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STUDY OF ADEQUACY OF INDIA'S FORIEGN RESERVES UNDER CRISIS SCENARIOS

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ABSTRACT

Demonetization, Lehman type scenarios and extreme stress scenarios like war severely test the economy and country's ability to provide liquidity buffers, tide over external shocks and avoid disruptive output adjustments. According to International Monetary Fund, emerging markets with adequate reserve holdings ahead of the global financial crisis in general suffered smaller output and consumption declines. It thus becomes imperative to study the adequacy of India's foreign exchange reserve. Foreign exchange reserves include foreign currency assets, reserve tranche positions and special drawing rights (SDRs) of the International Monetary Fund. This paper derives the optimum reserves needed for Lehman / Demonetization scenarios and extreme stress scenarios using modified Jeanne and Ranciere model. Based on the values of derived optimum reserves, it is determined that the reserves are adequate for India under extreme stress situation.

Key Words: Demonetization, Reserve adequacy, Jeanne and Ranciere model

I. Introduction

Sudden stress to economy due to internal factors like demonetization or external factors emanating from outside country – like Lehman type crisis has direct impact on India's ability to provide liquidity buffers, smoothen external shocks and potentially avoid disruptive output adjustments. According to International Monetary Fund, emerging markets with adequate reserve

holdings ahead of the global financial crisis in general suffered smaller output and consumption declines. However, carrying reserves also entails costs such as the interest sacrificed on reserve holdings. Therefore, assessing whether reserves are adequate and the optimum level of reserves is imperative. There are three distinct international methodologies for assessing the reserve adequacy in India: (i) Comparisons with appropriate peers countries, (ii) Econometric estimation of a reserve demand function, and (iii) Simulation of a rational optimization model of reserve holdings under different crisis scenarios. While a comparison with appropriate peers is useful, an assessment of reserve adequacy needs a more systematic examination vis-à-vis a set of potential sources of external vulnerability. External sector stress could emanate from uncertainties in both the current account and capital flows, which have increased over time in India, and may have a significant influence on the demand for reserves. The Econometric estimation of reserves is also inadequate as the underlying assumption in such estimation is that the Finance ministry is able take and is always taking an optimal decision on accumulation of reserves and there are 'no systematic biases towards over-or-under-insurance for the sample as a whole' . Due to the limitations of the two methods, this paper assesses reserve adequacy in India during 1996-2014 using simulation of a rational optimization model of reserve holdings under different crisis scenarios. The optimum reserve needed under Lehman/ Demonetization type scenario and extreme stress scenario is ascertained using Jeanne and Ranciere model after determining India specific values of the parameters.

II. Literature Review

Jeanne, O. and R. Ranciere (2006) examine the Optimal Level of International Reserves for Emerging Market Countries, Johns Hopkins University (2009) came up with new formula for determining optimal level of international reserve, Aizenman and Marion (2002), Edison (2003), Gosselin and Parent (2005), Park and Estrada (2009) and IMF (2011) estimate reserve demand equations emphasizing the precautionary motive, while Ghosh et al. (2012) document the mercantilist motive for emerging market economies. Sehgal and Sharma (2008) and Mishra and Sharma (2011) analyse the short-run dynamics of reserve accumulation in India with particular focus on monetary disequilibrium. Ramachandran (2004), on the other hand, derives the optimum reserves for India using external payment imbalances and the opportunity costs of holding reserves as the benchmark variables.

III. Objectives of the study:

- Determine the probability of Crisis for India
- Determine Size of Sudden Stop
- Determine Extreme Stress
- Determine optimum reserves under different crisis scenarios.

IV. Data Collection and Methodology :

Data Collection:

Secondary data was collated from World Development Indicators (WDI) database of the World Bank, World Economic Outlook database of the IMF and from the Reserve Bank of India's website.

Methodology Used:

Probability of Crisis estimation*:* Probit Model was used to determine the probability of crisis (π). The dependent variable in the model is a dummy variable indicating crisis years (dummy=1 for crisis year). Crisis years are years in which either the exports to GDP ratio or the FPI inflows to GDP ratio falls abruptly from the previous year. More precisely, a year is considered crisis year if the year-on-year percentage point decline in either of the two ratios is higher than the average fall observed in the sample. The explanatory variables in the model are real effective exchange rate overvaluations, the Indian Central government's external liability to GDP ratio and the absolute value of net FPI inflows to GDP ratio. The explanatory variables are taken as the average of their first and second lags. The probit model provides the estimated probabilities of the crisis.

Determining Size of Sudden Stop: Jeanne and Ranciere define a year of 'sudden stop' as one with a more than 5 percentage points decline in the capital inflows to GDP ratio over the previous year. In the Indian context, RBI defines 'Sudden Stop' as Crisis Year. The size of the sudden stop or Crisis Year in Indian context is estimated based on the year on year decline in exports to GDP ratio and FPI inflows to GDP ratio.

Hodrick- Prescott trend *:* The Hodrick–Prescott trend filter is a mathematical tool used in macroeconomics to remove the cyclical component of a time series from raw data. It is used to obtain a smoothed-curve representation of a time series which is more sensitive to long-term rather than to short-term fluctuations. In this paper, Real Effective Exchange Rate (REER) overvaluations used to determine the probability of crisis is deviation from its Hodrick- Prescott trend

Extreme Stress: The 'extreme stress' scenario refers to a situation of maximum possible macroeconomic loss from a crisis that an economy can potentially be susceptible to, pooling the possible worst conditions from any of the years. The losses are calculated based on fluctuations in the following four variables around their fitted trends: (i) Export earnings, (ii) FPI inflows, (iii) Real GDP growth, and (iv) Real Effective Exchange Rate. The trends are obtained by fitting OLS regressions where each of these variables is regressed on the polynomials of time. The maximum possible deterioration in these variables is estimated from the 2 (or 3) standard deviation band around the regression coefficients. The size of crisis (λ) is defined as the sum of the maximum gap between the predicted (with 2/3 SD band) value in period t and the observed value in period t-1 for exports to GDP ratio and FPI inflows to GDP ratio.

The output loss (γ) and the real exchange rate depreciation (Q) value under extreme stress are also obtained using the same methodology.

Optimum Reserves : The foreign exchange reserves include foreign currency assets, reserve tranche positions and special drawing rights (SDRs) of the International Monetary Fund (IMF). To determine the optimum reserve needed by India to tide over Crisis years and sudden shocks like demonetization to economy, modified Jeanne and Ranciere model is used. The Jeanne and Ranciere model doesn't take valuation change in external payments due to currency depreciation. However volatility of FPI inflows is also used as a driver of precautionary reserve demand and constitutes a significant source of financing of current account deficit in India hence the model in this paper takes this into consideration and adds the 'Q' parameter. The model used to determine the Optimum reserves of India is:

$$p_t = \frac{{x_t}^{-1}-1}{{\pi_t}^{-1}-1}(1+Q);\ \mathrm{x} = \pi + \delta$$

$$\frac{\lambda + \acute{y} - (\frac{1-(r-g)\lambda}{1+g})(1-{p_t}^{1/\sigma}) + \frac{1+r}{1+g}\lambda Q}{1 - x_t(1-{p_t}^{1/\sigma}) + (1-x_t)Q}$$

The model includes the variables - Probability of Sudden Stop (π) , Size of Sudden Stop (λ) Output Loss (ý) REER Depreciation (Q) Potential Output Growth (g) Risk Premium (δ) Risk Free Rate (r) Risk Aversion (σ). The parameters π, λ, ý, g and Q are estimated using the annual data for India during 1996-97 to 2014-15. Term premium (δ), risk free return on reserves (r), and risk- aversion coefficient (σ) are taken from Jeanne and Ranciere as these parameters are not determined by the country characteristics. δ is the average difference between the 10-year

US treasury bill rate and the federal funds rate over 1990-2005 under the assumption that reserves are denominated in US dollars, which is the case for India. r is set equivalent to the short-term dollar interest rate. σ is assumed to be 2, which is the standard value of risk aversion across literature on business cycle and growth.

V. Analysis and Results:

Probability of Crisis:

Table 1 shows the results of the Probit model for estimating crisis probabilities. The data period is from 1998-99 to 2014-15. The Probit Model uses 1998-99, 2006-07, 2008-09, 2009-10, 2010-11, 2011-12 and 2013-14 as the crisis years. All the explanatory variables (Absolute net FPI inflow/GDP, REER Overvaluation and Central Govt. foreign liability/GDP) are taken as the average of their first and second lags. The predicted value of the dependent variable from this model is used as the probability of crisis in the calibration of the Jeanne and Ranciere model for India. The numbers in parentheses indicate standard errors. * indicates the statistical significance of the coefficients at 5 per cent level.

Table 1: Probit Model for the Crisis Probability in India
Dependent Variable: Crisis Year Dummy

Constant & Explanatory Variables	**Coefficients**	**Coefficients**
Constant	-1.57	-1.60*
	(2.77)	*(0.82)*
Financial Openness	1.35	1.37*
(Absolute net FPI inflow/GDP)	*(0.94)*	*(0.73)*
REER Overvaluation	0.09	-
(Deviation from Hodrick-Prescott Trend)	*(0.15)*	
Central Govt. foreign liability/GDP	0.00	-
	(0.11)	
McFadden R-Squared	0.20	0.18
Probability (LR Statistic)	0.21	0.04

From the table, it can be seen that the REER overvaluation increases the probability of Crisis but the estimated coefficient is not statistically significant. Removing REER shows the Probability

of Crisis to be 0.04 (4%). This value is used in Jeanne and Ranciere model to determine the Optimal Reserve for India.

Size of Sudden Stop:

During the Lehman Crisis, the maximum Year On Year fall in FPI inflows to GDP ratio and exports to GDP ratio was observed in 2008-09 and 2009-10 respectively. Exports to GDP ratio fell by 1.8 percentage points from 14.9 per cent in 2008-09 to 13.1 per cent in 2009-10 which is the single largest Year on Year fall since 1996-97. FPI inflows to GDP ratio of 1.3 per cent during 2007-08 turned to net FPI outflows of 0.8 per cent of GDP during 2008-09. The size of the crisis (λ) is thus calculated as $[(14.9 – 13.1) + (1.3 – (–0.8))] / 100 = 0.04$. This value too is used in Jeanne and Ranciere model to determine the Optimal Reserve for India.

Output Loss and REER Depreciation:

The other values used in Jeanne and Ranciere model to determine the Optimal Reserve for India are output loss (γ) and REER Depreciation (Q). They are calculated as delineated below:

The annual growth rate of real GDP fell to 6.7 per cent in 2008-09 from 9.3 per cent in the 2007-08, which was the largest fall since 1996-97. Consequently, output loss (γ) is calculated as: $(9.3–6.7)/100 = 0.03$. The real effective exchange rate depreciated by 8.7 per cent on a Year On Year basis during 2008-09, the largest since 1996-97. Therefore, Q is estimated as $8.7/100 = 0.087$.

Extreme Stress Scenario:

Table 2 shows the results from the ordinary least squares (OLS) regressions of exports to GDP ratio, FPI inflows to GDP ratio, Real GDP growth rate and REER on polynomials of time (columns (1)-(4), respectively). The data period covers 1996-97 to 2014-15 for exports and FPI inflows; 1991-92 to 2014-15 for GDP growth; and 1993-94 to 2014-15 for exchange rate regressions. Column (2) also controls for crisis years. The years 1998- 99, 2006-07, 2008-09, 2010-11, 2011-12 and 2013-14 are defined as crisis years. The coefficient on crisis dummies is statistically insignificant, and therefore dropped from the other regressions. A quadratic time trend is included in regression as it provides a better fit.

Table 2: OLS Regression of External Variables and Growth

Regression coefficients				
Explanatory variables	**Dependent variable: Exports to GDP ratio**	**Dependent variable: Net FPI inflows to GDP ratio**	**Dependent variable: Real (2004-05) GDP growth**	**Dependent variable: 36 currency trade weighted real effective exchange rate (REER)**
	(1)	(2)	(3)	(4)
Constant	7.00*** (0.40)	0.23 (0.29)	3.31** (1.23)	96.72*** (1.70)
Time	0.52*** (0.04)	0.10*** (0.03)	0.56** (0.23)	0.47*** (0.13)
$(Time)^2$			-0.02* (0.01)	
Crisis (dummy)		-0.93** (0.31)		
Standard error of regression	0.84	0.60	1.85	3.86
Period	1996-97 to 2014-15	1996-97 to 2014-15	1991-92 to 2014-15	1993-94 to 2014-15

The fitted values from the above table of the regressions are used to estimate the trend in the dependent variables while the standard deviation of the estimated residuals of regression (standard error of regression) are used as estimates of the average fluctuations around trend of the variables.

The size of the crisis (λ) under the extreme stress years is derived from the sum of the maximum loss to exports to GDP ratio and FPI inflows to GDP ratio. The maximum loss to exports to GDP ratio under extreme stress was found in 2012-13 when the exports to GDP ratio with lower 2 SD band was estimated at 14.1 per cent, which was much lower than 16.6 per cent observed in 2011-12 . Similarly, there could have been an FPI outflows of 1.03 per cent of GDP in 2010-11 under extreme stress (at lower 3 SD band), as compared to the actual FPI inflows of 1.9 per cent of GDP. There were FPI inflows in 2009-10 which were 2.2 per cent of GDP. Therefore, the size of the crisis (λ) under extreme stress is estimated as [(16.6-14.1)-(2.2-(-1.03))]/100=0.06. Based on historical fluctuations, the year on year real GDP growth could have fallen to 3.8 per cent from the 9.6 per cent observed growth during 2006-07. Therefore, the estimated output loss (γ) coefficient under extreme stress is (9.6 – 3.8)/100=0.06. Similarly the REER could have depreciated by 13.1 per cent during 2011-12 relative to the previous year. Thus, the parameter Q is calculated as 13.1/100 = 0.13.

Optimal Reserve:

Based on aforementioned values and Jeanne and Ranciere model, the optimal reserve to GDP ratio for India is calculated and tabulated in Table 3:

Table 3: Optimal Reserve based on Jeanne and Ranciere Model

Parameter	Estimations by Jeanne and Ranciere (2011)	Estimated for India corresponding to the Lehman type scenario	Estimated for India corresponding to the Extreme Stress
Probability of Sudden Stop (π)	0.10	(Estimated based on Probit model: Table 1) [Mean Value = 0.4]	
Size of Sudden Stop (λ)	0.10	0.04	0.06
Output Loss (ϒ)	0.065	0.03	0.06
REER Depreciation (ΔQ)	-	0.09	0.13
Potential Output Growth (g)	0.033	(Hodrick-Prescott trend of annual growth in real (2004-05 prices) GDP at factor cost) [Mean Value = 0.07]	
Risk Premium (δ)	0.015	0.015	
Risk Free Rate (r)	0.05	0.05	
Risk Aversion (σ)	2	2	
Optimum Reserves to GDP ratio (averaged over 2008-09 to 2014-15) (Per cent)	9.1	8.02	14.1

In table 3, the parameters of the Jeanne and Ranciere model are calibrated for different crisis scenarios in India and it also depicts the original calibrations by Jeanne and Ranciere (2011) using data on a group of 34 emerging countries for the period 1975-2003.

For Indian scenario, parameters of risk premium, risk free return and the coefficient of risk aversion are taken from Jeanne and Ranciere (2011) model. The other parameters are estimated for India using annual data for the period 1996-97 to 2014-15.

The probability of crisis is estimated from a probit model where the crisis period dummy is regressed on the country's financial account openness, exchange rate overvaluation and the government's external liabilities (as shown in Table 2). The size of the sudden stop is estimated based on the year on year decline in exports to GDP ratio and FPI inflows to GDP ratio. The potential growth is the Hodrick-Prescott trend of the annual real (2004-05) GDP growth rate.

Output loss is estimated based on the year on year reduction in real GDP growth rate during a crisis. The Optimum Reserves to GDP ratio in percentage for Lehman type crisis is found to be 8.0 % and for extreme stress scenario (Hodrick-Prescott trend - 2SD) is found to be 14.1 % .

Figure 1: Optimum Reserves under Extreme Stress and Lehman/Demonetization Type Crisis

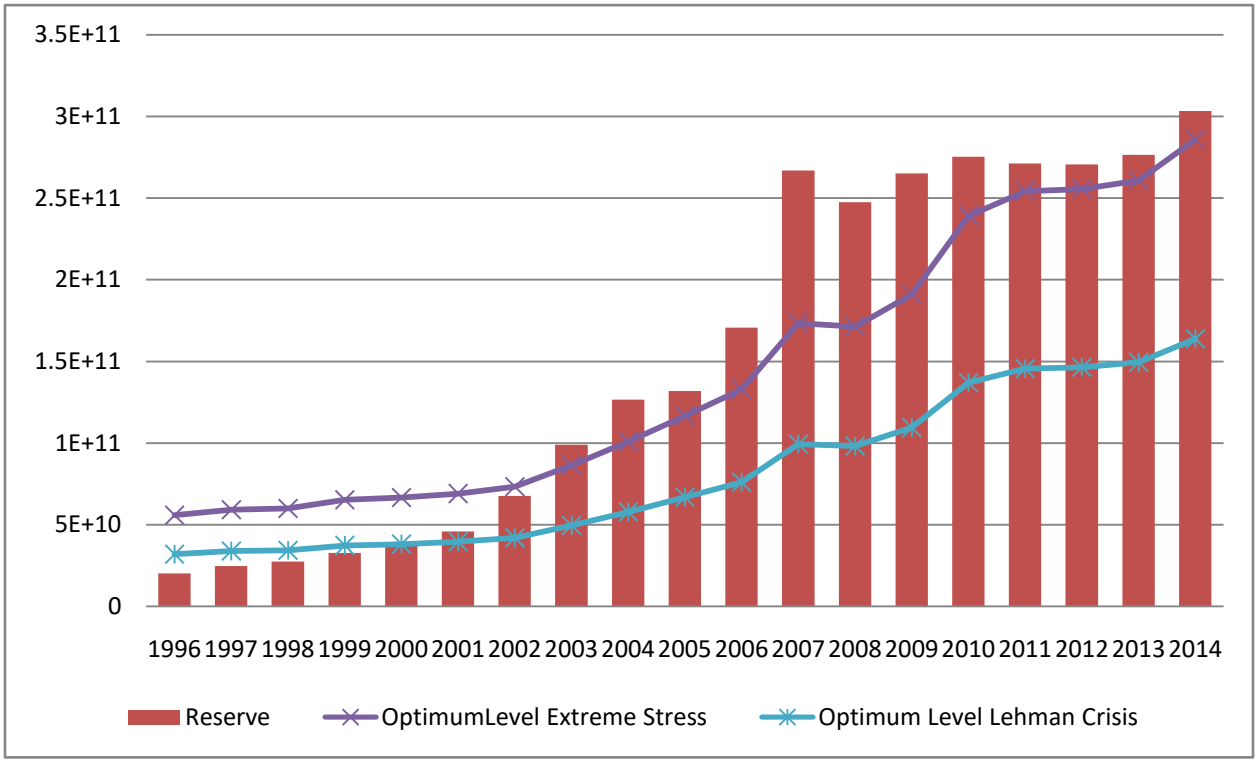

Figure 1 depicts the Optimum reserves for India which are calibrated using the Jeanne and Ranciere model for different crisis scenarios. The model produces the optimum level of reserves based on the parametric values of several macroeconomic indicators of risks to domestic and external sectors. The optimized reserves to GDP ratios are multiplied with the observed GDP levels to arrive at the optimum level of reserves. It can be noted from the chart that level of reserves was less than required Optimum during years 1996 to 2000. However the reserves were adequate after these initial years. The reserves under extreme stress was less than optimum level from 1996 to 2002. Later years shows adequate optimum reserves under extreme stress scenario. It can be concluded that there is enough reserves in India to tide over both Lehman/demonetization type crisis and Extreme Stress scenarios.

Size of Sudden Stop and Optimum Reserve:

The effect of size of sudden stop on Optimum reserve in extreme stress scenario for India is tabulated in Table 4 and depicted in Chart in Figure 2.

Figure 2: Sudden Stop vs Optimum Reserve

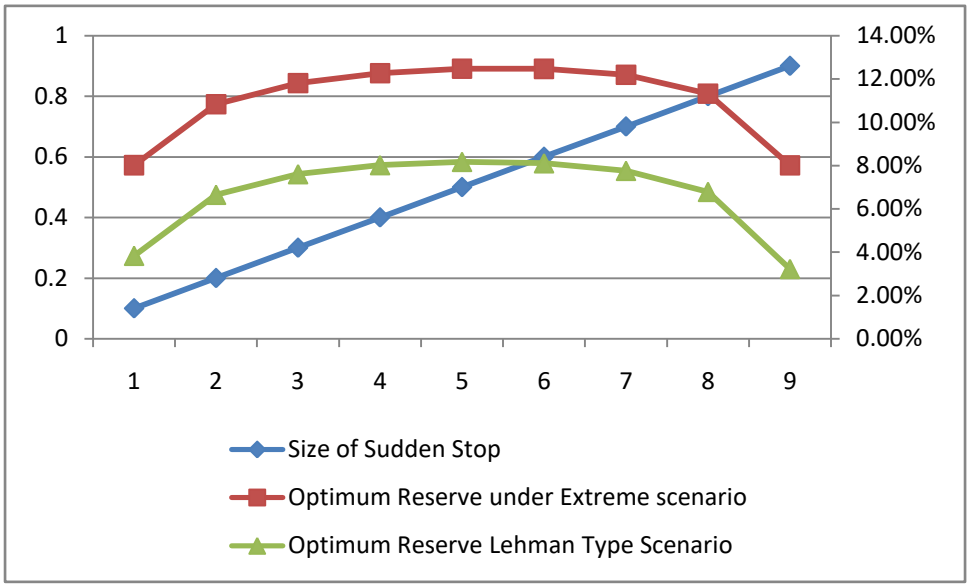

Table 4: **Sudden Stop vs Optimum Reserve**

Size of Sudden Stop	Optimum Reserve under Extreme scenario	Optimum Reserve under Lehman / Demonetization type Scenario
0.1	8.01%	3.83%
0.2	10.83%	6.65%
0.3	11.81%	7.60%
0.4	12.27%	8.02%
0.5	12.48%	8.17%
0.6	12.47%	8.11%
0.7	12.19%	7.76%
0.8	11.33%	6.79%
0.9	8.01%	3.22%

It can be inferred from table 4 that both under Extreme Stress scenario and Lehman/ Demonetization Type Scenario as the Size of Sudden stop increases, the required optimum reserve percentage increases up to the size of 0.5. However, the model breaks down as the sudden stop increases in size after 0.5. This indicates that after the sudden stop value above 0.5, the other parameters become important in deciding the optimum reserve.

VI. Limitations

1. The results of a different data period may differ depending on fluctuations in data set. Although the data so far gives accurate results to determine optimal foreign reserve to take care of sudden stress scenarios like demonetization, the full effect will be known only at the end of the year.
2. The accuracy of analysis depends on the secondary data's accuracy. No independent primary research was carried out to analyse the accuracy of data set as the data obtained were from relevant world and government bodies.

VII. Conclusion

The adequacy of foreign exchange reserves in India was determined using Jeanne and Ranciere Model. The optimum reserves' demand under a Demonetization / Lehman type scenario and an extreme stress scenario was found. It can be inferred that the actual reserves in India remained sufficiently high to cover the extreme stress scenario. There were no instances after year 2002 when actual reserves in India fell below adequate reserves as suggested by optimization models. Although, India's current reserve levels are adequate, it is important to examine the availability of various other foreign currency asset substitutes such as sovereign wealth funds, currency swaps and IMF's contingency funds to augment its foreign exchange reserves position to create sufficient reserves buffer to take care of higher size of sudden stop. The methodology used in this study can form the basis of further foreign exchange reserves and related sovereign wealth fund researches.

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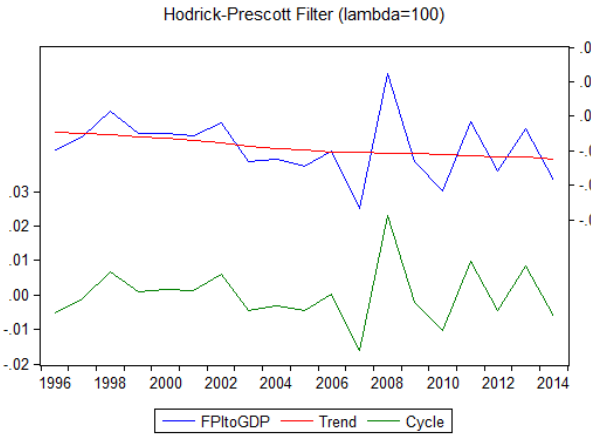
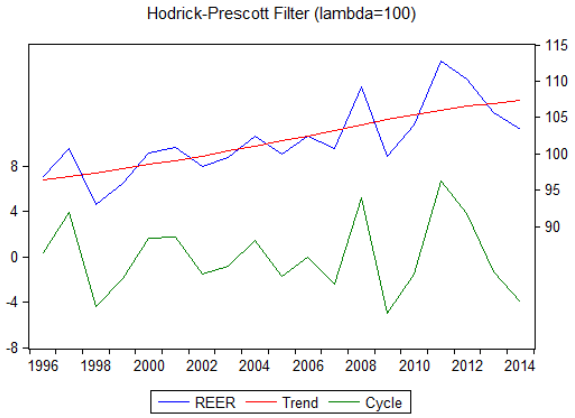
Annexure –I

Hodrick-Prescott Trend of parameters

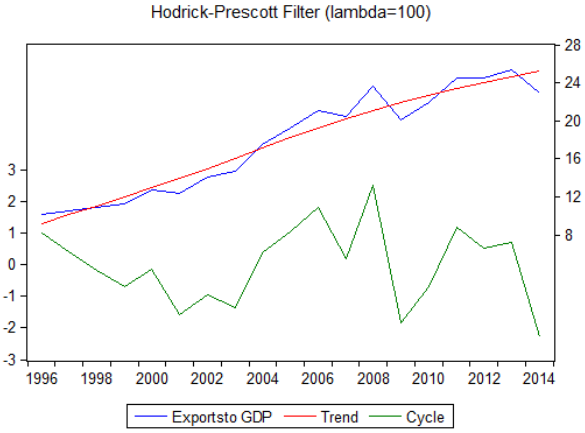
FPI to GDP HP trend



REER HP trend



Exports to GDP HP trend



GDP HP trend