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## Fisher Effect: An Empirical Re-examination in Case of India

Masudul Hasan Adil
*Mumbai School of Economics and Public Policy (Autonomous), University of Mumbai*

Shadab Danish
*University of Hyderabad*

Sajad Ahmad Bhat
*University of Hyderabad*

Bandi Kamaiah
*University of Hyderabad*

## Abstract

This study examines the Fisher's hypothesis by utilizing the dataset on India's macroeconomic variables with the objective to check whether long-run empirical relationship between the nominal interest rate and inflation expectation exists. To this end, study is conducted on monthly data from Jan-1993 to Mar-2015 by utilizing the autoregressive distributed lag model or bounds testing approach developed by Pesaran, Shin, and Smith (2001). The bounds testing is applied to analyze the co-integration and short-and long-run relationship among variables, for a different combination of the Fisher hypothesis. The present study concludes the existence of a long-run relationship between Treasury bill and expected inflation (estimated by WPI), with a long-run coefficient equal to 0.54, implying partial Fisher effect. While the long-run relationship does not exist between Treasury bill and expected inflation (estimated by CPI). Similarly, long-run relationship although not of one to one in nature, between call money rate and expected inflation (estimated by WPI), is found with a coefficient equal to 0.51; but not for any another combination. The implication of the result shows that the market interest rate is a good indicator of inflationary expectations (i.e. WPI). And the conduct of monetary policy is responsible for favoring the partial Fisher's effect in India.

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**Contact:** Masudul Hasan Adil - adilmasood.alig@gmail.com, Shadab Danish - say2danish@gmail.com, Sajad Ahmad Bhat - sajadeco@gmail.com, Bandi Kamaiah - kamaiahbandi@gmail.com.
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# Fisher Effect: An Empirical Re-examination in Case of India

Shadab Danish
*University of Hyderabad*

Masudul Hasan Adil
*Mumbai School of Economics and Public Policy*

## *Abstract*

Interest rate is a key financial variable, which affects almost all sectors of an economy. This study examines the long-run relationship between the nominal interest rate and inflation expectation in the case of India. The 91-days TBR and CMR are used as a measure of interest rate, while WPI and combined CPI for industrial workers are used for calculating inflation expectation. The expectation is calculated using rational expectation approach. The study is conducted for monthly data from Jan-1993 to Mar-2015 by utilizing the autoregressive distributed lag model (ARDL) or bounds testing approach to co-integration developed by Pesaran, Shin and Smith (2001). The ARDL technique is applied to analyze the co-integration and short-and long-run relationship among variables, for a different combination of the functional form of the Fisher hypothesis. Study finds a long-run relationship between TBR and WPIE, with a long-run coefficient equal to 0.54, implying partial Fisher effect. While the long-run relationship does not exist between TBR and CPIE. Similarly, long-run relationship although not of one to one in nature, between CMR and WPIE, is found with a coefficient equal to 0.51; but not for any another combination.

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# 1. Introduction

The one to one relationship between the nominal interest rate and expected inflation is established by Irving Fisher in his famous work '*the theory of interest'* (1930). This Hypothesis is popularly known as Fisher's effect or Fisher's equation (used interchangeably). Fisher's hypothesis, in the long-run, implies monetary super-neutrality and no money illusion. On the other hand, if there exists less than the proportional relationship between the nominal interest rate and expected future inflation, then this would entail partial money illusion which is commonly termed as the Fisher's effect puzzle in the relevant literature. The real interest rate is an important determinant of the saving and investment and therefore any increase in the expected inflation may cause serious economic problems in the absence of Fisher's hypothesis (Deutsch Bundesbank Report, 2001). The holding of Fisher's effect states that the conduct of monetary policy by the central bank is active i.e. there is an immediate policy rate response due to a change in inflation. Therefore, one may conclude that the monetary policy rate is sensitive to the inflation expectation. Another important implication of Fisher's effect is that market interest rates are good indicators of inflationary expectations (Christopoulos, 2007). To have better visibility and predictability of inflation, one of the implicit assumptions of this relationship is the market-determined interest rate structure, which is possible in the developed countries. However, in the underdeveloped economies where the interest rate is administered or regulated the expected inflation and nominal interest rate may or may not move at the same pace. In India, the market interest rate was deregulated in early 1990 which played an important role in the macroeconomic transmission mechanism. This brings to an interesting question of whether Fisher's hypothesis holds in the post-liberalization period.

In the backdrop of the above discussion, two major studies that have focused on India came up with two different conclusions. Nachane (1988) covers the data for the pre-reform period visibly in the early 1990s and the conclusion is drawn in his study may not hold well in the current liberalized era. Another study made by Anoruo et al. (2000) where they utilized cointegration analysis, which can seriously be questioned on the ground that inflation and interest rate may not have same order of integration as inflation has been tested by many as a long memory process (for instance Bhanumurthy, 2003 quoted Bekdache and Baum, 2000). Consequently, the motivation of this research is based on the fact that the literature with regards to the Indian economy, in particular, is very small.

This study is designed in the post-liberalization period where a number of economic events took place globally as well as domestically. The structural adjustment of 1991 is considered a watershed moment in the Indian economy. The 1990s liberalization helped the country to survive both fiscal as well as external accounts crisis smoothly. In the post-liberalization, the Indian economy enjoyed a high economic growth rate for almost a decade until the economic crisis burst up. During the financial crisis, the Indian economy faced many setbacks to a certain extent. The global financial crisis of 2008 slowed down the activities in the country. However, the various types of fiscal stimulus helped the Indian economy to stand firm even when the world was facing severe economic challenges after the financial crisis. The extent and recovery timing among the countries varied because the reaction to various economic indicators and transmission mechanisms of policy initiatives were different. According to Bhanumurthy and Kumawat (2009), India's GDP growth started slowing down much before the global financial crisis because of its structural bottlenecks. One cannot deny the fact that financial reforms in India strengthen the credit-GDP ratio; the way it helped in the overall development in the long run. Bhanumurthy and Kumawat (2009) estimate the financial crisis impact on the growth rate. They find that fiscal and monetary policy changes influenced aggregate demand only in the short and medium terms. In the post-financial crisis period, the Indian economy faced persistent high headline inflation. Along with this, the current account deficit (CAD) was also widening. Consequently, the Reserve Bank of India (RBI) was not able to adopt an easy monetary policy. The growth rate of broad money has been declining in the post-crisis period. This was mainly because of the sharp decline in the demand conditions due to high inflation (Bhanumurthy, 2014). In a study on the policy analysis of the post-crisis period, Bhanumurthy (2014) explains why RBI adopted a tight monetary policy which also seems to more appropriate policy measure in the given circumstances. In the given situation, the present study tries to explore the Fisher's idea of one to one relationship between the nominal interest rate and inflation leaving real interest rate unaffected.

Furthermore, there are several issues in the estimation of Fisher's effect at an empirical level. As mentioned by Abubakar et al. (2017), one of the issues related to the Fisher's effect is, when one of the variables is integrated of order one and the other is integrated of order zero, which implies that one variable is level stationary while other is differenced stationary. It is a well-known case, as inflation usually appears to be level stationary while nominal interest is differenced stationary. The modeling of this case empirically had remained problematic until the introduction of the autoregressive distributed lag model (ARDL) or bounds testing approach to co-integration developed by Pesaran et al. (2001).

By overcoming these limitations, the present study examines the Fisher's hypothesis using India's data on macroeconomic variables with the objective of ascertaining the empirical relationship between the nominal interest rate and expected inflation. To this end, the study employs the ARDL technique to co-integration, which depicts the cointegration amongst variables under study; in turn, Fisher's hypothesis holds well in the case of India. Further parameter stability is also tested by utilizing the CUSUM test. The paper is structured as follows: Section 2 discusses the existing empirical literature that concentrated primarily on verifying Fisher's hypothesis along with Fisher's own conclusions. Section 3 deals with data description and methodology. Section 4 discusses the empirical results. Section 5 concludes the paper.

## 2. Review of literature

Lack of any direct measure of inflationary expectations is a major problem that arises when testing for Fisher's hypothesis. For this reason, a proxy variable for inflationary expectations must be employed. Over the years, a number of approaches have been used to derive proxies for the expected rate of inflation. The majority of early studies on Fisher's effect used some form of distributed lag on past inflation rates to proxy for inflationary expectations including Fisher (1930) himself. He used annual data for the period 1890-1927 in the U.S, and 1820-1924 in the U.K. He found that inflationary expectations were not instantaneously reflected in interest rates. However, the long term interest rate and inflation were correlated with the magnitude of 0.86 in the U.S. with a price lag of 20 years. While for the U.K, a correlation coefficient of 0.98 was obtained when price changes were spread over a period of 28 years. In later years, many scholars such as Cagan (1956), Meiselman (1962), and Sargent (1969) validated Fisher's effect. Further, Muth (1961) and Fama (1970) developed an alternative approach to model expectation by using the rational expectation hypothesis.

The inflation rate is one of the crucial factors in the analysis of monetary policy, investment evaluation and intertemporal decision making. Anari and Kolari (2019) find that inflation and interest rates have a causal relationship and the estimated coefficients in the ex-post Fisher's equation are mixtures of Fisher and Wicksell effects. Furthermore, they relax the fixed coefficients of overtime conditions to estimate the ex-post Fisher and Wicksell equation effects with time-varying coefficients. The empirical results supported Fisher's original ideas that there is one to one relationship between inflation and interest rate and ex-ante real rates are positive and relatively stable over time. Crowder and Hoffman's (1996) study holds Fisher's relation without considering any changes in the dynamics of inflation over the sample period. They applied Johansen's reduced-rank estimation approach to deal with non-stationary data in a multivariate setting. This study was different from others (such as Mishkin 1992 or Evans and Lewis 1995) because the normalization of cointegration space is carried out after the cointegration estimates. Jansen (2009) supports the long-run Fisher's effect that changes in inflation lead to an equal chance in the nominal interest rate. One of the important take-ups away from his study is the long-run Fisher's effect cannot be tested with the reduced form approach. Koustas et al., (1999) conduct a study using post-war quarterly data on Belgium, Canada, France, Germany, Greece, Ireland, Japan, Netherlands, the United Kingdom, and the United States. The finding of this study corroborates with most of the literature on Fisher's hypothesis, which mostly shows that there is less than one to one relationship between inflation and nominal interest rate. Lnnee and Markku (2006) introduce a non-linear bivariate mixture of the autoregressive model to investigate the relationship between inflation and interest rate on U.S. quarterly data from 1953 to 2004. They find stationary of real interest rate which sounds contrary to many previous studies. However, it follows economic theory.

Fisher's hypothesis in the past has investigated the orders of integration of Fisher's equation. However, the ex-post data can be a noisy indicator of ex-ante variables. Therefore, conventional semi-parametric estimation by using ex-post data is criticized on the ground that it underestimates the true degree of persistence in the ex-ante variables. Sun and Phillips (2004) use bivariate exact Whittle estimator to test Fisher's equation. The result is based on the new estimator, which supports Fisher's hypothesis. However, the result does not support in the long run. Maki (2005) investigates the Fisher's hypothesis in Japan using a threshold cointegration test, which allows for asymmetric adjustment. Unlike the Engle−Granger method, the threshold cointegration technique provides clear evidence of the cointegration relationship characterized by asymmetric adjustment toward equilibrium. The finding of this study supports the long-run relationship between the nominal interest rate and the inflation rate. Panopoulou and Pantelidis (2016) apply simulated critical values instead of asymptotic ones to test Fisher's effect puzzle. The result provides ample evidence in support of the long-run relationship between inflation and interest rates in 17 OECD countries except for Ireland and Switzerland. Westerlund (2007) argues that panel estimates are more appropriate to estimate the Fisher's effect because it is not based on univariate tests. The study applies two new panel cointegration tests on 20 OECD countries. The findings do not reject the cross-sectional cointegration between inflation and interest rates. However, an individual country's cointegration result rejects the Fisher's hypothesis.

Most of the above studies were conducted for advanced economies, supporting the full and partial Fisher's effect, by citing different reasons such as non-linearity, asymmetry, and structural breaks. With methodological advancement in the time series econometrics, so many studies tested the validity of the Fisher's effect such as Rose (1988), Mishkin (1992), Wallace and Warner (1993), MacDonald and Murphy (1989) and Rapach and Weber (2004). In a similar fashion, some of the studies are also examined in the case of emerging economies like India. Due to the regulated nature of interest rate structure in India before the 1990s, very few studies have examined the Fisher's effect such as Nachane (1988), examined the relationship between the nominal interest rate and expected inflation by taking monthly data from 1970-71 to 1984-85. His result did not support the co-movement of the nominal interest rate and expected inflation in India. One explanation of his result was that during those time period most of the Indian interest rate was administered. Another study made by Paul (1984), which emphasizes the importance of adjustment lags, the variability of inflation, changes in real income, etc. in the empirical analysis of Fisher's hypothesis. This study covers data from 1952-53 to 1976-77 of short term rates (Call Money Rate and Bazar Bill Rate) and long term rate the 12-month Time Deposit Rate (TDR). For expected inflation, he applies an adaptive expectation hypothesis. The empirical result supports Fisher's effect on both short-and long-term interest rates in India. After the early 1990s when interest rates were de-regularized to some extent, so many studies have been conducted to test the validity of the Fisher's effect. Anuruo et al. (2000) conducted a study to check the validation of Fisher's hypothesis by utilizing cointegration in India, using monthly data for the period of 1977 to 1997. And the empirical result supports the long-run Fisher's effect in India. Jha (2002) corroborates the findings of Anuruo et al. (2000).

Bhanumurthy et al. (2003) examine the Fisher's hypothesis by applying the recent version of the cointegration concept. This study focuses on post-reform period data from April 1990 to December 2001. For inflation, they took proxy WPI and CPI and for the nominal interest rate they use Call Money Rate (CMR) and Treasury Bill Rate. The empirical results of the bounds test show the existence of long-run full Fisher's effect between CMR and WPI inflation. They found that the findings are sensitive to the lag length selection criterion. Bhanumurthy (2009) analyses the impact of the global financial crisis on the Indian economy. He finds that the Indian economy was facing different challenges mainly such as high fiscal deficit and slow export growth due to some cyclical factors. The global financial crisis reduced economic growth by 2 percent during 2009-10. To stimulate the demand in the economy he suggested fiscal and monetary stimulus packages in short to medium term. In a similar fashion, another study made by Bhanumurthy (2014), which suggests the number of reasons for the economic downturn in the post-policy reform period. These are domestic as well as external factors.[1] However, the crucial challenges before India are to balance three main objectives of faster, inclusive and sustainable development in the recent time. Thus, the emphasis made by Bhanumurthy on the effective role of fiscal and monetary policy to overcome the recession reinforces the importance of Fisher's effect analysis.

Apart from the above, some of the empirical evidence is not in favor of Fisher's effects. Abubakar et al. (2017) empirically examined Fisher's effect using monthly time series data from 1990M01 to 2015M03, in case of India. The result reveals the absence of a long-run equilibrium relationship between the nominal interest rate and inflation for the full and sub-sample which is against Fisher's proposition. He attributed the following reasons for his findings: firstly, the conduct of passive monetary policy by RBI. Secondly, the presence of distortion in the interest rate pass-through channel and finally, the dominant informal financial sector in India that makes short term policy rate ineffective monetary policy instrument. Furthermore, other studies at the theoretical level include the attempts made by Mundell (1963), Tobin (1985), Darby (1975) and Feldstein (1980) to explain the wealth and tax effects respectively as some of the reasons why Fisher's hypothesis failed to hold in some studies.

In the backdrop of the given ambiguity regarding the presence and absence of Fisher's effect from the above studies, the present study analyses the validity of the Fisher's hypothesis in India. The present study will differ in terms of explanatory variables used, methodological details, frequency of the data and the sample period selected for the study.

# 3. Data Description and Methodology

*3.1 Data Description*

This study considers the monthly data on different interest rates and inflation rates from 1991 to 2015. Four variables are used in this study *viz.,* Wholesale Price Index (WPI), Consumer Price Index (CPI)[2] for inflation and 91 days Treasury Bill Rate (TBR)[3] and Call Money Rate (CMR) as the nominal interest rate. The main source of the data is the *Handbook of Statistics on Indian Economy* published by Reserve Bank of India which is available at its site (https://www.rbi.org.in/).

To analyze the Fisher's effect, the real rate of interest, which is the difference between the nominal rate of interest and the expected inflation rate, is to be calculated. There are two approaches to derive proxies for the expected rate of inflation, *viz.* adaptive and rational. The present study uses the rational expectation approach for measuring expected inflation as used by Bhanumurthy et al. (2002). Hence, in this study, WPI and CPI are used as a proxy for inflation and one period ahead inflation rate is taken as the expected inflation rate by using rational expectations hypothesis and hereafter denoted by WPIE and CPIE respectively[4].

*3.2 Methodology*

The present study empirically tests long-run cointegration between the nominal interest rate and expected inflation in the case of India. Among various concepts of cointegration, the study utilizes recently developed

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[1] Domestic factors include high fiscal deficit and weak confidence of investors in the economy largely due to in-effective economic reform. On the other hand, external factors such as fuel price shock and the U.S. financial crisis have created growth instability.

[2] Due to unavailability of combined CPI data, we have taken CPI data of industrial workers only.

[3] Data for 91 days TBR is taken from Jan-1993 to Mar-2015 because of its availability from that date only. For other variables it is from Apr-1991 to Mar-2015.

[4] Data are available on different base year. WPI base year is 2004-05, whereas CPI base year is 2001. We changed different base year into one base year through *splicing techniques*. In splicing, to come at new base year following formula is adopted, i.e., (New series / Old series) * Old series = New Series.

ARDL techniques by Pesaran *et al.* (2001). For multivariate and bivariate analysis there are numbers of tests among them, such as Eangel-Granger (1987), Fully Modified Ordinary Least Squares (FMOLS) procedure of Phillips and Hansen (1990), Johansen (1988), Johansen and Juselius (1990) and Johansen's (1995) have been popularized. The main drawback of these methodologies is that they need variables to be integrated of the same order. If orders of integration are not the same, the results are inconclusive and hence affecting predictive powers (Perron, 1989, 1997). Pesaran *et al.* (2001) developed the autoregressive distributed lag model (ARDL) or ARDL bounds testing approach to check cointegration, which has some certain advantages in comparison to other concepts of cointegration. This model assumes all variables to be endogenous and it doesn't require all variables to be I (1) or I (0). It is relatively more efficient in small or finite sample data sets. And finally, both short-run and long-run estimators can be simultaneously estimated (Adil *et al.*, 2017).

Macroeconomics data are generally facing the problem of non-stationarity, which constraints the researchers in using the traditional methodological approach like, OLS, 2SLS, etc. Hence, we check the stationarity of the time series data before applying the ARDL bounds test to determine the order of integration. The main objective of the unit root test is to confirm that time series data is not integrated of order two i.e. I(2). To this end, we apply the augmented Dicky Fuller (ADF) test by Dickey and Fuller (1981) and Phillips-Perron (PP) test by Phillips and Perron (1988). We express the ARDL model for this study as follows.

$$\Delta TBR_t = C_O + \delta_1 TBR_{t-1} + \delta_2 WPIE_{t-1} + \sum_{i=1}^{p} \phi_i \Delta TBR_{t-i} + \sum_{j=0}^{q} \omega_j \Delta WPIE_{t-j} + \varepsilon_t \qquad (1)$$

Where, $\delta_i$ are long-run multipliers, $C_0$ is the drift and $\varepsilon_t$ are white noise errors. $\phi_i$ and $\omega_j$ are short-run coefficients. The very first step after checking the stationarity of the variables is to estimate the above equation. To estimate the long-run relationship among variables we use the Pesaran et al. (2001) procedure. The ARDL bounds test gives a clear picture of cointegration in the long-run. Noting that this procedure is based on the F-test. Null Hypothesis of F-test is the existence of no cointegration or long-run relationship among variables, i.e. denoted as: $H_N : \delta_1 = \delta_2 = 0$ i.e., there is no cointegration among variables, against alternative $H_A : \delta_1 \neq \delta_2 \neq 0$ i.e., there is cointegration among variables.

The ARDL bound test is based on the Wald-test (F-statistics) with the asymptotic distribution of non-standard in nature under the null hypothesis of no cointegration among variables. Two critical values have been suggested by the Pesaran *et al.* (2001) to determine the cointegration among variables, which is upper critical bound and lower critical bound. When the computed F-stat is less than that lower bound we accept the null hypothesis and vice-versa. If the F-stat falls in between the upper bound and lower bounds the result would be inconclusive in nature.

In the next step, when cointegration is established the conditional ARDL$(p,q)$ long-run model for $TBR_t$ can be estimated as:

$$TBR_t = C_o + \sum_{i=1}^{p} \delta_1 TBR_{t-i} + \sum_{i=0}^{q} \delta_2 WPIE_{t-i} + \varepsilon_t \qquad (2)$$

The assumption that errors are serially uncorrelated upon which the above specification is also based, is very significant. Therefore, the selection of the appropriate lag length is very important. The order of variables in the ARDL$(p,q)$ model is selected using different information criteria, as used in previous studies like Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Schwarz Information Criterion (SBC) and Hannan-Quinn (HQ).

In the final step, short-run parameters that are dynamic in nature are obtained by estimating an error correction model (ECM). The ECM for $TBR_t$ can be specified as follows:

$$\Delta TBR_t = \mu + \sum_{i=1}^{p} \phi_i \Delta TBR_{t-i} + \sum_{j=i}^{q} \omega_j \Delta WPIE_{t-i} + \zeta ecm_{t-i} + \varepsilon_t \qquad (3)$$

Here, $\phi_i and \omega_j$ are short-run coefficients of the model which converges to equilibrium with $\zeta$ a speed of adjustment. Noting that the study defines two different functional forms with dependent variables such as TBR and CMR. The first functional form (where the dependent variable is TBR) is further categorized into two different sub-models. Such as the first sub-model is TBR with WPIE and the second sub-model is TBR with CPIE. Similarly, the second functional form (where the dependent variable is CMR) is further categorized into two different sub-models. Such as the first sub-model CMR with WPIE and the second sub-model is CMR with CPIE. Here, we have just mentioned the estimation procedure of the first functional form where TBR is the dependent variable and WPIE is an explanatory variable. The same procedure is followed when CPIE is used as an explanatory variable. Similarly, CMR as another measure of the rate of interest with WPIE and then CPIE as an explanatory variable is estimated with the above-mentioned procedure or methodology. Lastly, diagnostic tests for heteroscedasticity, serial correlation and functional form misspecification are done by Bruesch-Pagan Godfrey (BPG), Bruesch Godfrey lagrangian multiplier (BG-LM) and Ramsey's RESET (regression equation specification error test) statistics respectivel**y**. For parameter stability, in the case of both the long-run and short-run, CUSUM (cumulative sum of recursive residuals) test has been used.

# 4. Empirical Analysis

*4.1 Unit root test*

Stationary of a data series is supposed to be one of the canonical assumptions in time series. The classical regression model requires that both dependent and independent variables need to be stationary. If not then there arises the problem of spurious regression (Granger and Newbold 1974). However, one of the basic advantages of ARDL is that it can be executed irrespective of whether the variables are purely I(0) or I(1) or a combination of both. But an investigation of unit root properties of the data series seems to be necessary because this approach provides spurious results, i.e. computed F statistics provided by Pesaran et al. (2001) for the bounds test will not be valid if variables are integrated of I(2). In order to assess the stationarity of the variables, we have used two alternative unit root tests. The ADF test which tests the null of unit root against the alternative of stationary data series. In addition to the conventional ADF test, we have used the PP test with the same null and alternative hypothesis since it is more robust to the problems of autocorrelation and heteroscedasticity. The results of both the tests are reported in Table 1. Results reveal that the CMR and CPIE are level stationary with a 1% level of significance. While the TBR and WPIE are stationary at first difference with the level of significance at 1%. Thus, results from Table 1 reveal a mixture of I (0) and I (1) variables which in turn guarantees that ARDL bounds testing could proceed.

**Table 1**

| Unit Root Test | | | | |
|---|---|---|---|---|
| At Level | | | | |
| Variables | TBR | CMR | CPIE | WPIE |
| ADF | -2927 | -4.9983* | -3.5677* | -1.432 |
| | (0.076) | (0.000) | (0.000) | 0.5664 |
| PP | -2.9705 | -7.0614* | -3.078* | -3.037 |
| | (0.039) | (0.000) | (0.000) | (0.0334) |
| At First Difference | | | | |

| | | |
|---|---|---|
| ADF | -21.076* | -9.9781* |
| | (0.000) | (0.000) |
| PP | -2.9705* | -12.832* |
| | (0.000) | (0.000) |

**Source:** Calculated by authors

**Note:** The values in parenthesis are probability values. (*) indicates values are significant at 1 percent level of significance.

*4.2 Bounds Test of Cointegration for Model A*

In this model, TBR is used as a measure of interest rate while WPIE and CPIE are used as a measure of expected inflation. The estimation procedure of the ARDL model involves three steps. First of which is the selection of lag order or lag length, because the computation of F statistic for cointegration is very much sensitive to lag order. Table 2 reports the result of different methods of lag selection criteria when variable TBR, WPIE, and CPIE are used. The lag order of 2 is selected on the basis of the lowest value of FPE, AIC, SC, and HQ as shown in Table 2. Once the optimal lag length is determined next step is to test the joint significance of the coefficient of the lagged levels of the variables, which in turn tests the existence of a long-run relationship among variables. Generally, the validity of the Fisher's effect is examined by testing the existence of null, which corresponds to no Fisher's effect against the existence of alternative, which corresponds to the existence of the Fisher's effect of a long-run relationship between variables of the model.

**Table 2**

| Lag Selection Criteria when TBR and WPIE are used | | | | |
|---|---|---|---|---|
| Order of lags | FPE | AIC | SIC | HQ |
| 1 | 0.81 | 2.62 | 2.669 | 2.644 |
| 2 | 0.77* | 2.58* | 2.635* | 2.603* |
| 3 | 0.779 | 2.588 | 2.656 | 2.615 |
| 4 | 0.777 | 2.586 | 2.668 | 2.619 |
| **Lag Selection Criteria when TBR and CPIE are used** | | | | |
| Order of lags | FPE | AIC | SIC | HQ |
| 1 | 0.81648 | 2.6351 | 2.6758 | 2.65 |
| 2 | 0.7805* | 2.59* | 2.64* | 2.61* |
| 3 | 0.78613 | 2.5972 | 2.66 | 2.62 |
| 4 | 0.78722 | 2.5986 | 2.68 | 2.63 |

**Source:** Calculated by authors

**Notes:** FPE= Final Prediction Error, AIC= Akaike's Information Criteria, SIC= Schwarz Information Criterion, HQ= Hannan- Quinn Criterion.

The estimation is carried out separately for two submodels. In the first sub-model, TBR is used as a dependent variable whereas WPIE is used as an explanatory variable. In the second sub-model, TBR is used as a dependent variable whereas CPIE is used as an explanatory variable. The results are reported in Table 3. From Table 3, calculated F-statistics value which is a measure of presence or absence of long-run relation falls above critical bounds value at 5 percent level of significance for TBR and WPIE only, which in turn reveals that variables TBR and WPIE are cointegrated. While calculated F statistics value for TBR and CPIE falls below the lower critical value given by Pesaran et. al (2001). Thus the variables TBR and CPIE are not cointegrated. This finding does not support the study of Sathy (2009) in the case of India, where he has shown that there exists cointegration between TBR and CPIE which supports Fisher's effect. Rather it supports the study of Abubakar et al. (2017) in the case of India. Further to check the robustness of our results we have used several diagnostic tests. Ramsey RESET test for functional form misspecification, LM test for serial autocorrelation and BPG for heteroscedasticity for both of the sub-models, the results of which are reported in Table 3. The results in Table 3 reveal that both submodels pass the given diagnostic test very well. Als, we have used cumulative sum

(CUSUM) for the stability of parameters over the sample period for both of the submodels (Figures 1 and 2). These Figures show that CUSUM statistics lie within the 5 percent confidence interval bands. This indicates the stability of the parameters.

**Table 3**

| ARDL Bounds test when T-Bill is used | | | | |
|---|---|---|---|---|
| Inflation Rate | F-statistics | co integration | Error correction term | Long-Run coefficient |
| WPIE | 5.81 | YES | -0.0764<br>(0.000) | 0.5449<br>(0.016) |
| CPIE | 4.747 | No | - | - |

| Diagnostic Tests when TB and WPIE is used | | |
|---|---|---|
| | F-Statistics | P-Value |
| Ramsey RESET Test | 0.17 | 0.67 |
| LM Test | 0.41 | 0.66 |
| BPG | 0.19 | 0.90 |

| Diagnostic Tests when TB and CPIE is used | | |
|---|---|---|
| | F-Statistics | P-Value |
| Ramsey RESET Test | 0.523 | 0.47 |
| LM Test | 0.250 | 0.77 |
| BPG | 1.073 | 0.36 |

**Source:** Calculated by authors

**Note:** *F* is the bounds test, the lower and upper bound critical values of the F statistic at the usual 5% level of significance are 3.23 and 4.35 respectively. These values came from Pesaran *et al*. (2001, Table CI (iii) - Case III, p. 300).

Besides the existence of a long-run relationship between variables for Fisher's effect, there should also exist one to one movement in both variables (Bhanumurthy 2003). This is measured by the long-run coefficient $\delta_2$ . From Table 3 it can be seen that the value of $\delta_2$ is equal to 0.54 for variables TBR and WPIE with the level of significance at 2 percent. Therefore, from the results of F statistics and long-run coefficient, we can infer that there is a long-run relationship between TBR and WPIE but not of one to one in nature between TBR and WPIE. This finding supports the result which is found by Thenmozhi (2005) in the case of India. Further proof of a stable long-run relationship is provided by the error correction term (Banerjee et al., 1998). In other words, the negative sign and high level of statistical significance of error correction term infer the stability of parameters. Results from Table 3 reveal that for variables TBR and WPIE, the value of the error correction term is -0.0764 at a 1 percent level of significance. This shows that in the long-run with the speed of 7.64 percent per month the dependent variable will return to equilibrium due to a change in the explanatory variable. Thus, variables TBR and WPIE are only cointegrated in nature with the long-run coefficient which is a measure of the responsiveness of interest rate to inflation, which is not equal to one resulting in the presence of partial Fisher's effect.

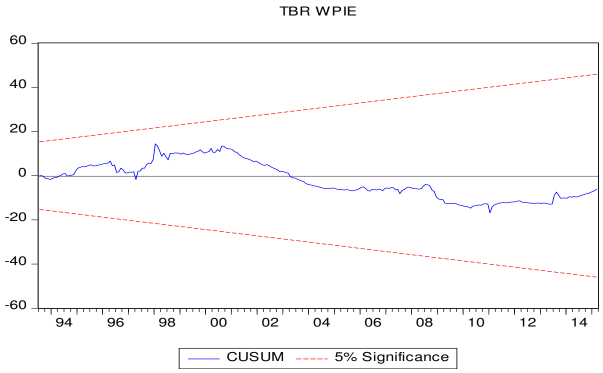


Figure 1

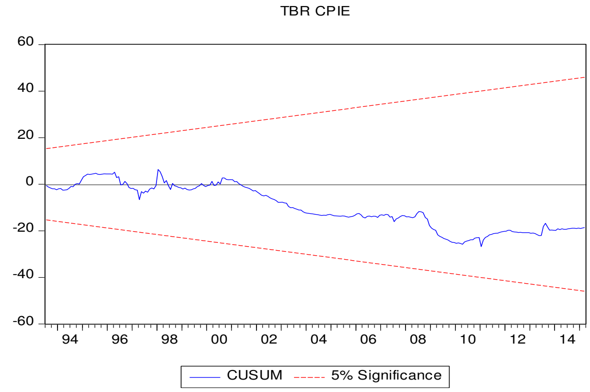


Figure 2

**Source:** Calculated by authors

*4.3 Bounds Test of Cointegration for Model B*

In this model, CMR is used as a measure of interest rate while WPIE and CPIE are used as a measure of expected inflation. The estimation procedure of the ARDL model is carried out in the same way as for model A. Similarly, firstly selection of lag order, because the computation of F statistic for cointegration is very much sensitive to lag order. Table 4 reports the result of different methods of lag selection criteria when variable CMR, WPIE, and CPIE are used. The lag order of 4 is selected on the basis of the lowest value of FPE, AIC, SC, and HQ as shown in Table 4. Once the optimal lag length is determined, next step is to test the joint significance of the coefficient of the lagged levels of variables which, in turn, tests the existence of long-run relationships among variables.

**Table 4**

| Lag Selection Criteria when CMR and WPIE are used | | | | |
|---|---|---|---|---|
| Order of lags | FPE | AIC | SIC | HQ |
| 1 | 10.106 | 5.151 | 5.189 | 5.166 |
| 2 | 10.074 | 5.147 | 5.199 | 5.168 |
| 3 | 9.913 | 5.131 | 5.196 | 5.157 |
| 4 | 9.536* | 5.093* | 5.17* | 5.124* |
| **Lag Selection Criteria when CMR and CPIE are used** | | | | |
| Order of lags | FPE | AIC | SIC | HQ |
| 1 | 10.24 | 5.164 | 5.202 | 5.179 |
| 2 | 10.22 | 5.162 | 5.214 | 5.183 |
| 3 | 10.13 | 5.153 | 5.217 | 5.179 |
| 4 | 9.747* | 5.114* | 5.192* | 5.145* |

**Source:** Calculated by authors
**Note:** FPE= Final Prediction Error, AIC= Akaike's Information Criteria, SIC= Schwarz Information Criterion, HQ= Hannan- Quinn Criterion.

The estimation is again carried out separately for two submodels. In the first sub-model, CMR is used as a dependent variable whereas WPIE is used as an explanatory variable. In the second sub-model, CMR is used as a dependent variable whereas CPIE is used as an explanatory variable. Results are reported in Table 5, the calculated F-statistics value which is a measure of presence or absence of long-run relation falls above critical bound given by Pesaran *et al.* (2001) at 5 percent level of significance for both the sub-models, which in turn reveals that variables CMR, WPIE, and CMR, CPIE are cointegrated. The long-run coefficient for CMR and WPIE is equal to 0.507 with a 2 percent level of significance and for CMR and CPIE is equal to 0.29 but insignificant in nature. In addition to the above, the error correction term is negative and highly significant for both the submodels.

**Table 5**

| ARDL Bounds test when Call Money Rate is used | | | | |
|---|---|---|---|---|
| Inflation Rate | F-statistics | cointegration | Error correction term | Long-Run coefficient |
| WPIE | 16.29 | YES | -0.291 | 0.5066 |
| | | | (0.00) | (0.013) |
| CPIE | 13.91 | YES | -0.261 | 0.2903 |
| | | | (0.00) | (0.165) |
| Diagnostic Tests when CMR and WPIE is used | | | | |
| | | | F-Statistics | P-value |
| Ramsey RESET Test | | | 12.75 | 0.0004 |
| L M Test | | | 1.507 | 0.2003 |
| BPG | | | 7.708 | 0.000 |
| Diagnostic Tests when CMR and CPIE is used | | | | |
| | | | F-Statistics | P-value |
| Ramsey RESET Test | | | 4.4004 | 0.000 |
| L M Test | | | 2.0807 | 0.083 |
| BPG | | | 9.6416 | 0.000 |

**Source:** Calculated by authors

**Note:** *F* is the bounds test, the lower and upper bound critical values of the F statistic at the usual 5% level of significance are 3.23 and 4.35 respectively. These values came from Pesaran *et al*. (2001, Table CI (iii) - Case III, p. 300).

Further to check the robustness of our results we have used several diagnostic tests. Ramsey's RESET test for functional form misspecification, LM test for serial correlation and BPG for heteroscedasticity for both of the sub-models, the results of which are reported in Table 5. The results from Table 5 reveal that both submodels pass the given diagnostic test very well except Ramsey's RESET test for functional form misspecification and BPG test of heteroscedasticity in both the submodels. Noting that for time series data presence of heteroscedasticity does not affect the robustness of the result much, hence overall both models are fine. Also, we have used the cumulative sum (CUSUM) for the stability of parameters over the sample period for both the submodels (Figures 3 and 4). These Figures show that CUSUM statistics lie within the 5 percent confidence interval bands; provided in the second sub-model line breaches the confidence interval for some time and then again it reverts towards stability. Therefore, the overall CUSUM test indicates the stability of parameters for both the submodels. Importantly, variables in both sub-model are cointegrated but the second sub-model is not good for policy analysis in nature due to the insignificant long-run coefficient. That is a measure of the responsiveness of interest rate to inflation, and it is not equal to 1 for both the sub-model, resulting in the presence of partial Fisher's effect but insignificant in the case of the second sub-model, i.e. for CMR and CPIE. Here, the first subpart of model A, i.e. CMR and WPIE, is consistent with the result of Bhanumurthy (2003) in the case of India.

In the backdrop of the above discussion, it is evident that in the case of Model A, the first subpart i.e. TBR and WPIE shows cointegration and also qualifies all the diagnostic tests, hence it can be used for policy analysis. While the second subpart, i.e. TBR and CPIE shows no cointegration hence it cannot be used for policy analysis. On the other hand in the case of Model B, although both the subparts show the existence of cointegration and qualify the major diagnostic test statistics, the second subpart i.e. CMR and CPIE having an insignificant coefficient of CPIE, is not good for policy analysis. Thus, this study establishes the partial Fisher's effect. In the case of both Model A and Model B both the first subparts i.e. TBR and WPIE, and CMR and WPIE respectively are giving a good signal about the expected inflation. The policy analysis and conclusion based on cointegrated models are discussed in the next section.

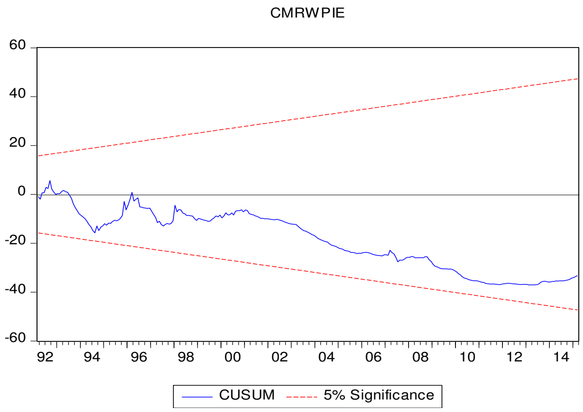


Figure 3

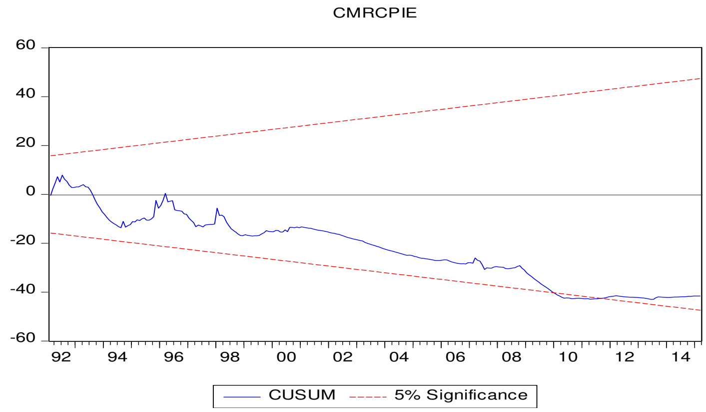


Figure 4

**Source:** Calculated by authors

## 5. Summary and Concluding Remarks

This paper has examined Fisher's effect i.e. the long-run relationship between inflation and nominal interest rates in the context of India, using autoregressive distributed lags or Bounds test of cointegration given by Pesaran *et al.* (2001). The 91 day's Treasury bill rate (TBR) and call money rate are used as long term and short term interest rates respectively. The wholesale price index and consumer price index for industrial workers are used as a proxy for the inflation rates. The expected inflation rate has been formed under the assumption of rational expectation. The results show that a long-run relationship exists between TBR and WPIE, with a long-run coefficient equal to 0.54 at a 2 percent level of significance, implying the partial Fisher's effect. The policy implication of this result would be that the market interest rate is good indicators of inflationary expectations. While no long-run relationship exists between TBR and CPIE. The results of the above both models pass the diagnostic tests very well.

Similarly when CMR is used as a measure of interest rate, while WPIE and CPIE as a measure of expected inflation. The results show that variables in both submodels are cointegrated but not robust in nature in case of second subpart, i.e. CMR and CPIE with the long-run coefficient which is a measure of responsiveness of interest rate to inflation not equal to 1 for both of the sub-model resulting the presence of partial Fisher's effect but insignificant for CMR and CPIE.

Thus, the study finds that there exists a long-run relationship but not one to one in nature between the nominal interest rate and expected inflation, i.e. only between TBR and WPI inflation, and between CMR and WPI inflation but not any another combination. This may be true because WPI inflation has been the inflation measure until 2014 in the case of India. After the *'Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework'* (Chairman: Dr. Urjit R. Patel) in 2014, CPI is used as a proxy measure of inflation. Consequently, it is not giving a good signal for one to one relation in the case of both the second subpart of Model A and Model B, i.e. for TBR, CPIE, and CMR, CPIE respectively. The second possible reason behind not getting cointegration in the second subpart of Model A, i.e. TBR, CPIE, and getting insignificant coefficients in the second subpart of Model B, i.e. CMR, CPIE may be the functional form misspecification. In most of the cases, the functional form requires the non-linear estimation instead of linear estimation. Since the study utilizes linear ARDL which may not be supposed to be. Hence one can check the robustness of the result by introducing non-linearity in the functional form of Fisher's hypothesis.

However, based on the existence of the combination of cointegrated model in the each first subpart of Model A (i.e. for TBR and WPIE) and Model B (i.e. for CMR and WPIE), following conclusion may be drawn, such as the conduct of monetary policy by Reserve Bank of India (RBI) is active; i.e. there is immediate policy rate response due to change in inflation. Therefore, it may be concluded that the monetary policy rate (i.e. TBR and CMR) is sensitive to the inflation expectation. Since expected inflation seems to have a significant impact on CMR, and CMR is the operating target of Monetary Policy in India, hence it becomes important from a policy perspective to track inflation expectation in order to align the CMR with policy repo rate. Similarly, TBR is also affected by inflation expectation, therefore inflation expectation needs to be taken care of while setting policy rate in the context of the Indian financial market. Lastly, having found the Fisher's effect in the case of India, monetary authorities may adopt strategies that can prevent inflation from rising if the nominal interest rate is to be kept at low levels in order not to discourage borrowing.

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