Alternative Specifications of Fisher Hypothesis: An Empirical Investigation

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Abstract:

Fisher hypothesis provides theoretical framework for the study of relationship between nominal interest rate and inflation. It assumes one to one direct relationship between nominal interest rate and inflation. Modifications to this model are explained by Mundell effect, Phillips curve and Friedman effect , Levi and Makin effect, Darby effect and Carmichael and Stebbing effect (Inverted Fisher Hypothesis). The objective of this paper is to explore the Fisher hypothesis and its alternative specifications using IFS Panel data set and applying General to Specific Methodology .Findings of this paper show that Inverted Fisher hypothesis holds in above average money supply/GDP countries. Full Fisher effect is present only when Phillips curve effect and Friedman effect are also present in below average money supply/GDP countries.

Key words: Fisher Hypothesis, Interest Rate, Inflation, Panel Data, General to Specific Model.

JEL Classifications:E40, E43, E52

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1. Introduction

The Fisher hypothesis offers a theoretical framework for the study of the connection between nominal rate of interest and rate of inflation. Fisher presented this hypothesis in 1930. The Fisher hypothesis asserts that when economic agents are rational, the equilibrium nominal rate of interest is composed of the real rate of interest and the fully anticipated future rate of inflation. However in case of uncertainty, the nominal rate of interest is a combination of the real rate of interest and the expected rate of future inflation.

Fisher Hypothesis forms the basis of the theoretical models which explain that the role of money is neutral in determining the real variables of the economy. It is also crucial for understanding the variations in nominal rate of interest. Rate of interest mechanism policy is used by the governments to control the inflation. The costs of inflation are enormous and dreadful. High inflation is the main cause of loss in welfare. During inflation the demand for real balances falls as the real purchasing power of the public falls. In inflation the efficiency of price mechanism is decreased and the resources are wasted in gathering information. The performance of the interest rate as a hedge and a predictor against inflation becomes suspicious in such situations. Consequently, the uncertainty about expected inflation also reduces both consumption and investment. It further impairs economic performance. These nominal interest rates play a dynamic role in today's world economies. Nominal rate of interest is affected by the inflationary expectations. The Fisher hypothesis has far-reaching effects for debtors and creditors as well as for the effectiveness of monetary and fiscal policies.

A monetary policy planned to achieve output and price level steadiness generally works through its effects on the economy's aggregate demand schedule. Central bank conducts its policies in financial markets, (the markets for government bonds, for interbank loans and for central bank credit). Central bank chooses an intermediate target that it can effectively control. Interest rates are mostly used as intermediate targets because they can be observed regularly by the central bank. Interest rate targeting is the popular policy in US, UK and Japan. These countries have adopted the zero interest rate policies. The State Bank of Pakistan also uses interest rate targeting policy in response to high inflation expectations. Our present study will be useful in exploring the effects of these policies on interest rate, inflation relationships.

There is a lot of research work on different aspects of Fisher hypothesis for different countries but a single, unique study covering almost all specifications of Fisher hypothesis is lacking. The present study is an effort in the same direction. Models of Fisher hypothesis have been tested by many researchers using different techniques but they have found conflicting results. Some studies accept the Fisher hypothesis, *e.g.* Westerlund (2006), while others reject it or have found mixed results, *e.g.* Badillo *et. al* (2011) and Ozean and Ari (2015) . The objective of this research study is to use the panel data estimation and General to Specific Modeling to resolve these issues.

2 THEORETICAL AND ECONOMETRIC ISSUES

2.1 The Fisher Hypothesis

In a precise form, the Fisher hypothesis is given by

$$(1+i)=(1+r^{e})(1+\pi^{e}) \quad (1)$$

Supposing that the term $r^{e}\pi^{e}$ is very minute, this equation reduces to

$$i_t = r_{t+1}^{e} + \Delta p_{t+1}^{e} \quad (2)$$

According to the Fisher hypothesis the spread between the return on financial assets (i_t) and the rate of return on real assets (r_t) changes according to the expected future inflation rate. Fisher hypothesis forecasts that the nominal interest rate completely adjusts for the fluctuations in the expected inflation rate and the real interest rate remains constant over the period during which the economic agents hold these financial assets. The real interest rate r_{t+1}^{e} is generally supposed to be fixed at, $\bar{r}$. The real interest rate is fixed due to a stochastic term, u_t u_t is not related with the expected future inflation rate [Sargent 1972]. The stochastic form can be written as:

$$r_{t+1}^{e} = \bar{r} + u_t \quad (3)$$

$$i_t = \bar{r} + \Delta p_{t+1}^{e} + u_t \quad (4)$$

Now to deal with expected future inflation, the mechanism upon which these expectations about future inflation are formed is as follows:

$$\Delta p_{t+1}^{e} = \mu\left(\Delta p_{t+1} \middle| \Omega_t\right) \quad (5)$$

where μ is the expected future value operator and Ω_t is the information set upon which the expectations are made. It is supposed that market is efficient and the information set Ω_t contains all the available information required to forecast the expected rate of inflation. The rate of inflation recognized from *t* to *t+1* time will be different from the expected future inflation rate by a random term. This random term is statistically unrelated to the past information. As shown by

$$\Delta p_{t+1} = \Delta p_{t+1}^{e} + \upsilon_{t+1} \quad (6)$$

Such that $\mu\left(\Delta p_{t+1} \middle| \Omega_t\right)=0$ and $E\left(\upsilon_{t+1}\upsilon_{t+1-i}\right)=0\forall_i \neq 0$. Substituting Equation (6) in Equation (3) and modifying the equation one in a regression model:

$$i_t = \alpha + \beta \Delta P_{t+1}^{e} + w_{t+1} \quad (7)$$

where α is the 'constant' long-run equilibrium real interest rate and $w_{t+1} = u_t - \upsilon_{t+1}$ is an error term including all the random variables which are not influenced with the anticipated future inflation rate. A strong-form Fisher hypothesis holds when the two identical restrictions that $(\alpha, \beta) = (0,1)$ and the error term w_t is stationary are not rejected.

2.2 Alternative Specifications of the Fisher Hypothesis

Mundell Effect

Mundell (1963) by introducing real balance effect into the Hicksian IS-LM framework reaches the conclusion that nominal interest rates increases less than unity in response to anticipated future inflation and so the real rate of interest decreases in high inflation periods. Specific channel through which this mechanism works is that, the reduction in real balances, under inflationary environment, puts downward pressure on consumption, raising real savings and lowering the investment demand, and ultimately reduces the real interest rate. Under real balance effect real interest rate falls in response to higher expected inflation.

Fisher Hypothesis with Phillips curve and Friedman Effect

In 1978, 1979 Levi and Makin using general equilibrium model formed the reduced form link between anticipated future inflation rate and nominal interest rate. New dimension to the relationship is given by incorporating the Phillips curve and inflation rate on uncertainty into the model to find the determinants of nominal interest rate. When variations in the real interest rate are controlled by introducing more variables in the Fisher equation, then the Fisher hypothesis is not rejected. In 1979 Levi and Makin discuss that if the short run Phillip curve holds then ΔP^e_{t+1} and w_{t+1} in equation (7) can be correlated. Hence, to take into account the bias, ΔY_{t+1} growth in real output (for the Phillips curve effect) is introduced in the Equation (7). The modified equation is:

$$i_t = \alpha + \beta \Delta P^e_{t+1} + \gamma \Delta Y_{t+1} + w_{t+1} \qquad (8)$$

where ΔY_{t+1} is the real income growth rate.

Friedman (1968) findings show that for several countries in the 1960's, the real output changes in response to the increase in price level suggesting the existence of upward sloping Phillips curve. The model specification is completed by adding the inflation uncertainty term to study the new avenues through which anticipated inflation can affect nominal interest rate. After including the Friedman and Phillips effects, Equation (8) becomes:

$$i_t = \alpha + \beta \Delta P^e_{t+1} + \gamma \Delta Y_{t+1} + \delta \sigma_t + w_{t+1} \qquad (9)$$

The new determinant ΔY_{t+1}, the growth in real income and σ_t, the degree of uncertainty about expected future inflation allow testing jointly the presence of Phillips and Friedman effects. Equation (9) implies the restriction $\beta = 1$ and $\gamma, \delta < 0$.

Taylor (1981), tests the Fisher hypothesis using the following equation:

$$i_t = \alpha + \beta_0 \Delta p^e_{t+1} + \beta_1 m_t + u_t \qquad (10)$$

where m_t is the nominal money supply.

Darby Effect

Darby (1975) notes that when taxes on interest or investment income are present then the nominal interest rate should rise by a greater amount than expected future inflation only if the after tax real return is to be unaffected. Thereby suggesting the exact link between the nominal interest rate and real interest rate as given by:

$$i_t = (r_t + \dot{P}^*_t)/(1-t) \qquad (11)$$

Inverted Fisher Hypothesis

Extending the Mundell (1963) and Tobin (1965) models, Carmichael and Stebbing (1983) offer another hypothesis. They question the validity of the assumption, the real rate of interest is fixed in the Fisher hypothesis. Under the Fisher hypothesis the real interest rate is assumed to be an exogenous variable. It is assumed that the real return on capital is influenced by the rate of time preference and technology. In such a situation, it is justified that the nominal rate of interest is completely modified according to the changes in the expected inflation rate. However in empirical literature the interest rate is used to check the Fisher hypothesis. It is not the return on capital but actually it is the real return on financial assets which are substitutes of money. The opportunity cost of money is the nominal return which is relatively constant due to financial regulations. It is not the real rate of interest. When money and financial assets are close substitutes for each other then expected real interest rate fluctuates in opposite directions in one-to-one direction with the expected future inflation rate. Hence phenomena termed as inverted Fisher hypothesis prevails. This is given by:

$$r^e_{t+1} = \gamma_0 + \gamma_1 P^e_{t+1} + \upsilon_{t+1} \qquad (12)$$

The inverted Fisher hypothesis holds in the financial markets if the restriction $(\gamma_0, \gamma_1) = (0, -1)$ is accepted. The inverted Fisher hypothesis is less expected to hold in situations when the level of substitution between money and other financial assets is low i.e; under deregulated financial markets and hyperinflation.

3 LITERATURE REVIEW

3.1 Literature Review of Fisher Hypothesis

Early studies support the Fisher hypothesis include Gibson (1972), Pyle (1972), Cargill (1976), Lahiri (1976) and Tanzi (1980). Gibson (1972) and Pyle (1972) find that the nominal rate of interest completely changes according to the changes in future inflationary expectations. They also find that the future inflationary expectations do not affect the real rate of interest. Cargill (1976), results confirm the hypothesis during the period (1950:6-1975:12) only. Lahiri (1976) and Tanzi (1980) use different proxies for expected future inflation *i.e*; distributed lags, adaptive expectations, extrapolative expectations and Frenkel's (1975) mechanism.

Later on Mishkin (1992), Phylaktis and Blake (1993), Evans and Lewis (1995) and Crowder and Hoffman, (1996), study the long run Fisher effect for US. They find a direct and one- to one link between nominal rate of interest and expected future inflation rate. Similarly Granville and Mallicks (2004) find that the Fisher effect holds in UK.

However studies of Nelson and Schwert (1977), Huizinga and Mishkin (1984), and Kinal and Lahiri (1988) show mix results. Huizinga and Mishkin (1984), Kinal and Lahiri (1988) and Rose (1988) focus on the assumption that the ex-ante real interest rate is fixed. This assumption forms the basis of Fisher hypothesis. They find that all the seven assets which they have used in their study have performed poorly as a hedge against expected future inflation. They find that the longer-maturity assets performance as hedge against inflation is even poorer. They also find that ex ante real interest rates are statistically significant for shorter periods of time. Kinal and Lahiri (1988) use interest –rate model to formulate investors' ex ante forecasts of inflation. They find that the Livingston survey forecasts are biased while the investors' ex ante forecasts of inflation are unbiased. They have also found that when price expectations are included in the model as a determinant of ex ante real interest rates, the mean squared prediction error of their inflation forecasts improves significantly.

Studies which reject the Fisher hypothesis include, Rose (1988), and Fahmy and Kandil (2003). In 1988 Rose, analyzes the univariate time series properties of interest rates and inflation rates. He concludes that nominal and real interest rates have unit root whereas inflation rate does not have unit root. This implies that the Fisher effect is rejected. Fahmy and Kandil (2003) find no cointegration between the long term and short term interest rates. They conclude that short term interest rates have very little significance to forecast future inflation rates. They also assert that the interest rates and inflation rates have a direct one to one link in the long run.

Fama (1975), Garbade and Watchel (1978) and Dawyer (1981) test both of the hypothesis jointly that the real interest rate is fixed over time and the Treasury bill market is efficient. Fama (1975) finds that the nominal interest rate is an unbiased forecaster of the market's expectations about the expected future inflation rate. Fama's results support the hypothesis that the market is efficient. Garbade and Watchel (1978) find no evidence in the favour of the hypothesis of efficiency of the market. Their results also reject their assumption related to the constancy of the real rate of interest during the sample period. They use the interest-rate model to construct investors' ex ante forecasts of inflation. They have shown that they are unbiased. Dawyer (1981) results are consistent with Fama (1975). He uses the information about past rates of interest and rates of inflation, past rates of growth of the base, money supply, and real *GNP*. His tests also allow for a positive marginal tax rate which changes the results a little. He finds that the hypothesis is mostly stable. His study provides the support for the suggestion that expected changes in the money supply do not affect expected real interest rates.

Fisher hypothesis has also been tested in Pakistan and India by Hasan, (1999) and Sathye, *et.al*, (2008) respectively. Hasan, (1999), tries to estimate the link between rate of inflation and rate of interest in the long run. He finds that the nominal interest rate and inflation rate are linked together in the long run. In his study the Fisher Hypothesis is accepted partially. Sathye, *et.al*, (2008), explain that in predicting expected future inflation short-term nominal interest rates are very useful.

Panel data study that support Fisher Hypothesis is done by Westerlund (2006). He includes twenty OECD countries from 1980:1 to 2004:4. He applies ADF and Durbin-Hausman techniques.

Panel data studies that reject the Fisher Hypothesis include Zisimos and Apostolos (1999), Crowder (2003), Herwartz (2011) and Ozean and Ari (2015). Zisimos and Apostolos (1999), use post war quarterly data set from 1957:1 to 1972:1 for Belgium, Canada, Denmark, France, Germany, Greece, Ireland , Japan, Netherland s, U.S, U.K. They conclude that fully expected future inflation has less than a unit effect on nominal interest rates, and it also decreases the real interest rates in the long run. Crowder (2003) uses monthly data from 1960:1 to 2000:12 of nine industrialized countries; US, UK, Germany, Japan, Italy, Belgium, France, Netherland s and Canada. He applies DOLS, FM-OLS Johansen (1991) Dickey – Fuller (ADF 1984), Phillips-Perron (PP 1988), Levin and Lin (1992), Im, Pesaran and Shin (IPS 1997) and Covariate Augmented Dickey Fuller (CADF) tests. He finds that the inflation rates and nominal interest rates are I(1) processes. He finds monetary super neutrality in 80% of the empirical specifications. He concludes that Fisher effect estimates depend on the deterministic specification and normalization of the regression. Herwartz (2011) uses unbalanced cross section data of 114 countries. He applies panel data methods and Functional coefficient models (Cai, Fan and Yao 2000). He finds less than one Fisher coefficient from a worldwide perspective. He concludes that when there is large positive change in inflation or high interest rates, a long run equilibrium association or link between expected future inflation and interest rate as assumed by Fisher (1930), does not prevail in the economies of the world. Ozean and Ari (2015) conducted their study for G7 countries. They find the presence of partial Fisher effect only.

Panel data studies of Engsted (1995), Said and Janor (2001), Berument and Jelassi (2002), Hakan (2007), Ghazali and Ramlee (2003), Ling *et.al*. (2007), and Badillo *et.al* (2011) find mix results. Engsted (1995), uses the monthly data set of thirteen OECD countries from 1962:2 to 1993:1. He applies Dicky Fuller test and Multivariate Maximum Likelihood method. He finds that for most countries inflation rates and interest rates are non stationary I(1) processes. Fisher hypothesis is rejected for Canada, USA, Belgium, France, Italy, Sweden, Switzerland, Denmark and Ireland. In Japan and UK the hypothesis is accepted. Said and Janor (2001) study Fisher hypothesis in Malaysia, Thailand, Indonesia, South Korea and Philippines. They find that inflation and interest rate series are integrated of order one and they are cointegrated for Indonesia only and there is bilateral causality between two variables. Berument and Jelassi (2002) confirm the Fisher hypothesis in 16 out of 26 countries. They say that Fisher hypothesis holds more in developed countries. Ghazali and Ramlee, (2003) examine the presence of Fisher effect in the G7 countries *i.e;* Canada, France, Germany, Italy, Japan, UK and USA. They use monthly data from1974:1 –1996:6. They find that the link between interest rates and expected future inflation does not hold in G7 countries in the long run. Hakan (2007) uses the International Financial Statistics (IFS) data set of G7 countries and 45 developing countries. He applies Garch technique. He confirms the presence of Fisher hypothesis in the G7 countries. It holds in only twenty three developing countries. There is positive and significant link between inflation uncertainty and interest rates in six G7 countries. Same positive and significant link between inflation uncertainty and interest rates exists in 18 developing countries. The link between inflation and interest rates is negative for seven developing countries. He concludes that the Fisher hypothesis holds in his study but it holds in its weak form. Ling *et. al*. (2007) use the monthly data of nine East Asian economies from 2001:1 to 2006:3. They apply unit root tests (ADF, DF-GLS). They conclude from the results of the short run data that the Fisher hypothesis holds in Malaysia, Taiwan and Philippines. Results of long run data show that Fisher hypothesis holds in China, Hong Kong, Indonesia, Singapore and South Korea as well. Badillo *et.al* (2011) use quarterly data of 15 EU countries from Jan 1983 to Jan 2009. They apply BKN (2009) methodology and find that global stochastic trends generate cross sectional dependence when this is ignored, a full Fisher effect is found otherwise a partial Fisher effect holds.

3.2 Literature Review of Alternative Specifications of Fisher Hypothesis

Fisher Hypothesis with Phillips curve and Friedman Effect

Taylor (1981) finds that the coefficients of expected future inflation rate are considerably decreased. The strong systematic link between interest rates and output does not hold. He also finds that the inflation uncertainty becomes an insignificant variable. His results show that the Phillips curve effect is responsible for the failure of Fisher hypothesis. He doesn’t find the presence of Mundell effect and the inflation uncertainty effects.

Literature Review of Darby Effect

The studies that confirm the presence of Darby effect is Feldstein (1976) and Crowder and Hoffman (1996). Feldstein (1976) says that corporation and personal income taxes highly affect the link between inflation rate and interest rate. The force of the Fisher effect lies in the factors like the real returns to the savers, the cost of the capital to the firm and equality of the real interest rates. All of these factors will be equal in the absence of taxes. In an economy with personal and corporate income taxes this is not true. Crowder and Hoffman, (1996), conclude that the nominal rate of interest changes according to the changes in inflation rate in both cases of Fisher hypothesis and Darby effect. Even after allowing for the changes in marginal tax rates. These changes in the marginal tax rates have occurred over the entire sample period. They also find that inflation can predict the future of interest rates.

The studies that have inconclusive results are Carr *et.al*, (1976) and Cargill (1977). Carr *et.al*, (1976) find inconclusive results about the Darby hypothesis. Cargill (1977), re-estimated his model by including real GNP and real money supply.

The study that rejects the Darby effect is Tanzi (1980). This study concludes that individuals do not suffer from the money illusion but they suffer from the fiscal illusion.

Literature Review of Inverted Fisher Hypothesis

Studies which find support of inverted Fisher hypothesis include Amsler (1986), Gupta (1991) and Choudhry (1997). Amsler (1986) studies both the Fisher effect and the inverted Fisher effect. His results support both the Fisher effect as well as Inverted Fisher effect. Gupta (1991) finds support for partial inverted Fisher effect.

Studies which find no relation between nominal interest rates and inflation include Viren (1986) and Gallagher (1986), Barth and Bradley (1988) and Choi (2002). Viren (1986) concludes that inflation and interest rates have very little covariance. Gallagher (1986), finds that inflation and nominal interest rates are contemporaneously uncorrelated. Barth and Bradley (1988) find that Fair's tax series is not useful as it is not built on taxes on interest income. They also find that Fair's tax series does not measure the marginal tax rate. Choi (2002), full sample results show that inverted Fisher hypothesis is rejected. Sub sample results show that inverted Fisher hypothesis is rejected in high forecastibilty regions and accepted in low forecastibilty regions.

4. METHODOLOGY

Estimation methodology of our study deals with the analysis of the variables of the model. Panel unit root analysis is done using Im, Pesaran and Shin (IPS) Test 1997 and for the estimation of the model, a general to specific methodology is used.

Models of Fisher hypotheses show that the equation (9) or Fisher hypothesis with Phillips curve and Friedman Effect encompasses the earlier models. By combining equation (9), (10) and (12), we have a general model of Fisher Hypothesis:

$$\begin{aligned} i_{i,t} &= a + b_0 i_{i,t-1} + b_1 \Delta p_{i,t} + b_2 \Delta p^e_{i,t} + b_3 \Delta p^e_{i,t+1} + b_4 \Delta Y_{i,t} + b_5 \Delta Y_{i,t+1} \\ &+ b_6 \sigma_{i,t} + b_7 \sigma_{i,t-1} + b_8 m_{i,t} + b_9 m_{i,t-1} + w_{t+1} \\ i &= 1,\dots\dots,N;\ t = 1,\dots\dots,T, \end{aligned} \qquad (13)$$

$i_{i,t}$ is the observation on *ith* country for the *t*th time period.

4.1 DATA

In this study we have used yearly data set of International Financial Statistics (IFS) from 1948 to 2012. This is an unbalanced panel data set. Nominal interest rates ($\boldsymbol{i}$) is measured through discount rate, lending rate, bank rate or money market rate. Inflation is measured by Consumer Price Index (CPI). Real income ($\boldsymbol{Y}$) is measured by data on Gross

Domestic Product (GDP). Nominal money supply (m) measured by M_1 and M_2. Uncertainty about anticipated inflation(σ) is measured by 3-5 years standard deviation of CPI. Data of taxes on interest income is not available so the Darby effect can not be calculated

5. EMPIRICAL RESULTS

5.1 Unit Root Test Analysis of the Variables

Unit root analysis of the variables of the model is done using Im, Pesaran and Shin (IPS) statistics. Our results show that the null hypothesis of unit root is accepted at 5% level of significance for interest rate data only and for CPI, GDP and nominal money supply the null hypothesis is accepted at the first difference.

Table 1 Unit Root Test Results

Method	Variable	Statistic at Level	Probability at Level	Statistic at First Difference	Probability at First Difference
Im, PesaranandShin W-Stat	$i_{i,t}$	-4.9798	0.0000		
Im, PesaranandShin W-Stat	$P_{i,t}$			-6.9153	0.0000
Im, PesaranandShin W-Stat	$Y_{i,t}$			-13.6555	0.0000
Im, PesaranandShin W-Stat	$m_{i,t}$			-2.4793	0.0066

5.2 A General Random Effects Model of Fisher Hypothesis

To estimate a general model of Fisher hypothesis or equation (13), International Financial Statistics (IFS) unbalanced panel data of 129 countries, 1955 – 2012, is used
The results of the general random effects model of Fisher hypothesis show that our model is a random effects model and $b_{1,i}$ changes across cross sections. A full Fisher effect $b_3 = 1$ can not be rejected. Inverted fisher hypothesis, Phillips curve and Friedman effect are rejected. Taylor effect holds here and this effect is significant at 1% level of significance.

Table 2 Estimation Results of a Random Effects General Model of Fisher hypothesis

Regressor	Coefficient	Std. Error	t-statistic	Probability
Constant	-32.13	8.23	-3.90**	0.00
$i_{i,t-1}$	0.4	0.02	29.50**	0.00
$\Delta P_{i,t}$	0.10	0.42	0.26	0.80
$\Delta P^e_{i,t}$	-0.82	0.53	-1.56	0.12
$\Delta P^e_{i,t+1}$	0.96	0.45	2.10*	0.04
$\Delta Y_{i,t}$	-197.27	18.1	-10.89**	0.00
$\Delta Y_{i,t+1}$	196.83	18	10.88**	0.00

$\sigma_{i,t}$	0.25	0.23	1.05	0.29
$\sigma_{i,t-1}$	-1.91	0.81	-2.35*	0.01
$m_{i,t}$	128.78	12.03	10.71**	0.00
$m_{i,t-1}$	-130.39	12.04	-10.83**	0.00

**indicates significance at 1%.
*indicates significance at 5%.

$R^2 = 0.515\ \overline{R}^2 = 0.513$

Durbin Watson Statistic=2.16, Mean dependent Var. 19.60,
S.D dependent Var. 140.09, S.E of Regression 97.78, Loglikelihood-11685.73
Akaik info criterion 12.008, Schawarz criterion12.04, Hannan-Quinn Criterion 12.02
F-Statistic 205.94, Prob(F-Statistic) 0.00

Nominal interest rate is positively and significantly related with its lagged value. Inflation is positively related with the nominal interest rate but this relationship is insignificant. Expected inflation is negatively related with the nominal interest rate. This relationship is insignificant. Real income is negatively related with the interest rate. This relationship is also significant. Uncertainity and money supply in the last year are negatively related with the nominal interest rate and these variables are significant at 5% and 1% level of significance respectively.

Table 3 Estimation Results of a Random Effects General Model of Fisher hypothesis, Effect Specification

	S.D	**Rho**
Cross Section Random	0.0000	0.0000
Ideosyncratic Random	97.1535	1.0000

Wald test is used to test the effects of inflation, expected inflation and Phillips curve in determining the nominal interest rates. The results indicate that the null hypothesis is rejected at 5% level of significance and these variables have no significant effect on nominal interest rate.

Table 4 Wald Test Results of a Random Effects General Model of FH

Test Statistic	**Value**	**df.**	**Prob.**
F-Statistic	1.02	(3,1937)	0.38
Chi-Square	3.05	3	0.38

Like Levi and Makin (1979) when Friedman and Phillips curve effects are included in the model the full Fisher effect holds but unlike Levi and Makin (1979) these effects either have opposite sign or are insignificant.

5.3 Estimation Results of a Random Effects Specific Model of FH

The estimation results of the specific model of fisher hypothesis show that all the variables of the model are now statistically significant at 1% level of significance. The numerical value of coefficient of anticipated inflation $\Delta P^e_{i,t+1}$ (b_1) is not equal to one so our null hypothesis of strong form fisher hypothesis is rejected. The null hypothesis of fisher hypothesis in weak form $0\angle b_1\angle 1$ is accepted. The numerical value of coefficient of future real income, b_3 is positive. So the Friedman effect does not hold. The numerical value of coefficient of nominal money supply, b_5 is 128.43. The null hypothesis $b_5 \neq 0$ is accepted. Taylor effect holds here as well.

Table 5 Estimation Results of Random Effects Specific model of Fisher hypothesis

Regressor	Coefficient	Std. Error	t-statistic	Probability
Constant	-30.64	8.14	-3.77**	0.00
$i_{i,t-1}$	0.49	0.02	29.51**	0.00
$\Delta P^e_{i,t+1}$	0.24	0.07	3.28**	0.00
$\Delta Y_{i,t}$	-191.88	17.62	-10.89**	0.00
$\Delta Y_{i,t+1}$	191.25	17.57	10.88**	0.00
$\sigma_{i,t-1}$	-0.67	0.22	-3.09**	0.00
$m_{i,t}$	128.43	11.98	10.71**	0.00
$m_{i,t-1}$	-130.09	12.01	10.83**	0.00

**indicates significance at 1%.

$R^2 = 0.514$ $\overline{R}^2 = 0.513$

Durbin Watson Statistic=2.15, Mean dependent Var. 19.60, Loglikelihood-11687.27 ,
S.D dependent Var. 140.09, S.E of Regression 97.78, F-Statistic 293.75, Prob. (F-Statistic) 0.00
Akaik info criterion 12.007, Schawarz criterion12.03, Hannan-Quinn Criterion 12.02

Unit root test on the residuals of the above model shows that the null hypothesis is rejected at 5% level of significance and there is a long run relationship among the variables of the model.

Table 6 Unit Root tests of the residuals of Equation (14)

Method	Statistic	Prob.
Im, Pesaran and Shin w-stat	-22.21	0.00
Im, Pesaran and Shin t-stat	-3.86	0.00

Our results of are consistent with the findings of Taylor (1981), Graham (1988), Hasan (1999) and Herwartz (2011).

5.4 Estimation Results of a General Random Effects Model of FH for Above Average Money Supply/GDP Countries

To estimate a general model of Fisher hypothesis or equation (13), International Financial Statistics (IFS) unbalanced panel data of 14 countries, 1973 – 2009, is used. The results show that Fisher hypothesis, inverted fisher hypothesis, Phillips curve and Friedman effect are rejected. Inverted Fisher hypothesis holds in its weak form and this effect is insignificant. Only the Taylor effect holds here. Lagged value of nominal interest rate and future real income has positive effect on nominal interest rate and this effect is significant at 1% level of significance. Real income in the current year, money supply and its lagged value are negatively and significantly related with the nominal interest rate.

Table 7 Estimation Results of a Random Effects General Model of Fisher hypothesis for Above Average Money Supply/GDP Countries

Regressor	Coefficient	S. E	t-stat	Prob.
Constant		6.41	-0.94	0.35
$i_{i,t-1}$	1.09	0.02	44.72**	0.00
$\Delta P_{i,t}$	0.53	0.98	0.54	0.59
$\Delta P^{e}_{i,t}$	-0.46	0.35	-1.29	0.20
$\Delta P^{e}_{i,t+1}$	-0.08	1.30	-0.06	0.95
$\Delta Y_{i,t}$	-53.14	11.86	-4.47**	0.00
$\Delta Y_{i,t+1}$	54.02	11.79	4.58**	0.00
$\sigma_{i,t}$	0.20	0.08	2.48	0.01
$\sigma_{i,t-1}$	0.17	2.37	0.07	0.94
$m_{i,t}$	-18.43	9.09	-2.03*	0.04
$m_{i,t-1}$	17.97	9.08	-1.98*	0.05

$R^2 = 0.94$ $\bar{R}^2 = 0.93$

Durbin Watson =1.33, Mean dependent Var. 34.69,
S.D dependent Var. 76.96, S.E of Reg. 20.22, Sum Squared Resid. 64185.97
F-Stat 226.27, Prob(F-Stat) 0.00

Table 8 Estimation Results of a Random Effects General Model of Fisher hypothesis for Above Average Money Supply/GDP Countries, Effect Specification

	S.D	Rho
Cross Section Random	0.00	0.00
Ideosyncratic Random	16.66	1.00

Wald test is used to test the effects of inflation, expected inflation, expected future inflation and uncertainty in the past in determining the nominal interest rates. The results indicate that the null hypothesis is not rejected at 5% level of significance and these variables have significant effect on nominal interest rate.

Table 9 Wald Test Results of a Random Effects General Model of FH for Above Average Money Supply/GDP Countries

Test Stat	Value	df.	Prob.
F-Stat	3.48	(4,157)	0.01
Chi-Square	13.92	4	0.01

5.5 A General Random Effects Model of Fisher Hypothesis for Below Average Money Supply/GDP Countries

To estimate a general random effects model of Fisher hypothesis or equation (13) for below average money supply/GDP countries, International Financial Statistics (IFS) unbalanced panel data of 111 countries is used.

Table 10 Estimation Results of a Random Effects General Model of Fisher hypothesis for Below Average Money supply/GDP Countries

Regressor	Coefficient	S. E	t-stat	Prob.
Constant	-45.96	9.35	-4.91**	0.00
$i_{i,t-1}$	0.45	0.02	25.73**	0.00
$\Delta P_{i,t}$	0.25	0.56	0.44	0.66
$\Delta P^{e}_{i,t}$	-1.19	1.24	-0.96	0.34
$\Delta P^{e}_{i,t+1}$	1.38	0.95	1.45**	0.15
$\Delta Y_{i,t}$	-290.19	21.24	-13.67**	0.00
$\Delta Y_{i,t+1}$	288.67	21.17	13.63**	0.00
$\sigma_{i,t}$	-2	1.18	-1.70**	0.09
$\sigma_{i,t-1}$	-2.83	1.02	-2.77**	0.01
$m_{i,t}$	156.36	13.05	11.98**	0.00
$m_{i,t-1}$	-156.63	13.01	-12.04**	0.00

$R^2 = 0.54$ $\overline{R}^2 = 0.54$

Durbin Watson=2.31, Mean dependent Var. 17.18,S.D dependent Var. 146.96, S.E of Reg. 99.61, F-Stat 202.83, Prob(F-Stat) 0.00

The results show that Fisher hypothesis in its strong form holds and Friedman effects and Taylor effects are also present here. Phillips curve effect does not hold. Lagged value of interest rate, growth in future real income and lagged money supply has a positive and significant effect on nominal interest rates. While growth in real income and uncertainty in the past have negative and significant effect on nominal interest rate. Inflation has positive effect while expected inflation has negative effect on nominal interest rate and both of these effects are insignificant.

Table 11 Estimation Results of a Random Effects General Model of Fisher hypothesis for Below Average Money supply/GDP Countries, Effect Specification

	S.D	Rho
Cross Section Random	0.0000	0.0000
Ideosyncratic Random	100.1535	1.0000

Wald test is used to test the effects of inflation and expected inflation. The results indicate that the null hypothesis is rejected at 5% level of significance and these variables have no significant effect on nominal interest rate.

Table 12 Wald Test Results of a Random Effects General Model of FH for Below Average Money supply/GDP Countries

Test Statistic	Value	df.	Prob.
F-Stat	0.51	(2,1705)	0.60
Chi-Square	1.03	2	0.60

5.6 Estimation Results of a Random Effects Specific Model of FH for Below Average Money supply/GDP Countries

The estimation results of the specific model of fisher hypothesis show that all the variables of the model are now statistically significant at 1% level of significance except uncertainity. The numerical value of coefficient of anticipated inflation $\Delta P^{e}_{i,t+1}$ (b_1) is not equal to one so our null hypothesis of strong form fisher hypothesis is rejected. The null hypothesis of fisher hypothesis in weak form $0 \angle b_1 \angle 1$ is accepted at 1% level of significance. The numerical value of coefficient of future real income, b_3 is not less than zero. So the Phillips curve effect does not hold. The numerical value of coefficient of nominal money supply, is 128.43. The null hypothesis is accepted at 1% level of significance so the Taylor effect exists. The numerical value of coefficient of uncertainty (Friedman effect), $b_4 \angle 0$ but it is not statistically significant.

Table 13 Estimation Results of Random Effects Specific model of Fisher hypothesis for Below Average Money Supply/GDP Countries

Regressor	Coefficient	S. E	t-stat	Prob.
Constant	-45.89	9.28	-4.95**	0.00
$i_{i,t-1}$	0.45	0.02	25.77**	0.00
$\Delta P^{e}_{i,t+1}$	0.43	0.08	5.35**	0.00
$\Delta Y_{i,t}$	-291.04	21.01	-13.85**	0.00
$\Delta Y_{i,t+1}$	289.46	20.95	13.81**	0.00
$\sigma_{i,t}$	-1.37	0.99	-1.39	0.17

$\sigma_{i,t-1}$	-2.73	1.00	-2.72**	0.01
$m_{i,t}$	155.63	13.03	11.95**	0.00
$m_{i,t-1}$	-155.89	12.98	-12.01**	0.00

$R^2 = 0.514$ $\overline{R}^2 = 0.513$

Durbin Watson =2.15, Mean dependent Var. 19.60, Loglikelihood-11687.27 ,
S.D dependent Var. 140.09, S.E of Reg. 97.78, F- Stat. 293.75, Prob. (F-Stat.) 0.00

6 CONCLUSIONS

In this research paper we have estimated alternative specifications of Fisher Hypothesis. Yearly data set of International Financial Statistics (IFS) from 1948-2012 is used. This is an unbalanced panel data set. Panel unit root analysis of the variables show that the interest rate data is stationary at the levels, while the inflation, real income and money supply data is stationary at the first difference. Our results show that the Fisher hypothesis, Phillips curve effect and Friedman effect does not hold. Fisher hypothesis in its strong form holds only when Phillips curve and Friedman effects are present but they are either insignificant or have not the expected sign. Removal of the insignificant variables from the model show that Fisher hypothesis holds in its weak form. Nominal interest rate in the last year, real income, future real income, lagged value of uncertainty and nominal money supply and its lagged value has significant effect on nominal interest rate. Unit root test of the residuals of the model show that there is a long run relationship among the variables of the model. Our results are consistent with the studies of Taylor (1981), Graham (1988), Hasan (1999) and Herwartz (2011).

Our analysis of the random effects general model of Fisher hypothesis for above average money supply⁄GDP countries show the presence of inverted Fisher effect but this effect is insignificant. Only the Taylor effect is significant here. Growth in real income, money supply and its lagged value have negative and significant effect on nominal interest rate while growth in future real income has positive and significant impact. Our analysis of the random effects general model of Fisher hypothesis for below average money supply⁄GDP countries show that here Fisher hypothesis holds and Friedman and Taylor effects are also present. Phillips curve effect does not hold. Lagged value of nominal interest rate, growth in future real income and money supply has positive and significant effect on nominal interest rates. Real income growth, lagged value of uncertainty and lagged value of money supply have negative and significant effect on nominal interest rate. Inflation and expected inflation are insignificant and their removal from the model depresses the numerical value of Fisher effect. Friedman and Tailor effects are present but Friedman effect is insignificant.

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APPENDIX

To estimate a general model of Fisher hypothesis or equation (4.6), International Financial Statistics (IFS) unbalanced panel data of 129 countries, 1955 – 2012, is used i.e; Albania, angola, Anguilla, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia & Herzegovina, Botswana, Brazil, Brunei Darussalam, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verda, Central African Republic, Chad, Chile, China, Colombia, Congo, Costa Rica, Cote d’Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Djibouti, Dominican Republic, Egypt, Elsalvadore, Equatorial Guinea, Estonia, Ethiopia, Euro Area, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guinea- Bissau, Guyana, Haiti, Honduras, Hungry, Iceland, India, Indonesia, Iran, Iraq, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyz, Latvia, Lesotho, Libya, Lao Peoples’s Dem., Luxembourg, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Malta, Mauritania, Mauritius, Mexico, Netherlands, Newzealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Portugal, Poland, Philippines, Peru, Paraguay, Papua New Guinea, Qatar, Romania, Russian Federation, Samoa, Saudi Arabia, Serbia, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, St. Kitts &Navis, St. Lucea, St. Vincent &Grens, Swaziland, Sweden, Syrian Arab Republic, Tajikstan, Tanzania, Thailand, Timor- Leste, Togo, United Kingdom, United States of America, Uganda, Ukraine, Uruguay, Venezuela, Vietnam, Yemen, Zambia and Zimbabwe is used.