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If Deficits Are Not the Culprit, What Determines Indian Interest Rates? An Evaluation Using the Maximum Entropy Bootstrap Method

by

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Abstract

This paper challenges two clichés that have dominated the macroeconometric debates in India. One relates to the neoclassical view that deficits are detrimental to growth, as they increase the rate of interest, and in turn displace the interest-rate-sensitive components of private investment. The second relates to the assumption of "stationarity"—which has dominated the statistical inference in time-series econometrics for a long time—as well as the emphasis on unit root–type testing, which involves detrending, or differencing, of the series to achieve stationarity in time-series econometric models. The paper examines the determinants of rates of interest in India for the periods 1980–81 and 2011–12, using the maximum entropy bootstrap (Meboot) methodology proposed in Vinod 1985 and 2004 (and developed extensively in Vinod 2006, Vinod and Lopez-de-Lacalle 2009, and Vinod 2010 and 2013). The practical appeal of Meboot is that it does not necessitate all pretests, such as structural change and unit root–type testing, which involve detrending the series to achieve stationarity, which in turn is problematic for evolutionary short time series. It also solves problems related to situations where stationarity assumptions are difficult to verify—for instance, in mixtures of I(0) and nonstationary I(d) series, where the order of integration can be different for different series.

What makes Meboot compelling for Indian data on interest rates? Prior to interest rate deregulation in 1992, studies to analyze the determinants of interest rates were rare in India. Analytical and econometric limitations to dealing with the nonvarying administered rates for a meaningful time-series analysis have been the oft-cited reason. Using high-frequency data, the existing attempts have focused on the recent financially deregulated interest rate regime to establish possible links between interest rates and macroeconomic variables (Chakraborty 2002 and 2012, Dua and Pandit 2002, and Goyal 2004). The results from the Meboot analysis revealed that, contrary to popular belief, the fiscal deficit is not significant for interest rate determination in India. This is in alignment with the existing empirical findings, where it was established that the interest rate is affected by changes in the reserve currency, expected inflation, and volatility in capital flows, but not by the fiscal deficit. This result has significant policy implications for interest rate determination in India, especially since the central bank has cited the high fiscal deficit as one of the prime constraints for flexibility in fixing the rates.

Keywords: Bootstrapping; Fiscal Deficit; Interest Rates; Maximum Entropy; Term Structure

JEL Classifications: E63, H62

INTRODUCTION

Understanding the dynamics of real interest rate movements—shorts and longs—is critical for two reasons. First, it allows the macro policy makers to gauge the efficiency of fiscal and monetary policies. Second, long-term interest rates determine investment and savings in the long run, thereby playing a key role in the business cycle movements of an economy. An interesting question therefore remains: what determines the short-term and long-term interest rates? Further, it is more informative to establish how the term structure of interest rates and expected inflation are related (if such a relationship exists) when conducting policy formulation exercises. The distinction between factors that determine the short-term and long-term interest rates is crucial as it is argued that inflation targeting is an important monetary policy decision that affects the levels of nominal rate in the long term. Fama (1990) and Mishkin (1990) argued that long-term interest rate variations are affected by shocks to expected inflation. Mundell (1963) and Tobin (1965) showed that there exists a negative correlation between expected inflation and real rates of interest. Ang et al. (2008) analyzed in detail the term structure of interest rates in United States and found that real short-term interest rates are negatively correlated with expected inflation.

In this paper, we have tested for both short-term and long-term interest rates and also looked at the term structure of interest rates in India. The attempts to determine the rate of interest are rare in the context of India. An oft-cited reason was the limitations—analytical and methodological— to dealing with the non-varying administered rates of interest for a meaningful time series analysis until recently, prior to the deregulation of rates of interest. The available attempts focused on the deregulated regime of interest rates, and established possible links between macroeconomic variables using high frequency data (Chakraborty, 2002; Dua and Pandit, 2002; Goyal, 2004; Chakraborty, 2007; Chakraborty, 2012). Using high-frequency data, the determination of interest rates so far has been attempted through time series methodology and engaging in pretests, such as unit root and cointegration analyses. However, in this study we try an advanced time series methodology which allows us to pre-empt the pretests.

There is a series of empirical studies, though rare, which deal with the asymptotic theory when the regression involves non-stationary time series leading to what are termed “spurious regressions.” These time series inferences thus suffer from violation of stationarity assumption, more so if the series are short and evolving over time. The problem one encounters, therefore, is how to involve a mixture of I(0) and non-stationary I(d) series, where the order of integration "d" can be different for different series. One of the widely accepted solutions to addressing this issue is the simple operation of differencing or de-trending the series and also capturing the finite structural changes. However, it may not be very easy to validate the notion of infinite memory of the random walk I(1) when the nature of the economic time series changes/evolves over finite time intervals (Vinod, 2006). The econometricians, thus, for many years, have tried to develop approaches to address such problems. For instance, Toda and Yamamoto (1995) attempted to eliminate these problems of pretests for vector autoregressions (VAR). Efron (1979) developed the methodology of bootstrap, which generates replicas of parameters to construct empirical distribution functions.

A recent development in the non-parametric bootstrap methodology is the maximum entropy bootstrap (Meboot) proposed by Vinod (1985, 2004) and has been developed extensively in Vinod (2006) and Vinod and Lopez-de-Lacalle (2009). The Meboot algorithm is a seven-step procedure which allows one to generate replicates or "reincarnations,"—as termed by Vinod, 2004—of the original series for further inferences. The methodology allows us to overcome the unit root and structural change pretests ruling out the need of any transformations of original time series for ensuring stationary assumption. This paper implements Meboot methodology for interest rate determination in India.

The paper is organized into five different sections. Section 1 interprets the empirics. Section 2 arrives at the model specification while Section 3 deals with econometric methodology adopted and reports the results obtained. Section 4 concludes.

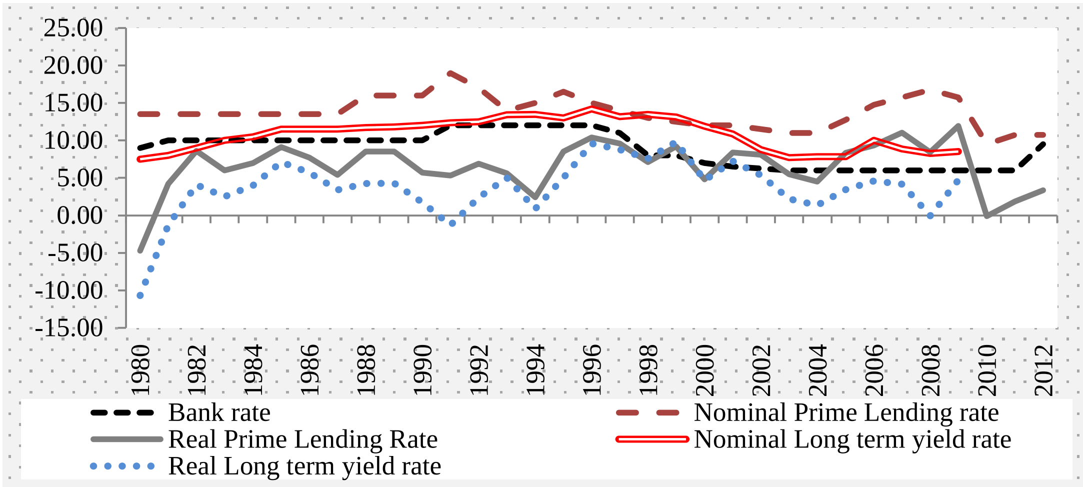
1. INTERPRETING EMPIRICS

Chakraborty (2012) has extensively surveyed the theoretical paradigms and cross-country empirical literature on the links between fiscal deficits and rates of interest. The survey suggests that the empirical analysis of fiscal deficits and interest rates is inconclusive. The set of studies, which observed no link, emphasizes either the context of financial integration or the Ricardian Equivalence paradigm. A few studies also highlighted the plausible liquidity in the system, which thwarted the possibility of crowding out of corporate investment from preemption of loanable funds through the financing decisions of fiscal deficit. The studies found evidence for the link between fiscal deficit and rate of interest highlighted the neoclassical arguments of crowding out of investment.

Selection of the appropriate interest rate from the available spectrum of interest rates in India is the crucial step in data mining towards interest rate determination. Data is organized from the annual series of macro variables from the data bank of RBI for the periods 1980–81 and 2011–12. The major interest rates are call money market rate, prime lending rate, treasury bill rates (91 days, 364 days, and 182 days), and interest rates on dated securities of the government of India. Among these interest rates, the call money market rate has exhibited large volatility, and the bank rate has appeared to be non-varying in nature, which can be opted out in analyzing the link between fiscal deficit and interest rate. The prime lending rate is relevant as it is a significant determinant of private investment behavior as a long-term rate, and has also shown a broad stickiness in the rates. The redemption yield on dated securities of India is identified on the grounds that a shift from seigniorage financing to bond financing of fiscal deficit in India can have some effect on the interest rate—especially the interest rate on bonds or securities—and is also opted in as a long-term interest rate. The treasury bill rate is also tested as the reference interest rate.

Theoretically, a reference rate is defined as the price of a short-term low-risk instrument in a free liquid market. The treasury bill rate of 91 days is also used as the interest rate variable in this paper while opting out the 182-day and 364-day treasury bills due to limitations in annual data of these rates. The financial system in India was characterized by an administered interest rate structure until the 1990s. The process of financial deregulation since 1991 has been aimed at making the financial sector market-oriented to improve allocative efficiency. The administered interest rates were simplified beginning in 1992–93. A small number of fixed rates for priority sector loans were retained, while large commercial borrowers faced a floor-lending rate. From 1993–94, the markets for commercial paper and certificates of deposit were deregulated, allowing companies to access credit at market terms that were considerably below the minimum lending rate (Chakraborty, 2012). In October 1994, the minimum lending rate was eliminated. The deregulation of interest rates has been accompanied by the introduction of new instruments like 14-day and 182-day auction treasury bills, in addition to the 91-day and 364-day auction treasury bills. It is to be noted that the 182-day treasury bill was reintroduced in mid-1999.

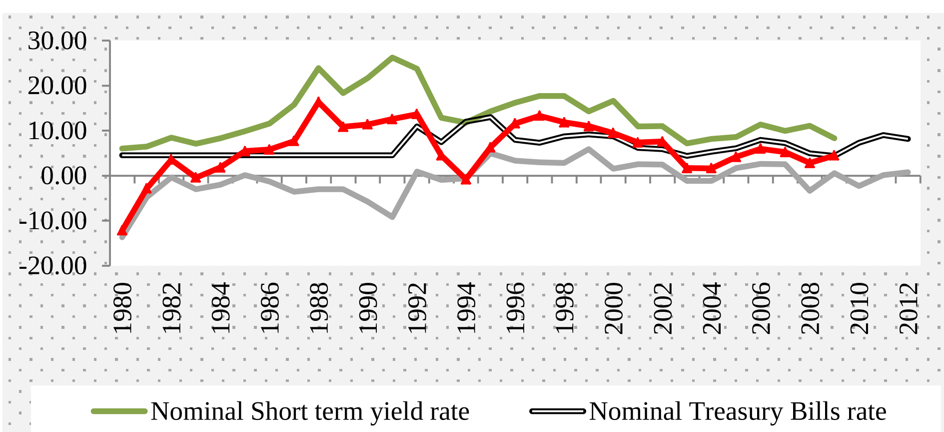
Figure 1 Movements in Long-term Interest Rates



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

However, the administered interest rate in developing countries is responsive to market signals. The literature shows that an administered interest rate does accommodate market perceptions, and in order to analyze that, the literature has suggested examining the intertemporal movement of the interest rate and its variability in real terms (Gupta, 1992). The analysis of intertemporal movements in the selected interest rates adjusted for inflationary expectations showed that the interest rates in India, though administered, have shown intertemporal variations, and real interest rates remained positive in a substantial number of years, and hence there is strong support for the argument that India was financially repressed, and the administrative interest rate can be ruled out.

Figure 2 Movements in Short-term Interest Rates



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

The subsequent logical step is to transform these interest rates into an *ex ante* real interest rate. The Fisher hypothesis is postulated as;

$$\gamma^n = \gamma^r + \pi^e$$

where γ^r is the real interest rate and π^e is the expected rate of inflation. The studies have used the low-frequency component of consumer price changes as generated by the Hodrick-Prescott (HP) filter to model expected inflation (Correia-Nunes and Stemitsiotis, 1995). Let us assume that observed inflation π contains both expected π^e and unexpected components π^u.

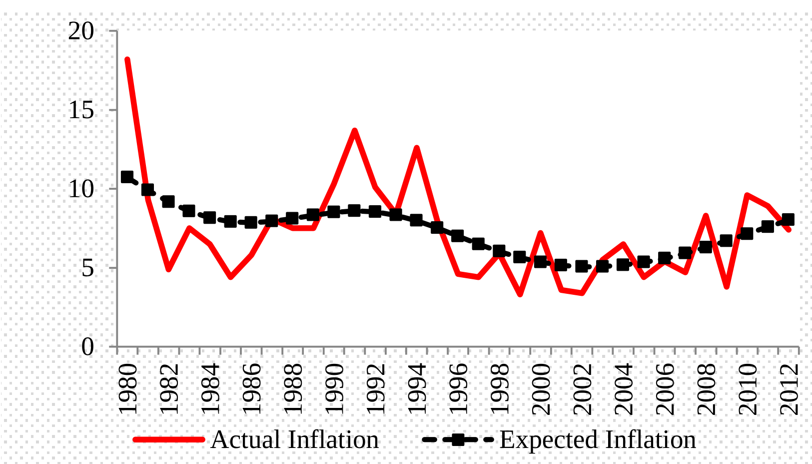
$$\pi = \pi^e + \pi^u$$

The HP filter decomposes observed inflation into a stationary cyclical component and a smooth trend component (π and π^e) denote the logarithms of observed and expected inflation, respectively, by minimizing the variance of the cyclical component subject to a penalty for the variation in the second difference of the trend component. This results in the following constrained least squares equation.

$$Min \sum_{T=1}^{i} (\pi - \pi^e)^2 + \lambda \sum_{t=2}^{T} [(\pi_{t+1}^e - \pi_t^e) - (\pi_t^e - \pi_{t-1}^e)]^2$$

Figure 3 Shows the co-movements of actual inflation and expected inflation derived using the HP filter in India.

Figure 3 Actual Inflation and Expected Inflation Derived Using HP Filter



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

We have analyzed the prime lending rate and government securities yield rate (more than 10 years) as long-term rates and 90-days treasury bills and government securities yield rate (less than 5 years) as short-term rates.

2. SPECIFICATION OF MODEL

Chakraborty (2012) derived a theoretical specification for interest rate determination based on Sargent (1969) titled "Commodity Price Expectations and the Interest Rate," where the basic functional form of the model derived is as follows:

$$R_t = \beta_0 + \beta_1 FD + \beta_2 BMS + \beta_3 REER + \beta_4 EInfl + \beta_5 OG + u_t$$

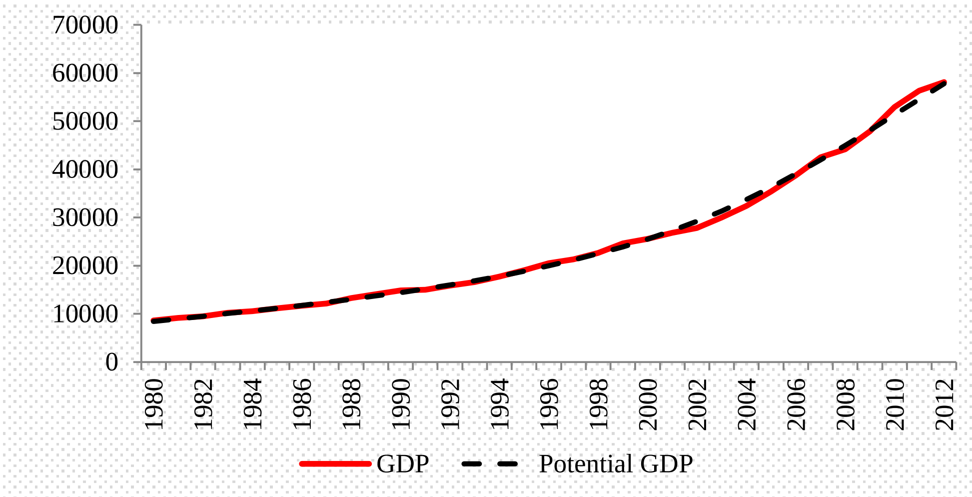
where "R" is the real interest rate adjusted for actual inflation, "FD" is the gross fiscal deficit of central government of India, "BMS" is the broad money supply or M2. Both the fiscal deficit and the broad money supply are in log forms. "REER" is the real effective exchange rate index of the Indian rupee and "EInfl" is the expected inflation derived using the HP filter. "OG" stands for the output gap in the economy. The stylized facts related to the macroeconomic links of each of these variables with rates of interest are elaborated in Chakraborty (2012).

The *output gap* index can be defined as

OG= [(Actual GDP-Potential GDP)/Potential GDP] *100

Conceptually, the potential level of output would be higher than the actual level, as the resource utilization is maximized at the potential level. However, it is argued that cyclical factors, such as a recession or boom, could cause the actual level of output to be below or above the potential output, respectively (Tanzi 1985). The Hodrick-Prescott filter (HP filter) is the method used in this paper for the derivation of the potential output. The purpose of this filter is to decompose a nonstationary time series, such as actual output, into a stationary cyclical component and a smooth trend component (Y_t and Y_t^* denote the logarithms of actual and trend/potential output respectively) by minimizing the variance of the cyclical component subject to a penalty for the variation in the second difference of the trend component. Figure 4 shows the movement of actual and Hodrick-Prescott-filtered potential output in India.

Figure 4 Actual and Hodrick-Prescott-Filtered Potential Output



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

To analyze the term structure of interest rates in the long term, we included the short-term interest rates as an explanatory variable in the equation and estimated the results. The term structure of the long-term interest rate is defined as follows:

$$R_t = \beta_0 + \beta_1 FD + \beta_2 BMS + \beta_3 STR + \beta_4 REER + \beta_5 EInfl + \beta_6 OG + u_t$$

where, "STR" stands for short-term interest rate. Here we used the treasury bills rate and short-term government security yield rate separately for determining the structure of long-term interest rates.

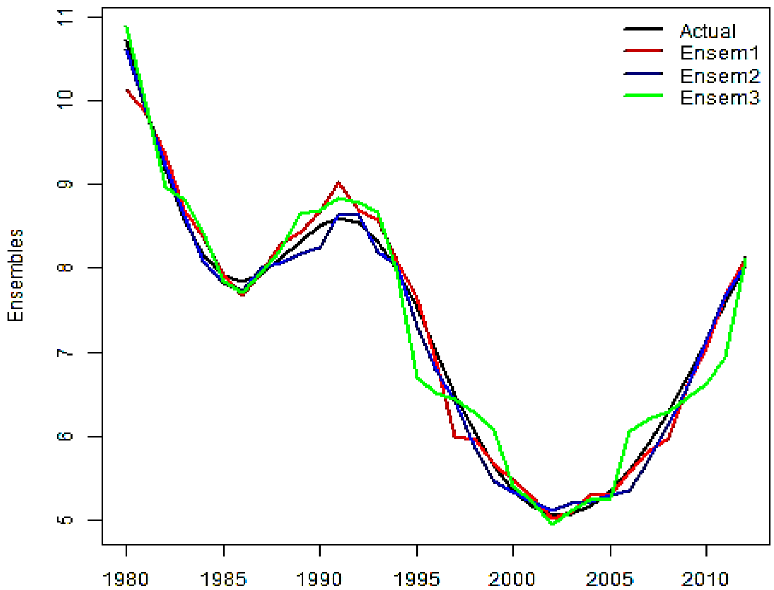
3. ECONOMETRIC ESTIMATION

Using Vinod (2004, 2006, 2009), we attempt the maximum entropy bootstrap for time series (Meboot) methodology for the interest rate determination in this paper, for both shorts and longs. Meboot constructs a maximum entropy density f(x) subjected to certain mass- and mean-preserving constraints, thus maximizing the Shannon[2] information defined by "H"=E (-logf(x)).

[2] Shannon entropy is the average unpredictability in a random variable, which is equivalent to its information content (with the opposite sign). If we want to impose minimum prior knowledge about the shape of the

The ensembles or the replicates so created satisfy the ergodic theorem, central limit theorem and the Doob's theorem. In addition, the constructed ensembles have the property of retaining the shape and autocorrelation and partial autocorrelation functions of the original time series data, which is more important for short and non-stationary dependent data. Figure 5 (below) shows the actual data and some replicas generated from the Meboot algorithm.[3]

Figure 5 Actual and Generated Ensembles of Expected Inflation



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

The above figure clearly indicates that the Meboot resample retains the shape of the original time series under consideration as the resamples are strongly dependent on it.

In the recent literature, researchers have discussed in detail the reliability of Meboot methodology for time series inferences (Yalta 2011; Plasil, 2011; and Lundholm, 2012). This paper therefore attempts to use the algorithm and tests for applicability for a short macroeconomic time series in the Indian context. We have reported the confidence intervals as

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distribution, it is well known that the exponential distribution f(x) $=\theta e^{-x\theta}$, having $0 \leq x \leq \infty$ and a mean of θ^{-1}, will maximize the entropy (ignorance), defined to be the negative of the information, by H = $-\int_{-\infty}^{\infty} f(x) log f(x) dx$.

(For details, see: Vinod (1982): Vinod, (1982), "Maximum Entropy Measurement Error Estimator of Singular Covariance Matrices," Journal of Econometrics, 20, 163-174.

Vinod (1985). "Measurement of Economic Distance Between Blacks and Whites." Journal of Business and Economic Statistics, 3, 78–88.)

[3] See appendix for graphs of shape retention by Meboot resamples for other variables.

suggested by Vinod and Lopez-de-Lacalle (2009) and the asymptotic intervals from the OLS regressions for comparisons. The description of the confidence intervals is as follows:

Simple percentile: the method is based on ordering b_j^*, j = 1,…, J values from the smallest to the largest as b_j^*, j = 1,…, J. If J = 999, α = 0.05, (J+1)(α /2) = 25 and (J+1)(1-α /2) = 975. Hence the "simple percentile" interval is given by the order statistics: $[b_{(25)}^*, b_{(975)}^*]$.

Boot percentile: This interval improves upon the "simple percentile" interval by working on a transformed scale to force the distribution of *b** to be symmetric, without knowing that transformation explicitly.

Norm: The "norm" interval uses a normal approximation to the distribution of "*b"* based on bootstrap estimates *b** of the bias and variance.

Basic: The "basic" interval uses the following basic notion to better approximate the "norm" interval. Instead of directly using *b** to approximate the unknown β, the observable deviations *b**-*b* are likely to be better at approximating the unknown deviations *b*-β.

Table 1 Estimated Coefficients for Real Prime Lending Rate

Variable	**Coefficients**
Gross Fiscal Deficit	0.38841
Broad Money	-1.686629
Real Exchange Rate	-.0562075
Expected Inflation	-1.71988*
Output Gap	4.322904
Constant	37.45186

Note: * significant at 95% confidence intervals. Data: (Basic), RBI data (various years)

Table 2 Confidence Intervals: Real Prime Lending Rate

Variable	OLS		Meboot								HDR	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-4.799	5.576	-2.359	3.213	-2.359	3.221	-2.183	3.372	-2.445	3.136	-2.485	3.089
Broad Money	-5.208	1.835	-3.554	0.183	-3.559	0.184	-3.704	0.005	-3.557	0.186	-3.389	0.294
Real Exchange Rate	-0.147	0.035	-0.098	-0.015	-0.098	-0.014	-0.099	-0.015	-0.097	-0.014	-0.096	-0.013
Expected Inflation	-2.732	-0.707	-2.408	-0.941	-2.408	-0.941	-2.573	-1.129	-2.498	-1.031	-2.309	-0.880
Output Gap	-1.771	10.417	1.897	6.938	1.889	6.940	1.767	6.847	1.704	6.756	1.772	6.803

Data: (Basic), RBI data (various years)

Table 3 Estimated Coefficients for Real Government Security Yield Rate (More than15 Years) Rate

Variable	Coefficients
Gross Fiscal Deficit	5.2224144#
Broad Money	-6.1587779*
Real Exchange Rate	-0.0035832
Expected Inflation	-2.9098437*
Output Gap	7.1834000*
Constant	45.54759

* significant at 95% confidence intervals, # significant at 90% confidence intervals. Data: (Basic), RBI data (various years)

Table 4 Confidence Intervals: Real Government Security Yield Rate (More than 15 Years)

Variable	OLS		Meboot								HDR	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-0.081	10.526	1.045	9.593	1.039	9.607	1.173	9.721	0.837	9.404	0.676	9.233
Broad Money	-9.716	-2.601	-7.583	-2.137	-7.598	-2.137	-10.236	-4.905	-10.179	-4.719	-7.428	-2.050
Real Exchange Rate	-0.093	0.0861	-0.049	0.076	-0.049	0.076	-0.080	0.044	-0.083	0.041	-0.053	0.072
Expected Inflation	-4.245	-1.574	-3.501	-0.927	-3.507	-0.924	-4.906	-2.298	-4.895	-2.312	-3.461	-0.885
Output Gap	0.911	13.455	3.877	10.147	3.850	10.174	4.366	10.640	4.192	10.515	3.682	9.985

Data: (Basic), RBI data (various years)

Table 5 Estimated Coefficients for Real Treasury Bills (91days) Rate

Variable	Coefficients
Gross Fiscal Deficit	1.497844
Broad Money	-1.254771
Real Exchange Rate	.0354172
Expected Inflation	-1.922336*
Output Gap	2.836437
Constant	11.05681

* significant at 95% confidence intervals. Data: (Basic), RBI data (various years)

Table 6 Confidence Intervals: Real Treasury Bills (91 Days) Rate

Variable	**OLS**		**Meboot**								**HDR**	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-3.951	6.947	-2.592	3.691	-2.603	3.698	-0.692	5.430	-0.703	5.598	-2.405	3.741
Broad Money	-4.954	2.444	-2.223	1.860	-2.227	1.860	-4.166	-0.102	-4.370	-0.282	-2.469	1.740
Real Exchange Rate	-0.060	0.131	-0.034	0.080	-0.034	0.080	-0.012	0.103	-0.009	0.105	-0.030	0.082
Expected Inflation	-2.985	-0.858	-2.275	-1.142	-2.277	-1.139	-2.707	-1.575	-2.704	-1.566	-2.271	-1.139
Output Gap	-3.565	9.238	0.259	5.330	0.257	5.341	0.388	5.432	0.330	5.415	0.215	5.298

Data: (Basic), RBI data (various years)

The short-term government security yield rate is affected by broad money supply. Real exchange rate and expected inflation are found to be statistically significant (all are negative and statistically significant at 95%) while the output gap is positively related to it (tables 7 and 8).

Table 7 Estimated Coefficients for Real Government Security Yield Rate (1-5 Years)

Variable	**Coefficients**
Gross Fiscal Deficit	4.303496
Broad Money	-5.269662*
Real Exchange Rate	-.3143189*
Expected Inflation	-3.185327*
Output Gap	11.72629*
Constant	77.50463

* significant at 95% confidence intervals. Data: (Basic), RBI data (various years)

Table 8 Confidence Intervals: Real Government Security Yield Rate (1-5 Years)

Variable	**OLS**		**Meboot**								**HDR**	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-1.846	10.453	-1.389	8.403	-1.389	8.418	0.777	10.761	0.188	9.996	-1.872	7.913
Broad Money	-9.393	-1.145	-5.860	0.871	-5.860	0.883	-11.110	-4.452	-11.423	-4.678	-6.094	0.696
Real Exchange Rate	-0.418	-0.210	-0.405	-0.236	-0.405	-0.235	-0.396	-0.231	-0.392	-0.223	-0.399	-0.231
Expected Inflation	-4.733	-1.637	-3.684	-0.687	-3.685	-0.681	-5.693	-2.790	-5.689	-2.685	-3.601	-0.610
Output Gap	4.454	18.997	4.981	14.083	4.980	14.086	9.637	18.846	9.365	18.471	4.617	13.781

Data: (Basic), RBI data (various years)

The estimates show the real long-term government security yield rate is affected by broad money supply, the expected inflation rate (both are negative and statistically significant at 95%), and the output gap in the long run. In the short run, the 91-day treasury bill rate is only affected by expected inflation (Table 9).

Table 9 Estimated Coefficients for Long-term Real Government Security Yield Rate (More than15 Years)

Variable	**Coefficients**
Gross Fiscal Deficit	2.432843
Broad Money	-2.74293*
Real Exchange Rate	0.2001616*
Expected Inflation	-0.8450824
Short-term yield rate	0.6482102*
Output Gap	-.4176998
Constant	-4.691711

* significant at 95% confidence intervals, # significant at 90% confidence intervals . Data: (Basic), RBI data (various years)

Table 10 Confidence Intervals: Long-Term Real Government Security yield Rate (More than15 Years)

Variable	**OLS**		**Meboot**								**HDR**	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-1.302	6.168	0.531	7.474	0.527	7.476	-2.167	4.631	-2.611	4.338	0.200	7.095
Broad Money	-5.471	-0.014	-6.123	-1.280	-6.127	-1.264	-4.397	0.392	-4.220	0.641	-6.010	-1.023
Real Exchange Rate	0.102	0.298	0.069	0.256	0.069	0.257	0.146	0.329	0.142	0.331	0.068	0.253
Expected Inflation	-2.038	0.348	-2.517	-0.217	-2.519	-0.215	-1.641	0.685	-1.475	0.828	-2.325	-0.052
Short-term yield rate	0.402	0.893	0.253	0.707	0.252	0.709	0.583	1.045	0.586	1.044	0.257	0.710
Output Gap	-5.539	4.704	-1.103	5.895	-1.107	5.919	-6.772	0.220	-6.754	0.272	-1.049	5.934

Data: (Basic), RBI data (various years)

To determine the term structure of long-term interest rates, we included the short-term interest rates as one of the explanatory variables. The results show that the estimated coefficients for the long-term government security yield rate. In determining the long-term structure of interest rates here, broad money supply is negatively related to interest rates while the real exchange rate and short-term interest rate is positively related to it. Expected inflation is significant only at 90% levels and maintains its relationship as earlier (i.e., negatively correlated to interest rates). For long-term prime lending rate, only the short-term treasury bill rate is statistically significant (positive related) in determining the long-term structure.

Table 11 Estimated Coefficients for Long-term Real Prime Lending Rate

Variable	**Coefficients**
Gross Fiscal Deficit	-0.3849057
Broad Money	-1.038809
Real Exchange Rate	-0.0744929
Expected Inflation	-0.7274056
91days treasury bills rate	0.5162857*
Output Gap	2.858492
Constant	31.74339

Notes: * significant at 95% confidence intervals, # significant at 90% confidence intervals. Data: (Basic), RBI data (various years)

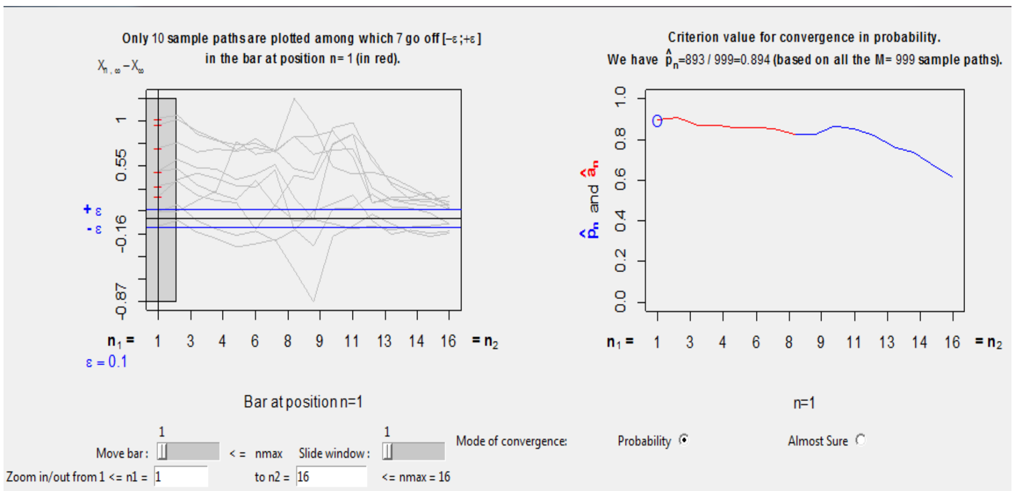
Table 12 Confidence Intervals: Long-Term Real Prime Lending Rate

Variable	**OLS**		**Meboot**								**HDR**	
			Simple percentile		Boot Percentile		Boot norm		Boot Basic			
	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%	2.5%	97.5%
Gross Fiscal Deficit	-4.860	4.090	-2.578	2.720	-2.579	2.733	-3.290	1.986	-3.502	1.810	-2.764	2.522
Broad Money	-4.086	2.008	-3.579	0.359	-3.580	0.363	-2.629	1.156	-2.440	1.502	-3.271	0.502
Real Exchange Rate	-0.153	0.004	-0.111	-0.023	-0.111	-0.023	-0.125	-0.039	-0.125	-0.037	-0.111	-0.023
Expected Inflation	-1.794	0.339	-1.596	-0.231	-1.597	-0.230	-1.342	0.058	-1.223	0.142	-1.528	-0.134
91 treasury bills rate	0.193	0.838	0.295	0.633	0.295	0.634	0.410	0.746	0.398	0.737	0.284	0.625
Output Gap	-2.447	8.164	0.545	5.424	0.526	5.440	0.176	5.159	0.276	5.190	0.593	5.441

Data: (Basic), RBI data (various years)

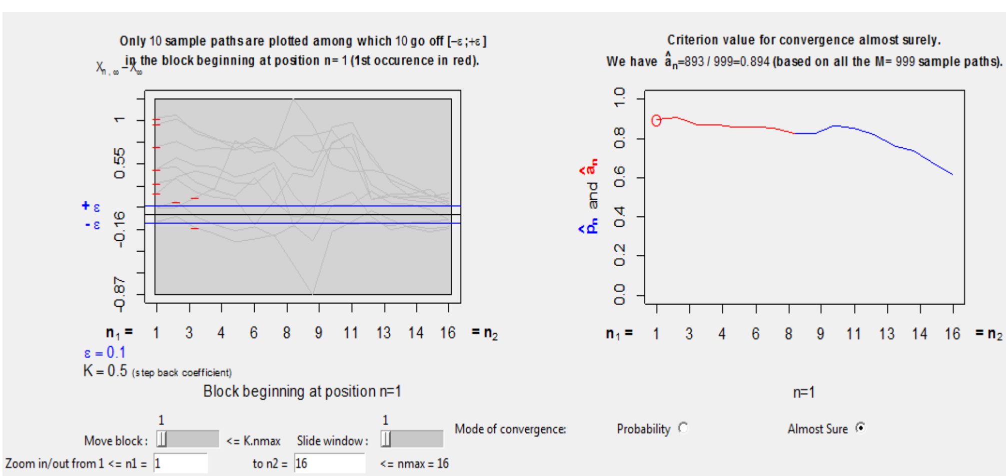
We also tried to check "convergence in probability" and "almost sure convergence" suggested by Vinod (2010) and Lafaye de Micheaux and Liquet (2009) using package "Convergence Concepts" in R, which allows us to evaluate the proportion of sample paths straying outside the error bounds as the sample size increases. In simpler words, this allows a user of a Meboot package to check if the replicas created by the Meboot algorithm converge to their true values and are statistically significant as the sample size increases, especially for a short time series. Figures 6 and 7 show how the convergence is tested for one of the parameters, i.e., expected inflation.[4]

Figure 6 Convergence in Probability



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

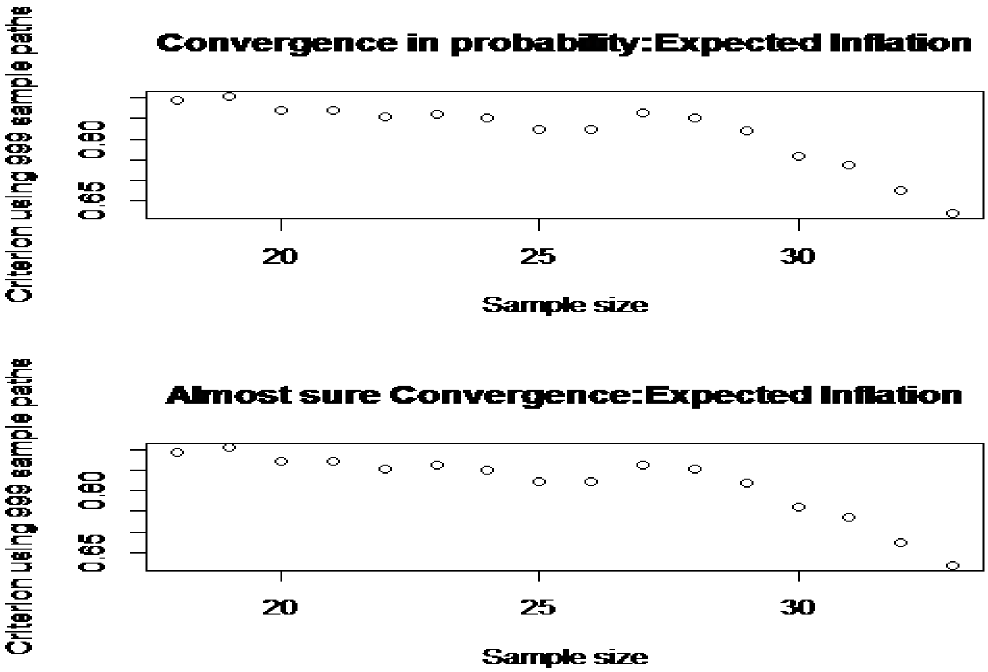
Figure 7 Almost Sure Convergence



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

[4] The results are available upon request for all variables.

Figure 8 Convergence in Probability and Absolute Convergence Plot of Expected Inflation



Source: Reserve Bank of India (various years), Hand Book of Statistics on Indian Economy

If the Meboot algorithm converges to the true values, then the values defined by the convergence concept decline and can be tested for statistical significance with increase in sample size. Thus, the slope coefficient of both concepts (i.e., convergence in probability and absolute convergence) should be negative and the t statistics should be large. Table 13 reports the results for both concepts and approves the working of Meboot for a short time series in our case.

Table 13 Convergence in Probability and Almost Sure Convergence

	Estimate	**Std.error**	**t value**	**Pr(>|t|)**
Convergence in Probability				
Intercept	1.18631131	0.059788188	19.841901	1.197451e-11
expected inflation	-0.01447771	0.002307238	-6.274911	2.039499e-05
Almost sure convergence				
Intercept	1.18631131	0.059788188	19.841901	1.197451e-11
expected inflation	-0.01447771	0.002307238	-6.274911	2.039499e-05

The estimates showed that expected inflation has a negative relationship in the long-term and is statistically significant. The results showed that in all the four intervals reported from “Meboot” package including HDR intervals, the CIs tend to be strict and narrower as compared to OLS intervals.

4. CONCLUSION

The link between the rate of interest and fiscal deficit is a highly controversial issue. This paper revisits the determination of interest rates in India using a recent methodology of maximum entropy bootstrap (Vinod, 2006, 2010, 2013). The results showed that fiscal deficit is not statistically significant for interest rate determination. This is in alignment with one of the earlier findings (Chakraborty [2002, 2012]), where it was established that the interest rate is affected by other macroeconomic variables, not fiscal deficit. The identified determinants of the rate of interest are the changes in the reserve currency, expected inflation, and volatility in capital flows, but not by the fiscal deficit. This result has significant policy implications for interest rate determination in India, especially since the central bank has cited the high fiscal deficit as the prime reason for lack of operational flexibility to change the policy rates. The results also highlight that Maximum Entropy Bootstrap procedure can perform well for short-term economic series. The results showed that it provides improvements in terms of narrower bands in comparison to the standard OLS intervals. This is useful for short time sample series where the time series properties of data are quite difficult to establish.

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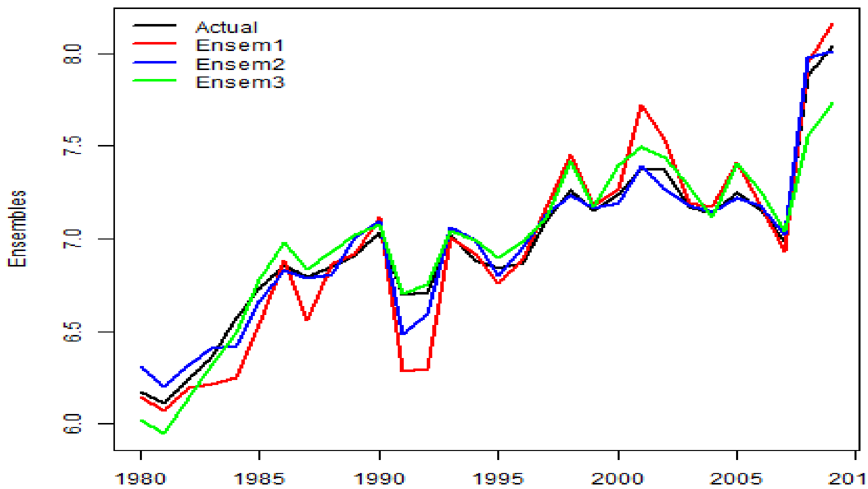
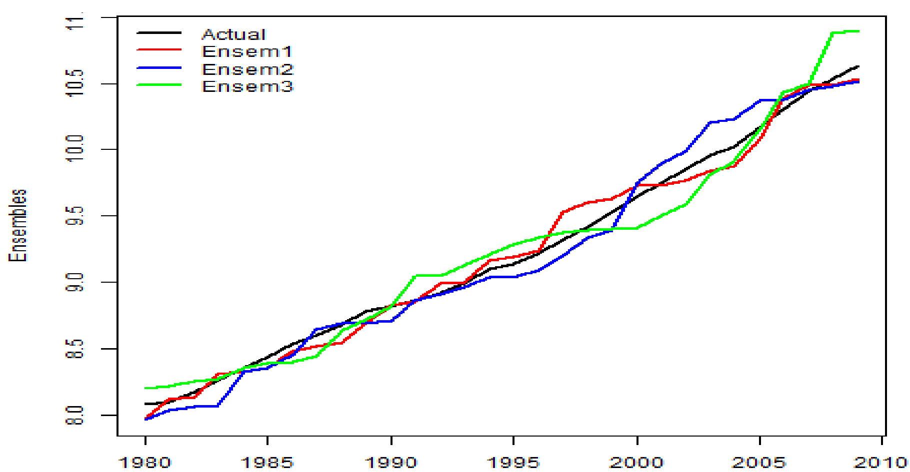
Appendix

Maximum Entropy Ensembles

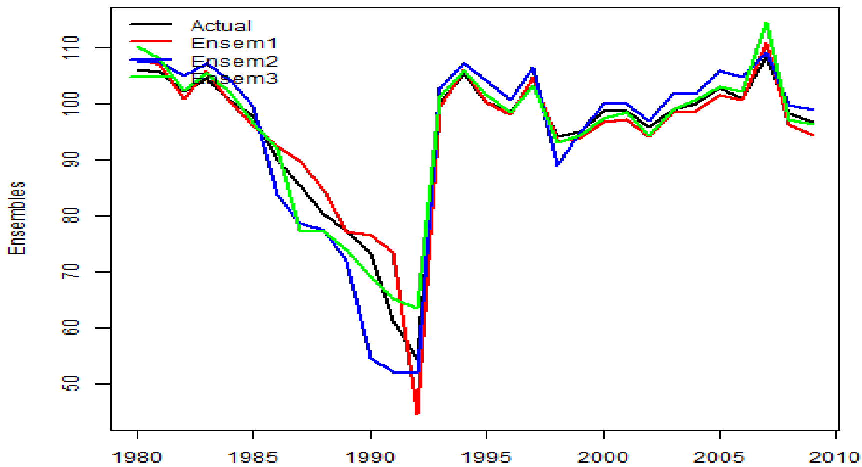
a) Fiscal Deficit



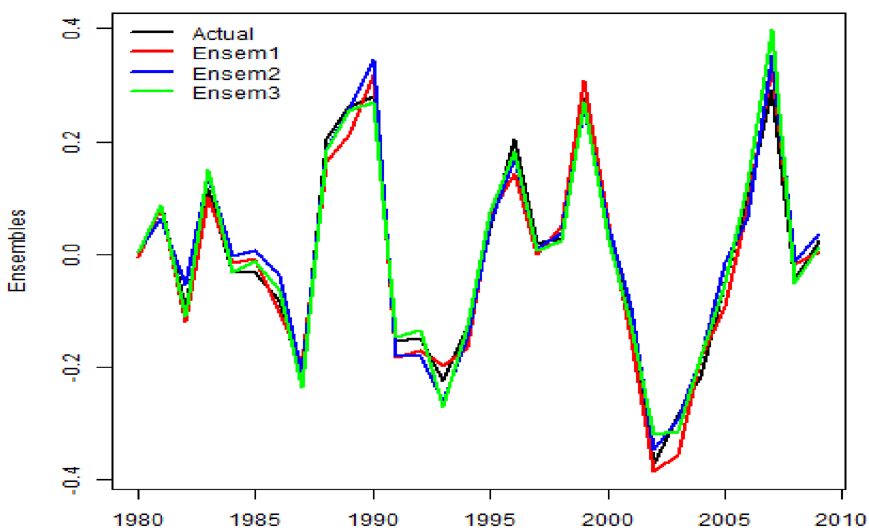
b) Broad Money Supply



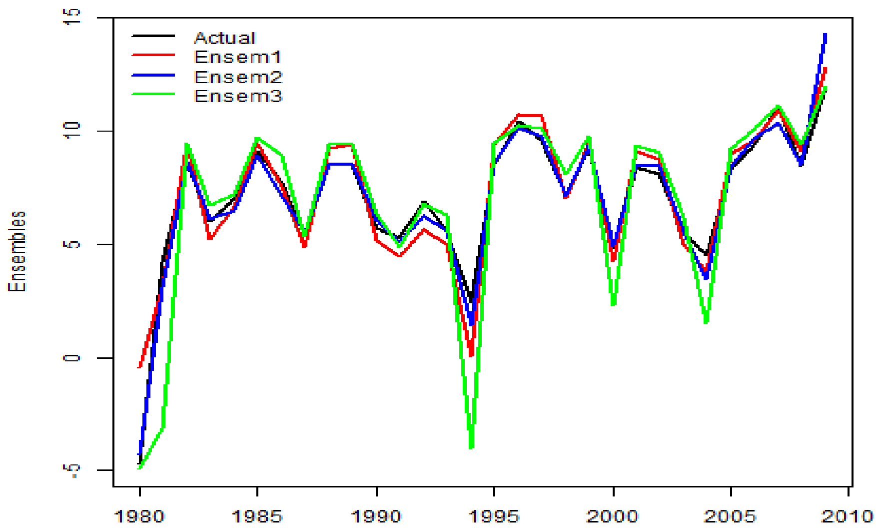
c) Real Effective Exchange Rate



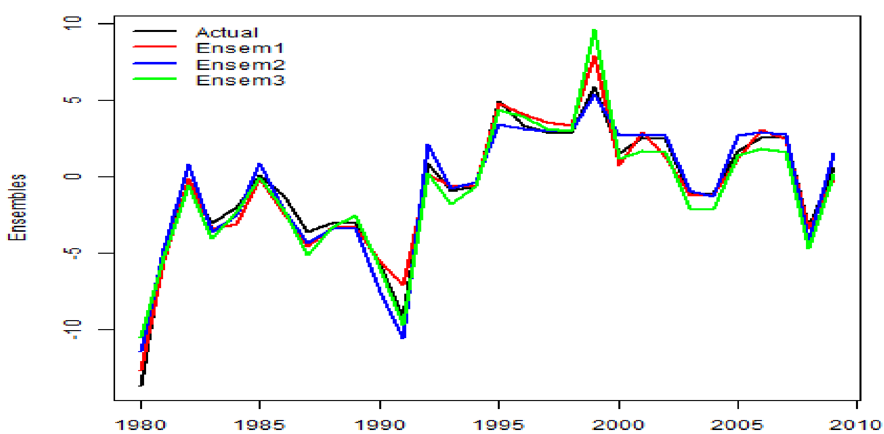
d) Output Gap



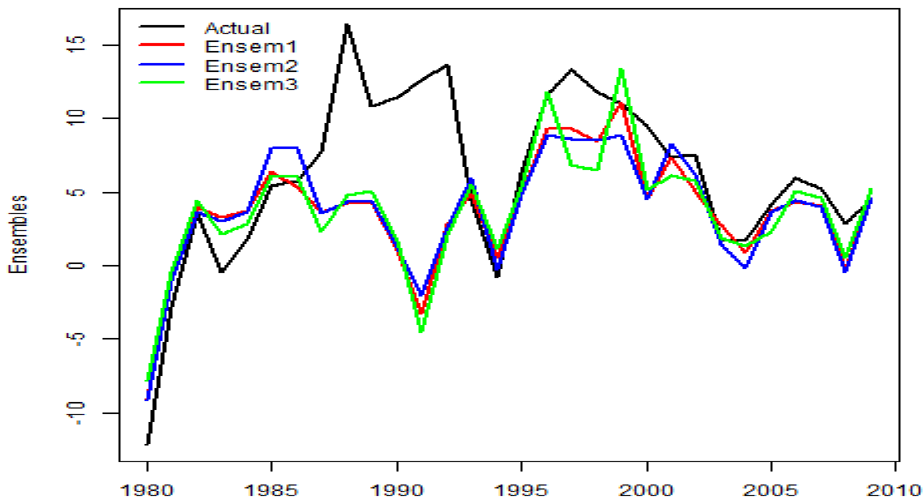
e) Real Prime Lending Rate



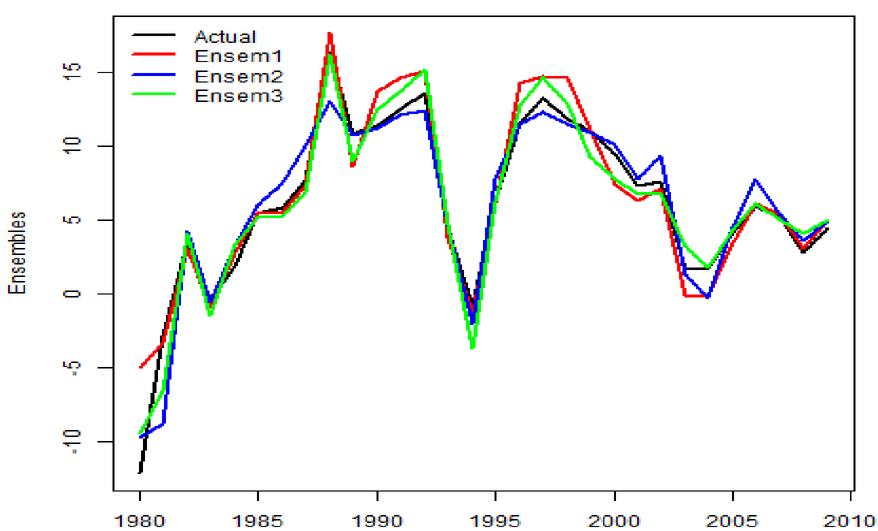
f) Treasury Bills



g) Real Long-term Government Security YieldRrate

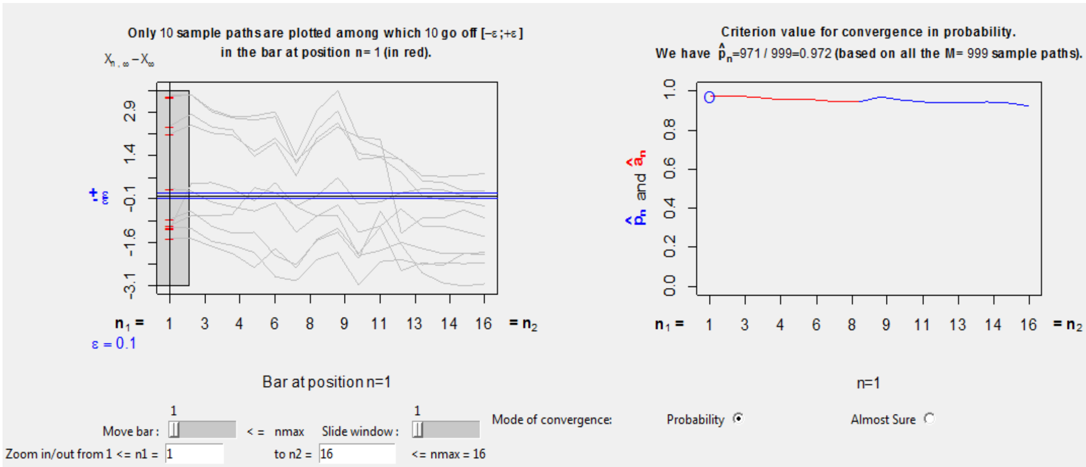


h) Real Short-term Government Security Yield Rate

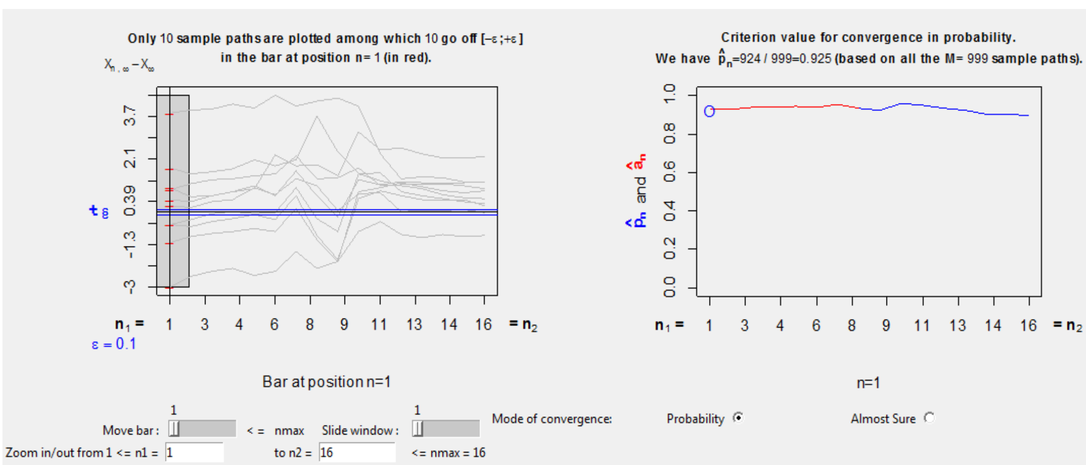


Convergence in Probability

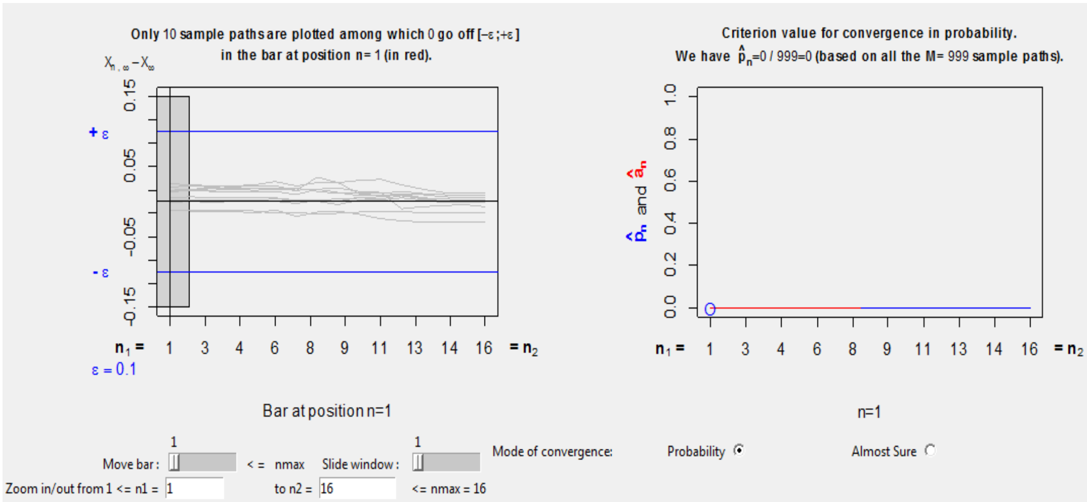
a) Fiscal Deficit



b) Broad Money Supply

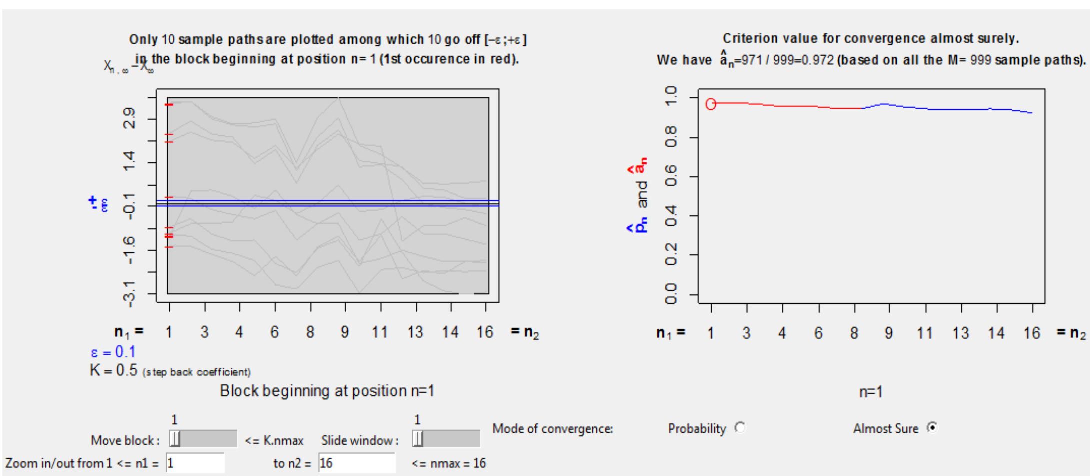


c) Real Effective Exchange Rate

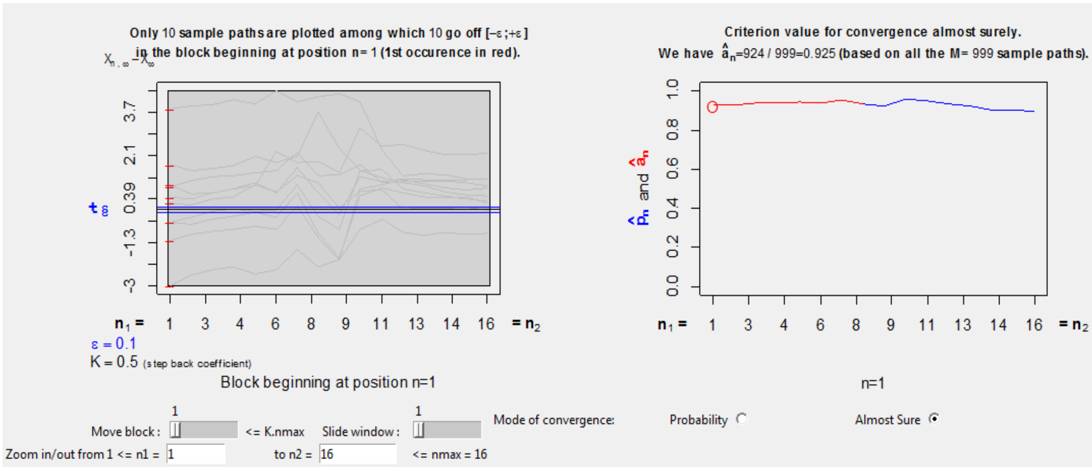


Almost Sure Convergence

a) Fiscal Deficit



b) Broad Money Supply



c) Real Effective Exchange Rate