DOES FISHER EFFECT EXIST IN PAKISTAN?
A COINTEGRATION ANALYSIS

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Abstract. This paper attempts to test the long run relationship between nominal interest rate and inflation rate using Johanson and Juselius (1990) cointegration approach. The existence of this relationship has far reaching implication for policy makers, debtors and creditors since inflationary expectation influences nominal interest rate. Both adaptive and rational expectation approaches are used to model the expected inflation. We find a long run relationship between nominal interest rate and rate of expected inflation in both cases and accept the conventional Fisher Hypothesis that there is one to one relationship between nominal interest rate and expected inflation, *i.e.* interest rate accurately anticipates inflation. The results show that there is efficiency in banking sector during the period under investigation. The results also show that the interest rate cannot be a good indicator for monetary policy stance.

I. INTRODUCTION

The extent to which the nominal interest rate reflects anticipated inflation has been the subject of investigation since Fisher (1930) argued that nominal interest should be equal to the sum of real interest rate and anticipated inflation rate. The real rate of interest is determined by the marginal productivity of capital stock and will, therefore, be approximately constant in the short run. Rational investors have an incentive to ensure that changes in nominal interest rate exactly mirror changes in anticipated inflation:

$$i_t = r_t + \pi_t^e,$$

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where i_t is nominal interest rate, r_t is real interest rate and π_t^e is expected rate of inflation, when expectations are formed in period t. With Keynesian revolution, Fisher's argument was decisively rejected. But in late 1960s and in 1970s as inflation and interest rates rose together, the Fisher hypotheses got a second wind. Considerable attentions on the Fisher equation, which implies that a given increase in the expected rate of inflation will generate an equal increase in the nominal interest rate, has been focused during the past several decades (Carr and Smith, 1972; Feldstein and Chamberlain, 1973; Feldstein and Ekstein, 1970; Friedman, 1968; Gibson, 1970, 1972; Pyle, 1972; Sergent, 1969; Rutledge, 1974; Yoha and Karnousky, 1969; Fama, 1975; Graham, 1988; MacDonald and Murphy, 1989; Crowder and Hoffman, 1969 and Hasan, 1999). A number of papers argument the basic Fisher equation with explanation of real interest mounts that presumably reconcile these findings. Levi and Makin (1978), Melsin (1982) and Peck and Wilcox (1983) demonstrate that Mundell-Tobin effects (the decline in marginal product of capital due to the real balances response to inflation) may have considerable significance. Lucas (1980) and Fried and Howitt (1983) contained that in models characterized by supper neutrality, inflation will not affect real interest rates in this manner over the long run. Several empirical studies recognize that valid tests of Fisher relation may require considerations of the time series properties of the data (Rost, 1988; Muskin, 1992 and Ellan and Lewis, 1995).

In this paper, we examine the extent to which movements in nominal interest reflect changes in anticipated inflation in Pakistan. Pakistan economy witnessed high inflation (double digits) in 1990s. However, the inflation was brought down to lower level in 2000s. Both adoption and rational expectation model will be used. Using cointegtration techniques developed by Johanson, which implies long run equilibrium relationship, will test the hypothesis. For short run relationship Error-correction model will be used. The study is divided into six sections. Section II presents literature review, Section III gives model specification, section IV covers methodology and data, section V gives empirical results and, finally, section VI presents conclusions.

II. LITERATURE REVIEW

The relationship between money and the nominal interest rate has been extensively studied at theoretical as well as empirical levels. Changes in supply of money are expected to affect the nominal rate of interest in two

opposite directions. When money stock is increased at a rate higher than the rate of growth of the demand for money, the excess liquidity so created induces an increase in the demand for alternative financial assets and a consequent increase in their prices. The interest then tends to be depressed until the demand for real cash balances raises enough to eliminate the discrepancy in the money market. Working in the same direction as this portfolio or liquidity effect, a credit effect can be distinguished: Since many of the increases in the money supply are channeled mainly through the financial market, the supply of loanable funds tends to increase relative to the demand, reducing the interest rate independently of the dis-equilibrium in the money market.

On the other hand, increase in the rate of monetary expansion set in motion process, which work in the opposite direction and tends to raise the interest rate. The most important of these is the result of the acceleration in the rate of inflation that may be caused by greater monetary imbalances. Such a higher inflation rate, if sustained, becomes expected by the public and thus induces an increase in nominal interest in order to keep the real value of the realized rate unchanged. This is well known Fisher effect; it is supposed appear with some lag relative to the liquidity and credit effects, mainly because it takes time for expectation to adjust.

Theoretical studies have suggested that although liquidity and credit effects may initially dominate they will eventually be more than offset by the expectations effect; a sustained acceleration in the rate of monetary growth will therefore result in a higher nominal rate of interest rate after all adjustment have taken place (Friedman, 1968). If this is the case, a rise in short-term interest rate does not indicate a tightening of the stance of monetary policy but rather a rise in expected inflation. This would suggest a need for caution in using the level of nominal interest rate as indicator of tightness of monetary policy.

Because of its importance for policy, the relationship between the level of interest rate and future inflation has been studied in many countries. The Fisher effect has been found to be strong in some countries over certain period, for example in United States, Canada and United Kingdom, in post-war period until 1979. However, the correlation between interest rate and expected inflation has not been high post-1979. It was weak in other countries.

Irving Fisher's analysis, which concluded that nominal rate of interest, rises by the anticipated rate of inflation or fall by anticipated deflation. He noted that in equilibrium the nominal rate of interest must equal the sum of

marginal rate of return from holding real capital and expected proportionate rate of change of prices.

$$\gamma_n(t) = \gamma_e(t) + \Delta P_{(t)}^e / P(t)$$

where $\gamma_n(t)$ is nominal rate of interest at time t and $\Delta P_{(t)}^e$ is the rate of change in price level expected as of time t.

Fisher further assumed that the expected rate of change of prices was a distributed lag of current and past-realized price changes.

$$\Delta P_{(t)}^e = \sum_{i=0}^{m} W(i)\Delta P(t-i) + ut. W(i) \geq 0. \forall I,$$ and Ut is a random term.

Fisher Hypothesis, however, was attacked by Keynes. Fisher himself seems to have had misgivings about the empirical reliability of his explanation and presented evidence suggesting that the adjustment of nominal rate of interest was only partial. Sargent (1969) analyzed the Fisher effect and concluded that it remains valid even when it was implemented in the context of multivariate model, which allow for impact of several monetary and real variables, which influence the nominal rate of interest.

Gibson (1970) also found a positive relationship between nominal rate of interest and expected rate of price changes detectable in US data.

The controversy began again when Fama (1975) accepted the joint hypothesis that real rate of interest was constant and that expected inflation was an un-biased predictor of actual inflation.

Darby (1975) argued that Fisher analysis applies only in a tax free world. For a world with taxes, this analysis is incomplete, because it ignores the transfer of income tax liability on the part of the interest payments representing a return of real capital.

Carr, James and Smith (1976) based their investigation on Darby's Hypothesis that income tax consideration would cause the nominal rate of interest in equilibrium to increase by more than increase in expected inflation. They used both distributed lag and rational expectation approaches as proxies for expected inflation. However, their analysis was inconclusive with respect Darby hypothesis.

Blejer (1978) investigated empirically the effects of monetary imbalances on nominal rate in high inflationary environment using Argentinean data and concluded that fisher effect connected with monetary

changes is dominant even with in the quarter in which the monetary changes take place.

Mishkin (1992) found no support, empirically for short-term Fisher effect in which a change in expected inflation is associated with a change in interest rate, but supports the existence of long-term Fisher effect in which inflation and interest rates have common stochastic trend they exhibit trends. Hassan (1999) tested Fisher hypothesis using cointegration technique on Pakistan's data. He found that partial Fisher hypothesis hold in case of Pakistan.

III. THE MODEL

Our point of departure is definition of ex-post real interest rate:

$$(1 + \gamma_t) = \frac{(1 + i_t)}{(1 + \pi_t)} \tag{2}$$

where γ_t is real interest rate, i_t is nominal interest rate, and π_e is actual inflation rate. By taking log of (2), we get,

$$\gamma_t^r = \left(i_t^* - \pi_t^* \right) \tag{3}$$

where $\gamma_t^* = \log(1 + \gamma)$, $i_t^* = \log(1 + i_t)$ and $\pi_t^* = \log(1 + \pi_t)$.

The advantage of working with (3) is that we have a linear relationship that does not ignore the term including the cross product between inflation rate and the real rate of interest. Suppose that the actual inflation rate differs from *et ante* expected inflation rate by a stationary zero mean forecasting error term e_t.

$$\pi_t^* = \pi_t^e - e_t \tag{4}$$

Where π_t^e is expected inflation at time t. Assume that real interest rate is constant equal to ϕ.

Substituting (4) and ϕ into (3) and solving for i_t^*, we get,

$$i_t^* = \phi + \pi_t^e + U_t \tag{5}$$

So we can write the model as:

$$i_t^* = \alpha_0 + \alpha_1 \pi_t^e + U_t \tag{6}$$

IV. METHODOLOGY AND DATA

Unit Root, Cointegration and Error Correction Model

There is wide consensus among researchers that cointegration provides a correct method of estimating and testing hypotheses in models characterized by long-run relations between non-stationary time series data. It avoids the spurious regression problem and indicates whether it is possible to model the integrated data in an error correction model. In a full-specified regression model, there is a presumption that the disturbance terms are white noise series and by implications, the error term is stationary series. Greene (1993) argues that this is not true, for instance, Y_t and X_t are integrated of different orders, as these series will be drifting apart. Intuitively, if both series are $I(1)$, the difference between them might be stable around a fixed mean. This implies that they are drifting upward together at roughly the same rate. The series that satisfy this requirement are said to be cointegrated. In such a case, it is possible to distinguish the long-run relationship among the series (*i.e.* the manner in which the variables drift upwards together) and the short-run dynamics (*i.e.* the relationship between deviations of each variable from its long-run trend).

The use of the cointegration approach has enabled one to explicitly examine the distinction between the short-run and the long-run relationship between variables, which traditionally were modeled in terms of the partial adjustment mechanism. In most recent empirical work, cointegration and error correction method is used as a guide to such an appropriate dynamic specification.

Before testing for cointegration, we first need to determine whether the individual series are integrated of order one, *i.e.* $I(1)$. Since it is a necessary but not sufficient condition for a set of variables to be cointegrated, we have used Augmented Dicky Fuller (ADF) test for a unit root (Dicky and Fuller, 1981). This is a test for stochastic non-stationarity. It is also possible that the non-stationarity in individual series results from a deterministic process such as time trend. Therefore, we estimate the following regression using ordinary least square (OLS).

$$\Delta x_t = C + \delta_1 t + \delta_2 x_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta x_{t-1} + \varepsilon_t$$

Where x_t is individual time series, t is linear time trend and Δ is first difference operator, *i.e.* $\Delta x_t = x_t - x_{t-1}$, ε_t is a serially uncorrelated random

term, and C is a constant, the terms Δx_{t-1}, $i = 1, 2, \ldots, n$ are included to ensure that ε_t is white noise.

First we test the hypothesis:

H_0: $\delta_2 = 0$

H_1: $\delta_2 < 0$ series contains a unit root

The second Hypothesis that H_0: $(\delta_1 \ \delta_2) = (0, 0)$ is also tested. If we fail to reject the second Hypothesis we re-estimate the equation without time trend and again test the first hypothesis.

For any model of dynamic specification co-integration techniques are used to find the long run relationship between variables which are integrated of order one, *i.e.* $I(1)$. Johanson approach will be used to check the existence of cointegration between interest rate and rate of inflation.

Quarterly data from 1981:1 to 2002:4 has been used. Data are taken from SBP Statistical Bulletin. Proxy used for nominal rate and inflation are call money rate and consume price index respectively.

We estimate the error correction model (ECM), which shows short-run dynamics and helps the variables to cointegrate in the long run. The following ECM model has been used.

$$\Delta i_t^* = \phi + \alpha_0 \Delta \pi_t^e + \alpha_1 (i_{t-1} - \pi_{t-1}^e) + \varepsilon_t$$

SPECIFICATION OF PRICE EXPECTATION

In order to test the Fisher hypothesis we utilized the rational expectation hypothesis to create a synthetic price expectation series and then introduce this series into the nominal interest rate equation. Because of its prevalence in the literature, we also used a distributed lag specification (Adoptive Expectations approach) to generate price expectation in the nominal interest rate equations.

Distributed Lag Approach

The standard procedure for generating price expectation has to be assumed that individuals employ only the information contained in past history of inflation when formulating their forecasts of future inflation, and to estimate weights on lagged prices from the relationship.

$$\dot{P}_t^* = \sum_{i=1}^{n} \beta_i \dot{P}_{t-i}$$

Implicit in this procedure is the further assumption that the sum of the lagged weights ($\sum \beta_i$) is equal to one, *i.e.*

$$\sum \beta_i = 1$$

This assumption is necessary to have unbiased expectations of inflation in a world where inflation rate can be considered as coming from a stationary stochastic process.

Rational Expectation Approach

We created a synthetic price expectations variable using a variant of rational expectation hypothesis. Empirical researchers have equated the rational expectation hypothesis with the proposition that expectations fully incorporate all of the information contained in specified information set.

Following the method of Modigliani-Shelber (1973), we assume that the information set that investors use to forecast future rate of inflation consists of the observed histories of both nominal interest rate and the rate of inflation:

$$(t+1)\gamma_t^* = \sum_{j=1}^{n} \alpha_j \gamma_{t-j+1} + \sum_{j=1}^{n} \beta_j \dot{P}_{t-j+1}$$

$$(t+1)\dot{P}_t^* = \sum_{j=1}^{n} \gamma_j \gamma_{t-j+1} + \sum_{j=1}^{n} \delta_j \dot{P}_{t-j+1}$$

since the real interest rate defined ex-post as the nominal interest rate less the realized rate of inflation, the information contained in the variables on the right-hand-side of above equations is equivalent to the information contained in the histories of nominal interest rate and rate of inflation. According to the rational expectation hypothesis, the parameter of the above equations should be estimated using the equations:

$$\gamma_t = \sum_{j=1}^{n} \alpha_j \gamma_{t-j} + \sum_{j=1}^{n} \beta_j \dot{P}_{t-j}$$

$$P_t = \sum_{j=1}^{n} \gamma_j \gamma_{t-j} + \sum_{j=1}^{n} \delta_j \dot{P}_{t-j}$$

Wald Test

Wald test is used to test the significance of the coefficient of inflation, *i.e.* π_i^e.

$$F = \frac{e_1'e_1 - e'e/q}{e'e/n-k}$$

Where the q is number of restrictions, n is number of observation and k is number of parameters to be estimated. Three versions of Fisher Hypothesis will be tested.

(1) Conventional Fisher Hypothesis, which implies that coefficient of, π_e' is unity in regression equation i.e. nominal interest rate responds one for one with expected inflation rate:

$$I_t = \alpha_0 + \alpha_1 \pi_t^e + U_t$$

Here $H_0: \alpha_1 = 1$

(2) Partial Fisher Hypothesis implies that the coefficient of inflation is less than unity, *i.e.* nominal interest rate changes proportionally less than change in expected inflation rate.

Here $H_0: 0 < \alpha_1 < 1$

(3) Inverted Fisher Hypothesis which implies that there is no relationship between nominal interest rate and rate of inflation.

Here $H_0: \alpha_1 = 0$.

V. EMPIRICAL RESULTS

In this section the empirical results are discussed separately for adaptive as well as rational expectations.

ADAPTIVE EXPECTATIONS

Table 1 presents ADF statistic to test whether interest rate and rate of inflation are stationary. Results show that both interest rate and rate of inflation are not stationary at level but are stationary at first difference which implies that interest rate and rate of inflation are $I(1)$.

TABLE 1

Augmented Dickey Fuller Test

Variables	Level	1st Difference	Results
i	−2.55	−10.22*	I (1)
π^e	−2.5	−7.6*	I (1)

*Indicates stationarity at 5% level of significance.

Since both interest rate and inflation rate are $I(1)$. We apply Johansson co-integration approach to test whether these variables are co-integrated Table 2 presents the results that show that both series are co-integrated, which confirm the long run relationship.

TABLE 2

Johansson Test for Cointegration

Maximum Eigen value Test

Null Hypothesis	Alternative Hypothesis	Eigen value
$\gamma = 0$	$\gamma = 1$	11.92302*
$\gamma = 1$	$\gamma = 2$	2.773501

Trace Test

Null Hypothesis	Alternative Hypothesis	Likelihood Ratio
$\gamma = 0$	$\gamma \geq 1$	30.81*
$\gamma = 1$	$\gamma \geq 2$	5.82

*Indicates the significance at 5 percent level.

After normalizing and having the unique co-integrating vector we get the long run relationship by the following equation, t-values are given in parentheses.

$$i_t = 8.41 + 0.15\,\pi_t^e - 0.27T$$

$$(7.5) \quad (-6.75)$$

Short Run Dynamic

After establishing the long run relationship between the variables we move to short run dynamic by using Error Correction Model.

Table 3 presents the results of ECM. Error correction term has expected sign and significant. The coefficient is -0.498, which implies that 49% of deviation from long-run equilibrium is filled each period.

TABLE 3

Error Correction Model

Dependent Variable: $D(i_t)$

Variable	Coefficient	Std. Error	*t*-Statistic
C	-1.187325	0.331678	-3.579754
EC(-1)	-0.488170	0.089368	-5.462448
$D\pi_t^c$	0.676244	0.171831	3.935529

R-squared = 0.295   F-statistic = 16.72

Table 4 presents the result of Wald test for significance of the coefficient of π_t^c test failed to reject that $C_3 = 1$ which implies that there is one to one relationship between i_t and π_t^c. The Hypothesis $H_0: C_3 = 0$ is rejected.

Table IV

Wald Test

Null Hypothesis: C(3) = 1

F-statistic	3.550040	Probability	0.063132
Chi square	3.550040	Probability	0.059544

Null Hypothesis: C(3) = 0

F-statistic	15.48839	Probability	0.000175
Chi square	15.48839	Probability	0.000083

RATIONAL EXPECTATIONS

Table 5 presents ADF statistic to test whether interest rate and rate of inflation are stationary. Results show that both interest rate and rate of inflation are not stationary at level but are stationary at first difference which implies that interest rate and rate of inflation are $I(1)$.

TABLE 5

Augmented Dickey Fuller Test

Variables	Level	1ˢᵗ Difference	Results
I	−2.55	−10.22*	$I(1)$
π^e	−2.19	−3.17*	$I(1)$

*Denotes stationarity at 5% level of significance.

Since interest rate and inflation rates are both $I(1)$, 2e apply Johanson cointegration approach to test whether these variables are cointegrated. Table 6 presents the results which show that both series are cointegrated which confirm the long run relationship.

TABLE 6

Johansson Test for Cointegration

Maximum Eigen Value Test

Null Hypothesis	Alternative Hypothesis	Eigen Value
$\gamma = 0$	$\gamma = 1$	12.13244*
$\gamma = 1$	$\gamma = 2$	2.732428

Trace Test

Null Hypothesis	Alternative Hypothesis	Likelihood Ratio
$\gamma = 0$	$\gamma \geq 1$	31.19*
$\gamma = 1$	$\gamma \geq 2$	5.77

*Indicates the significance at 5 percent level.

After normalizing having the unique co-integrating vector we get the long run relationship by the following equation, t-values are given in parentheses.

$$I_t = 8.4 + 0.149\,\pi_t^e - 0.26T$$

$$(5.38) \qquad (-6.5)$$

Short Run Dynamics

After establishing the long run relationship between the variables we move to short run dynamic by using Error Correction Model.

Table 7 presents the results of ECM. Error correction term has expected sign and significant. The coefficient is -0.51, which implies that 51% of deviation from long run equilibrium, is filled each period.

TABLE 7

Error Correction Model

Dependent variable is $D(i_t)$

Variable	Coefficient	Std. Error	t-Statistic
C	−1.254759	0.338787	−3.703684
EC1 (−1)	−0.515089	0.091640	−5.620803
$D(\pi_t^e)$	0.718657	0.177636	4.045679

R-squared = 0.28 F-statistic = 17.24

Table 8 presents the result of Wald test for significance of the coefficient of π_t^e test failed to reject that $C_3 = 1$ which implies that there is one to one relationship between i_t and π_t^e. The Hypothesis H_0: $C_3 = 0$ is rejected.

TABLE 8

Wald Test

Null Hypothesis: C(3) = 1

F-statistic	2.508486	Probability	0.117131
Chi-square	2.508486	Probability	0.113235

Null Hypothesis: C(3) = 0

F-statistic	16.36752	Probability	0.000118
Chi-square	16.36752	Probability	0.000052

VI. CONCLUSIONS

This paper has been an attempt to test the validity of Fisher hypothesis in Pakistan by investigating long run relationship between nominal interest rate and inflation rate by applying cointegration analysis. The inflationary expectation has been modeled using adaptive and rational expectation approach. This study accept the conventional Fisher Hypothesis that there is one to one relationship between nominal interest rate and rate of inflation, against the Inverted Fisher Hypothesis that there is no relationship between the two variable and partial Fisher Hypothesis that interest rate does not fully or accurately anticipate inflation. These results show that banking sector is efficient in Pakistan. This may be due to liberalization of financial sectors initiated in 1990s. Monetary policy may not be effective in such a situation because inflation nullifies the impact of low interest rate by raising inflation and hence interest rate. The nominal interest cannot be an indicator of policy easiness or tightness because it incorporates future inflation rates.

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