Exchange Market Pressure and its Predictors: Evidence from India and South Korea in the Perspective of Global Recession and Pandemic, Covid -19

Sanjay Kumar*
(Department of Humanities, Delhi Technological University)

Associate Professor, Department of Economics, Dyal Singh College.

Delhi University, New Delhi.

*sanjaykumar.eco@dsc.du.ac.in

Nand Kumar *

Professor, Department of Humanities.

Delhi Technological University, New Delhi.

*nandkumar@dce.ac.in

Abstract

Exchange market pressure (EMP) index is a comprehensive indicator of pressure on a currency. This paper relates the EMP index of India to Government credit, international money supply and GDP growth. During major economic events, the relationship of EMP index with its determinants may significantly change. This paper also does a structural break analysis to see if there is any significant change in this relationship in the post global recession period beginning 2007-IV. We also present a corona period comparison of the EMPI of India and South Korea.

Keywords: Exchange market pressure. Market exchange rates. Reserve. Credit. Money Supply. GDP. Corona.

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1 Introduction

Post 1977, with the seminal work of Girton and Roper (henceforth GR) (1977), there is an attempt in the literature to understand currency shocks by using a comprehensive index of EMP (Exchange Market Pressure). Bank of International Settlement used the idea of EMP in case of ERM (European Exchange Rate Mechanism) crisis of 1992, 1993. IMF in its World Economic Outlook (2009) used EMP index as a component of EMFSI (Emerging Market Financial Stress Index).

Girton-Roper (1977) developed a model of EMP based on monetary framework. Using money demand and supply equations with absolute purchasing power parity sans expectations. This is the first model to give a formula for creating EMP index. Though it gives an un-weighted index still, it is the most discussed one because it is simple and it also, inter-alia, gives the determinants of EMP. During economic instability, the parameters showing the relationship between the EMP index and its determinants may significantly change. Monetary policy prescriptions without factoring in such changes may lead to sub-optimal or completely wrong results.

This paper is an attempt to estimate the G-R Model for the Indian economy for the period 2001-I to 2017-IV. By fitting this model, we will be able to understand the relative importance of the key drivers of EMP index in India. In this paper we also examine the change in the relative importance of these key drivers by doing a stability analysis of the GR Model (1977) for the post global financial crisis period of 2007-IV to 2009-II. We date the crisis with reference to the data available with the Bureau of Economic Analysis, Board of Governors of the Federal Reserve, USA. We also present a corona period comparison of the EMPI of India and South Korea using WHO (World Health Organization) (2021) data for corona dating.

In Figure 1, we present the box plot of EMPI of twelve countries of the world. These EMP indices are based on the market exchange rate (MER),

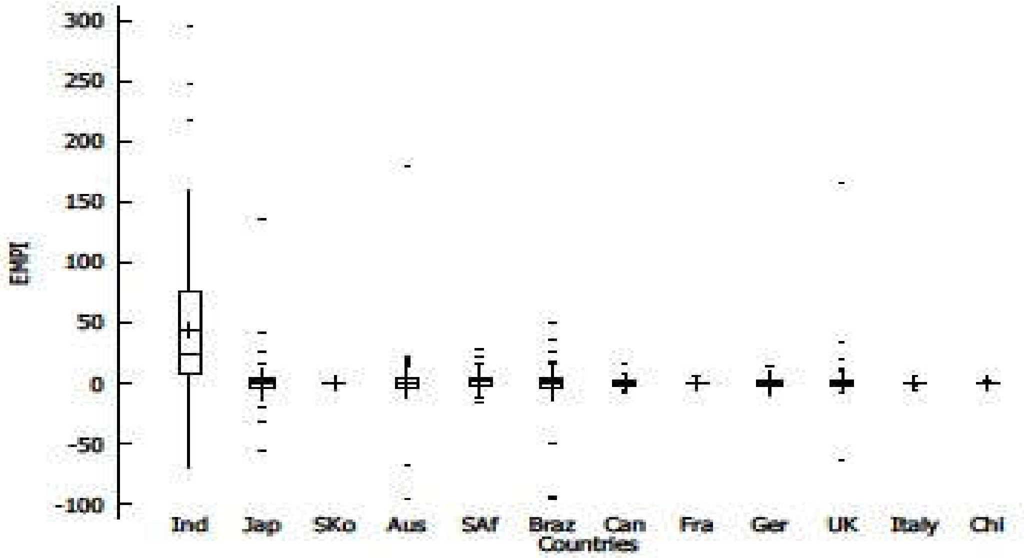

Figure 1 Box Plot EMPI of Selected Countries

In this chart name of countries are shown by their initials. We have, Ind = India. Jap= Japan, SKo = South Korea, Aus= Australia, SAf= South Africa, Braz= Brazil,Can= Canada, Fra= France, Ger= Germany, UK= United Kingdom, It= Italy, Chi = China. The chart reveals that the EMPI for India has been on the positive side while the same for all the other eleven countries has kept below zero or around zero on the average. The EMPI in case of China has been the lowest and less than zero for the entire period with no extreme volatility; this may be because the Chinese currency is not on free float. In case of South Korea also EMPI is almost zero i.e., has no extreme volatility. India's EMPI has been more volatile on the positive than on negative side in comparison to all the other countries. In case of Australia average EMPI has been around zero but has extremes both on the positive as well as on negative side. In case of Japan, Brazil, and UK the EMPI on the average has hovered around zero but has both positive as well as negative extremes though their EMPIs are not as volatile as that of India and Australia.

Refer to Table A 1, which presents a summary statistic of the EMPIs of twelve countries. India's mean EMPI is highest at 43.929 and the mean EMPI of South Korea is the lowest at 0.000070204 followed by China. The data about the median EMPI also reveals the same picture. The range of minimum and maximum is the highest in case of India. India's EMPI attained a lowest of -69.621 and a highest of 295.37. The high volatility of India's EMPI is also revealed by its standard deviation of 60.598 which is highest among all the countries. The lowest standard deviation of 0.00060137 is in the case of the EMPI of South Korea, this is also confirmed by an exceptionally low range in the minimum and maximum EMPI of this country. The EMPI of South Korea attained a minimum level of -0.00067310 and a maximum level of 0.0055828 in the entire period. The fifth percentile, the ninety fifth percentile and the inter-quartile range for India is also the highest at -49.654, 145.13 and 68.963 respectively while the same for South Korea is the lowest at -0.00030102,0.00035365. and 0.00015434. Thus, in case of India the EMPI has been below -49.654 only five percent times in the entire observation period while in case of South Korea it has been below 0.00035365 ninety five percent of times. The inter-quartile range of the EMPI of India is also extremely high in comparison to that of South Korea. Thus, mostly the EMPI index of India has been on the higher side which is way above South Korea- the lowest EMPI country in the group of twelve countries. In case of India, we have 95 peaks (positive values) and 11 troughs (negative values) while in case of South Korea we have 59 peaks and 47 troughs. In the case of both the countries the EMPI attains the highest peak during the second US recession. The highest EMPI peak for India (295.37) comes in the early phase of recession while the same for South Korea (0.0055828) comes in the late phase of recession. The effect of the first US recession on the both the countries is muted in comparison to the effect of the second recession. This may be because of greater financial integration of economies in the second US recession phase in comparison to the first phase. During the first US recession India's EMPI moves up on the positive side while South Korea's EMPI shows negative movement. During the period of our analysis the US economy faced two recessions. The first and the second US recession periods are from 2001-I to 2001-IV and from 2007-IV to 2009-II respectively (NBER).

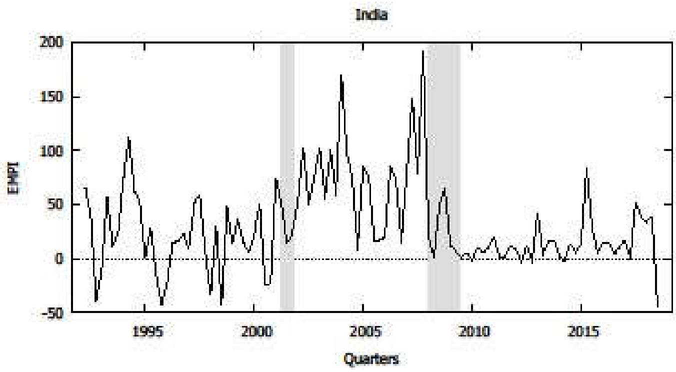

Figure 2-EMPI India

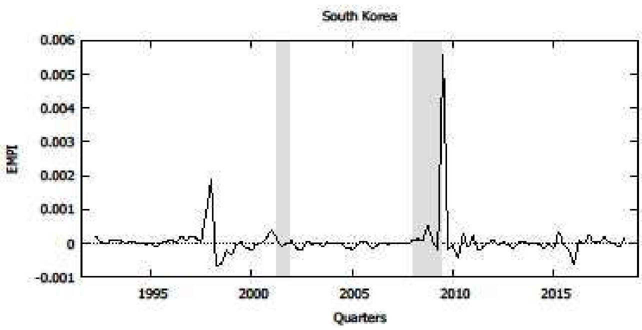

Figure 3-EMPI South Korea

This paper is organized in the following parts: in section two we present the GR Model as well as the empirical evidences on the model, in section three we discuss the dating issues related with the global financial crisis 2007-IV-2009-II in section four we discuss the data sources and the behavior of the data, in section five we estimate the GR Model(1977) for India by using the data for the period 2001-I to 2017-IV, in section six we examine the structural changes in the GR Model(1977) post global recession in section seven we present a comparative performance of the EMPIs of India and South Korea and in section eight we present conclusion and findings.

2 EMP Index: Girton and Roper Model, The Theory and Empirics

In this paper We create an EMP index for India using the GR Model (1977).

Following is the mathematical version of the G-R Model (1977)-

$$EMP_t = -\beta_1 \Delta d_t + \beta_2 \Delta m^*{}_t + \beta_3 \Delta y_t - \beta_4 \Delta y^*{}_t \qquad (2.1)$$

Here,

EMP_t = Exchange market pressure at time t.

Δs_t = Rate of appreciation of currency.

Δf_t = Percentage change in forex reserve to previous period monetary base.

Δd_t = Percentage change in domestic credit at time t.

Δm_t^* = Percentage change in the rest of the world money supply at time t.

Δy_t = Percentage change in domestic growth rate at time t.

Δy_t^* = Percentage change in international GDP at time t. Here we have-

$$EMP_t = \Delta s_t + \Delta ft \qquad (2.2)$$

The model suggests that an increase in government credit (Δdt) and rest of the world GDP (Δy^*) decrease the value of national currency and the level foreign exchange reserve or both and increase in the rest of the world money supply (Δm^*) and national GDP (Δy_t) increases the value of national currency and level of foreign exchange reserve. GR estimated the above for Canadian economy for the period 1952-74. All the coefficients of the above model were found to be significant. The estimated coefficients did also have appropriate signs validating the G-R model of Exchange Market Pressure. A simplified version of the G-R model was empirically validated for

Brazil by Michael Connolly and Jose Dantas de Silveira (henceforth C-S) (1979). The C-S model retained the partial equilibrium approach of the G-R model but removed foreign GDP as an independent variable. Modeste (1981) estimates the C-S version of the G-R Model (1977) and found the model valid. Kim (1985) used a modified form of C-S approach to the GR model. He used the model to study the Korean economy for the period 1980-83. The result of regression strongly supports the monetary model of EMP. Ghartey (2002) empirically tested the G-R model for the economy of Jamaica and found it valid. Besides the above studies there are studies by Wohar and Burkett (1989) for Honduras, Thornton (1995) for Costa Rica, Mah (1991) for Korea, Bahmani-Oskoee and Bernstein (1999) for Canada, France, Germany, Italy, UK, US and Japan, Burdeking and Burkett (1990) for Canada and USA, Wohar and Lee (1992) for Japan, Taslim (2003) for Australia. The G-R Model (1977) was first adapted to Indian conditions by Pradhan, Paul and Kulkarni (1989). Hallwood and Marsh (2003) incorporated rational expectation as independent variable in the G-R equation and estimated the model for the economy of the United Kingdom for the period from 1925-31 i.e. interwar period and found the model valid. Mathur (1999) presented a modified version of the G-R model to incorporate expectation as an independent variable. She made an empirical estimation of the original G-R model as well as the modified G-R model (M-G-R) for India for the period December 1986 to July 1998 using monthly data. She found that the performance of the G-R model was not good. She retested the G-R model by dividing the entire period into two sub-periods of December 1986 to June 1991 and from March 1992 to July 1998, to consider the structural change that may have happened in July 1991 (due to balance of payment crisis) when INR was devalued substantially and introduction of LERMS in March 1992 (ibid). In this case also the performance of the G-R model did not improve. Estimation results of the M-G-R model were a significant improvement over the results of the G-R model. All the coefficients in the case of M-G-R were found to be significant and adjusted R^2 indicated a good fit. Coefficient of the e^e_t was found to be negative which was contrary to the model. The author says that the poor performance of the model on empirical test may be due to the partial equilibrium approach to EMP which the G-R model takes. The G-R Model (1977) is based on the twin assumptions of a stable money demand function and purchasing power parity (PPP). The empirical tests on the long run parametric stability of the G-R Model (1977) requires these two relationships to be stable. Khan (1974) tested and validated a stable money demand function for the USA for period 1901-1965. Laumas and Mehra (1976) tested and validated the stability of the money demand function for USA for the period 1952-II and 1973-IV. Bahmani-Oskoee and Bohl (2000) evaluated the effect of German unification on German money demand function and found it stable. Empirical evidence on the stability of PPP is mixed. Frenkel (1978), Kravis and Lipsey (1978) and McKinnon (1979) validated PPP for 1920s, 1950-70 and 1953-77 respectively. However, Frenkel (1981) found that PPP did not work for 1970s and Levich (1985) and Dornbusch (1987) found that PPP did not work for the 1980s.

Besides the above evidence on the key assumptions of the G-R Model (1977) we also have empirical studies on overall parametric stability of the G-R Model (1977) during the periods of economic upheavals. Hodgson and Schneck (1981) tested the stability of Exchange Market Pressure model for seven advanced countries. The sample period is 1959-II to 1976-I for six of the countries i.e., Canada, France West Germany, Belgium, Netherlands and Switzerland For the United Kingdom the sample period is 1964-II to 1976-I, this is due to data availability problem. The authors applied Brown-Durbin Test. They found that during price shocks and reorganization of world money markets, stability of EMP models may suffer. For example, the period from mid 1960s to the early 1970s there were important events like oil crisis, collapse of Breton Woods so during these periods the empirical models show instability. The equations of France, Germany and Belgium begin to show instability in about 1965 or 1966. The disruption appeared to have continued into 1974 for Belgium and France and 1971 for Germany. The equations for United Kingdom begin to show instability in about 1969. This continues for only one quarter for Netherlands (1969-III) and until 1975 for U.K. Switzerland's equation was unstable only during the period 1962-II and 1962-III. Canada's equation was stable for whole sample period.

3 Global Financial Crisis and Structural Break

Since 2007 the US financial system entered a crisis. It started with the sub-prime mortgages problem and spread to other sectors and economies. It resulted in heavy losses in GDP and employment and increase in public debt. Lavean and Valencie

(2012) pointed out that the median output loss (computed as deviations of actual output from its trend) is 25 percent of GDP in recent crises, compared to a historical median of 20 percent of GDP, while the median increase in public debt (over the three-year period following the start of the crisis) is 24 percent of GDP in recent crises, compared to a historical median of 16 percent of GDP. IMF (2009) noticed that the real GDP in the USA and most of the advanced countries contracted substantially in the quarters following the financial crisis. Advanced economies in Asian also contracted substantially as per this report. Indian economy is linked to the rest of the world economy via the flow of commodities and capital. Majority of India's commodity and capital flow to-from the rest of the world is invoiced in USD. We, in this study, take US economy as a proxy for global economy. To study recession we can use the graph and the data given below:

Fig: 4,5,6,7 (Appendix 2) gives time series plots of four variables starting 2002-I and ending 2017-2. These variables are India's GDP (INDGDP), India's internal credit (INDDEBT), USA GDP (USGDP) and USA money supply (USMONEY)[1]. A look at the line graph of USGDP reveals that there is a double dip in the USA GDP data, the first decline in the GDP of USA is somewhere in the fourth quarter of 2007 or the first quarter of 2008 and there is a deeper decline in last quarter of 2009. India's GDP also takes a dip, but the decline starts one or two quarters later to the start of the same in the USA. Interestingly, however, the INDGDP chart does not show any double dip in the recession period. The plot of India's government credit (INDDEBT) shows some noticeable increase during the recession period. No noticeable recession period change in USA money supply (USMONEY) is visible in the graph. To pinpoint the starting quarter of recession we have also presented part of the data (2006-I-2009-IV) related to recession period in Table 1. Looking at USGDP numbers one can find out that 2007-IV to 2008-I USA GDP dips from USD 14685.330 Billion to USD 14668.445

[1]For definition and measurement see Appendix: I

Billion then it goes up to USD 14842.983 Billion in 2008- III and dips again in 2008-IV to USD 14549.949 Billion. This second dip is quite big in comparison to the first dip. The effect of US recession on India's GDP comes with three period forward lag. India's recession starts during 2008-III whereas US recession starts during 2007-IV. There is also no double dip recession in case of India. The GDP of India was INR 14110.8 Billion during 2008-III, it goes down to INR 13958.2 Billion during 2008-IV and INR 13671.3 Billion during 2009I, thereafter it does not dip. In the GR Model (1977) equation we are using percentage change in INDGDP and USGDP as independent variables along with change in percentage change INDDEBT and USMONEY so to be inclusive we will take 2007-IV as the cut off point for analysis of structural break.

Table 1 Quarterly Data on USGDP, INDGDP, INDDEBT, USMONEY Around Financial Crisis

Quarters	USGDP	INDGDP	INDDEBT	USMONEY
01.01.2006	13648.904	9579.7	6,382.04	46,295.15
01.04.2006	13799.794	9875.3	6,348.55	28,321.70
01.07.2006	13908.498	10408.6	6,472.10	29,357.92
01.10.2006	14066.370	10735.5	6,437.53	30,401.47
01.01.2007	14233.226	11178.2	6,489.46	31,672.96
01.04.2007	14422.313	11591.3	6,399.42	31,672.96
01.07.2007	14569.675	11942.2	6,443.06	35,499.53
01.10.2007	14685.330	12522.8	6,362.88	36,976.52
01.01.2008	14668.445	12944.4	6,362.26	38,722.26
01.04.2008	14812.974	13577.9	6,401.12	41,420.51
01.07.2008	14842.983	14110.8	6,494.08	41,420.51

01.10.2008	14549.949	13958.2	6,485.44	44,437.75
01.01.2009	14383.885	13671.3	6,478.89	46,295.15
01.04.2009	14340.417	14630.9	6,569.11	46,295.15
01.07.2009	14384.14	15558..2	6,402.9	51,270.87
01.10.2009	14566.511	16294.5	6,496.14	52,883.54
01.01.2010	14681.063	17164.3	6,476.21	54,384.71
01.04.2010	14888.600	17881.3	6,550.89	57,834.70
01.07.2010	15057.660	18708.9	6,513.91	16,618.94
01-10-2010	15230.208	19610.5	6,680.37	61,108.14

4. Methodology Model Specification and Data

In this paper we estimate the following model for India-

$$\Delta f_t + \Delta s_t = \beta_1 \Delta INDEDEBT_t + \beta_2 \Delta USMONEY_t + \beta_3 \Delta INDGDP_t + \beta_4 \Delta USGDP_t + \nu_t \quad 4.1$$

Following is the detail about the variables of the above model –

Table 2 Summary of Dependent and Independent Variables for the Model in Equation 4.1

Label	Description	Form of measurement scale	Coefficient	Sign
		Dependent Variable		
EMP = $\Delta s_t + \Delta f_t$	Exchange market pressure at time t	Percent	N.A.	N.A.
Δs_t	Appreciation rate of INR	Percent	N.A.	N.A.
Δf_t	Change in forex reserve	Percent	N.A.	N.A.
		Independent Variable		
$\Delta INDDEBT_t$	Change in domestic credit	Percent	$\beta 1$	-
$\Delta USMONEY_t$	Change in international money supply	Percent	β_2	+
$\Delta INDGDP_t$	Change in India's GDP	Percent	β_3	+
$\Delta USGDP_t$	Change in international GDP	Percent	β_4	-

The Source of USA data (USD Billion) is the U.S. Bureau of Economic Analysis, Board of Governors, Federal Reserve USA. The Indian data (INR Billion) is from the Database on Indian Economy (DBIE) Reserve Bank of India and the Central Statistical Organization, Ministry of Statistics and Program Implementation, Government of India. There are sixtysix observations in the sample, adjusting for three deleted/missing observations.

Our data set contains five series. We have data sample from 2002: I to 2017: II due to differencing there is loss of one observation from the sample.

We draw a joint time series graph of all the five variables to check whether they share long run equilibrium relationship with one another for the sample period 2002: I to 2017: II. The time series seem to be co integrated as all the charts appear to have the same movement and do not deviate far from one another. In fact, all the charts seem to be I (0) i.e., integrated of order zero. To confirm that value of d is zero for all the five series we conduct the Augmented Dicky Fuller Test, in Table A 2, for all the variables individually. The hypotheses on test are: H_0 = Unit root (non-stationary). H_1= No unit root (stationary). The p value of for the ADF Test for all the four series is very low, so we reject the null the hypothesis that the series are non-stationary hence all the series are stationary. Before estimating the model, it is important to run the data through certain basic diagnostic tests. In the case of time series data stationary test is required to ensure that the regression results are not spurious (Granger and Newbold,1974).A look at the simple time series plot of all the five variables also reveals that all of them are stationary, see Figure 2 Figure 6, Figure 7, Figure 8 and Figure 9. The result of the Augmented Dicky Fuller Test is presented in Table:A1, Classical Linear Regression Model is based on the assumption of no multicollinearity among the independent variables. In the presence of perfect linear relationship among regressors coefficients will become indeterminate. In case of strong correlation, though not perfect, variances may get inflated thereby widening confidence intervals leading to errors in hypothesis testing. The variance inflation factor (VIF) in the case of all the four is less than 10. Thus, we can conclude that multicollinearity does not pose any serious problem here (though pairwise correlation coefficient between Δd_t and $\Delta USMONEY_t$ is high Table A 3. The classical linear regression model (CLRM) assumes of equal variances of the error term. In the presence of unequal variances (heteroscedasticity) OLS estimators are not with minimum variance and confidence intervals may not be reliable. We conduct the Breusch Pagan test, in table Table A 4, to check for heteroscedasticity. The p value reported from the chi square table (for nR^2 is high indicating there is no heteroscedasticity in the data. Presence of auto correlation in the data creates the same set of problems which heteroscedasticity presents. We conduct Breusch-Godfrey test, in Table A 5 , with four lags to check the presence of auto correlation in the data. p value of the F statistics $(n-p)\ R^2$ is low thereby indicating the presence of autocorrelation in the data. The test also reports the Ljung Box Q statistics the p value of this statistics is quite high (5% level of significance) indicating that there is no autocorrelation in the data. Thus, there is a confusing picture here. To get rid of this problem we have run HAC (Heteroscedasticity and Auto correlation Consistent) OLS regression.

5. Estimation of the Model

The result of the estimation of the model 4.1 is presented in Table 3. The overall significance of the model is also high as indicated by very low p value of the F statistics. The value of adjusted R^2 is 0.97 percent indicating thereby that the variables included in the model explain 97 percent of the changes in EMP. β_1 β_2 and β_3 are significant ate 5 percent (because the p values associated with these coefficients are lower than 0.025 for two tailed test i.e. 0.0164,0.0299,0.000 respectively) level and β_4 is not significant because the p value associated with β_4 is 0.3272 which is higher than 0.025 for two tailed test. Mathematical signs of the coefficients of

$\Delta INDDEBT_t$ and $\Delta USMONEY_t$ are positive and negative respectively and this is in line with the G-R model whereas the mathematical signs of the coefficients of $\Delta INDGDP_t$ and $\Delta USGDP_t$ are not matching with the hypothesis of the G-R model. The value of β_1 is 87.15, it means that with one percent increase in credit the EMP in India increased by 87 points for the sample period. The value of β_2 is -47.05, this means that with one percent increase in M1 supply in the USA for the sample period the EMP in India eased by 47.05 points with the availability of cheap foreign money in the country. The value of β_3 is 77.10, implies that with one percent increase in India's GDP the EMP in the country increased by 77.10 points. The G-R model suggests a negative relationship between growth in domestic GDP and EMP i.e., a rise in GDP should ease the pressure on local currency. In the case of India, however, we are seeing that a rise in GDP increases pressure on currency. Rise in GDP can have effect on EMP via current account and capital account i.e., balance of trade and net flow of foreign capital. GDP rise may increase trade gap via increase in import and consequent depreciation leading to increase in EMP. GDP rise, at the same time, may reduce EMP via currency appreciation resulting from increase in net flow of foreign capital. Which effect will dominate will depend on the period of analysis, future expectation of economic agents vis-a-vis returns and the exchange rate regime of the country. The result of our regression says that, at least for the period of analysis, the current account effect of GDP rises in more dominating than the capital account effect. The relationship between US GDP and India's EMP is not found to be significant.

Table 3 OLS Using Observations 2001-II:2017-IV (t=66), Dependent Variable: EMPI

	Coefficient	Coefficient	*t*-ratio	p-value
$\Delta INDDEBT_t$	87.1588	35.3166	2.4679	0.0164

$\Delta USMONEY_t$	−47.0543	21.1647	−2.2232	0.0299
$\Delta INDGDP_t$	77.1073	2.05761	37.4742	0.0000
$\Delta USGDP_t$	−1.43376	1.45189	−0.9875	0.3272
Mean dependent variable	70.77886	S.D. dependent var	10454.50	
Sum squared residual	1.47e+08	S.E. of regression	1541.080	
R^2	0.979275	Adjusted R^2	0.978272	
F (4, 62)	172499.6	P-value (F)	1.2e–124	
Log-likelihood	−576.0425	Akaike criterion	1160.085	
$\hat{\rho}$	0.261502	Durbin–Watson	1.476740	

6. Structural Change Post Global Recession

It is quite likely that during global recession the relationship of India's EMP with its determinants might have got a structural change. This structural change will result in significant change in slope coefficients of the equation 4.1. To check whether there is a structural change we divide our time series into pre - recession and post- recession phase. For 2007− IV onward we use the dummy 1 and for data before that we use the dummy 0. To incorporate the effect of recession on the EMP model for India we can express the model in the following form:

$$EMP = \beta_1 \Delta INDEDEBT_t + \beta_2 \Delta USMONEY_t + \beta_3 \Delta INDGDP_t + \beta_4 \Delta USGDP_t + \beta_5 \Delta INDEDEBT_t Recession_{2007} + \beta_6 \Delta USMONEY_t Recession_{2007} + \beta_7 \Delta INDGDP_t Recession_{2007} + \beta_8 \Delta USGDP_t Recession_{2007} + \nu_t \quad 6.1$$

Here,

$\Delta INDEDEBT_t Recession_{2007}$ = Percentage Change in the Indian government debt with interactive dummy. $Recession_{2007}$= 0 before 2007-IV and $Recession_{2007}$= 1 after 2007IV.

$\Delta USMONEY_t Recession_{2007}$ = Percentage Change in the supply of international money (USA) with interactive dummy. $Recession_{2007}$= 0 before 2007-IV and $Recession_{2007}$= 1 after 2007IV.

$\Delta INDGDP_t \, Recession_{2007}$ = Percentage Change in Indian GDP with interactive dummy. $Recession_{2007}$= 0 before 2007-IV and $Recession_{2007}$= 1 after 2007IV.

$\Delta USGDP_t Recession_{2007}$ = Percentage Change in the US GDP with interactive dummy. $Recession_{2007}$= 0 before 2007-IV and $Recession_{2007}$= 1 after 2007IV.

By introducing differential slope dummies for every independent variable, we are trying to examine whether post- recession the values of the slope coefficients have significantly changed. Following is the result of the regression –

Table 4 OLS, Using Observations 2001:2–2017:4- With Interactive Dummies (T = 67) Dependent variable: EMP HAC Standard Errors, Bandwidth 3 (Bartlett Kernel)

	Coefficient	t-ratio	Standard error	P-value
$\Delta INDDEBT_t$	106.917	114.835	0.9310	0.3556
$\Delta USMONEY_t$	−28.6391	36.4665	0.7854	0.4354
$\Delta INDGDP_t$	195.494	39.5959	4.937	0.0000
$\Delta USGDP_t$	−383.086	378.434	−1.012	0.3155
$\Delta INDDEBT_t Recession_{2007}$	−53.1098	117.725	−0.4511	0.6535
$\Delta USMONEY_t Recession_{2007}$	−7.90272	41.0869	−0.1923	0.8481
$\Delta INDGDP_t Recession_{2007}$	−118.593	39.5977	−2.995	0.0040
$\Delta USGDP_t Recession_{2007}$	381.545	378.433	1.008	0.3175
Mean dependent var	−69.72246	S.D. dependent var	10375.00	
Sum squared resid	1.35e+08	S.E. of regression	1512.530	
R^2	0.981001	Adjusted R^2	0.978747	
F (8, 59)	191039.7	P-value (F)	3.3e–127	
Log-likelihood	−581.3523	Akaike	1178.705	

		criterion	
Schwarz criterion	1196.342	Hannan–Quinn	1185.684
$\hat{\rho}$	0.313689	Durbin–Watson	1.369722

The p value of coefficient of EMP (with interactive dummy i.e., β_7) with India's GDP is low (0.0040) i.e., less than 0.025 at the α of 5 percent. Similarly, the p value of the coefficient of EMP (without interactive dummy, i.e., β_3) with GDP is also low at 0.000. Thus, these are the only two coefficients which are significant in the equation 6.1 The overall fit of the regression equation, with structural break, is good as shown by high adjusted R^2. In the pre- recession phase one percent rise in India's GDP created a positive pressure of 196.494 on EMP whereas in the post-recession phase one percent rise in GDP created 118.593 points negative pressure on EMP. the pressure creating effect of GDP was reduced by 118.593 points. That is, in the post-recession phase, one percent rise in India's GDP caused only (196.494 − 118.593) i.e., 77.901 points increase in EMP. For the entire period of analysis this effect is 77.107 points. From these results we can say that recession abroad is less depreciation pressure creating on India currency. The result seems logical also as an examination of raw data of GDP growth of India shows substantial fall in India's GDP immediately following the recession phase.

We also conduct Chow Test for drawing inference about structural break in the EMP model post- recession. This is the second test we have done in this paper to check for structural break apart from the dummy variable one. Chow test is a popular test for checking a significant change in the parameters of the model because of major economic changes during a period. The sample is split in post-recession and pre-recession period and split dummies are used for all the independent variables to account for this change. The Chow F statistics in this case has a low p value Table 5. Thus, we reject the null hypothesis that there is no structural change in the data in the post-recession phase. Thus, the dummy variable tests as well as the Chow Test are showing the same results. We a have already analyzed the effect of structural change on individual parameters taking the help of the dummy variable test. Following is the result of the test-

Table 5 Augmented Regression for Chow Test for Structural Break at Observation 2007:4 F (5,58) = 7.664872 with p value 0.000 OLS Using Observations 2001:2-2017:4 (T=67)

	Coefficient	t-ratio	Standard error	P-value
$\Delta INDDEBT_t$	106.917	69.6245	1.536	0.1301
$\Delta USMONEY_t$	-28.6391	41.4531	-0.6909	0.4924
$\Delta INDGDP_t$	195.494	82.44 31	2.371	0.0211
$\Delta USGDP_t$	-383.086	181.286	-2.113	0.0389
SD	1104.71	207.967	5.312	1.80e-06 ***
SD$\Delta INDEBT_t$	-93.2457	74.861574	-1.246	0.2179
SD$\Delta USMONEY_t$	20.7378	45.7530	0.4533	0.6521
$SD\Delta INDGDP_t$	-116.926	82.4606	-1.418	0.1616
$SD\Delta USGDP$	382.388	181.290	2.109	0.0392 **
Mean dependent variable	−69.72246	S.D. dependent variable	10375.00	
Sum squared residual	90802082	S.E. of regression	1251.221	
Uncentered R^2	0.987219	Centered R^2	0.982719	
F (9, 58)	497.7871	P-value (F)	1.73e–51	
Log-likelihood	−568.0721	Akaike criterion	1154.144	
Schwarz criterion	1173.9873	Hannan–Quinn	1161.996	
$\hat{\rho}$	0.029308	Durbin–Watson	1.369722	

7. A Q- to -Q Comparison of EMPI of India and South Korea During Corona Period- Evolving and Inconclusive Evidence

Corona Related Disruption of the World Economy started from the Month of March 2020 that is the last quarter of the FY 2019 and India was the second worst affected country after USA going by the number of cumulative total number of reported cases. South Korea was, on the other hand. was the least affected country (WHO,2021). It is interesting, in this context, to compare the EMP indices of the two countries for the entire corona phase. Here is the EMPI data for the two countries for the period.

Table 6 A Comparison of the EMPI of India and South Korea for the Corona Period

Period	EMPI India	EMPI South Korea
2020Q1	1.41561062	7.23145E-06
2020Q2	4.973825136	-0.000129016
2020Q3	-1.522713853	3.29379E-05
2020Q4	-0.352184297	5.98393E-05

A quarter-to-quarter comparison of the EMPI of two countries clearly establishes that India's BOP faced the maximum pressure during the early phases of the corona crisis while South Korea was not affected at all for the entire period.

Let us look at the chart of the EMPI of the two countries for the corona period:

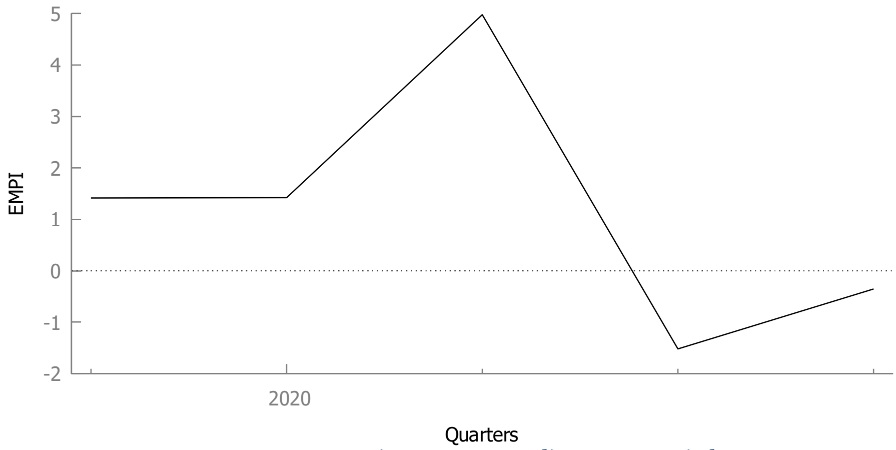

Figure 4 EMPI India,Corona Period

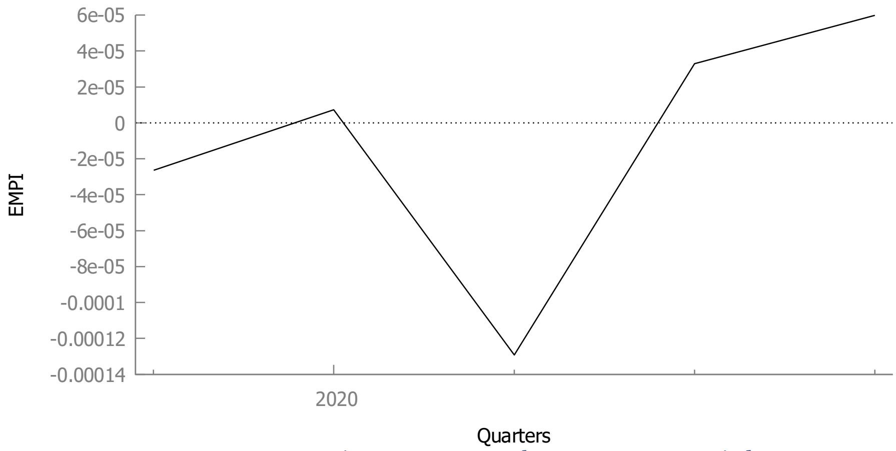

Figure 5 EMPI South Korea, Corona Period

Differences in the pressure on the EMPI of the two countries can be seen with the help of the above graphs too.

A comparison of the sample data of EMPI of India for pre-corona period (PCP) and corona period (CP), presented in the table below establishes that India faced higher exchange market pressure with more volatility during PCP in comparison to CP.

Table 7 Two Samples F-Test for the Comparison of Population Mean and Population Variance of the EMPI of India Pre Corona Period(PCP) 2001:II-2017:IV and Corona Period(CP) (2019:IV-2020-IV)

	Sample 1, PCP (India)	Sample 2, CP (India)	Test Statistics	P value for Right Tail Test	Conclusion
Sample Size	67	5			
Sample Mean	43.929	1.338			
Sample Standard Deviation	60.598	11.246			
Null and Alternate Hypothesis for comparison of population mean	$H_0 : \mu_1 - \mu_2 = \Delta_0 = 0$ $H_a: \mu_1 > \mu_2$		t = 4.75878	2.142e-005	Reject the null. Population mean for India's EMPI during PCP higher than that during CP.
Null and Alternate Hypothesis for comparison of population Variances	$H_0 : \sigma_1^2 = \sigma_2^2$ $H_a: \sigma_1^2 > \sigma_2^2$		F(66, 4) = 29.032	0.002329	Reject the null. Population variance for India's EMPI during PCP is higher than the same during CP.

8.Conclusion

In this paper we estimated the G-R model for India over the period 2001:2-2017:4. The G-R model gives an index of EMP and relates it to the variables determining it following a monetary approach. We used the OLS method to estimate the model. Before running the regression, we put the data to standard diagnostic tests to ascertain that the data is stationary, and it conforms to the basic assumptions required for the CLRM. The empirical analysis reveals that for the period of our analysis government debt from the banking sector played the most important role in increasing exchange market pressure in India followed by GDP growth, increase in international money supply helped in decreasing exchange market pressure whereas international GDP growth had no significant influence on the EMP in India. The global financial crisis of 2007-08 had no significant effect on the relationship of EMP with its determinants except the relationship between EMP and growth rate of India's GDP. It is interesting to note here that in the pre-recession period India's GDP growth aggravated the EMP while in the post-recession period India's GDP growth eased the EMP.

A quarter-to-quarter comparison of the EMPI of India and South Korea clearly establishes that India's BOP faced the maximum pressure during the early phases of the corona crisis while South Korea was not affected at all for the entire period.

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Appendix-1

EMP = $\Delta f_t + \Delta s_t$ = Exchange Market Pressure Index.

Δs_t = Percentage appreciation of INR with USD with respect to previous quarter.

Δf_t= Percentage change in foreign exchange reserve with respect to previous period monetary base.

Foreign exchange reserve includes foreign currency assets, gold, SDR and reserve with the International Monetary Fund. The data is taken from DBIE, RBI.

Monetary Base= The data is taken from DBIE, RBI.

$\Delta\, INDDEBT_t$ = Percentage change in government credit. The data is taken from DBIE, RBI.

$\Delta USMONEY_t$ = The rest of the world money supply in billions of USD. (M1 supply in the USA).(70 percent of international trade is invoiced in USD hence USD supply is taken here to represent the rest of the world money supply).The source is the Board of Governors of the Federal Reserve. USA.

$\Delta INDGDP_t$ = Percentage change in the growth rate of India. Data source is the Central Statistical (CSO), Ministry of Statistics and Program Implementation, Government of India

$\Delta USGDP_t$ = Percentage change in the growth rate of the rest of the world/USA. Source: Bureau of Economic Analysis Board of Governors of the Federal Reserve. USA.

Appendix-2

Table A 1 Summary Statistics, Using the Observation 2001:2-2017:3

Variable	Mean	Median	Minimum	Maximum
EMP	70.7789	1071.35	83082.2	10144.6
$\Delta INDDEBT_t$	2.27139	1.45932	34.9132	56.9844
$\Delta USMONEY_t$	0.0255893	0.330192	54.7130	91.8976
$\Delta INDGDP_t$	13.0699	3.09936	1062.72	6.78370
$\Delta USGDP_t$	0.0277627	0.118823	1065.32	1062.72
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
EMP	10454.5	147.707	7.74384	59.1093
$\Delta INDDEBT_t$	9.56191	4.20972	2.06682	18.5134
$\Delta USMONEY_t$	16.3942	640.667	1.66088	16.1343
$\Delta INDGDP_t$	131.199	10.0383	7.93682	61.0007
$\Delta USGDP_t$	186.650	6723.05	0.0205817	29.9946
Variable	5% perc.	95% perc.	IQ Range	Missing obs.
EMP	138.648	2107.33	1106.00	0
$\Delta INDDEBT_t$	3.27664	10.4605	3.55892	0
$\Delta USMONEY_t$	29.6148	17.8426	5.25048	0
$\Delta INDGDP_t$	0.503853	5.23886	1.46906	0
$\Delta USGDP_t$	2.79698	2.85111	1.92141	0

Table A 2 Augmented Dickey-Fuller test for EMP Including 2 Lags of (1-L) EMP

(Max was 10, criterion AIC) sample size 61 unit-root null hypothesis: a = 1 test with constant

Model : (1-L) y = b0 + (a-1) *y (-1) + ... + e

Estimated value of (a - 1): -0.31127

Test statistic: tau_c(1) = -2.91392

Asymptotic p-value 0.04374

1st-order autocorrelation coeff. for e: -m0.166

Lagged differences: F (2, 57) = 0.137 [0.8727]

Model with constant and trend: (1-L) y = b0 + b1*t + (a-1) *y(-1) + e

Estimated value of (a - 1): -1.05336

Test statistic: tau_ct(1) = -8.18638

P-value 1.285e-008

1st-order autocorrelation coeff. for e: 0.063

Table A 3 Correlation Coefficients, Using the Observations 2001:2{2017:4Table: A2

$\Delta INDDEBT_t$	$\Delta USMONEY_t$	$\Delta INDGDP_t$	$\Delta USGDP_t$	
1:0000	0:8711	0:0028	0:0114	$\Delta INDDEBT_t$
	1:0000	0:0060	0:0133	$\Delta USMONEY_t$
		1:0000	0:7113	$\Delta INDGDP_t$
			1:0000	$\Delta USGDP_t$

Table A 4 The Breusch Pagan Test for Heteroscedasticity Dependent Variable: Residual² Method: Ordinary Least Square Sample:68 Included Observations: 67

	Coefficient	Coefficient	t-ratio	p-value
C	0.973606	0.670316	1.452	0.1514
$\Delta INDDEBT_t$	0.0279576	0.105310	0.2655	0.7915
$\Delta USMONEY_t$	0.151261	0.0720559	0.2099	0.8344
$\Delta INDGDP_t$	0.00187559	0.00698617	01.2685	0.7892
$\Delta USGDP_t$	0.000905021	0.00491074	0.1843	0.8544

Explained Sum of Squares = 3 and 80965 Test statistic: LM =1 and 904825

With p-value = P (Chi-square (4)>1 and 904825) = 0 and 753259

Table A 5 Breusch-Godfrey Test for Autocorrelation up to Order 4 OLS, Using Observations 2001:3-2018:1 (T = 67)

Dependent variable û

	Coefficient	Coefficient	*t*-ratio	p-value
$\Delta INDDEBT_t$	26.6697	29.1306	0.9155	0.3636
$\Delta USMONEY_t$	16.6734	19.8839	0.8385	0.4051
$\Delta INDGDP_t$	0.782742	1.38051	0.5670	0.5729
$\Delta USGDP_t$	−1.43376	1.45189	−0.9875	0.3272
$\hat{u}_1$	0.184238	0.129461	1.423	0.1600
$\hat{u}_2$	0.160784	0.131196	1.226	0.171133
$\hat{u}_3$	0.171133	0.129843	1.318	0.1926
$\hat{u}_4$	0.152903	0.129833	1.178	0.2436

Test statistic: LMF = 3 and 276546, with p-value = P (F (4,59) > 3.27655) = 0 and 0171
Alternative statistic: T R^2 = 12 and 178072, with p-value = P (Chi-square (4) > 12 and 1781) 0 and 0161
Ljung-Box Q’ = 0 and 402045, with p-value = P (Chi-square (4)> 0 and 402045) = 0 and 982

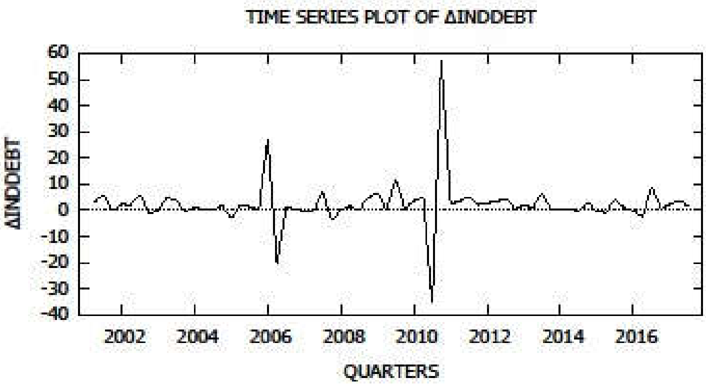

Figure 6 Time Series Plot of ΔINDDEBT

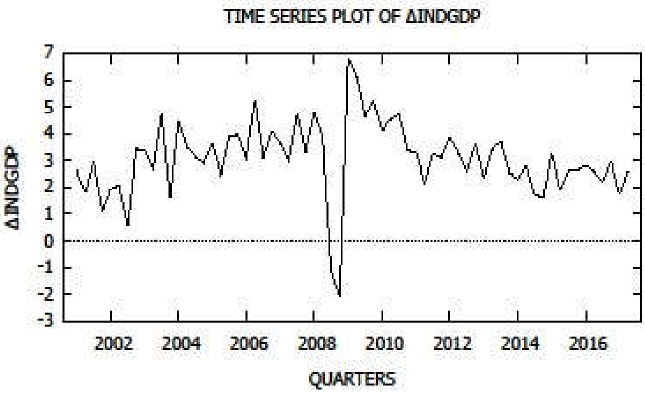

Figure 7 Time Series Plot of ΔINDGDP

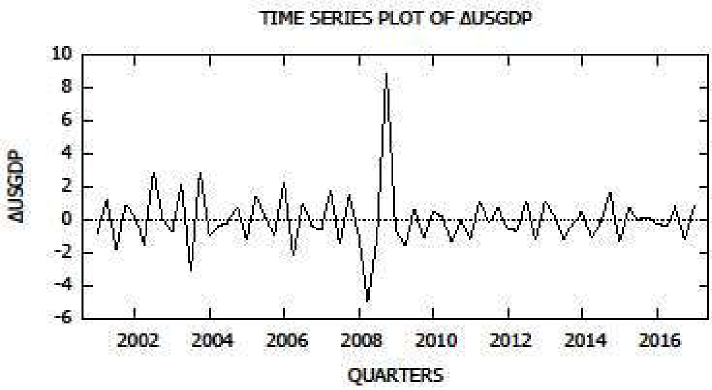

Figure 8 Time Series Plot of ΔUSGDP

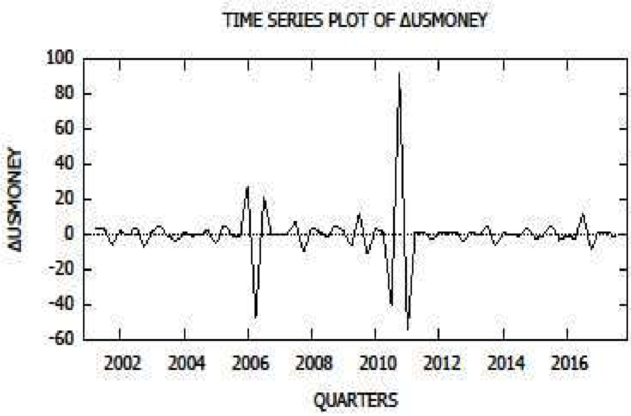

Figure 9 Time Series Plot of ΔUSMONEY