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An Impact of Anticipated Inflation On Short–Term Interest Rates

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Abstract: The study "influence of anticipated inflation on short term interest rates" is done with an intention to understand the impact of inflation in the short run over the interest rates. The objective of the study is to characterize the relationship between anticipated inflation changes and nominal rates of interest, secondly to co integrate between Inflation and nominal interest rates and thirdly to regress the short term interest rates of treasury bill and government of India yields, correlation and regression analysis is used to obtain the outcome along with ADF and Co integration test. The outcome is to regress the short term Interest rates.
Keywords: ADF, Co integration, Nominal Interest rates, Treasury bill and Government of India yields

Introduction:

Inflation is an increase in the amount of currency in circulation, resulting in a relatively sharp and sudden fall in its value and rise in prices. It may be caused by the increase in the volume of paper money issued or of gold mined, or a relative increase in expenditures as when the supply of goods fails to meet the demand. This definition includes some of the basic economics of inflation and would seem to indicate that inflation is not defined as the increase in prices but as the increase in the supply of money that causes the increase in prices i.e. inflation is a cause rather than an effect.

Measures of Inflation

Two most widely used price indices are 'consumer price index 'and 'wholesale price index'.

Consumer price index:

It is the annual percentage change in the cost of acquiring a fixed basket of goods and services. There are four different types of consumer price index released for different levels of working class in the country viz.

consumer price index for urban non manual employee, consumer price inflation for agriculture laborers, consumer price index for industrial workers, and consumer price inflation for rural laborers. Different governmental and monitoring agencies use these indices for their purpose. These indices also form the basis of decisions regarding the dearness allowance for the government employees.

Wholesale price index:

This is the index that is used to measure the change in the average price level of goods traded in wholesale market. A total of 435 commodities data on price level is tracked. The Wholesale Price Index (WPI) is the most widely used price index in India. It is the only general index capturing price movements in a comprehensive way. It is an indicator of movement in prices of commodities in all trade and transactions. It is also the price index which is available on a weekly basis with the shortest possible time lag only two weeks. It is due to these attributes that it is widely used in business and industry circles and in Government, and is generally taken as an indicator of the rate of inflation in the economy. It is imperative that the index is put on as sound a footing as possible.

Calculation of inflation rate:

$$\text{Rate for Inflation for year t} = \frac{\text{PIN t} - \text{PIN t-1}}{\text{PIN t-1}} * 100$$

Where, PIN t is index for year t

PIN t-1 is index for previous year.

Irving Fisher(1930) provided the relationship between the expected inflation and interest rates. Fisher's doctrine is that nominal interest rate can be taken as the sum of real rate of interest and inflation anticipated by the market. Fisher's hypothesis is that the nominal interest rate(rt) can be taken to be the sum of real rate of interest (pt) and the rate of inflation anticipated by the public(πt). $rt=pt + \pi t$

This means, the real interest rate equals the nominal rate minus inflation therefore, if rt rises, so must πt, if you assume pt to be constant. If an economic theory or model has this property, it shows the Fisher effect. The relationship between inflation and nominal interest rate and real interest rate put in simple words is;

Real interest rate= Nominal Interest Rate - Inflation Rate

Nominal Interest Rate= Real interest Rate +Inflation Rate

Literature Review

Thomas J Sargent [i] in his work *"Anticipated Inflation and the Nominal Rate of Interest"* proposed his work to estimate whether the Fisher's equation $r_t = a + \Pi_t + e_t$ [1] can in general be taken to characterize correctly the relationship between inflation and nominal rate of interest. In his studies he studied the relationship between the r_t (nominal rate of interest) and Π_t (rate of inflation at time t) within the context of simple linear dynamic macroeconomic model. The model used is a Keynesian in structure and has assigned important roles to price level adjustments and anticipations of inflation effects frequently emphasized by monetarists. The factors that determine the appropriateness of above said equation were the same factors that within the standard IS-LM framework determine the relative short-term potency of money and fiscal policy in affecting the level of aggregate output.

William E Gibson[ii] in his study *"Interest rates and Inflationary Expectations: New Evidence"* alleviates the need to test the market determining the interest rates using directly observed data on price expectations. Gibson's work made use of the data of Joseph Livingston[2] for the period of 1952 to 1970 for measuring the Fisher's hypothesis. In his studies Gibson used the Joseph Livingston data for constructing expected rates of price changes, which were related to market interest rates. Gibson used US treasury securities to measure market interest rates. He considered five different maturity categories of Us Treasury bills ranging from 3 month bills to 10years and longer term to maturity bond along with market yields. Estimates for 6 month and 12 month expected rates of inflation indicated a strong association between interest rates and measures of expectations. Interest rates have shown quick response to changes in expectations.

Leiderman's [iii] study succeeded Eugene Fama's study on Fisher's theory. In his paper titled *"Interest Rates as Predictors of Inflation in a High-Inflation Semi-Industrialized Economy"* suggests that Fama's findings which are based on inflation where inflation has been mild and so has been at variability through time.

Liderman's study aimed at emphatically assessing the role of interest rates as the predictors of inflation in different settings, one characterized by the co-existance of the high and volatile inflation and of less than well developed financial markets. Thus he selected the markets of Argentina for the same and used the data for period of 1964-1976. he supported the selection of Argentina as it is a semi-industrialized country, less than well developed financial market which have experienced relatively high degree of government intervention, which probably impair the operational efficiency of capital market as well as prediction of interest rates.

Alexander B . Holmes and *Myron L. Kwast* [iv] in their paper *"Interest Rates and Inflationary Expectations: Tests for Structural Changes 1952-1976"* studied the relationship between the nominal interest rates and anticipated inflation rates during the structural changes i.e. during the period 1952-1976 in the US economy. Holmes and Kwast used Brown-Durbin tests for structural stability, for the data used and the results indicated were found significant. In their analysis Holmes and Kwast used CPI data, short term Treasury bill data and expected prices were constructed from Livingston survey, for the analysis. Their analysis found that there was radical upward shift in size of the coefficients at the estimated period and immediately after the period of estimated structural change, which confirms that market rates adjust more strongly to inflationary expectations in the late 1960s and thereafter than they had before. And also interest rates are estimated not to adjust to inflationary expectations before the period of structural change, but to make a significant positive adjustment after the estimated shift.

Hakan Berument (1999) Inflation uncertainty may affect interest rates. In their paper, they made an effort to understand the effect of conditional variability into the Fisher equation. They have identified positively affects conditional variability on the Treasury-bill rate (UK three-month). Like many previous studies, this paper also confirmed the long-run relationship among the t-bill rate, expected inflation and inflation risk. Author established that higher inflation risk increases the interest rates.

Fountas, S. (2000) UK Inflation data in time series from 1885 to 1998 was used to find the relationship between inflation uncertainty and inflation output. Paper established a positive relationship between inflation uncertainty and lower output.

Amihud Dotan 1979 - The Effect of Price Level Uncertainty on the Determination of Nominal Interest Rates - Taking expected inflation as an independent variable to find the impact on nominal interest rate, study revealed positive partial correlation. Survey of leading economist and Yields on treasury bills data from Federal Reserve from 1959 to 1974 used in this study. Research paper used Price expectations to measure of price level uncertainty. Panel data study showcased price expectation has a significant partial effect on interest rates.
E F Fama in his paper " Short-Term interest rates as a predictors of inflation" observed positive relationship between nominal interest rate (bond market of one to six month) and information available on the future inflation rate during 1953-71.

Michael Debabrata Patra and Partha Ray in their paper "Inflation Expectations and Monetary Policy in India: An Empirical Exploration" paper state they found that the "real interest rate has a significant effect on people's anticipations, outweighing the effects of fiscal policy or even exchange rate changes". Monetary policy is heavily dependent on inflation expectations. This paper stresses the importance of general expectation of people's and its impact on success of a monitory policy of country, we observe the same in their quote "The effectiveness of monetary policy is likely to be greater if inflation expectations remain anchor".
M. Thomas PAUL in his study "INTEREST RATES AND THE FISHER EFFECT IN INDIA An Empirical Study" found a positive relationship between nominal interest rate and inflationary expectations for both short term and long term interest rates in India. To test the hypothesis, 1952 to 1977 data on Call Money Rate (CMR), Bazar Bill Rate (BBR), and as long-term rate the 12-month Time Deposit Rate (TDR) are used.

Purpose of the Study

The effects of expected inflation on market interest rates have been of great concern for decades. Irving Fisher's description of interest rates relationship with expected inflation is convincing on the theoretical levels.

I. Fisher's doctrine holds that the nominal interest rate(r_t) can be taken to be the sum of real rate of interest (p_t) and the rate of inflation anticipated by the public (π_t).
Thus Fisher's equation as proposed by him is $r_t = p_t + \pi_t$ (1)
In his works Fisher and group assume that real rate of return (p_t) is unaffected by the change in anticipated inflation rate (π_t). Thus one can conclude that the term p_t (real rate of return) in equation (1) is a constant and stochastic term e_t hat is uncorrelated with π_t.
symbolically
$p_t = a + e_t$ (2)
Where e_t represents numerous factors affecting r_t, which are not included in 'a' or π_t. From both the equations we can rewrite the equation (1) as follows
$r_t = a + e_t + \pi_t$ (3)
The purpose of this paper is to establish whether equation (3) can in general be taken to characterize correctly the relationship between anticipated inflation changes and nominal rate of interest.

Scope of the Study

Inflation hampers the living conditions of Indians by affecting the purchasing power through the variations in the Interest rates. The scope is hence confined to Indian Inflation and interest rates.

Study Objective

- To characterize the relationship between anticipated inflation changes and nominal rates of interest.
- To study the stationarity and to co- integrate between Inflation and Nominal Interest Rates.
- To regress the Interest rates through Inflation conditions in the economy.

Statistical Method

Correlation and regression analysis will be made use in order to analyze the relationship between interest rates and inflation. Regression and correlation analysis show us how to determine nature and strength of relationship between two variables. We need to find out the causal relationship between changes in interest rate to the changes in inflation. Regression analysis shows the relationship between the variables and correlation shows the degree of relationship between the variables.

The regression equation is given as follows
$Y = a + b (X)$
Where, Y is dependent variable, the value which is dependent on changes in X. X is the independent variable 'a' is the Y intercept, the value of Y is the value at which regression line crosses the Y –axis.

Analysis & Interpretation

Long Term Yield:

The redemption yields of the Government of India Securities are takes as proxy for long term yields. The data is collected for every month from Oct 1998 to Apr 2007. This data is tested for stationary.
H0: There is a unit root for the series.
Ha: There is no unit root for the series. The series is stationary.

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Augmented Dickey-Fuller Unit Root Test on RATES

Null Hypothesis: RATES has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=4)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.177054	0.0368
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0 and accept the alternative hypothesis Ha. The risk to reject the null hypothesis H0 while it is true is lower than 0.05%.

Interpretation of ADF test: For long-term series (long-term yields) The computed ADF test statistic(-3.177054) at none, critical values (-3.808546) @1%, (- 3.020686) @ 5% level, (-2.650413) @ 10% level. The probability (0.0368) is less than (0.05) Thus the hypothesis is rejected for unit root; the data for long-term series is stationary. It is clear that data has passed the Dickey –Fuller test and we can continue further tests.

Interpretation of Co-integration test: The co-integration test for series Y at 1 to 1 lag intervals has critical value of 3.841466 @ 0.05% Which leads to rejection of the hypothesis Ho which says no co-integration exists, thus the result indicates the co-integration of both the series X and Y.thus the existence of co-integration further supports the study methodology.

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JOHANSEN COINTEGRATION TEST

Date: 04/18/17 Time: 10:38
Sample (adjusted): 1982 2017

Included observations: 36 after adjustments

Trend assumption: Linear deterministic trend

Series: RATES

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
No. of CE(s)	0.165075	6.49487	3.84147	0.0108

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized	Eigen value	Max Eigen Statistic	0.05 Critical Value	Prob.**
No. of CE(s)	0.165075	6.49487	3.84147	0.0108

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

RATES

0.39597

Unrestricted Adjustment Coefficients (alpha):

D(RATES) 1.140174

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Short Term Yield

The 91 day treasury bill yield from Oct 2006 to Apr 2015 is taken as the short term yield. This data is also tested for stationarity.

H0: There is a unit root for the series.

Ha: There is no unit root for the series. The series is stationary.

Augmented Dickey-Fuller Unit Root Test on RATES

Null Hypothesis: RATES has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=4)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.177054	0.0368
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0 and accept the alternative hypothesis Ha. The risk to reject the null hypothesis H0 while it is true is lower than 0.05%.

Interpretation of ADF test: *For long-term series(long-term yields)* The computed ADF test-statistic (-3.177054) at none, critical values (-3.808546) @1%, (-3.020686) @ 5% level, (-2.650413) @ 10% level. The probability (0.0368) is less than (0.05) Thus the hypothesis is rejected for unit root; the data for long-term series is stationary. It is clear that data has passed the Dickey –Fuller test and we can continue further tests.

Date: 04/19/17 Time: 09:09

Sample (adjusted): 1998 2017

Included observations: 20 after adjustments

Trend assumption: Linear deterministic trend

Series: RATES

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.229585	5.21653	3.84147	0.0224

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

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Unrestricted Cointegration Rank Test(Maximum Egile Value)				
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.229585	5.216531	3.841466	0.0224

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):
RATES
0.39597

Unrestricted Adjustment Coefficients (alpha):	
D(RATES)	-0.649874

Interpretation of Co-integration test: The co-integration test for series Y at 1 to 1 lag intervals has critical value of 3.841466 @ 0.05% Which leads to rejection of the hypothesis Ho which says noco-integration exists, thus the result indicates the co-integration of both the series X and Y.thus the existence of co-integration further supports the study methodology.

Short Term Yield : The 91 day treasury bill yield from Oct 2006 to Apr 2015 is taken as the short term yield. This data is also tested for stationarity.

H0: There is a unit root for the series.
Ha: There is no unit root for the series. The series is stationary.

Augmented Dickey-Fuller Unit Root Test on D(RATES)

Null Hypothesis: D(RATES) has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=4)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.235089	0.0001
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0 and accept the alternative hypothesis Ha. The risk to reject the null hypothesis H0 while it is true is lower than 0.05%.

Interpretation of ADF test: *For short-term series (Short-term yields)* The computed ADF test-statistic(-6.235089)at none, the critical values (-3.808546) @1%, (-3.020686) @ 5% level,(-2.650413) @ 10% level. The

probability (0.0001) is less than (0.05) Thus the hypothesis is rejected for unit root; the data for short-term series is stationary. It is clear that data has passed the Dickey –Fuller test and we can continue further tests.

Interpretation of Johansen Co-integration test: The co-integration test for series Y at 1 to 1 lag intervals has critical value of 3.841466 @ 0.05% Which leads to rejection of the hypothesis Ho which says no co-integration exists, thus the result indicates the co-integration of both the series X and Y. thus the existence of co-integration further supports the study methodology.

Inflation:
H0: There is a unit root for the series.
Ha: There is no unit root for the series. The series is stationary.

Augmented Dickey-Fuller Unit Root Test on RATES

Null Hypothesis: RATES has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=9)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.140240	0.0321
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0 and accept the alternative hypothesis Ha. The risk to reject the null hypothesis H0 while it is true is lower than 0.05%.

Interpretation of ADF test: *For Inflation Rate series :* ThecomputedADFtest-statistic(-3.140240)atnone,isthecriticalvalues (-3.621023) @1%, (-2.943427) @ 5% level,(-2.610263) @ 10% level. Thus the hypothesis is rejected for unit root; the data for inflation rate series is stationarity. It is clear that data has passed the Dickey –Fuller test and we can continue further tests.

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Date: 04/18/17 Time: 10:38

Sample (adjusted): 1982 2017

Included observations: 36 after adjustments
Trend assumption: Linear deterministic trend

Series: RATES

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigen value	Max Eigen Statistic	0.05 Critical Value	Prob.**
None	0.165075	6.494869	3.841466	0.0108

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test(Maximum Egile Value)				
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.165075	6.494869	3.841466	0.0108

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):
RATES
0.39597

Unrestricted Adjustment Coefficients (alpha):	
D(RATES)	-1.140174

Interpretation of Johansen Co-integration test: The co-integration test for series Y at 1 to 1 lag intervals has critical value of 3.841466 @ 0.05% Which leads to rejection of the hypothesis Ho which says no Co-integration exists, thus the result indicates the co-integration of both the series X and Y. thus the existence of co-integration further supports the study methodology.

TESTING OF STATIONARITY

To start with, the stationarity of Long term yield, short term yield and inflation rates are tested using the Augmented Dickey fuller test.

The results of the test carried for first difference, lag 0 for *Long term yields* are as follows.

ADF Test Statistic	-3.17705	1%	Critical Value*	-3.8085
		5%	Critical Value	-3.0207
		10%	Critical Value	-2.6504

Interpretation

The data is stationery at 5% critical value for long term yields.The results of test carried for first difference, lag 0 for *Short term yields* are as follows;

ADF Test Statistic	-6.2351	1%	Critical Value*	-3.8085
		5%	Critical Value	-3.0207
		10%	Critical Value	-2.6504

Interpretation: The data is stationary at 5% critical value for short-term yields.

The results of test carried for first difference, lag 1 for *inflation* are as follows;

ADF Test Statistic	-3.1402	1%	Critical Value	-3.621
		5%	Critical Value	-2.9434
		10%	Critical Value	-2.6103

Interpretation: Inflation rates are stationary at 5% critical value.

Since long term yield, short-term yield and inflation data series are proved to be Stationary by using ADF test. The series is proved to be stationary then it can be said that a relationship exists between interest rates and inflation over a long term and short-term.

Summary of Findings & Suggestions

Findings

1. The main purpose in this study tries to find out the effect of real GDP, interest rate and inflation on real economic growth in India. Study had adopted a set of economic tools such as: Unit root, Co-integration test, Regression analysis, Augmented Dickey Fuller (ADF) test,.
2. In order to obtain accurate results, researchers had to analyse the relationship between macro-economic factors which are: interest rate, inflation rate, GDP, and real growth rate.
3. From unit root method, the study adopted ADF unit root to test the results that all of variables were belonging to I (1) structure and lag length in interest rate was 0, inflation rate was 3, GDP was 1, and real growth rate was 0.
4. Co integration tests: the study adopted co integration test to examine whether the five variables had long term equilibrium relationship.
5. The findings indicated that all the variables in this test had significant existence in co integrated vector. This means that all the variables had long term equilibrium existence. Meanwhile interest rate and real growth rate had feedback relation existence.
6. However, this study proved that interest rate and real growth rate have interdependent lead and lag relationship. Regression shad tested variables' relations and had indicated one and two lags of inflation rates which influenced current interest rate and one lag of GDP had influenced power to current interest rate.
7. However testing the regressions indicated that interest rate and inflation rate had some kind of relations. Meanwhile interest rate and real growth rate had feedback relation existence.
8. One thing was proved by this study that interest rate with real growth rate have lead and lag relationship with each other. From the regressions of testing those variables; relations indicated one and

two lag of inflation rate had influenced the current interest rate and one lag of GDP also had certainly influenced the power of current interest rate.

9. However some regression tests indicated that interest rate and inflation rate had Indian Economic and Financial Review, and some kinds of relations; one or two lag of inflation rates had shown significant power to explain interest rate.
10. However some regression tests indicated that interest rate and inflation rate had Indian Economic and Financial Review, and some kinds of relations; one or two lag of inflation rates had shown significant power to explain interest rate.
11. Next, we check the stationarity of the residuals obtained. If the residuals are stationary, then the two variables are said to co-integrate with each other. i.e., there exists a relationship between inflation and long-term interest rates.

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