$\alpha 3$ -0.046	1.939	0.164	-0.033	1.013	0.314	-0.046	1.939	0.164
GDP growth (annual %)	$\alpha 1$ 0.004	0.272	0.602	0.001	0.004	0.952	0.004	0.272	0.602
	$\alpha 2$ 0.33	0.153	0.695	1.23	1.141	0.285	0.33	0.153	0.695
	$\alpha 3$ -0.015	0.215	0.643	-0.008	0.058	0.81	-0.015	0.215	0.643
Goods exports (BoP, current US\$)	$\alpha 1$ 0.02	5.723	0.017**	0.042	4.684	0.03***	0.02	5.723	0.017**
	$\alpha 2$ -2.01	2.854	0.091	-10.199	0	1	-2.01	2.854	0.091
	$\alpha 3$ 0.021	0.04	0.841	-0.042	0	1	0.021	0.04	0.841
Wholesale price index (2005 – 100)	$\alpha 1$ 0.012	5.99	0.014**	0.012	4.63	0.031**			
	$\alpha 2$ -25.318	0	1	-16.365	0	1			
	$\alpha 3$ 2.24	0	1	1.591	0	1			
Money and quasi money (M2) to total reserves ratio	$\alpha 1$ 0	0.001	0.982	0.016	2.572	0.109			
	$\alpha 2$ 1.247	1.487	0.223	27.609	0	0.999			
	$\alpha 3$ -0.015	0.233	0.63	-0.71	0	0.999			
Cash surplus/deficit (% of GDP)	$\alpha 1$ -0.001	2.633	0.105	0	0.223	0.636	-0.001	2.633	0.105
	$\alpha 2$ -6.4	0	1	0.655	0.421	0.517	-6.4	0	1
	$\alpha 3$ 0	0	0.00***	0.001	0.242	0.623	0	0	0
Broad money growth (annual %)	$\alpha 1$ 0.041	2.547	0.11	0.17	27.316	0***			
	$\alpha 2$ -2.951	2.646	0.104	-9.993	14.239	0***			
	$\alpha 3$ 0.065	0.402	0.526	0					
Lending interest rate (%)	$\alpha 1$ 0.019	4.451	0.035**	0.01	3.107	0.078			
	$\alpha 2$ -1.019	0.791	0.374	-0.505	0.267	0.605			
	$\alpha 3$ -0.033	0.241	0.623	0.009	0.017	0.896			

Note: α_1 is the coefficient of P , α_2 is the coefficient on I , the zero/one indicates variable, and α_3 is the coefficient on $I^*(P-T)$, and represents additional effect of changes in the variable above the threshold. Calculated on 5% significance level.

Model started with the most general piecewise-linear specification for all the variables (allowing the estimation, for each variable, of the slope below the threshold (P), the jump at the threshold (I), and the slope above the threshold ($I^*(P-T)$). these parameters are explained using $\alpha_1, \alpha_2, \alpha_3$ i.e. coefficient of percentiles of indicators (P), coefficient of crisis (I) and coefficient of jump in the slope above the threshold respectively. As we look into the results of the probit model for USA, we will find that only 5 indicators out of 13 are significant. In which four variables (inflation (consumer prices), goods exports wholesale price index and lending interest rate) enters with a significant slope below the threshold means all these indicators are capable in defining crisis but their optimal threshold frequencies are not able to provide probable occurrence of the crisis and it is also not able to provide level of jump in the threshold. Out of these 5 significant indicators only one variable (cash surplus/deficit) enters with a significant slope above the threshold means the variable has a drastic jump whenever it goes beyond the threshold level.

Similarly, table 3 also shows the results of probit regression technique of the sample economy India. Out of 13 informative variables only 4 variables works significantly. In which goods exports and wholesale price index enters with a significant slope below the threshold means all these indicators are capable in defining crisis but their optimal threshold frequencies are not able to provide probable occurrence of the crisis and it is also not able to provide level of jump in the slope of the threshold.

Out of these 4 significant indicators only one variable (Real effective exchange rate) enters with a significant slope above the

threshold means the variable has a drastic jump whenever it goes beyond the threshold level. And one of these variables i.e. broad money growth rate enters with a significant slope below the threshold and jump at threshold means it is capable in defining the crisis and its optimal threshold can correctly signal a warning whenever its value goes beyond the threshold level. As broad money has worked significantly for the slope below and jump at the threshold it is very important variable for the Indian economy. It can define the crisis and also it can help in predicting the probable occurrence of crisis in India hence, study of deviation in its trend will be very crucial.

Likewise, table 3 also shows the results of probit regression technique of another sample economy European Union. Out of 13 informative variables only 2 variables works significantly. Only goods exports and inflation (consumer prices) enters with a significant slope below the threshold means all these indicators are capable in defining crisis but their optimal threshold frequencies are not able to provide probable occurrence of the crisis and it is also not able to provide level of jump in the slope of the threshold.

It is very prominent to note that amongst all the 13 indicators goods exports is the only variable which works significantly for all the three economies and is able to define the crisis. Therefore, it is very important to note the trend of the goods exports and whenever it shows any uncertain behavior and goes beyond its threshold level there is probability of any event.

Also the wholesale price index works for both the USA and India in defining the crisis and inflation (consumer prices) works common for USA and European Union in explaining crisis. Therefore USA is the dominating economy which will affect both the Indian economy as well as the European Union. Whenever there is any event occurs in USA it will generate some impact on India and European Union.

Table 4 : Hypothesis H0 : There is no significant effect of variable in occurrence of economic crisis						
H1 : There is a significant effect of variable in occurrence of economic crisis						
Indicators	USA		India		European union	
	H0	H1	H0	H1	H0	H1
Inflation, GDP deflator (annual %)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Real effective exchange rate index (2005 = 100)	Accepted	Rejected	Rejected	Accepted	Accepted	Rejected
Total reserves (includes gold, current US\$)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Domestic credit provided by banking sector (% of GDP)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Current account balance (BoP, current US\$)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Inflation, consumer prices (annual %)	Rejected	Accepted	Accepted	Rejected	Rejected	Accepted
GDP growth (annual %)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Goods exports (BoP, current US\$)	Rejected	Accepted	Rejected	Accepted	Rejected	Accepted
Wholesale price index (2005 = 100)	Rejected	Accepted	Rejected	Accepted	Accepted	Rejected

Money and quasi money (M2) to total reserves ratio	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Cash surplus/deficit (% of GDP)	Rejected	Accepted	Accepted	Rejected	Accepted	Rejected
Broad money growth (annual %)	Accepted	Rejected	Rejected	Accepted	Accepted	Rejected
Lending interest rate (%)	Rejected	Accepted	Accepted	Rejected	Accepted	Rejected
Goods imports (BoP, current US\$)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Foreign direct investment, net (BoP, current US\$)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Gross domestic savings (current US\$)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected
Consumer price index (2005 = 100)	Accepted	Rejected	Accepted	Rejected	Accepted	Rejected

Conclusion

This study deals with the objective of generating noise to signal ratio for determining an optimal threshold level for each indicator selected. For the purpose 17 macroeconomic indicators were selected. All the indicators were studied for the period of 21 years i.e. from 1991-2011 for three sample economies i.e. USA, India and European Union. The paper follows the KLR approach used by various researchers in signaling currency crisis. With the help of this model, noise to signal ratio were generated for each indicator which is further used to create a optimal threshold level for each indicator which is same across all countries.

An indicator issues a signal whenever it moves beyond a given optimal threshold level. It is not necessary that the signal so generated will be a good signal; it may generate bad signals also. With the help of this noise to signal ratio we are also able to get most informative macroeconomic indicators amongst all. The total number of informative indicators is 13 out of 17. To give more reliable results binary probit regression analysis is used which provides the probability of occurrence of crisis. This model uses the percentiles and thresholds values of each indicator for calculating indicators level of significance in the crisis.

The results of probit model shows that in USA five indicators were significant in different manners, in India four indicators were significant and in European Union only 2 variables were significant. One of the major findings of probit model is the goods exports is only a common significant variable which is able to define crisis for all the three sample economies. Also the wholesale price index works for both the USA and India in defining the crisis and inflation (consumer prices) works common for USA and European Union in explaining crisis.

Therefore USA is the dominating economy which will affect both the Indian economy as well as the European Union. Whenever there is any event occurs in USA it will generate some impact on India and European Union.

Also, it is very important to note that broad money growth, one of the significant indicators of India is providing signals in 2011 (calculation part) which shows that there can be an event in 2012 or 2013. This is very important to use this information predicting economic crisis and taking suitable policy measures to lessen the impact of probable economic crisis on an economy.

Although the results are not very satisfactory but we are able to provide some of the various global macroeconomic variables that are able to define crisis and can help in predicting crisis.

Bibliography

- Berg, A., Pattillo, C. (1999), Predicting currency crises: The indicators approach and an alternative, *Journal of international money and finance*, Research Department, International Monetary Fund, 700 19th St. N.W., Washington D.C., 20431, USA
- Berg, A., Pattillo, C., 1998. Are currency crises predictable? A test. IMF Working Paper 98/154. International Monetary Fund.
- Blackburn, K., Sola, M., (1993). Speculative currency attacks and balance of payments crises. *Journal of Economic Surveys* 7, 119–144
- Blanco, H., Garber, P., (1986). Recurrent devaluation and speculative attacks on the Mexican peso. *Journal of Political Economy* 94, Board of Governors of the Federal Reserve System (U.S.), Bureau of Economic Research, Cambridge, Massachusetts.
- Bussiere, M., (1998). Political instability and economic vulnerability. International Monetary Fund, unpublished.
- Bussiere, M., Fratzscher, M., (2002). Towards a New Early Warning System of Financial Crises. ECB Working Paper 145.
- Cumby, R., Wijnbergen, S., (1989). Financial policy and speculative runs with a crawling peg: Argentina 1979–1981. *Journal of International Monetary Fund*, Washington
- Diebold, F.X., Lopez, J.A., 1996. Forecast evaluation and combination. Technical Working Paper No. 192, National Bureau of Economic Research, 1996.
- Dornbusch, R., Goldfajn, I., Valdes, R.O., (1995). Currency crises and collapses. In: *Brookings Papers on Economic Activity*, vol. 2.
- Edison, H., (2003). Do indicators of financial crises work? An evaluation of an early warning system. International

- Journal of finance and economics John Wiley & Sons, Ltd., vol. 8(1)
- Eichengreen, B., Rose, A., Wyplosz, C., (1994). Speculative Attacks on Pegged Exchange Rates: An Empirical Exploration with special reference to European monetary system, C.E.P.R. Discussion Papers 1060.
- Eichengreen, B., Rose, A., Wyplosz, C.,(1995). Exchange market mechanism: the antecedents and aftermath of speculative attacks. Center for International and Development Economics Research (CIDER) Working Papers C95-046, University of California at Berkeley
- Eichengreen, B., Rose, A.K., Wyplosz, C., (1996). Contagious currency crises: first tests. *Scandinavian Journal of Economics* 98 (4),Englewood Cliffs, NJ.
- Flood, R., Garber, P., (1984). Collapsing exchange rate regimes: some linear examples. *Journal of International Economics* 17, 1–13.
- Flood, R., Marion, N.,(1998). Perspectives on the recent currency crisis literature. Working Paper No. 6380, National Bureau of Economic Research, 1998 for International Development, unpublished.
- Frankel, J., Rose, A.,(1995). Currency crashes in emerging markets: an empirical treatment. *Journal of International Economics* 41, 351–366.
- Frankel, J., Rose, A., (1996). Currency crashes in emerging markets: an empirical treatment. *Journal of International Economics*
- Fratzcher, M., (2003). On currency crises and contagion. *International Journal of Finance and Economics* 8 (2), 109–129. FRS International Finance Discussion Paper 675.
- Furman, J., Stiglitz, J.E., 1998. Economic crises: evidence and insights from East Asia. World Bank working paper,
- Glick, R., Moreno, R.,(1999). Money and Credit, Competitiveness, and Currency Crises in Asia and Latin America. Center for Pacific
- Glick, R., Rose, A.K., (1999). Contagion and trade: why are currency crises regional? *Journal of International Money and Finance*
- Gochoco-Bautista, S.M., (2000). Periods of currency pressure: stylized facts and leading indicators. *Journal of Macroeconomics* 22 (1).
- Goldstein, M., (1996). Presumptive Indicators/Early Warning Signals of Vulnerability to Financial Crises in Emerging Market
- Goldstein, M., (1998). Early warning indicators and the Asian financial crisis. Institute for International Economics, unpublished.
- Goldstein, M., Kaminsky, G., Reinhart, C.,(2000). Assessing Financial Vulnerability: An Early Warning System for Emerging economies
- Gujarati, D.N., (2003). *Basic Econometrics*, fourth ed. McGraw Hill.
- Kaminsky, G., (1998). Currency and banking crises: a composite leading indicator. Board of Governors of federal reserve system
- Kaminsky, G., December (1999). Currency and Banking Crises: The Early Warnings of Distress. IMF Working Paper 178.
- Kaminsky, G., Lizondo, S., Reinhart, C.,(1998). Leading indicators of currency crises. *International Monetary Fund Staff Papers* 45, 1–48.
- Kaminsky, G., Reinhart, C., (1996). The twin crises: the causes of banking and balance-of-payments problems. *International Finance Discussion Paper* 544, Board of the Governors of the Federal Reserve System.
- Kaminsky, G., Reinhart, C., (2000). On crises, contagion, and confusion. *Journal of International Economics* 51 (1), 145–168.
- Karmarkar, Y., Karamchandani, M., & Mantri, A. Exchange Rate and Macro-economic indicators: A Causal Study for India of the Past Decade.
- Krugman, P., (1979). A model of balance-of-payments crises. *Journal of Money, Credit and Banking* 11, 311–325.
- Krugman, P. (1996). Are currency crises self-fulfilling? *NBER Macroeconomics Annual* 11.
- Levy-Yeyati, E., Ubide, A.,(2000). Crises, contagion, and the closed-end country fund puzzle. *IMF Staff Papers* 47 (2), 54–89.
- Milesi-Ferretti, G.M., Razin, A., (1998). Current Account Reversals and Currency Crises: Empirical Regularities. *IMF Working Paper*
- Moreno, R., (1995). Macroeconomic behavior during periods of speculative pressure or realignment: evidence from Pacific Basin NBER Working Paper No. 6370. Cambridge, Massachusetts.
- Obstfeld, M., 1994. The Logic of Currency Crises. *NBER Working Paper*, No. 4640 of *Business and Economic Statistics* 10, 461–465.
- Otker, I., Pazarbasioglu, C., (1996). Speculative attacks and currency crises: the Mexican experience. *Open Economics Review* 7 (1),
- Ozkan, F.G., Sutherland, A., (1995). Policy measures to avoid a currency crisis. *The Economic Journal* 105 (March), 510–519.
- Pesaran, M.H., Timmermann, A., (1992). A simple nonparametric test of predictive performance. *Journal of Business and Economic Statistics* 10, 461–465.
- Qi, M., (1999). Nonlinear predictability of stock returns using financial and economic variables. *Journal of Business and Economic*
- Qi, M., Maddala, G.S., (1999). Economic factors and the stock

- market: a new perspective. *Journal of Forecasting* 18, 151–166.
- Radelet, S., Sachs, J., (1998). The East-Asian financial crisis: diagnosis, remedies, prospects. Harvard Institute for International Development, unpublished.
- Sarda, V., Karmarkar, Y., Lakhota, N., & Sen, P. (2010). What Can the Log-periodic Power Law Tell about Stock Market Crash in India?