

# Predicting Indian Foreign Exchange Market Crashes through Log-Periodic Power Law

**Varun Sarda, Yamini Karmarkar & Neha Lakhotia**

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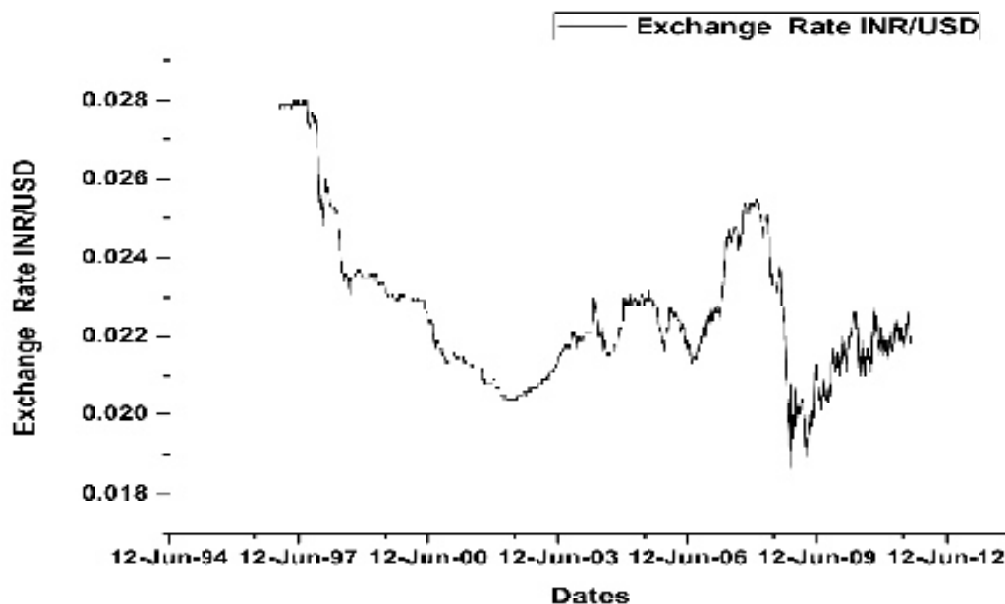
*A sudden crash in the foreign exchange market can wipe out a lot of value for the investors in the market. The present study analyzes crashes in the Indian foreign exchange market using Log-Periodic Power Law during 1997- 2011. The fall in prices in Indian foreign exchange market is less than required due to the fact that, though there is full current account convertibility, there still are restrictions on capital account convertibility. Further, the Central Bank intervenes in the foreign exchange market to influence the exchange rate of Rupee. Log-Periodic Power Law will be more applicable in a situation where there will be no restrictions and controls on exchange rate determination.*

**Varun Sarda** is Assistant Professor, Prestige Institute of Management and Research, Indore. E-mail: [inboxofvarun@gmail.com](mailto:inboxofvarun@gmail.com). **Yamini Karmarkar** is Reader, Institute of Management Studies, Indore. E-mail: [ykarmarkar@gmail.com](mailto:ykarmarkar@gmail.com). **Neha Lakhotia Sarda** is an Indore based Entrepreneur and Freelancer. E-mail: [neha.pimd@gmail.com](mailto:neha.pimd@gmail.com)

## Introduction

In the process of prediction of the exchange rate, its movement and the way it is determined becomes an important factor. Even a small fluctuation in the exchange rate can affect the business houses manifolds. Today, the exchange rate system followed by India is the Liberalized Exchange Rate Management System (LERMS). The Tarapore Committee of 1997 on Capital Account Convertibility had made significant recommendations to strengthen the Foreign Exchange Market of India. In the years 1997-98 and 1998-99 the Reserve Bank of India (RBI) stuck to its objective of reducing the volatility and speculation in the foreign exchange market as a part of its exchange rate policy. The value of rupee was allowed by the RBI to be determined in the market and it intervened whenever undue volatility was introduced into the market due to any political, social or economic reasons. An evaluation of the effective exchange rates indicates that there is a sharp depreciation in the valuation of the rupee in nominal terms. The nominal effective exchange rate (NEER)

Graph 1 Plot of the data of exchange rate (INR/USD) from 1997 to 2011



has also fallen by an approximate value of 23% between Jan 1993 and Jan 1999. The reasons behind the same are attributed to the transition from artificially suppressed “managed rates” to the market determined exchange rates. The same period saw an appreciation in the real effective exchange rate (REER) by about 2.8% indicating that there must have been marginal gain in overall export competitiveness.

Foreign exchange constitutes the largest financial market not only in the rest of the world but also in India. The growth in Indian foreign exchange market has been manifold in the last several years. The daily average turnover has seen a significant rise, from about US \$ 5 billion during 1997-98 to US \$ 18 billion during 2005-06. Also, the average monthly turnover in Indian foreign exchange market has continuously

improved from 175 billion US dollars (USD) in 2003-04 to 359 billion USD in 2005-06. The foreign exchange markets have seen a tripled growth in the years from 2000-01 to 2005-06, with the annual compound growth rate exceeding 25%. There has been a lock step pattern in the movement of the USD and the rupee. Also, the relationship of the Indian Rupee (INR) has been particularly stable with the USD. During the 1999-2004 the correlation between the two was 0.94.

The Tarapore Committee defined the concept of Capital Account Convertibility as “the freedom to convert local financial assets into foreign financial assets and vice versa at market determined rates of exchange”. India has seen a speedy accumulation in foreign exchange reserves in the last few years. During 2003 and 2004 the USD fell against the Euro by 19% and against the rupee by

9%. The annual foreign exchange turnover in India in the year 2007 was US \$ 10.73 trillion. It increased to US \$ 13.08 trillion in 2008, US \$ 9.88 trillion in 2009, US \$ 12.72 trillion in 2010 and US \$ 13.95 trillion in 2011. Thus, the foreign exchange turnover in India has risen steadily from 2007 to 2011. Various theories have been propounded such as Purchasing Power Parity, Interest Rate Parity, Fisher Effect, Asset Market Model and the like to explain the movements in the Foreign Exchange Markets of the World and India. But all these techniques are not able to predict short term volatilities. As of now the majority of trades in the Indian Foreign Exchange Market are done by the institutional players thus the volatility is also not very high.

#### **Log Periodic Power Law**

A Log Periodic Power Law (LPPL) can be fitted to financial market bubbles which precede large market falls or crashes, containing parameters which are confined within certain ranges. The underlying principle on which the LPPL is based is the influence perception and martingale condition. The equation of LPPL captures the particular oscillating movement of the financial markets showing their growth and evolution. A crash can be predicted in a financial time series using LPPL. The parameters of the

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equation can be estimated using a hybrid Genetic Algorithm. With respect to a financial market, a crash can be defined as a sudden and dramatic decline in the price of an asset or an index over a short period of time. As a result of this there is a large percentage drop which further leads to a devastating condition for the market. In a financial market, the price of an asset fluctuates as a function of the supply and demand, which reflects continuous flow of news as interpreted by the analysts and traders. When a condition of panic is triggered by extreme sell orders by the traders it results into a condition of crash. External events have an impact on the market and leads to a crash. These events could be any bad piece of information capable of impacting the market adversely. A speculative bubble occurs when a crash is identified as endogenous and is triggered due to the bubble. At this time the price of an asset or index undergoes a significant increase and becomes overvalued. This is due to a positive feedback.

In two independent works by Feigenheim and Freund (1996), and Sornette, Johansen and Bouchaud (1996), have described the scenario of endogenous crashes in financial markets. According to them, during the bubble there is an increase in the index as a power law decorated with log periodic oscillation and that the ending crash is the climax of LPPL signature. The oscillation of LPPL captures the behavior of a bubble and follows the critical time of a crash. A drawdown can be used to measure losses in a financial time series. It is a way to measure the continuous down-

ward movement from a local maximum to a local minimum. A largest negative drawdown will single out abnormal movements as crashes in financial time series.

According to Johansen and Sornette (2006), a crash is defined as an outlier departing from a fit to a logarithmic expression of the complimentary cumulative Weibull distribution. Jacobsson (2009) has defined a crash as an empirical quantile of 99.5% as against the one described by Johansen and Sornette (2006).

Why do we need to introduce a new measurement of drawdown? In case of a crash, a financial index falls rapidly with large negative returns, where largest ones are extreme events in the market. The real dynamics of price movements is not captured by independency and financial time units. The origin of LPPL is in the prediction of the damage caused by meteorological disasters. The accuracy of predicting these disasters is very crucial. In the vicinity of a catastrophic event it can be observed that LPPL exhibits oscillations with increasing frequency. Thus, by fitting the LPPL to the observations it is possible to predict the catastrophic events. Successful predictions were made in many application areas ranging in ruptures of fuel tanks to earthquakes to stock market disruptions. The LPPL is not a result of a specific nature of a system but occurs due to general properties of the system.

### **Rationale**

Most technical analysis tools are able to generate sell signal but are not able to

predict the percentage fall. Although some techniques are able to do this to a certain extent using Golden mean and Fibonacci series etc., but they are not able to do it precisely. Log-Periodic Power Law structures are able to predict a stock market crash of more than 25% at a very early stage and the similarity between Log-Periodic Power Law structures and other technical analysis tools is that they both generate a sell signal near about the starting point of the crash but the difference between these techniques lies in the fact that whereas other tools are not able to differentiate between large decline and small decline in prices but Log-Periodic Power Law structures are able to do so. It does not generate a signal for smaller price declines while it generates a very clear signal for a price decline of more than 25%. In this study it is proposed to apply Log-Periodic Power Law in Indian Financial Markets to predict the crashes and compare with other techniques of technical analysis. The study will help the academicians to understand the dynamics of the financial market namely Foreign Exchange Market in a better way.

### **Research Questions**

The basic question for which this research tries to seek an answer is: Can a “Crash” in Foreign Exchange Market in India be predicted?

The specific research questions are as follows:

- 1) Can Log-Periodic Power Law be applied to predict the “Crash” in Indian Financial Markets?

- 2) Can Log-Periodic Power Law be used to estimate the amount of expected fall in the price during the “Crash”?
- 3) Can Log-Periodic Power Law predict the “Crash” in prices in appropriate time and create an alarm for the investors?
- 4) Can the signals generated by Log-Periodic Power Law are reliable or they are just false signals of a “Crash”?

To analyze these crashes, the present study applies Log-Periodic Power Law to the data. An evaluation is done on the basis of quantitative parameters namely Predictive Efficiency, Time Lap and Quantum of Fall. The parameters used for comparison are of specific importance as they judge the Log-Periodic Power Law on the basis of their preciseness, timeliness and surety with which they predict a crash.

### Objective

The objective of the study is to find out whether signals can be generated prior to beginning of a downward trend in Indian Foreign Exchange Market using Log-Periodic Power Law.

### Literature Review

According to Blanchard (1979), investors must be compensated by higher returns to induce them to hold an asset that might crash. Blanchard and Watson (1982) introduced the concept of Rational Expectation bubbles which allow for

arbitrary deviations from fundamental prices while keeping the fundamental anchor point of economic modeling.

**A major problem relates to detecting the bubbles since they are helpful in predicting the financial impacts.**

A major problem relates to detecting the bubbles since they are helpful in predicting the financial impacts. Research related to testing the explosive trends in time series of asset prices and foreign exchange rate has also been carried out by Evans (1991). The set of assumptions on which the study done by Johansen and Sornette (1999) is based are as follows:

(a) The key assumption used here is that a crash may be caused because of the local reinforcing imitation between traders. This can be defined as a tendency of traders to imitate their friends thus increasing up to a certain point called the “critical point”. This results into formation of a bubble. Since many investors place sell orders at this point it results into a crash.

(b) Investors adopt a rational outlook since they remain invested with a possibility of being compensated by a higher rate of growth of bubble for taking the risk of crash.

They based the focus of the study on the parameters like the system of traders who are influenced by their neighbors, local imitation turning into global cooperation, global cooperation causing crash.

Ilinski (1999) pointed out that traders expect the price to rise and the same is reflected in the prediction model. Traders support the bubble and the bubble supports them. Market level does not stay constant in a bubble, it rises. Therefore, the market must rise and compensate the buyers for taking risk. Market price is a reflection of the greed of the buyers and the fear of the sellers. According to Lux and Sornette, (2001), many Rational Expectation bubbles are seen to exhibit shapes which are difficult to reconcile with the economic intuition or facts. Matsushita, Gleria, Figueiredo and Silva (2005) found that crashes result from a build-up of correlations. Imitation between traders in a bull market leads to a bubble. Stress pushes the market into a state of critical time interval. This critical point is the threshold point where many traders place orders at the same time thereby provoking a crash. Crashes thus are outliers with characteristics distinct from population.

Johansen, Sornette and Ledoit, (2000) in their study on financial markets have found that log-periodic signatures precede the stock market crashes. They have shown notable universality of the results for all events. Eight unrelated crashes from 1929 to 1998 on stock markets of United States, Hong-Kong and Russian and on currencies have been documented by them. They have also identified a noteworthy bubble on Wall Street ending in 1962 and “anti-bubbles” on the Nikkei since 1990. According to them, no major financial crash preceded by an extended bubble has occurred in the past two decades without exhibiting

log periodicity. All the cases presented by them along with the crash of 1962 and the anti-bubbles indicate that the log-periodicity concept applies to bubbles which end in crash and also to the bubbles landing smoothly.

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An extensive review of literature disclosed a number of research works on Technical Analysis. Although the methods used in these studies were helpful in anticipating the trend reversals to a certain extent but they were unable to give a hint about the size of upswing and downswing. Therefore, a substantial analysis of literature relating to Log-Periodic Power Law appears to address this issue. The probe is whether it can be utilized to anticipate price movements in the Indian Foreign Exchange Market? Also, can it be used to anticipate these movements in suitable time and generate a reliable signal for the investors?

### **Research Methodology**

The present study focuses on prediction of “Crash” in Indian Foreign Exchange Markets. Therefore, the basic question of how to predict a “Crash” is addressed with the help of Log-Periodic Power Law. This model is applied to the sample data from 1997 to 2011. An attempt is made to evaluate the model in terms of efficiency of predicting “Crash”. From the review of literature above it is

clear that most of the tools used for technical analysis are capable of generating sell signal but are unable to predict the percentage of fall. Given the fact that some of the techniques namely Golden Mean and Fibonacci Series are able to do it but only to a limited extent, Log-Periodic Power Law structures are able to predict stock market crash of more than 25% at a very early stage. Other technical analysis tools namely chart patterns and trend indicators are able to generate sell signal only. This study proposes to apply Log-Periodic Power Law in Indian Foreign Exchange Markets to predict the crashes.

Evaluation of the model has been done using Predictive Efficiency, Time Lap and Quantum of Fall. The capacity of the technique to predict the trend reversal is measured by Predictive Efficiency. Time Lap is the number of days that have passed after the peak was achieved and the signal was generated. Quantum of Fall may be calculated as the percentage decline in the stock prices from the peak it has achieved.

For the purpose of this study on Indian Foreign Exchange Market, Exchange Rate of Indian Rupee and US Dollars has been taken. The time series data of Exchange Rate of Indian Rupee and US Dollars has been taken from Oanda Corporation website. Oanda Corporation is one of the non-bank Futures Commission Merchants (FCMs) registered with the Commodity Futures Trading Commission (CFTC) and a member of the National Futures Association (NFA). Its headquarters is at Toronto, Canada.

### Defining Crash

Bree and Joseph (2007) have used the following features in defining Crash: First, for the last 262 days (weekdays in a year) the value of the peak must be the highest. Secondly, from this value of peak there should be a decline of 25%. Finally, the time period of this decline should be 60 weekdays. The same concept has been used in the present study. There were various downfalls during the period under consideration but only the falls which fulfill the above criteria were defined as “Crash” and further study is limited to these crashes.

### Active Movements of Price

Johansen, Ledoit, and Sornette (1998) have considered an entirely speculative security that pays no dividends and for not increasing the complexity of the model, interest rate, risk aversion, information asymmetry and the market-clearing conditions have been ignored. Thus, according to the Martingale Hypothesis the expected price dependent on the information available up to time  $t$  is given by

$$E_t [p(t')] = p(t) \dots \dots \dots (1)$$

$$\forall t' > t \dots \dots \dots (2)$$

where  $p(t)$  = price of the security at time  $t$ .

If the price is not allowed to change due to noise the solution to the above equation is

$$p(t)=p(t_0), \dots \dots \dots (3)$$

where  $t_0$  = initial time. Since the security is the one which is non-dividend paying, its intrinsic price is  $p(t) = 0$ . Therefore, a speculative bubble is said to exist when there is positive value of  $p(t)$ .

According to conventional economics markets are said to be efficient if all available information is reflected in the prevailing market prices. This approach is based on the Rational Expectation Theory. Shiller (1989) argues that most of the investors in the stock market are not the investors following the Rational Expectation Model but they follow trends and fashions. Johansen, Ledoit, and Sornette (1998) have taken the view that the forecast of a particular investor may be sub-optimal but the collective effect of all the forecasts forces market price to follow Rational Expectation Model. Rational Expectation Theory results in no-arbitrage condition which explains a self-adaptive active state of the market arising due to the continual activities of the traders.

### Understanding & Modeling the Crash

According to Johansen, Ledoit, and Sornette (1998) a crash occurs when a huge number of participants of a finan-

**A crash occurs when a huge number of participants of a financial market place sell orders at the same time.**

cial market place sell orders at the same time. A crash occurs when the order wins, that is, everyone in the network has the same opinion of selling. It is found by Boissevain and Mitchell (1973) and Cosmides and Tooby (1994) that participants are influenced by their neighbors within a network. Thus, the model in this study has a system of participants who are influenced by the people to whom they are connected in their network. Local imitation of the participants leads to global cooperation, and this global cooperation among participants ultimately causes crash. The growth phase sometimes may not end in crash rather it can switch smoothly. Thus, a crash is not a certain outcome and has a probability to occur between 0 and 1. The concepts and theory and the model given by Johansen and Sornette (2000) indicate that the log-periodicity is the basis of crashes. In order to maximize the gain a very important part is played by the human characteristics. When this is done in a broader way and in association with price dynamics, the Log-Periodic Power Law or equation of Log-Periodic Power Law structures may be derived.

### Comprehensive Modeling of Crash

According to the “mean field” theory of collective systems (Goldenfeld, 1992), in order to explain an imitation process, it may be assumed that the hazard rate  $h(t)$  develop as per the following equation

$$\frac{dh}{dt} = Ch^\delta, \text{ with } \delta > 1, \dots \dots \dots (4)$$

where, C is a positive constant. Mean field theory represent the variety of in-

vestor activities by a sole characteristic performance produced from a normal communication between the investors. Thus,  $h(t)$  may be considered as the combined consequence of the communication between the investors. The total communications felt by an investor is  $\delta - 1$  as quantified by the exponent  $\delta > 1$ . The quantity  $h^\delta$  in the above equation symbolizes the truth that the hazard rate will change in proportion to the occurrence of communications between the investors. When equation number (6) is integrated, following is the result

$$h(t) = \left( \frac{h_0}{t_c - t} \right)^\alpha \dots\dots\dots (5)$$

where  $\alpha \equiv \frac{1}{\delta - 1}$

where,  $t_c$  is the critical time;  $t_c > 0$ . The exponent  $\alpha$  should lie within 0 and 1 or else the price will reach infinity as it reaches  $t_c$ . Thus,  $2 < \delta < +\infty$ , this indicates that an investor is in connection with more than one other investor.

### Minute Modeling of Crash

As discussed in Johansen, Ledoit, and Sornette (1998), let each one of the agents in a network be denoted by an integer  $i = 1, \dots, I$ . Let the set of agents directly in connection with agent  $i$  be  $N(i)$ . As per the concepts of herding and imitation all the agents in the above set will influence each other. If one of the traders is considered and one set  $N(i)$  consisting of  $j = 1, \dots, n$  individuals adjacent to that trader then for every unit of time, every agent of the set is in either of the two states namely purchasing ( $= +1$ , symbolizing being optimistic) or

selling ( $= -1$ , symbolizing being negative). The integration of states of all the agents on the market  $\sum_{i=1}^N s_i$ , will move the price in the appropriate route, where  $s$  denotes the two states of purchasing or selling. When this sum is positive the best choice is to purchase and it is sell when the sum is negative. There are equal number of purchasers and sellers when this sum is equal to zero and there should be no change in price in this case. A single agent does not know this sum; so in this situation, the optimum plan that will maximize the gain is asking the network of known neighbors. Expectantly this set of neighbors will be a depiction of the entire market. The agent has to decide in advance the distribution of the probability for each agent selling P- and purchasing P+. The easiest case is of a market with equal number of purchasers and sellers ( $P- = P+$ ).

### Effect of Communication in Network on Crash

Johansen, Ledoit, and Sornette (1998) have proposed a two-dimensional grid structure. Assuming that investor is located on a two-dimensional grid in the Euclidean plane, she would be surrounded by four fellow members from her family and friends. This is a similar model as the so-called two-dimensional Ising model solved unambiguously by Onsager (1944), in relation to the alignment of atomic spins. The pertinent factor is  $K/\sigma$  which determines the propensity to behave as per advice from family and friend vis-à-vis doing what the investor herself deems fit. The properties of the system are decided by critical point  $K_c$ . When  $K$  is

smaller than  $K_c$ , disorder rules since the chances of having an effect of a little international event is minute, the group of investors who are in consensus is a petite mass and imitation spreads among nearby group of family and friends. Thus, the susceptibility  $\chi$  of the system is limited. Order begins to become visible when  $K$  augments, the system now is enormously susceptible to a little international event, the group of investors who are in consensus form huge huddles and imitation spreads over extensive space. This process is referred to as critical event in natural sciences. Thus, the susceptibility of the system now becomes eternal. The critical event is depicted by a power law and this corroborates the fact that the susceptibility of the system becomes eternal

$$\chi \approx A(K_c - K)^\gamma \dots \dots \dots (6)$$

where  $A$  is a non- negative constant and  $\gamma$  is not smaller than or equal to zero and is known as critical exponent of the susceptibility.

Now, letting  $t_c$  denote the most probable time of crash,  $h(t)$  as hazard rate and putting the values in the above equation the following equation is available:

$$h(t) \approx B(t_c - t)^\alpha \dots \dots \dots (7)$$

where  $B$  is a non-negative constant. If the bubble has not crashed so far and  $t$  is not within the range of zero and one then price will reach infinity as it approaches. Now, putting the value of  $h(t)$  in equation (3) following equation is available before crash:

$$\log [p(t)] \approx \log [p_c] - \kappa B / \beta^* (t_c - t)^\beta \dots \dots \dots (8)$$

where  $p_c$  is the price at the critical time and  $\beta = 1 - \alpha \in (0, 1)$  According to Johansen, Ledoit, and Sornette (1998), equation (7) may be generalized to give first order expansion of the solution for the hazard rate as

$$h(t) \approx B(t_c - t)^{-\beta} + C(t_c - t)^{-\beta} \cos[\omega \log(t_c - t) + \phi] \dots \dots \dots (9)$$

Thus Log-Periodic Power Law structures are now present in the crash hazard rate. Prior to the crash and prior to the critical date the development of the price is represented by

$$p(t) \approx A + B(t_c - t)^{-\beta} + C(t_c - t)^{-\beta} \cos[\omega \log(t_c - t) + \phi] \dots \dots \dots (10)$$

where  $\phi$  is a phase constant. Thus, the main proposal is as follows: the huge selling of the security happening at the time of the stock market crash is due to local imitation of participants leading to global co-operation among them eventually causing a crash in some instances. The above equation used by Bree and Joseph (2007) in ‘Log-Periodic Power Law fits to financial crashes: a preliminary replication’ has been used here.

$$\hat{y}_t = A + B(t_c - t)^\beta + C(t_c - t)^\beta \cos(\omega \log(t_c - t) + \phi) \dots \dots \dots (11)$$

Where:  
 $y_t$  is the price (index);  $y_t > 0$   
 $A$  is the value of  $y_t$  at the critical time;  
 $A > 0$

B is the increase in  $t_i$  over the time unit before the crash;  $B < 0$

C is the proportional magnitude of fluctuations around the exponential growth;  $|C| < 1$

$t_c$  is the critical time;  $t_c > 0$ .

$t$  is any time into the bubble, preceding  $t_c$ ;  $t < t_c$

$\beta$  is the exponent of the power law growth;  $\beta = 0.33 \pm 0.18$

$\omega$  is the frequency of the fluctuations during the bubble;  $\omega = 6.36 \pm 1.56$

$\phi$  is a shift parameter;  $0 \leq \phi \leq 2\pi$ .

**Empirical Test of Crash Using Log-Periodic Power Law Structures**

The data taken for analysis is the time series of Exchange Rate of Indian Rupee and US Dollars. The procedure followed by Jacobsson (2009) and Johansen, Ledoit and Sornette (1998) is applied. For reducing the number of free parameters controlling the fit, the linear variables namely A, B, and C have been “slaved” and their values have been calculated from the obtained values of the nonlinear parameters as suggested by Johansen, Sornette and Ledoit (2000). The Log-Periodic Power Law structures equation (11) -

$$t_i = A + B (t_c - t)^\beta + C (t_c - t)^\beta \cos (\omega \log (t_c - t) + \phi)$$

is rewritten as

$$t_i = A + B f(t) + C g(t) \dots \dots \dots (12)$$

Where  $f(t) = (t_c - t)^\beta$  and  $g(t) = (t_c - t)^\beta \cos (\omega \log (t_c - t) + \phi)$ . From nonlinear parameters, the best values of the linear parameters were obtained by using matrix multiplication -

$$\begin{pmatrix} \Sigma y(t_i) \\ \Sigma y(t_i) f(t_i) \\ \Sigma y(t_i) g(t_i) \end{pmatrix} = \begin{pmatrix} N & \Sigma f(t_i) & \Sigma g(t_i) \\ \Sigma f(t_i) & \Sigma f(t_i)^2 & \Sigma f(t_i) g(t_i) \\ \Sigma g(t_i) & \Sigma f(t_i) g(t_i) & \Sigma g(t_i)^2 \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix}$$

N is the total number of the days for which data is under observation. When a function is required to be fitted on the data then it is essentially the minimization of the residual sum of squares RSSE, for which the function to be optimized may be written as

$$\min F(\theta) = \Sigma (y(t_i) - (t_i))^2$$

where,  $\theta = (t_c, \beta, \omega, \phi)$ . Thus,  $(t_c - t)$  and  $\min F(\theta)$  is found out. The corresponding values of beta, omega and phi are also found out. The expected date of crash is the date for which the value of the objective function is the minimum that is  $t_c$ .

**Description of the Sample**

According to Ponsi (2016), as per the elementary conceptions of Dow theory, a primary trend in a financial market is measured in years. In the present era of highly increased market integrations the structural changes in the capital markets happen fast. A period of 10-12 years in the study of a financial market sufficiently captures such changes.

This study therefore focuses on a period of past 14 years, from July 1997 to August 2011. This period has seen the Indian Liberalization having settled and capital markets sufficiently established.

Also, this period captures three major crises that the world economy has seen i.e., the Southeast Asian Crisis, the burst of Dot com Bubble, the Subprime Crisis and some parts of the European Crisis.

**Table 1 Crashes in the Indian Market in the Exchange Rate of Indian Rupee and US Dollar (1997 -2011)(crashes that might fit in the definition used in this study)**

From Date (mm/dd/yy) (Peak)	Close Value of Index	+60 Working Days from Peak	-262 Working Days from Peak	To Date (mm/dd/yy)	Close Value of Index	Percentage Fall
1-Apr-04	0.023	31-May-04	14-Jul-03	15-May-04	0.022	-4.35
22-Jul-05	0.023	20-Sep-05	2-Nov-04	20-Sep-05	0.023	-1.72
25-Jul-07	0.025	23-Sep-07	5-Nov-06	29-Aug-07	0.024	-2.17
9-Jan-08	0.026	9-Mar-08	22-Apr-07	9-Mar-08	0.0247	-3.14
10-Jan-10	0.022	12-Mar-10	23-Apr-09	9-Feb-10	0.021	-3.61
15-Oct-10	0.023	14-Dec-10	26-Jan-10	29-Nov-10	0.0215	-5.29

**These corrections cannot be called crashes.**

Analyzing the above data, as per the definition of Crash, in the case of Foreign Exchange Market in India, the fall in price is never more than 5.29 %. So, these corrections cannot be called crashes. Thus, Log Periodicity or Log Periodic Structures or Log-Periodic Power Law may not be applied to these corrections. The fall in prices is less due to the fact that in India though there is full Current Account Convertibility still there are restrictions on Capital Account Convertibility further there are evidences that the Indian Central Bank intervenes

**Log-Periodic Power Law will be more applicable in a situation where there will be no restriction and control on exchange rate determination.**

in the Foreign Exchange Market to affect the exchange rate of rupee. Therefore, the Foreign Exchange Market is yet to be fully floating so Log-Periodic Power Law will be more applicable in a situation where there will be no restriction and control on exchange rate determination.

**Conclusion**

The investors who do not have very large ticket sizes are in the category of those who are affected the most due to a crash. When a crash occurs a lot of money is lost in seconds which messes up the life of many investors. Crashes have not been studied widely and a lot of scope of work remains particularly in the area of Log-Periodic Power Law with respect to Indian Financial Markets. The present study has analyzed various crashes in the Indian Foreign Exchange market from 1997 to 2011 using Log-Periodic Power Law. When the graph of the Index begins to travel close to the

Log-Periodic Power Law then it is advisable for the investors to sell the Index and exit the market and if the peak of the Index price touches or crosses the Log-Periodic Power Law projected curve then it is suggested that a crash is in the offing. As per the definition of Crash, in the case of Foreign Exchange Market in India, the fall in price is never more than 5.29 %. So, these corrections cannot be called crashes. Due to the regulated Foreign Exchange Market the total effect of demand and supply dynamics does not get reflected in the movements in the values of the currencies therefore Log-Periodic Power Law could not be applied on this market as none of the crashes were of the magnitude as required by the definition used in the study.

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