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   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

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TERM STRUCTURE OF INTEREST RATES AND FISHER EFFECT IN INDIA: AN EMPIRICAL ANALYSIS

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ABSTRACT

Interest rate is a key financial variable affecting almost all the sectors of the economy .The aim of the study is to examine the non-linear relationship in term structure of interest rate and Fisher effect in India by using monthly data for the period from April 1996 to June 2010. Standard unit root test suggests that all the variables are stationary at first difference. Johansen (1991) Cointegration test found that there exist one cointegrating relationship in all the four pair of interest rates, GSEC1-TB91, GSEC5-GSEC1, GSEC10-GSEC1 and GSEC10-GSEC5. This study supports that Fisher effect exists in India in both short and long term interest rates. Hansen-Seo (2002) Threshold Cointegration test is employed to empirically examine non-linearity in all the four pairs of interest rates. But out of these four pairs of interest rates non-linearity exists only in case of GSEC1and TB91. The current analysis has clear policy implications. An understanding of the behaviour of the interest rate is crucial for a developing country like India as it affects almost all the sectors of the economy.

KEYWORDS
Fisher Effect, Hansen-Seo Threshold Cointegration, Interest Rate, Johansen Cointegration.

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I. INTRODUCTION

Interest rate is a key financial variable affecting almost all the sectors of the economy. It has been playing a catalyst role in the smooth functioning of an economy. Movements in the interest rates have important implications for the economy's business cycle and crucial to the understanding of financial developments and changes in economic policy. In the era of globalization and stabilization, one of the macro variables that have come into greater focus is the interest rate. This is due to the strengthened integration of the domestic financial sector with the external sector. As there is slackening of restriction in the cross movement of capitals across the countries, this has affected the behavior of domestic variables, particularly interest rates. This has led to the emergence of a new interest rate channel through which the policy shock can be transmitted to attain growth objectives. The channel has become significant and stronger in most of the emerging economies in recent years, depending on the degree of openness of their capital account. This has made to the domestic financial markets vulnerable to the international shocks or cycles.

Understanding the behavior of the interest rate is crucial for appropriate monetary policy, particularly for developing countries that are in the process of deregulating their financial system. Interest rates targets are also a vital tool of monetary policy and are taken into account when dealing with variables like investment, inflation, and employment. Timely forecasts of interest rates can provide valuable information to financial market participants and policy makers. Forecasts of interest rate can also help to reduce interest rate risk faced by individuals and firms. Forecasting interest rate is very useful to central banks in assessing the overall impact of its policy changes and take appropriate corrective action, if necessary. In the last two decades, economists have emphasized the critical role that interest rate policies play in the development process.

I.1 INDIAN CASE

The Indian economy witnessed a regime of complex administered interest rates till the early nineties, when the interest rate policy was driven by considerations of promoting overall investment and channeling credit to identified priority sectors. The policy framework underwent a radical change with the initiation of economic reform in 1991, as a consequence of which the financial sector was gradually liberalized and domestic interest rate were substantially deregulated. In the course of the process of financial sector reform the focus has shifted from the impact of interest rate deregulation to the determination of interest rates in a deregulated economy. The factors influencing interest rates would obviously vary with the extent of openness of the economy.

A study of interest rates in India for 1951-52 to 1985-86 (a period characterized by low or no interest rate deregulation) reveals that domestic factors like the rate of Inflation , Balance of payments, Government market borrowings and Budgetary deficits had a significant effect on interest rates (Bhole,1988). In contrast, in countries with a completely open economy, some form of interest rate arbitrage would hold, with domestic interest rates depending on world interest rates, expected devaluation and some risk factors. In fact, for a highly open economy with dynamic and sophisticated financial markets, the uncovered interest parity theory states that the difference between the domestic and international interest rate equals the expected rate of depreciation of domestic currency whereas domestic factors play an insignificant role in the determination of domestic interest rates (Edward and khan, 1985).

The increasing globalization of the domestic markets has ensured that India can no longer be considered to be a closed economy. Although domestic monetary factors are found to be highly significant in explaining some domestic market rates (Bhole and Sebastian, 1996), exchange rates seem to play an important role in determining some interest rates (Trivedi, 1998). In India, the financial sector has under gone radical changes since stabilization program initiated in the early 1990s with financial liberalization in the economy, flexibility has been imparted to the movements of interest rates. This is supposed to be a good sign for the economy as it is expected to enhance the efficiency in financial system and thereby leading to the achievement of a higher growth rate.

I.2 TERM STRUCTURE OF INTEREST RATE

The stochastic dynamics of interest rates is a crucial element in modern term structure theories and in pricing of the various interest rate options which are embedded in bond issues today. International studies show that no model of these dynamics is valid world-wide. Further the dynamics of interest rates have important implications for the economy and their forecasts are necessary for all most all economic activities. There is wide agreement that, in the real world the behavior of nominal Interest rates affect the decision making of firms, households and governments. If nominal interest rates are expected to shift in the future, such an expectation will influence a firm's investment in production equipment, a household's savings, debt management policy of governments and so on. These changes in the economic activity of each individual agent will inevitably affect the economic performance of the country. Investigating the behaviour of nominal interest rates is thus undoubtedly crucial for a better understanding of actual macroeconomic performance.

The term structure of interest rate is the variation of the yield of bonds of similar risk profiles with the terms of the bonds. In most cases, bonds with longer maturities have higher yields. However, sometimes the yield curve becomes inverted, with short-term rates and bonds having higher yields than long-term bonds. The yield curve is the relationship of the yield of bonds to the time of maturity. There are 3 characteristics of the term structure of interest rates:

1) The change in yields of different term bonds tends to move in the same direction.
2) The yields on short-term bonds are more volatile than long-term bonds.
3) The yields on long-term bonds tend to be higher than short-term bonds.

The expectations hypothesis has been advanced to explain the first two characteristics and the premium liquidity theory have been advanced to explain the last characteristic.

I.2.1 EXPECTATIONS HYPOTHESIS

According to the expectations hypothesis, long term interest rate is the average of the current and future short term rates that people expect to occur over the life of the long term bond. Hence the expectations hypothesis implies that the yield curve provides information on the future changes in short-term rates. An upward-sloping yield curve causes the rise of the short rate in the future, and a downward-sloping curve causes the fall of the short rate. Thus, the expectations hypothesis implies that the term spread is mean-reverting.

I.2.2 LIQUIDITY PREMIUM THEORY

The liquidity premium theory has been advanced to explain the third characteristic of the term structure of interest rates: that bond with longer maturities tend to have higher yields. It states that interest rate on a long term bond will equal on an average to short term interest rates expected to occur over the life of the long term bond plus the liquidity premium that responds to demand and supply conditions of that bond. It assumes that bonds of different maturities are substitutes but not perfect. Investors prefer short term bonds because these bonds bear less interest rate risk. For this reason investors must be offered positive liquidity premium to induce them to shift to longer term bonds.

In this paper, Section II discusses the theoretical framework and literature on term structure of interest rates and the Fisher effect. Section III presents the importance, objectives, data source and the methodology used in this study. Section IV provides with the empirical results and interpretations and Section V concludes with a summary of the study and suggest policy implications.

II. REVIEW OF LITERATURE AND THE THEORETICAL FRAMEWORK OF FISHER EFFECT

This Section reviews the theoretical framework and empirical studies on the relationship between short and long term interest rates and the Fisher effect.

II.1 EARLIER STUDIES ON TERM STRUCTURE OF INTEREST RATES

Recent studies of the term structure of interest rates, *Campbell and Shiller (1987), Stock and Watson (1988)* found support for a stable relationship between short and long term interest rate, that is, these are "cointegrated.". *Wallace and Warner (1993*), by using quarterly data from the period 1948:1-1990:4 to test for stable long-run relationship between 3month inflation rate, 3month treasury bills and 10-years Government bond rates, supported both for the existence of a Fisher effect on short- and long term interest rates and for the expectations theory of the term structure of interest rates. *Mankiw and Summers (1984)* examined the hypothesis that financial markets are myopic by studying the term structure of interest rates. The findings in this study suggested that participants in bond markets are not myopic or overly sensitive to recent events. *Dua, Raje and Sahoo (2003)* developed univariate (ARIMA and ARCH/GARCH) and multivariate models (VAR,VECM,and Bayesian VAR) to forecast short and long term interest rates by using weekly data over the period April 1997 through December 2001. The study concluded that the forecasting performance of Bayesian VAR models is satisfactory for most interest rates and their superiority in performance is marked at longer forecast horizons. *Singh and Sen (2006)* have developed a robust model for the forecasting of long term interest rates in India by using multivariate time series technique. The analysis revealed that the long term interest rate is cointegrated with various variables which are macroeconomic in nature.

Dua and Pundit (2002) examined the role of domestic and external factors in the determination of short term interest rates in India in the period from March 1993 to May 2000. Cointegration analysis and Granger causality tests in the framework of error correction models are used to examine the relationship. The result showed that both domestic and external factors have influenced movements in the domestic real interest rate in the post reform period.

Bhattacharya, Bhanumurthy and Malick (2006) investigated how the domestic interest rates are determined by the domestic macro economic variables by using monthly data covering the period from April 1996 to March 2005. *Bhole and Sebastian (1996)* analyzed the determinants of interest rates in a deregulated open economy taking the case of India. Using a capital market integration model and the ratio- cum graph analysis, they found that Indian economy is partial deregulated and open. *Gupta (1986)* examined the determinants of interest rates using a general equilibrium model incorporating the IS-LM model, fisher equation, a Barro type supply function and the uncovered interest rate parity theory. The study found that expected inflation, exogenous expenditure, monetary variables; supply shocks; inflation uncertainty, a foreign interest rate determine nominal interest rates.

Edwards and khan (1985) have examined determination of interest rates in the developing countries taking the example of Colombia and Singapore by using quarterly data with ordinary least squares. *Ang and Bekaert(1998)* have measured the non-linearity in interest rate by using the regime switching model. This study demonstrated theoretically and empirically that univariate regime-switching models can capture the non-linear mean reversion observed in interest rates in an economically appealing and stationary model.

Bidarkota (1996) examined the real interest forecasts by using both univariate and bivariate model. Within the estimation sample, the bivariate model provides more accurate forecasts of the real interest rate in terms of the prediction error mean deviation. In the post-sample period, the bivariate model outperforms the univariate model both in terms of accuracy of the forecasts and their precision.

Hansen and Seo (2002) examined a two-regime vector error correction model with a single cointegrating vector and a threshold effect in the error correction term by using data from 1952-1991 in case of US. Applying these models to the term structure model of interest rate, they found strong evidence for a threshold effect. *Gospodinov (2004)* addressed some empirical problem in the term structure of interest rate of US by using a threshold autoregressive framework with GARCH errors from the period July 1954 to April 2003. The empirical results indicated a presence of threshold nonlinearities in the AR and GARCH representations of the conditional moments of short-term rates. The paper also reported that allowing for threshold non-linearities in conditional mean and variance leads to significant forecast improvements. The economic significance of these findings is evaluated by the term structure implications of the estimated TAR-GARCH model.

II. *2 THEORETICAL FRAMEWORK OF FISHER EFFECT*

The analysis was started with finding relationship between interest rates and expected inflation as per Fisher hypothesis, which states that the nominal interest rate is the sum of real interest rate and expected inflation. The real interest rate in an economy by and large remains unchanged but nominal interest rates undergo point to point adjustment with the expected rate of inflation. Several studies have found strong empirical evidence in support of Fisher hypothesis in developed countries where interest rates are market determined. But in many developing countries interest rates are administered by their central banks and hence a natural relationship is willfully distorted.

Fisher (1930) proposed that nominal interest rate i_t at any period is composed of real interest rate r_t and expected inflation π_t^e as follows.

$(1+i_t) = (1+r_t)\,(1+\pi_t^e)$ ……………………….. (2.1)

The equation can be simplified as

$i_t = r_t+\pi_t^e+r_t.\ \pi_t^e$ ……………………………..(2.2)

Assuming that both interest rate and inflation rate are fairly small (on order of few percentage points) $r_t+\pi_t^e$ is much larger than $r_t.\ \pi_t^e$ and therefore the term can be dropped. Thus the Fisher equation can be approximated to $i_t = r_t+\pi_t^e$. Using the rational expectations model to estimate inflation expectations would mean that the difference between realized inflation π_t and expected inflation π_t^e is captured by an error term (ε_t) and thus $\pi_t^e=\pi_t+\varepsilon_t$ where $E(\varepsilon_t)=0$.

The equation (2.1) can therefore be modified to $i_t = r_t+\pi_t+\varepsilon_t$ and a regression equation for testing the hypothesis can be found as follows:

$i_t = \alpha+\beta.\ \pi_t+\varepsilon_t$ ……………………………..(2.3)

If the value of β is 1 and found significant, it would mean one to one correspondence between interest rate and inflation. Ever since Irving Fisher's "Theory of interest,'' the conjecture that nominal interest rates vary, *ceteris paribus*, point-for-point with expected inflation has become one of the most studied topics in economics. The fisher effect is a cornerstone of many theoretical models that generate monetary neutrality and is important for understanding movements in nominal interest rates.

In the empirical literature, past studies in both term structure of interest rate and Fisher effect ignored the stochastic features of these variables and its nonlinearities. This has resulted in identifying only a partial adjustment (temporal co-movement) between the variables. To model the true dynamics of *Rt* and, π_t, now we have an appropriate and powerful econometric methods in the form of "threshold cointegration" methodology developed by Hansen-Seo (2002).

III.SIGNIFICANCE AND METHODOLOGY PART

This Section presents the importance, objectives, data source and the methodology part that is used in this study.

III.1 NEED OF THE STUDY

There are a number of studies regarding the non-linearity in term structure of interest rate and fisher effect in Developed countries like US and UK, but in case of India there is only very few studies in this topic. Several studies have found strong empirical evidence in support of Fisher hypothesis in developed countries where interest rates are market determined. But in many developing countries like India interest rates are administered by their central banks and hence a natural relationship is willfully distorted. In this study, we attempt to characterize discrete adjustment in terms of threshold cointegration. In particular, we examine the case where the cointegrating relationship is inactive inside a given range and then becomes active once the system gets too far from the "equilibrium". That is, once the system exceeds a certain threshold, cointegration becomes active. The concept of threshold cointegration captures the essence of nonlinear adjustment process envisioned to hold for many economic phenomena. Here, we test in case of the relationship between short and long term interest rates and the relationship between the inflation and interest rate.

III.2 OBJECTIVES OF THE STUDY

1) To empirically examine the non-linear relationship between short-term and long-term interest rates in India.
2) To identify the presence of non-linearity in Fisher effect in India.

III.3 DATA SOURCE AND METHODOLOGY

This study uses monthly data for the period from April 1996 to June 2010. To measure the relationship between short and long term interest rate, it used 91-days Treasury Bill (TB91), Government securities with (residual) maturities of one year (GSEC1), five years (GSEC5) and ten years (GSEC10). To empirically test the Fisher effect, inflation and all the four interest rates have been considered. Monthly data on TB91, GSEC1, GSEC5, GSEC10, and Wholesale Price Index (WPI) have been collected from Hand book of statistics on Indian economy published by Reserve Bank of India. The inflation rate is calculated from the Wholesale price index (WPI) data for the same period. Further we classified the interest rates as long and short rate into four pairs namely GSEC1-TB91, GSEC5-GSEC1, GSEC10-GSEC1 and GSEC10-GSEC5.

Johansen (1991) cointegration test is applied to measure the short and long rate relationship and the relationship between inflation with all the four interest rates. Hansen-Seo (2002) threshold cointegration test is employed to empirically examine non-linearity in these relationships.

IV. EMPIRICAL INVESTIGATION

This section presents the empirical results and interprets with discussion.

IV.1 GRAPHICAL REPRESENTATION

To give some initial sense of relationship between long-term and short-term interest rate, we have plotted these variables. The graphs plotted below have clearly shown that there exists the relationship between the long term and short term interest rates. The Figure 1 depicts that the GSEC1 and TB91 are co-move with each other. Both the rates fall continuously in the initial period from April-96 to October-97. From October-97 to july-98 there is sharp rise in both the rates and thereafter there is continuous fall in both the periods which is attributed to increased openness of the economy. Similarly Figure 2 to 4 describes that interest rate at various (TB91, GSEC1, GSEC5 and GSEC10) levels are closely related.

FIGURE 1: GSEC1 AND TB91

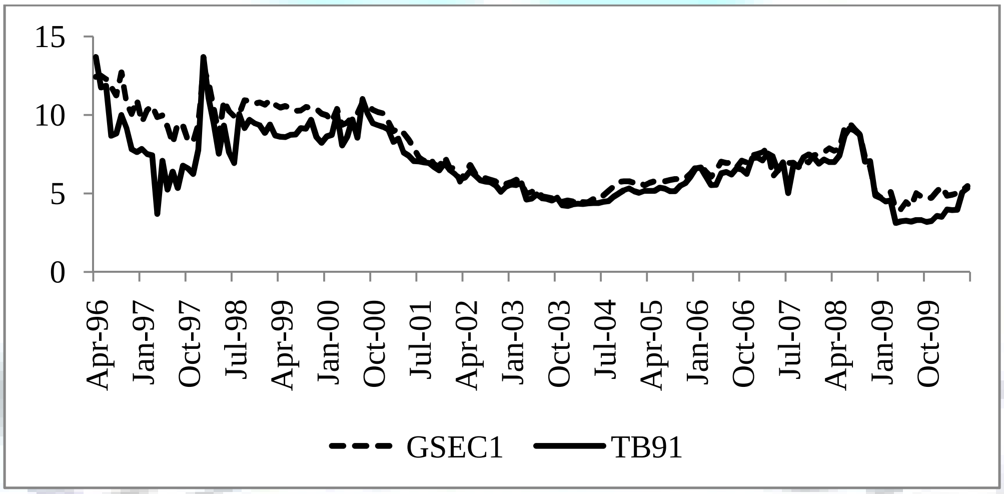


FIGURE 2: GSEC5 AND GSEC1

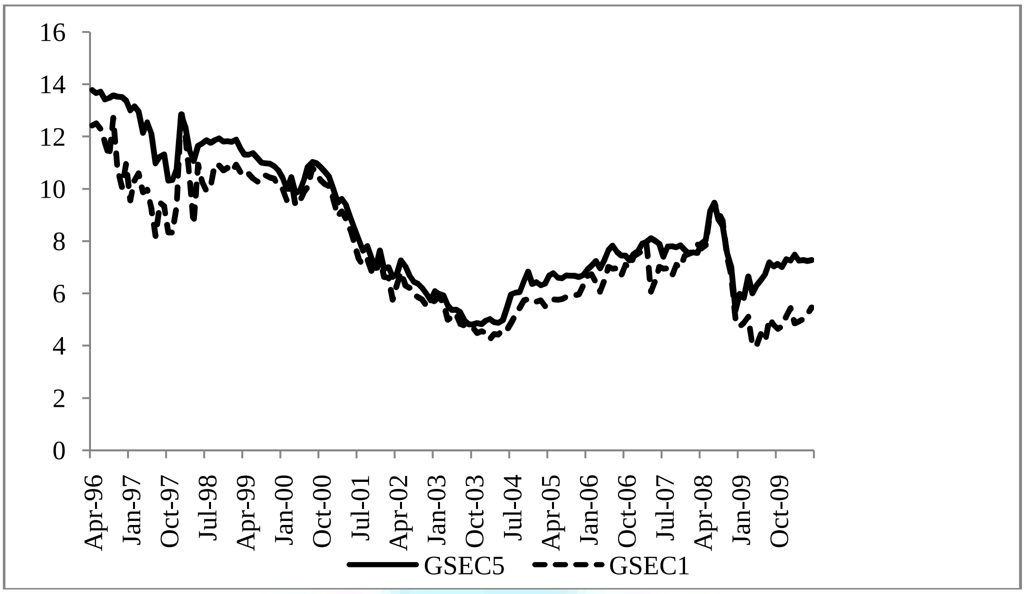


FIGURE 3: GSEC10 AND GSEC1

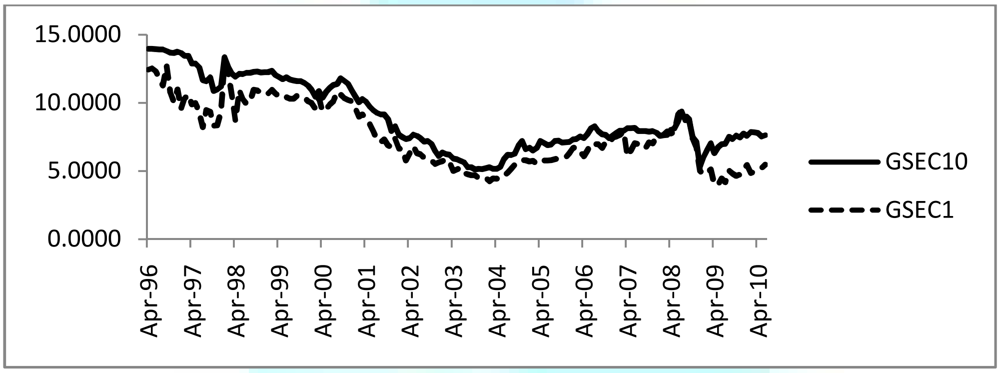
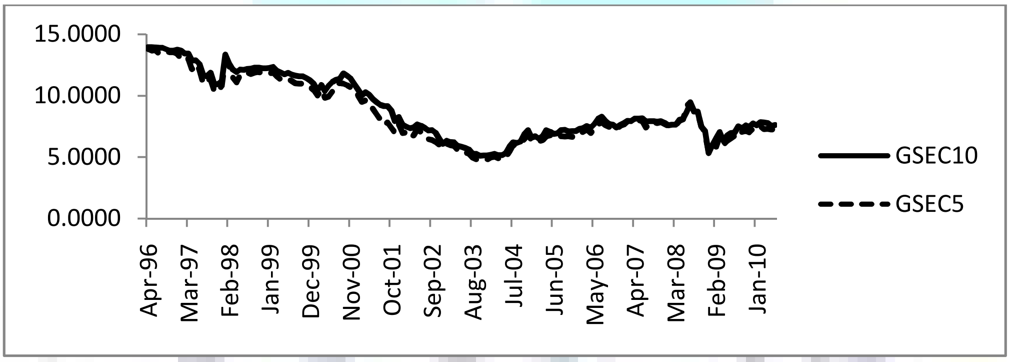


FIGURE 4: GSEC10 AND GSEC5



The figure -5 to 8 depicts co- movement between inflation and all the interest rates.

FIGURE 5: TB91 AND INFLATION

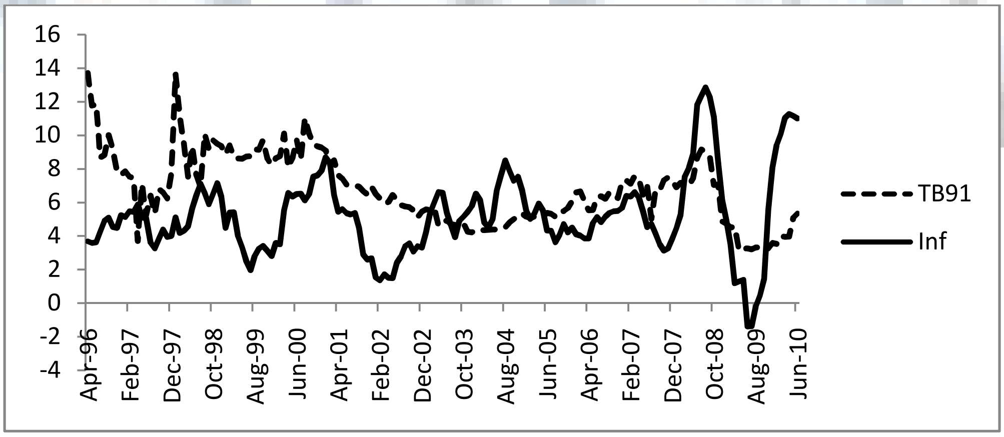


FIGURE 6: GSEC1 AND INFLATION

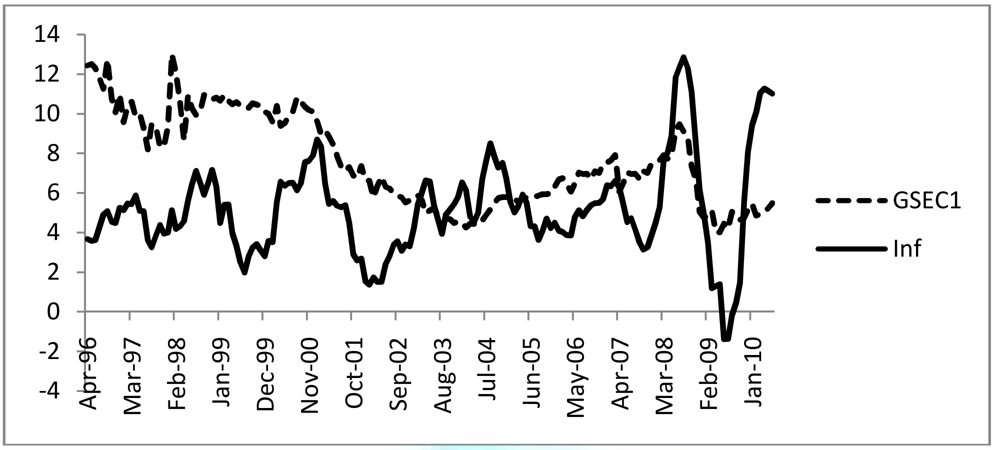


FIGURE 7: GSEC5 AND INFLATION

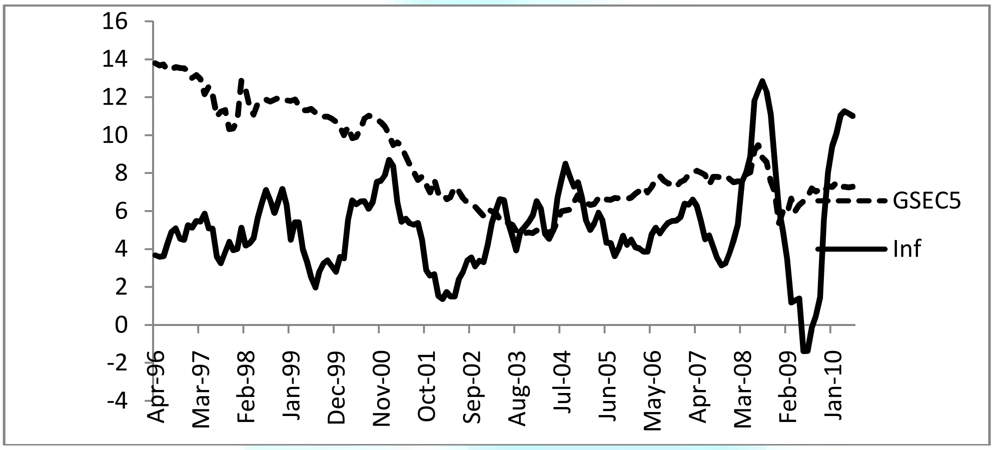
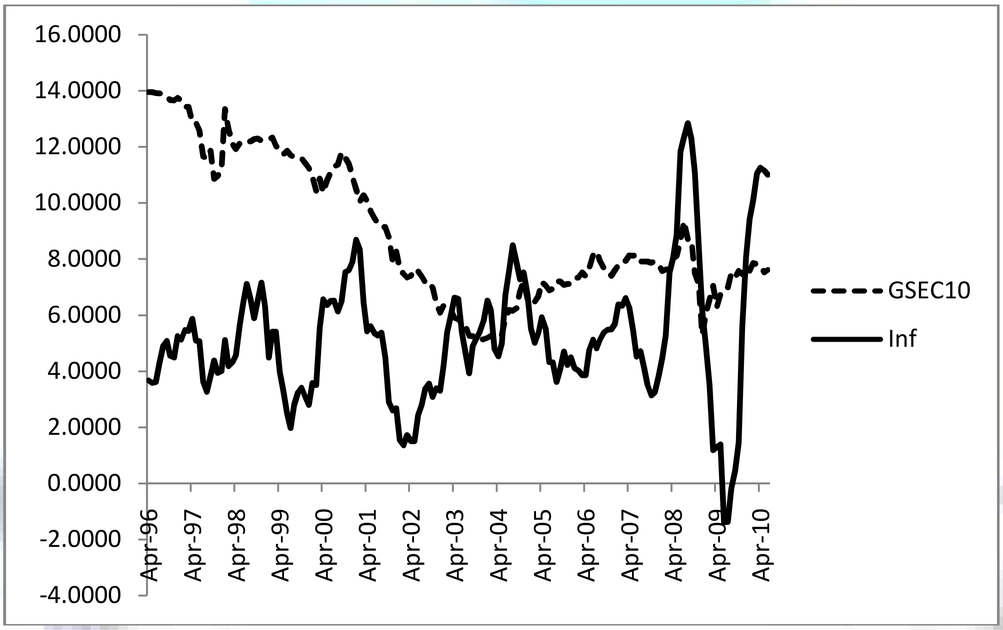


FIGURE 8: GSEC10 AND INFLATION



IV.2 RELATIONSHIP BETWEEN SHORT AND LONG TERM INTEREST RATES

The interest rates are checked for the stationarity using an Augmented Dickey-Fuller test. Table 4.1 clearly shows that the null hypotheses of unit root cannot be rejected at the levels for TB91, GSEC1, GSEC5 and GSEC10 for the period from April 1996 to June 2010. However, the results of ADF for all the series at first difference are stationary.

TABLE 4.1: UNIT ROOT TEST

Variables	Level ADF Statistic	1st difference ADF Statistic
TB91	-1.5813	-17.4938*
GSEC1	-1.4710	-9.3005*
GSEC5	-1.8037	-12.4141*
GSEC10	-1.7597	-12.9834*

*denotes significance at 5% level.

TABLE 4.2: JOHANSEN COINTEGRATION TEST FOR SHORT AND LONG TERM INTEREST RATES

Variables	Lag	Hypothesis	Eigen Value	λ_{TRACE}	λ_{MAX}
GSEC1-TB91	L=2	r = 0	0.092	18.761* (0.0037)	16.253* (0.0061))
		r ≤ 1	0.014	2.508 (0.13)	2.508 (0.13)
GSEC5-GSEC1	L=1	r = 0	0.064	13.787* (0.02)	11.346* (0.04)
		r ≤ 1	0.014	2.441 (0.13)	2.441 (0.13)
GSEC10-GSEC1	L=1	r = 0	0.076	16.183* (0.01)	13.501* (0.01)
		r ≤ 1	0.015	2.682 (0.11)	2.682 (0.11)
GSEC10-GSEC5	L=1	r = 0	0.096	20.359* (0.001)	17.241* (0.03)
		r ≤ 1	0.018	3.117 (0.09)	3.117 (0.09)

In the parentheses are p-values and *denotes significance at 5% level.

Further we designed four pairs of interest rates as long rate and short rate namely GSEC1-TB91, GSEC5-GSEC1, GSEC10-GSEC1 and GSEC10-GSEC5. To understand the cointegrating relationship across these pairs we applied *Johansen (1991)* cointegration test on these pairs and the results are provided in Table 4.2. The λ_{TRACE} and λ_{MAX} statistics indicate the presence of one cointegrating relationship exists in all of these pairs of long and short term interest rates. Further Table 4.3 shows the estimated normalized cointegrating vectors for all the cases.

TABLE 4.3: RESULTS OF COINTEGRATION SPACE

Variables	Normalized Cointegrating Vector
GSEC1-TB91	(1,-1.15)
GSEC5-GSEC1	(1,-1.15)
GSEC10-GSEC1	(1,-1.19)
GSEC10-GSEC5	(1,-1.04)

IV.3 TERM STRUCTURE OF INTEREST RATES

Let r_t be the interest rate on a one-period bond and R_t be the interest rate on a multi-period bond. As suggested by *Campbell and Shiller (1987)*, the theory of the term structure of interest rates suggests that r_t and R_t should be cointegrated with, a unit cointegrating vector. This has led to a large empirical literature estimating linear VAR models such as:-

$$\begin{pmatrix} \Delta R_t \\ \Delta r_t \end{pmatrix} = \mu + \alpha w_{t-1} + \Gamma \begin{pmatrix} \Delta R_{t-1} \\ \Delta r_{t-1} \end{pmatrix} + u_t \quad \text{.............................. (4.1)}$$

With, $w_{t-1} = R_{t-1} - \beta r_{t-1}$. Setting β =1, the error correction term is the interest rate spread. Linearity, however, is not implied by the theory of term structure. In this section, we explore the possibility that a threshold cointegration model provides a better empirical description. To address this question, we estimated threshold cointegration model of *Hansen and Seo (2002)* the short and long term interest rate pairs classified above. The lag length criterion consistently picked l=1 and l=2 across specifications. We run the threshold model for both l=1 and 2 and presented the results.

Further the threshold model is estimated for both fixing the cointegrating vector β =1 and letting $\hat{\beta}$ be estimated by the threshold model itself. For the complete bivariate specification, the SupLM test (estimated β) and the SupLM^{O} test ($\beta = 1$) with 100 grid points, and the *p*-values calculated by the parametric bootstrap. All *p*-values were computed with 15000 simulation replications. The results are presented in Table 4.4

The multivariate tests point to the presence of threshold cointegration in some of the bivariate relationships. In one of the four models, the SupLM^{O} statistic is significant at the 10% level when L=1 and β is fixed at unity. If we set L=2, the evidence appears to weakens, with none of the models is significant at 10% level. If instead of fixing β we estimate it freely, the evidence for threshold cointegration is increased, with one of four significant at the 5% level. If we set L=2, the evidence appears to strengthen, with two of the four significant at the 5% level.

TABLE 4.4: TEST FOR THRESHOLD COINTEGRATION

Long rate	Short rate	Bivariate			
		β =1		$\hat{\beta}$ estimated	
		L=1	L=2	L=1	L=2
GSEC1	TB91	0.125	0.500	0.005	0.008
GSEC5	GSEC1	0.072	0.378	0.378	0.087
GSEC10	GSEC1	0.176	0.134	0.344	0.175
GSEC10	GSEC5	0.757	0.284	0.407	0.237

Next, we report the parameter estimates for one of the relatively successful models, the bivariate relationship between the GSEC1 (360days) and TB91 (91 days). The estimated cointegrating relationship is $w_t = R_t - 1.47 r_t$, more to a unit coefficient .The results we report are for the case of estimated cointegrating vector ,but the results are very similar if the unit coefficient is imposed.

The estimated threshold is $\hat{\gamma}$ = -0.29. Thus the first regime occurs when $R_t \leq 1.47 r_t - 0.29$ i.e., when the GSEC1 is more than 0.29 percentage points below the TB91 days. This is the 'typical' regime in our study with 94 percent of observations falling in that period. The second regime with the remaining 6 percent of observations is when $R_t > 1.47 r_t - 0.29$, which we label as the "extreme" regime.

The estimated threshold VECM is given below.

$$\Delta R_t = \begin{cases} 0.29 + 0.13\, w_{t-1} - 0.13\, \Delta R_{t-1} + 0.10\, \Delta r_t + u_{1t}, & w_{t-1} \le -0.29 \\ (0.16) \quad (0.05) \qquad (0.14) \qquad (0.09) & \\ -0.01 + 0.68\, w_{t-1} + 0.47\, \Delta R_{t-1} + 0.92\, \Delta r_{t-1} + u_{1t}, & w_{t-1} > -0.29 \\ (0.14) \quad (0.52) \qquad (0.28) \qquad (0.65) & \end{cases}$$

$$\Delta r_t = \begin{cases} 0.50 + 0.23\, w_{t-1} + 0.25\, \Delta R_{t-1} - 0.22\, \Delta r_{t-1} + u_{2t}, & w_{t-1} \le -0.29 \\ (0.27) \quad (0.09) \qquad (0.17) \qquad (0.10) & \\ 0.18 - 1.04\, w_{t-1} + 0.32\, \Delta R_{t-1} - 2.09\, \Delta r_t + u_{2t}, & w_{t-1} > -0.29 \\ (0.14) \quad (0.82) \qquad (0.38) \qquad (0.99) & \end{cases}$$

Eicker-white standard errors are in parentheses. In the typical regime, ΔR_t and Δr_t have minimal error-correction effects and minimal dynamics. They are close to white noise, indicating that in this regime, R_t and r_t are close to drift less random walk.

Error-correction appears to occur only in the unusual regime (when R_t is much below r_t). There is a strong error-correction effect in the short-rate equation. In the long rate equation, the point estimate for the error-correction term is moderately large, and on the borderline of statistical significance. The remaining dynamic coefficients are imprecisely estimated due to the small sample in this regime. In this estimated model, ΔR_t and Δr_t are a function of w_{t-1}, holding the other variables constant. In this model, R_t and r_t refers to GSEC1 and TB91 respectively.

One finding of great interest is that the estimated error-correction effects are positive. A large positive spread $R_t - r_t$ means that the long term interest rate is earning a higher interest rate; so long term interest rate has a scope to readjust its value. Using linear correlation methods, *Campbell and Shiller (1991) and Campbell (1995*) found considerable evidence contradicting this prediction of the term structure theory. They found that the changes in the short rate are positively correlated with the spread, but changes in the long rate are negatively correlated with the spread, especially at longer horizons. But this finding is viewed as a puzzle. In contrast, our results are roughly consistent with this term structure prediction. In all four estimated bivariate relationships, the four error-correction coefficients (for the long and short rate in the two regimes) are positive in three cases and in one case it is significantly different from zero. As expected, the short rate coefficients are typically positive (two of four models the coefficients are positive in both regimes), and the three long rate coefficients are positive and one is negative.

IV.4 THE FISHER EFFECT

The Fisher hypothesis requires nominal interest rate (r_t) to be cointegrated with the inflation rate (π_t) with a unit cointegrating vector. In order to test for this, we estimated the following equation

$$\begin{pmatrix} \Delta r_t \\ \Delta \pi_t \end{pmatrix} = \mu + \alpha w_{t-1} + \Gamma \begin{pmatrix} \Delta r_{t-1} \\ \Delta \pi_{t-1} \end{pmatrix} + u_t \qquad \text{.. (4.2)}$$

with $w_{t-1} = r_t - \beta \pi_{t-1}$ being the error correction term. When β =1, the error correction term is the traditional fisher equation. Any other value of β would imply a partial Fisher effect. First we run the *Johansen (1991)* test of bivariate cointegration (to reject the null hypothesis of no cointegration). Then based on these results we examine for threshold cointegration between nominal interest rate and the inflation rate.

Before apply *Johansen cointegration (1991)* test we have to test for stationarity of the series. Table 4.5 shows the ADF unit root test for the inflation rate. The results of ADF test show that inflation rate is I (1) in the sample period.

TABLE 4.5 UNIT ROOT TEST

Variable	Level ADF statistic	1st difference ADF test
INF	-0.3577	-9.8768*

We examined the cointegration analysis by taking the short and long term interest with the monthly inflation rate .It shows there is one cointegration relation in each case. The test rejects the null hypotheses of no cointegration. Table 4.6 shows that there is a cointegration between INF-TB1, INF-GSEC1, INF-GSEC5, and INF-GSEC10. It shows that the fisher effect exists in Indian case in both short and long run. It refers to that inflation is related to short as well as long term interest rate. Fisher effect is partial. It is not a one-to-one relationship.

TABLE 4.6: JOHANSEN COINTEGRATION TEST FOR INFLATION AND INTEREST RATE

Variables	Lag	Hypothesis	Eigen Value	λ_{TRACE}	λ_{MAX}
INF-TB91	l=2	r=0	0.075	14.947* (0.017)	13.108* (0.023)
		r≤ 1	0.010	1.838 (0.206)	1.838 (0.206)
INF-GSEC1	l=4	r=0	0.073	16.511* (0.009)	12.651* (0.027)
		r≤ 1	0.022	3.859 (0.058)	3.859 (0.058)
INF-GSEC5	l=4	r=0	0.087	18.609* (0.003)	15.243* (0.009)
		r≤ 1	0.020	3.366 (0.078)	3.366 (0.078)
INF-GSEC10	l=4	r=0	0.090	18.901* (0.003)	15.795* (0.007)
		r≤ 1	0.018	3.106 (0.092)	3.106 (0.092)

In the parentheses are p-values. *denotes significance at 5% level

Table 4.7 shows the estimated normalized cointegrating vectors for the inflation rate and short and long term interest rates for each cases in which evidence of cointegration was found. The cointegrating relationship between Inflation and TB91 with a normalized cointegration coefficient is equal to (1,-0.82). The normalized cointegration coefficient in case of Inflation- GSEC1, Inflation- GSEC5, Inflation- GSEC10 are (1,-0.62) (1,-0.62) and (1,-0.59) respectively.

TABLE 4.7: RESULTS OF COINTEGRATING SPACE

variables	Normalized cointegrating vector
INF-TB91	(1,-0.82)
INF-GSEC1	(1,-0.62)
INF-GSEC5	(1,-0.62)
INF-GSEC10	(1,-0.59)

Table 4.8 gives the *p*-values for tests of threshold cointegration, which are calculated by a parametric bootstrap, with 15000 replications. The tests used are the SupLM test for estimated β (the cointegrating vector is estimated) and $SupLM^{O}$ for β =1 (the cointegrating vector is estimated)

TABLE 4.8: TESTS FOR THRESHOLD COINTEGRATION

Inflation rate	Interest rate	Bivariate			
		β =1		$\hat{\beta}$ estimated	
		L=1	L=2	L=1	L=2
INF	TB91	0.197	0.576	0.206	0.258
INF	GSEC1	0.082	0.439	0.188	0.288
INF	GSEC5	0.343	0.374	0.086	0.140
INF	GSEC10	0.413	0.752	0.144	0.134

In testing for threshold cointegration, we estimate equation (4.2) and then use the SupLM test (estimated cointegrated vector) and $SupLM^{O}$ test (cointegration coefficient=1), with *p*-values calculated by bootstrap. None of the bootstrap parametric values is significant in either lag specification in both cases. The result shows absence of threshold cointegration. This clearly mentions that there is no non-linearity in Fisher effect in India but there exists a linear cointegration relationship.

V. SUMMARY AND CONCLUSIONS

This section summarizes the findings with some policy implications. This study aimed at empirically validating non-linearity in term structure of interest rate and Fisher effect for India. This study has taken four interest rates and classified into four groups as short and long term interest rates. They are TB91, GSEC1, GSEC5, and GSEC10. For examining the Fisher effect, inflation is calculated from the Wholesale Price Index (WPI). The data period covers from April 1996 to June 2010. Standard unit root test suggests that all the variables are stationary at first difference. Johansen (1991) cointegration test found that there exist one cointegrating relationship in all the four pair of interest rates, GSEC1-TB91, GSEC5-GSEC1, GSEC10-GSEC1 and GSEC10-GSEC5. To examine Fisher effect, it has tested Johansen (1991) cointegration for Inflation with all the four interest rates. There exists one cointegrating relationship with inflation and all the interest rates. There is a linear relationship between inflation and interest rate. This study supports for Fisher effect in India. It confirms that Fisher effect exists in India in both short and long term interest rates. The non-linearity in interest rate is tested by Hansen-Seo (2002) threshold model in all the four pairs of interest rates. But out of these four pairs of interest rates non-linearity exists only in case of GSEC1and TB91. While there is a co-movement in inflation and interest rates in India, Threshold cointegration test clearly rejects the non-linearity in this relationship.

V.1 POLICY IMPLICATIONS

Appropriate monetary policy framed by monetary authority as desired by different circumstances of the economy has a significant impact on different economic variables such as interest rate and inflation. The current analysis has clear policy implications. For better macroeconomic performance, an understanding of the behaviour of the interest rate is crucial for a developing country like India as it affects all the sectors of the economy.

V.2 DIRECTION FOR FUTURE RESEARCH

1) Comparing the non-linearity measure of term structure and Fisher effect by threshold model with other alternative models existing in the literature will be a value addition to the literature.
2) This study can be extended by including many countries there by enabling us to examine the non-linearity in term structure of interest rate and Fisher effect in other developing and developed countries.

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APPENDIX

DESCRIPTIVE STATISTICS

The descriptive statistics and Jarque-Bera test of normality shows that all the series i.e.TB91, GSEC1, GSEC5, GSEC10 and Inflation rate are not following a normal distribution.

FIGURE A: DESCRIPTIVE STATISTICS OF TB91

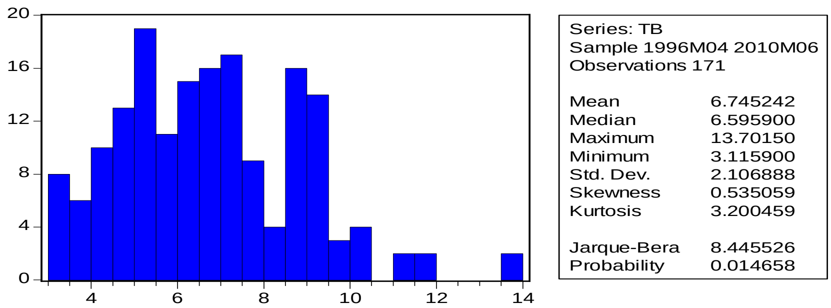


FIGURE B: DESCRIPTIVE STATISTICS OF GSEC1

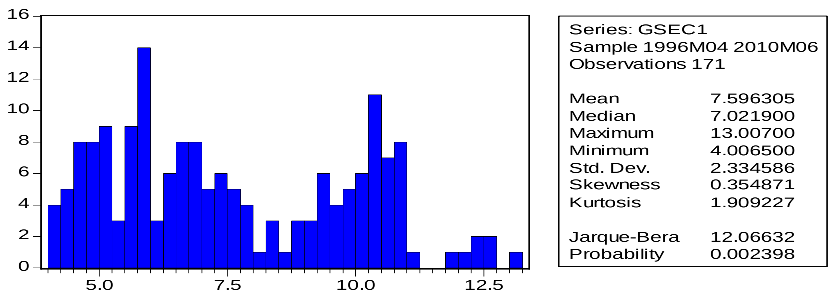


FIGURE C: DESCRIPTIVE STATISTICS OF GSEC5

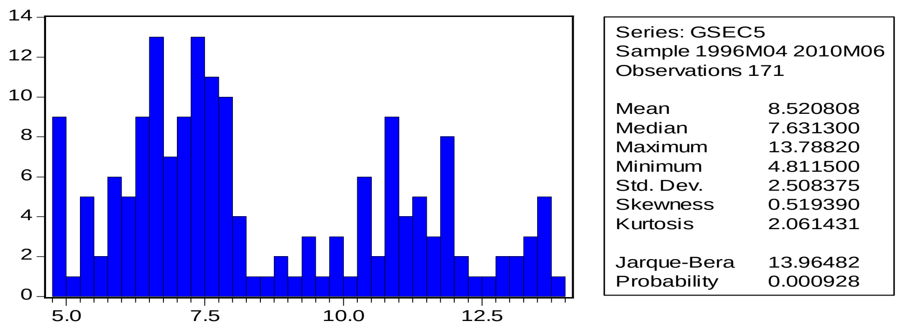


FIGURE D: DESCRIPTIVE STATISTICS OF GSEC10

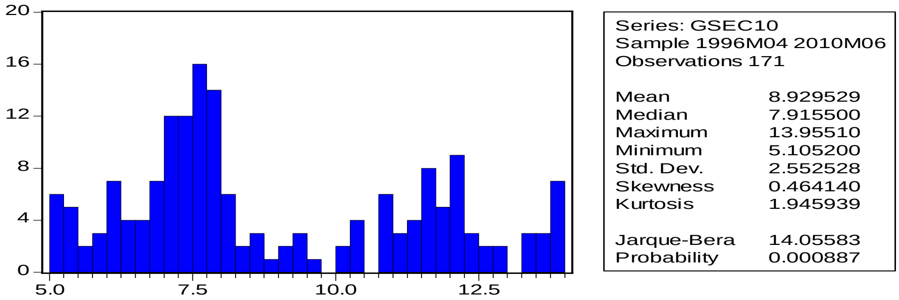
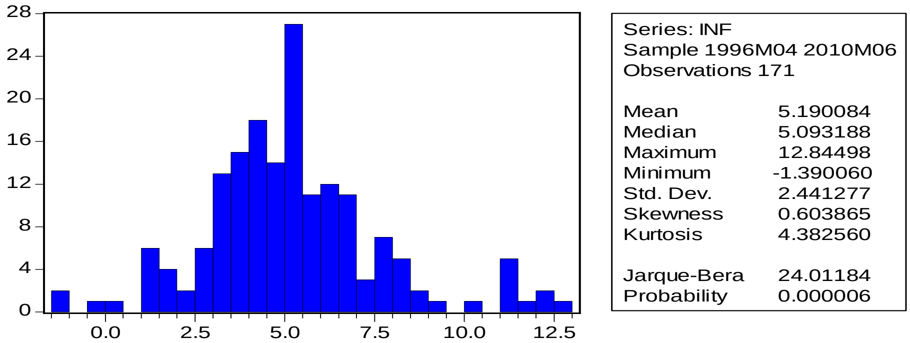


FIGURE E: DESCRIPTIVE STATISTICS OF INFLATION RATE



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