Econometric model to predict usd inr exchange rate economics essay

The purpose of this paper is to build a model which successfully predicts the medium/long term USD/INR exchange rate movement. There has been a lot of research and analysis work already in the area of exchange rate prediction as this is an area of interest for Scholars, Business houses, Investors and Governments. While researchers have tried Random walk model and fundamental asset pricing model as well, this paper attempts to predict the exchange rate based on macroeconomic variables using statistical techniques like correlation analysis and stepwise multiple regression analysis.

Analysis was performed on the Quarterly level data for various Indian and American economic indicator variables over the period of 1996 to Q2, 2012.

Data from Qtr 1, 1996 to Qtr 4, 2010 (60 Qtrs) was used for building and training the model and data from Qtr 1, 2011 to Qtr 2, 2012 (6 Qtrs) was used for validating (checking out-of-sample accuracy) the model.

The model which has come out of the research predicts the exchange rate with

70% accuracy within +/-1. 5% range of actual Exchange rate

53% accuracy and +/- 1. 0% range of actual Exchange rate

44% accuracy and +/-0. 75% range of actual Exchange rate

30% accuracy and +/-0. 50 range of actual Exchange rate

19% accuracy and +/-0. 25 range of actual Exchange rate

As the model is based on macroeconomic variables and no microeconomic variables are taken into consideration, given the time frame, hence, the influence of microeconomic factors is not accounted for in this model, which can pose a margin of error in the prediction.

It is observed that the model is unable to predict the exchange rate for some specific period within accepted residual range; it is likely that some variables which are not considered in the regression equation will need to be accounted for. Hence, there is further scope for this analysis to be extended and study those periods carefully and account for those variables which will add more flavors to the results and reduce the areas where the model is unable to trace the actual price.

Major data sources were – IMF and IFS, American bodies like CSO, BEA, BLS and Reserve Bank of India

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Abbreviations

ADF

Augmented Dickey-Fuller test

USD

United States Dollar

INR

Indian National Rupee

GDP

Gross Domestic Product

SAS

Statistical Analysis System

CORR

Procedure Correlation SAS

REG

Procedure Regression in SAS

US_GDP_N

GDP, nominal [bn. USD]

US_GDP_R

GDP, real (2005) [bn. USD]

US_INF_YOY

Inflation [%yoy]

US_FOREX_RES

Foreign exchange reserves [bn. USD]

US_INTR_LT

Interest rate, long term [ppa]

US_INTR_ST

Interest rate, short term [ppa]

US_TB_BOP

Trade balance, BOP [bn. USD]

US_FDI_BOP

Foreign direct investment, net, BOP [bn. USD]

US_S_EXPO_BOP

Exports, services, BOP [bn. USD]

US_M_EXPO_BOP

Exports, merchandise, BOP [bn. USD]

US_INTR_ST_R

Interest rate, short term, real [ppa]

US_INTR_LT_R

Interest rate, long term, real [ppa]

US_GNP

Gross National Product [250000000 USD]

IN_GDP_N

GDP, nominal [bn. INR]

IN_GDP_R

GDP, real (2005) [bn. INR]

IN_INF_YOY

Inflation [%yoy]

IN_FOREX_RES

Foreign exchange reserves [bn. INR]

IN_INTR_LT

Interest rate, long term [ppa]

IN_INTR_ST

Interest rate, short term [ppa] (CF)

IN_TB_BOP

Trade balance, BOP [bn. INR]

IN_FDI_BOP

Foreign direct investment, net, BOP [bn. INR]

IN_S_EXPO_BOP

Exports, services, BOP [bn. INR]

IN_M_EXPO_BOP

Exports, merchandise, BOP [bn. INR]

IN_INTR_ST_R

Interest rate, short term, real [ppa]

IN_EXCH_R_A

Exchange rate INR per USD, aop [INR per US$]

IN_EXCH_R_E

Exchange rate LC per USD, eop [INR per US$]

Introduction:

In today's truly globalized world, where International trade practices have evolved to a greater extent, keeping a track of the currency exchange rate plays a pivotal role in realization of real profits. Think of a scenario where some export-based company promised to deliver some goods/services at a pre-decided amount in foreign currency at a specified time and somehow within that specified time period the foreign currency becomes cheaper (devaluation of currency happens). So in this scenario the actual realized profits shrink and the exporter may also face losses in some extreme cases (cases where margins are really low). It's a difficult and unpredictable situation to be in, when one in exposed to the risk of exchange rate fluctuation and economic scenario goes against the company. So, this example clearly shows that Currency exchange rate movement is an

important subject of research. Hence, it has been of great interest to various categories of institutions exposed to currency fluctuation risk e. g. Importers, Exporters, International investors etc. With most countries following an open economy today, ability to predict a closer range of Currency exchange rates has become really critical.

We aim to resolve to a certain extent, the kind of unpredictability in the currency exchange rate scenarios, so that institutions, which are exposed to currency fluctuation risks, can make intelligent decisions in such situations. The purpose of this research is to figure out the macro-economic indicators, which may impact the currency exchange rate between two countries and then studying the level of impact these variables could make on the exchange rate. Finally come up with a predictive model, which can predict the future exchange rate, based on macro-economic environment.

If various institutions exposed to currency fluctuation risks can predict the currency exchange rate beforehand they can take more efficient decisions. While on one hand we focus on deriving the predictive model to forecast the currency exchange rates as accurately as possible, on another hand we also believe that short term currency exchange rates depend on micro-economic factors to a greater extent. Change in supply and demand of foreign currency vs. home currency & market sentiments keep on impacting the short-term currency exchange rates. However, the study of micro-economic factors is not under the scope of this research.

Problem Formulation: The purpose of the research is to help out the institutions exposed to the foreign currency exposures to manage the

exchange rate risk in an efficient way. The focus will be on the exchange rate between American currency i. e. USD and Indian currency i. e. INR.

We would be studying the quarterly movement of various macro-economic factors from the point of view of American and Indian economy and will try to narrow down on the important drivers to come up with a predictive model.

Literature reviewed: Abundant amount of theoretical and experimental researches is present in the area of Currency exchange rate. Forecasting the exchange rate has been a contentious issue amongst researchers. There have been numerous studies on predicting or forecasting the foreign exchange rate that have been done in various dimensions. This easily shows that with the shrinking trade boundaries and extensive foreign trades, this area of foreign exchange rate prediction keeps on attracting a lot of researchers and scholars across the world. A lot of work has been done by researchers aiming to figure out the hidden trend and in estimating the exchange rate behavior. With the increase in international trade practices various economists across the globe are continuously trying to figure out the determinants of the fluctuations in currency exchange rates.

Study on Model based on fundamentals

In 1995, Nelson C. Mark found out that the models were helpful in predicting exchange rates at long horizons. After studying the data for five large economies, Mark found that the regressions of multiple period changes in the log exchange rate on the deviation of the log exchange rate display robust evidence of long horizon changes in log nominal exchange rates. According to the paper, the noise generated by short horizon changes is

averaged out over time, enabling the exchange rate movements to be determined by the fundamentals. In his research, he shows that the coefficient estimates display a pattern with nominal rigidities, though gradually, but it causes the exchange rate to adjust to nominal or real shocks. For three of the four exchange rates studied by him, the out of sample forecasts outperform the drift less random walk at the longer horizons. He investigated the extent to which deviations of the exchange rate from a fundamental value are useful in predicting exchange rates in the long run. The empirical work was restricted to an analysis of a regression on one variable, in order to conveniently characterize the predictive relation.

Though his empirical work had achieved great success in finding the empirical relativity between exchange rate and fundamentals, but the research had certain limitations as relative time series was short making the asymptotic reference as unreliable.

Subsequent work had casted doubts on forecasting the exchange rate at long horizons. There are certain schools of thoughts that believe in the forecasting power of non linear models. The models come into play in predicting the exchange rate when they are far out of line with the fundamentals.

Present Value models of exchange rate

It was believed that many exchange rate models can be written so that they can be explained as a weighted sum of current fundamentals like money supply, prices, output levels and the expected future value of the exchange rate, putting little weight on current fundamentals as compared to the

expectations. Engel and West, in 2004, questioned this standard criterion, and found that, for this class of models, if the fundamentals are integrated of order 1 (that is, their first difference is stationary), and the discount factor is close to one, then the exchange rate will approximately follow a random walk. According to their research, exchange rate is determined by the fundamentals, but floating exchange rate between countries with different inflation rates are well approximated as random walks. They found evidence, for the link between exchange rate and fundamentals, being consistent with the assets pricing models of the exchange rate. They first proved how random walk in asset pricing may result from a discount factor near one in a present value model. They applied this theorem to various exchange rate models successfully and displayed evidence that the changes in the exchange rate help future fundamentals

M. B. Devereux and C. Engel, in 2006, studied on " Expectations and Exchange Rate Policy". The paper talks about the implications of the fact that exchange rates respond primarily to news about future fundamentals. According to the new Keynesian economics, the aim should be at eliminating the distortions that occur due to sticky nominal prices. In the ideal state, monetary policy should try to reproduce the outcome that would be achieved if nominal prices were flexible. But the problem comes, when in an open economy, the nominal exchange rate of any country pair responds to news about the future, taking into account that there are nominal goods prices that are set in the currency of each country. Then with the change in the nominal exchange rate the relative prices (-the prices of goods set in one currency relative to those set in another currency) are bound to change. The

problem is that these relative prices are changing at times when there is news about the future fundamentals, the drivers of the nominal exchange rate. And if good prices were flexible, then relative goods prices would not be influenced by news about the future that is driving the nominal exchange rate. The research puts an argument on the fact that, since most of the variation in exchange rates comes from the news about these future fundamentals; most exchange rate variation generates inefficient relative price movements. They argue that there is a case for monetary policy to target unexpected changes in nominal exchange rates in addition to targeting inflation.

There have been numerous other studies and research work that have been done, but there seems to be no unanimous agreement about predicting/ forecasting the exchange rate.

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In a paper " Forecasting exchange rates in transition economies: A comparison of multivariate time series models" Cuaresma and Hlouskova compares the accuracy in forecasting through various multivariate models such as unrestricted VAR, BVAR, VEC, Bayesian VEC and deterministically restricted VAR, when applied to forecasting the exchange rate of different Central and Eastern European currencies against the Euro and the US dollar. Several factors have been studied, that determines the exchange rate in such economies, termed by Cuaresma and Hlouskova as transition economies. The results extend and confirm the conclusions in Meese and Rogoff (1983) and presents further evidence on the difficulties found by more sophisticated time series models (in this case VAR, VEC, BVAR, BVEC

and restricted VAR models in different specifications) in outperforming the naive forecasts of the random walk for exchange rates. (Res.)

In another paper from FLORIDA INTERNATIONAL UNIVERSITY Miami, Florida named " ESSAYS ON EXCHANGE RATE ECONOMICS" Yan Shu (2008) studied the issues related to comprehending the exchange rate behavior better. It is evident from the vast research available on this topic that modeling and forecasting exchange rates depends on lot variables, whose behavior pattern and impact of exchange rate is difficult to determine. Decades ago, Meese and Rogoff (1983) empirically analyzed several important macro-structural models based on monetary and asset theories of exchange rate determination. They found that none of these models could outperform the naÃ¯ve random walk model in terms of out-of-sample forecast accuracy at the short horizons. Several researchers post this confirmed the findings for a number of exchange rates.

A lot of literature is available on time series techniques on exchange rate movements. Many researchers have pursued nonlinear modeling of exchange rates, but with little success. (Res)

The Research Problem:

After studying the limitations of modeling the exchange rate behavior by lots of researchers and scholars in the past and several efforts which are still going on, this research paper attempts to study and derive the following:-

Movement in the USD/INR exchange rate

The factors which affect the movement in USD/INR exchange rate

Econometric model to predict USD/INR exchange rate

Challenges & Issues faced during this model development and scope for further refinement and fine-tuning

Assumptions made:

Economic conditions of US and India are only responsible in driving the USD/INR exchange rate and no other country's economy drives this combination of exchange rate in longer run

Indian Rupee and US Dollar are fully floating currency and both the countries are not making any explicit effort to drive the exchange rates

The Research Design:

Methodology adopted for study

Various economic indicators were studied to gauge their impact on the USD/INR exchange rate in both American and Indian scenario and following variables were finally narrowed down to study further

USA

GDP, nominal [bn. USD]

GDP, real (2005) [bn. USD]

Inflation [%yoy]

Foreign exchange reserves [bn. USD]

Interest rate, long term [ppa]

Interest rate, short term [ppa]

Trade balance, BOP [bn. USD]

Foreign direct investment, net, BOP [bn. USD]

Exports, services, BOP [bn. USD]

Exports, merchandise, BOP [bn. USD]

Interest rate, short term, real [ppa]

Interest rate, long term, real [ppa]

Gross National Product [250000000 USD]

Unemployment rate, U. S. A

Brent Crude Oil Spot Price

Spot gold price in USD

INDIA

GDP, nominal [bn. LC]

GDP, real (2005) [bn. LC]

Inflation [%yoy]

Foreign exchange reserves [bn. LC]

Interest rate, long term [ppa]

Interest rate, short term [ppa]

Trade balance, BOP [bn. LC]

Foreign direct investment, net, BOP [bn. LC]

Exports, services, BOP [bn. LC]

Exports, merchandise, BOP [bn. LC]

Interest rate, short term, real [ppa]

Exchange rate

Exchange rate LC per USD, Average, Average of Period

Exchange rate LC per USD, End of Period

Various types of statistical techniques have been used to study the relationship between these variables and then econometric modeling has been used to derive a causation relationship among various economic factors (independent variables) and USD/INR exchange rate (dependent variable).

Sample data and data source:

Data for all the required variables doesn't get changed/published at a very high frequency e. g. daily or monthly so data for all the variables was collected at the quarterly level only

Data was collected from Quarter 1, 1990 till Quarter 2, 2012.

Below is the snapshot of the data tables

Sample data India (Table 1)

India

1997Q1

1997Q2

1997Q3

1997Q4

1998Q1

1998Q2

1998Q3

1998Q4

GDP, nominal [bn. INR]

3, 669. 09

3, 688. 36

3, 845. 60

4, 038. 85

4, 148. 94

4, 308. 27

4, 479. 20

4, 551. 04

GDP, real (2005) [bn. INR]

5, 446. 51

5, 435. 55

5, 643. 35

5, 744. 39

5, 788. 79

5, 841. 12

5, 957. 34

6, 079. 34

Inflation [%yoy]

10. 60

7. 74

5. 18

5. 45

9. 02

10. 35

15. 51

17. 79

Foreign exchange reserves [bn. INR]

802. 48

909. 82

925. 75

913. 01

1, 019. 73

975. 46

1, 115. 33

1, 143. 70

Interest rate, long term [ppa]

13. 51

12. 77

11. 70

11. 00

12. 70

12. 05

12. 22

12. 25

Interest rate, short term [ppa] (CF)

14. 75

14. 25

13. 50

13. 00

14. 00

13. 32

12. 83

12. 83

Trade balance, BOP [bn. INR]

-119. 22

-147. 84

-96. 98

-172. 81

-160. 29

-194. 66

-143. 63

-145. 48

Foreign direct investment, net, BOP [bn. INR]

28. 13

40. 85

27. 57

29. 07

33. 16

37. 92

20. 34

14. 19

Exports, services, BOP [bn. INR]

74. 12

79. 47

76. 99

100. 71

93. 83

123. 86

137. 97

128. 08

Exports, merchandise, BOP [bn. INR]

334. 92

310. 69

323. 87

326. 41

365. 85

316. 57

372. 63

349. 42

Interest rate, short term, real [ppa]

3. 75

6. 05

7. 91

7. 17

4. 56

2. 71

-2. 32

-4. 21

Exchange rate INR per USD, aop [INR per US$]

35. 88

35. 81

36. 03

37. 54

39. 26

40. 76

42. 60

42. 43

Exchange rate LC per USD, eop [INR per US$]

35. 91

35. 82

36. 18

39. 28

39. 50

42. 47

42. 49

42. 48

Sample Data U. S. A (Table 2)

United States

1997Q1

1997Q2

1997Q3

1997Q4

1998Q1

1998Q2

1998Q3

1998Q4

GDP, nominal [bn. USD]

2, 034. 25

2, 069. 20

2, 102. 48

2, 126. 43

2, 150. 15

2, 174. 65

2, 211. 80

2, 256. 88

GDP, real (2005) [bn. USD]

2, 414. 50

2, 450. 30

2, 481. 05

2, 500. 08

2, 523. 70

2, 546. 40

2, 580. 00

2, 624. 65

Inflation [%yoy]

2. 94

2. 30

2. 23

1. 89

1. 48

1. 58

1. 60

1. 53

Foreign exchange reserves [bn. USD]

32. 45

32. 93

32. 06

30. 81

30. 22

31. 17

32. 88

36. 00

Interest rate, long term [ppa]

6. 56

6. 70

6. 24

5. 91

5. 59

5. 60

5. 20

4. 67

Interest rate, short term [ppa]

5. 06

5. 05

5. 05

5. 09

5. 05

4. 98

4. 82

4. 25

Trade balance, BOP [bn. USD]

-51. 54

-47. 05

-47. 82

-52. 02

-56. 61

-62. 94

-63. 80

-64. 88

Foreign direct investment, net, BOP [bn. USD]

-4. 00

-3. 61

-4. 28

12. 66

-25. 19

-25. 84

2. 15

85. 27

Exports, services, BOP [bn. USD]

62. 52

64. 29

64. 86

64. 43

64. 69

66. 17

64. 79

67. 11

Exports, merchandise, BOP [bn. USD]

162. 67

170. 25

173. 16

172. 29

171. 06

165. 56

164. 05

169. 74

Interest rate, short term, real [ppa]

2. 05

2. 68

2. 76

3. 14

3. 52

3. 34

3. 18

2. 69

Interest rate, long term, real [ppa]

3. 62

4. 35

4. 04

4. 03

4. 13

3. 99

3. 61

3. 13

Gross National Product [250000000 USD]

8, 160. 10

8, 307. 70

8, 433. 10

8, 522. 30

8, 626. 00

8, 721. 40

8, 856. 80

9, 039. 00

Brent Crude Oil Price Dollars Per Barrel

18. 53

18. 22

19. 96

15. 86

13. 87

11. 84

14. 71

10. 54

Gold Price USD

351. 30

343. 00

323. 60

307. 70

294. 20

299. 70

288. 90

294. 00

Quarter End Unemployment rate

5. 20

5. 00

4. 90

4. 70

4. 70

4. 50

4. 60

4. 40

Data sources: Various Indian, American and International data and statistics sources were referred for obtaining the required data for all the above mentioned variables. Below is the detailed list of the sources from where the data was downloaded online:

IHS Global Insight

International Monetary Fund (IMF)

International Financial Statistics (IFS)

Reserve Bank of Indiawww. rbi. org. in

Central Statistical Organization

Bureau of Economic Analysis

World Gold Council (http://www. gold. org/investment/statistics/)

Bureau of Labor Statistics (http://www. bls. gov/)

U. S. Energy Information Administration (http://www. eia. gov/)

Data analysis

Selection of time period to study currency exchange rate movement.

Quarterly level data from Quarter 1, 1990 till Quarter 2, 2012 was collated for all the above mentioned economic indicators. But all the data usage was not possible in model formation. Here the aim is to derive the model for predicting currency exchange rate and it can't be modeled over the period when the USD/INR exchange rate was fixed or pegged. Modeling can only be performed over the period when USD/INR exchange rate actually started floating.

USD/INR exchange rate before 1991 – In 1991, India still had a fixed exchange rate system, where the rupee was pegged to the value of a basket of currencies of major trading partners. India started having balance of payments problems since 1985, and by the end of 1990, it found itself in serious economic trouble. The government was close to default and its foreign exchange reserves had dried up to the point that India could barely finance three weeks' worth of imports. (Res.)

USD/INR exchange rate after 1991 – Before 1990s was period of severe economic crisis for India and in 1991, the Indian government decided to go for several reforms which led to the liberalization of Indian economy and hence opening the door for foreign investments.

The initiation of economic reforms saw, among other measures, a two-step downward exchange rate adjustment by 9 per cent and 11 per cent between July 1 and 3, 1991 to counter the massive draw down in the foreign

exchange reserves, to install confidence in the investors and to improve domestic competitiveness. The Liberalized Exchange Rate Management System (LERMS) was put in place in March 1992 involving the dual exchange rate system in the interim period. The dual exchange rate system was replaced by a unified exchange rate system in March 1993. The experience with a market determined exchange rate system in India since 1993 is generally described as ' satisfactory' as orderliness prevailed in the Indian market during most of the period. Episodes of volatility were effectively managed through timely monetary and administrative measures. (Res.). After 1993, Rupee actually started floating.

This forms the basis of the time-window over which we would focus our analysis of USD/INR exchange rate and we extracted data points of USD/INR exchange rate and driving factors over this time-window.

Selection of driver variables – US and India economic indicators

Among various macro-economic indicators present we carefully selected few of them and we would explain one by one the reason behind selecting these variables

1. Economic growth (GDP, GNP): Growth in the country's economy that is reflected through its GDP/GNP numbers indicates the strength of the economy. Increase in GDP could mean increased demand for the domestic currency or increase in supply of foreign currency in the economy as investments

2. Inflation: Rising inflation indicates lesser purchasing power of the domestic currency compared to other currencies, hence lower exchange rate. It has been observed that country's with high inflation typically see depreciation of their currency vis a vis developed economies with lower inflation rates

3. Interest Rates: Interest rates play an important role in determining the exchange rates. Higher interest rates would mean higher foreign investments which would drive the currency to rise

4. Current Account Balance: A deficit in the current account balance means that the country has a negative balance of trade and has to pay more in terms of foreign currency. Hence, the domestic country would borrow more in foreign currency to pay off its debts. The excess demand for foreign currency lowers the exchange rate

5. Exports: higher exports would mean greater demand real appreciation of the domestic currency

6. Foreign Direct Investments: In today's global economy, FDIs are an important factor affecting exchange rates. If the domestic country attracts more foreign currency through FDIs, it would mean appreciation of the domestic currency and vis-à-vis.

Trend Analysis Factor vs. Exchange rate movement

Selected Macro-economic factors' (Indian and American) movement over the period w. r. t. the movement in USD/INR exchange rate

Its clearly seen that between 2008 and 2009 when US GDP (Nominal) was declining and Indian GDP (Nominal) was increasing sharply a dip in Exchnage rate was seen when value of 1USD came down from Rs 50 to Rs 45.

US inflation figures clearly show a negative correlation between the Inlfation percentages and USD/INR rates.

Forex reserve figures are not showning as such any impact on the past Exhange rate figures as such for both Indian and American markets but it would be more clear when we'll model the data to check the causation effect.

US long term interest rates are clearly showing some impact on the value of USD vs. Indian Rupee

Short term Interest rate doesn't seem to play much role in defing the long term term currrency exchnage rate movements.

Trade Balance figures for both US and India clearly showing some impact on the exchnage rates, where a relative increase in Trade Balance figure for US shows strong USD vs Rupee and similarl