European Journal of Business and Management
ISSN 2222-1905 (Paper) ISSN 2222-2839 (Online)
Vol.7, No.35, 2015

The Relationship between Inflation Pressure and Interest Rates: An Empirical Analysis of the Fisher Hypothesis in Kenya

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Abstract

The Fisher effects theory holds that there exists a relationship between nominal interest rates and inflation rates: an increase in the inflation rate should lead to a proportionate increase in the nominal interest rate holding the real interest rate constant. A market in which this theory is valid is therefore more effective at pricing debt securities correctly. This paper investigated the bivariate relationship between monthly inflation rates and monthly yields on 3-Month Treasury bills over the January 2009 to August 2015 period. Both time series were found to be integrated of order one. Cointegration testing concluded that there was no long run relationship between interest rates and inflation, and therefore the Fisher effects theory was not valid in Kenya over the study period. A VAR model was fitted on the data to investigate the lead-lag interactions between the variables and their lags. Finally, granger causality tests, which concluded bi-directional causality between interest rates and inflation, were carried out.

Keywords: Fisher Effects, Inflation, Interest Rates, Cointegration, Vector Autoregression

1. Introduction

The relationship between interest rates and inflation has been an interesting area of research for quite a while now. Essentially, inflation is seen as one of the key determinants of the nominal interest rate. An overarching theory on the relationship between nominal interest rates and inflation is the Fisher effects theory (Fisher, 1930) which theory holds that the nominal interest rate is a function of the real interest rate and the expected inflation rate. The main postulation of the Fisher effects theory is that holding the real interest rate constant, an increase in expected inflation should lead to an increase in the nominal interest rate. Hordahl (2008) posits that of the theoretical premiums which are loaded on the real interest rate to calculate the nominal interest rate, inflation is the most important and impactful. Movements in the inflation rate tend to have more influence on the movement of the nominal interest rate than other determining factors.

The Fisher hypothesis is an important tool in finance since it shows how efficient a market is in incorporating expected inflation i in the nominal interest rate. Markets in which strong Fisher effects are present therefore have a high efficiency in incorporating inflation expectations in the nominal interest rate. Consequently, this enhances the price discovery function of such markets. Inasmuch as research into the Fisher effects theory has been carried out in several other developed and developing economies, there is a dearth in the literature on research in this crucial area in the East African region. This paper therefore attempts to fill this research gap by investigating the relationship between nominal interest rates and inflation in Kenya.

2. Nominal Interest Rates and Inflation Pressure: A Review of Literature

There are numerous studies focused on the relationship between nominal interest rates and inflation in the literature. Mishkin (1992) validated the Fisher effects theory in the United States using monthly data for the Jan 1953 to Dec 1992 time period. He carried out cointegration tests on both inflation and nominal interest rates and concluded that the Fisher effects theory held in the US economy only from October 1979 to September 1992. Peng (1995) evaluated the presence of Fisher effects in France, the U.K, the U.S, Germany and Japan. The study concluded that the Fisher effects theory was strongly valid in France, the U.K and the U.S. There was evidence of Fisher effects in Germany and Japan too, albeit on a weaker level. Wallace and Warner (1993) used Johansen Cointegration tests to investigate the relationship between inflation and both long run and short run interest rates. Using U.S data from the first quarter of 1948 to the last quarter of 1990, they confirmed the presence of Fisher effects in the US over the study period.

Using a Vector Error Correction (VEC) Model and granger causality tests, Sahibzada and Fatima (2012) investigated whether Fisher effects were present in Pakistan for the 1980 to 2010 period. This research yielded evidence of both Fisher effects and bi-directional granger causality over the study period. Mishkin (1984) yielded evidence of strong Fisher effects in the U.K, the U.S and Canada and weak Fisher effects in Germany, Switzerland and Netherlands. For all six countries, he analyzed biannual data from 1967 to 1979 using the Johansen (1988) methodology.. Quoc (2012) used unit root tests, the Johansen cointegration test, and autoregressive distributed lag (ARDL) bound tests to investigate Fisher effects in six developing nations, i.e. Vietnam, Pakistan, india, Argentina, China, and Brazil over the 1997 to 2010 period. The research concluded weak Fisher effects in India, Vietnam, and Argentina. Results for Brazil were inconclusive while in China and India, the null hypothesis of Fisher effects was rejected.

Using unit root tests, cointegration tests and the VEC model, Benazic (2013) carried out a study on the relationship between inflation and nominal interest rates in Croatia over the 1996 to 2012 time period. The research concluded that in the Croatian scenario, Fisher effects hold only in the long run. Booth and Ciner (2000) used monthly values of inflation rates and Eurocurrency interest rates data to test the Fisher hypothesis in ten countries (Italy, the Netherlands, Norway, Sweden Belgium, Denmark, France, Germany, the UK and the US) over the Jan 1978 to Feb 1997 time period. The paper used unit root tests and Johansen cointegration tests to investigate the relationship between the study variables in each of the ten countries. The conclusion was that in all countries except France, the inflation rates and Eurocurrency interest rates were integrated of order one. Further, cointegration tests suggested long run cointegration with a stochastic trend between changes in the two time series. Azari et al (2011) investigated the effect of inflation on both interest rates and exchange rates in Malysia from 1999 to 2009. This study used a VEC model to investigate the relationship between the three time series and an impulse response function (IRF) to evaluate the response to shocks within the study variables. Analysis yielded evidence of a negative influence of inflation on interest rates. Further, the paper suggested a link between a rise in the inflation rate and increased volatility of exchange rates.

Wijesinghe (2002) carried out a study using the monthly yield of 3 month Treasury bills and monthly inflation in Sri Lanka. Data was for the 1960 to 1999 time period. The analysis consisted of conducting unit root tests, Johansen cointegration tests, and vector autoregressive (VAR) model fitting. The results concluded that the Fisher hypothesis did not hold in Sri Lanka, and this finding was attributed to the prevalence of government control of major macroeconomic factors in Sri Lanka. Asgharpur et al (2007) used data for a panel of forty Islamic countries to investigate the causal relationship between inflation and nominal interest rates over the 2002 to 2005 period. The research concluded unidirectional granger causality, from the interest rate to the inflation rate, in all forty cases. Yaya (2015) tested the Fisher hypothesis in ten African countries, i.e. Benin, Cameroon, Ivory Coast, Gabon, Gambia, Ghana, Kenya, Nigeria, Senegal and South Africa using data over the 1970 to 2013 period. The research found nominal interest rates to be integrated of order one while inflation rates did not contain a unit root. Due to the differential in the order of integration, analysis was carried out using bound tests for cointegration. The results suggested that strong Fisher effects were present only in Kenya. In Gabon and Ivory Coast, there was evidence of weak Fisher effects while in all other countries; there was no evidence of Fisher effects.

3. Study Variables

This study utilized monthly inflation rates for Kenya and monthly returns for 3 Month Central Bank of Kenya treasury Bills. The research data was for eighty monthly observations, i.e. from January 2009 to August 2015 as available on the Central Bank of Kenya website. Monthly data was chosen due to its availability in raw form.

4. Research Design and Methodology

Analysis of the research data commenced with testing both series for stationarity using the Phillips Perron test. This test showed that the data was not stationary and hence it was differenced once after which stationarity was attained. Consequent analysis was carried out on the differenced values. Next, various information criteria were used to guide the selection of the optimal lag order. After optimal lag selection, the Johansen cointegration test was carried out. This test showed that the data didn't have any cointegrating relations and therefore a vector autoregressive model was most appropriate for this study. Lastly, granger causality tests were carried out to investigate the presence, magnitude, and direction of granger causality.

4.1 Unit Root Testing

In order to analyze data using VAR/VEC type models, it must be stationary. Non stationary data is likely to result in spurious regressions since mean and standard deviation estimates derived from such data will be non-constant. To test the data for stationarity, the Phillips Perron (1988) test was applied. This test estimates the AR (1) equation below:

$$y_i = \alpha + \rho y_{i-1} + \varepsilon_i \qquad (1)$$

The estimate of the autocorrelation coefficient, ρ , is computed as below:

$$\hat{\rho}_n = \frac{\sum_{i=1}^{n} y_{i-1} y_i}{\sum_{i=1}^{n} y_i^2} \qquad (2)$$

Where n is the number of observations.

The Philips Perron test has two *Z* test statistics, which are specified below:

$$Z_\rho = n(\hat{\rho}_n - 1) - \frac{1}{2}\frac{n^2\hat{\sigma}^2}{s_n^2}(\hat{\lambda}_n^2 - \hat{\gamma}_{0,n}) \qquad (3)$$

$$Z_\tau = \sqrt{\frac{\hat{\gamma}_{0,n}}{\hat{\lambda}_n^2}}\frac{\hat{\rho}_n - 1}{\hat{\sigma}} - \frac{1}{2}(\hat{\lambda}_n^2 - \hat{\gamma}_{0,n})\frac{1}{\hat{\lambda}_n}\frac{n\hat{\sigma}}{s_n} \qquad (4)$$

Where:

$$\hat{\gamma}_{j,n} = \frac{1}{n}\sum_{i=j+1}^{n} \hat{u}_i \hat{u}_{i-j} \qquad (5)$$

$$\hat{\lambda}_n^2 = \hat{\gamma}_{0,n} + 2\sum_{j=1}^{q}(1 - \frac{j}{q+1})\hat{\gamma}_{j,n} \qquad (6)$$

$$s_n^2 = \frac{1}{n-k}\sum_{i=1}^{n} \hat{u}_i^2 \qquad (7)$$

u_i is the regression residual of (i)

$\hat{\sigma}$ is the regression standard error of $\hat{\rho}$

k is the number of covariates in (i)

q is the number of Newey-West lags used in calculation of $\hat{\lambda}_n^2$

The values of the Z_ρ and Z_τ test statistics should be compared with Fuller (1996) critical values. If the value of the two test statistics is less than that of the critical value, the conclusion is that the data is stationary.

4.2 Optimal Lag Order Selection

In time series modeling, selecting the lag order for model construction is often one of the biggest challenges. In response to this, model selection criteria have been developed to guide the selection of the optimal lag order. An optimal lag order ensures balance between goodness of fit and parsimony. Using such a lag helps in constructing models which are neither too simplistic nor excessively complex. The current paper employed four common information criteria to establish the optimal lag order: Akaike's Final prediction error (FPE), Akaike information criterion (AIC), Bayesian information criterion (BIC) and the Hanna Quinn Information criterion (HQIC). A consensus of the four information criteria on one lag order would establish a strong confidence on the optimality of the pertinent lag order.

4.3 Testing for Cointegration

After selecting the optimal lag order, the next step was to test the research data for the existence of cointegrating relations. Cointegration is a concept in econometrics which was popularised towards to end of the 20th century,

most notably by Johansen (1988; 1995). Testing for cointegration was a critical juncture in the analysis since the output of the cointegration test would provide guidance on whether to analyze the data using a VAR model or a VEC model. If there are no cointegrating relations, vector autoregression is carried out. Conversely, vector error correction models are used for time series with at least one cointegrating equation.
In the simplest terms, cointegration is defined viz:

If two time series, i.e. m_t and n_t are both integrated of order one, i.e. they both contain a unit root, these series will be cointegrated if there exists a parameter α such that the process μ specified below is stationary:

$$\mu = n_t - \alpha m_t \tag{8}$$

The study used the Johansen (1995) cointegration test to evaluate whether the time series data had any cointegrating quations. The specification of this test is as below:
Consider the basic vector error correction model:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{t-1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{9}$$

Where:

y is a (*Kx1*) vector of I(1) variables.

α and β are (*Kx1*) parameter matrices with rank r<K.

Γ_1 ,.................... Γ_{p-1} are (*KxK*) matrices of parameters.

ε_t is a (*Kx1*) vector of normally distributed errors.

Johansen (1995) derives two likelihood ratios (LR) tests for inference on r, the minimum rank of the parameter matrices. These tests are the trace statistic test and the maximum eigenvalue statistic test. The trace statistic test is the one which was applied in this paper. The trace statistic is computed as:

$$-T \sum_{i=r+1}^{K} \ln(1 - \hat{\lambda}_i) \tag{10}$$

Where:

T is the number of observations

$\hat{\lambda}_i$ are the estimated eigenvalues

r is the maximum rank of cointegrating equations.

The maximum rank of cointegrating equations, r, is the value of the rank in which the size of the critical value exceeds the trace statistic for the first time. The null hypothesis of the Johansen cointegration test is that the number of cointegrating relations does not exceed r.

4.4 Testing for Granger Causality

The granger causality test is a post estimation procedure which enables further inference on the result of fitting a VAR/VECM model. Granger (1969) devised a concept of evaluating the existence and nature of a novel form of causality between two time series, aptly denoted as 'granger causality'. Essentially, one time series y is said to be 'grange caused' by a second time series x if lagged values of x are useful in predicting current values of y. The granger causality test tests the null hypothesis that the coefficients of the lagged values of x are jointly zero. Failure to reject the null means that x does not 'grange-cause' y.
In this paper, the null hypotheses were:

H_{0a}: T-Bill rate does not grange cause the inflation rate

H_{0b}: Inflation rate does not grange cause the T-Bill rate

Granger causality is different from the literal meaning of the term 'causality'. When a time series 'grange causes' another time series, this means that lagged values of the first time series contain information which could be useful in predicting the second time series. However, this does not indicate that the first time series is a direct predictor of the second one. In many cases, bi-directional granger causality is the case, i.e. a time series x 'grange causes' another time series y and y 'grange causes' x.

5. Analysis, Results and Discussion

In this part, we analyze the research data empirically and then present the results and their discussion.

5.1 Descriptive Statistics

In order to create a general profile of the data, descriptive statistics of the T-Bill rate and the inflation rate were computed and reported in Table 1 below.

Table 1. Descriptive Statistics

	Mean	Maximum	Minimum	s.d.	Skewness	Variance	Median
T-Bill rate	8.457	20.56	1.6	3.868	0.783	14.963	8.475
Inflation	8.072	19.72	3.18	4.423	1.146	19.561	6.645

The T-Bill rate was noted to be marginally larger than the inflation rate. Further, the highest observed value of the T-Bill rate over the study period was 20.56% while the highest inflation rate was 19.72%. It is also readily observable from the standard deviations of both series that the inflation rate was more volatile than the T-Bill rate.

5.2 Testing for Stationarity

The Phillips Perron test was used to test the research data for stationarity. As evident in table 2 below, the test statistic for both inflation rate and T-Bill rate was larger than the respective critical value at each of the three levels of significance. As such, we failed to reject the null hypothesis of a unit root in each of the two time series.

Table 2. Phillips Perron Test

	Test Statistic (Inflation Rate)	Test Statistic (T-Bill Rate)	1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-6.444	-7.195	-19.404	-13.524	-10.868
Z(t)	-1.876	-1.856	-3.541	-2.908	-2.589

The implication of this result was that both time series were not stationary and hence differencing was necessary.

5.3 Testing for Stationarity on First Differencing

In order to attain stationarity, the research data was differenced once. The Phillips Peron test was applied on the differenced time series and the results of this test are shown in table 3 below.

Table 3. Phillips Perron Test after First Differencing

	Test Statistic (dinflation)	Test Statistic (dtbill)	1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-30.947	-47.867	-19.404	-13.524	-10.868
Z(t)	-4.369	-5.98	-3.541	-2.908	-2.589

Since the test statistic for both series was less than the critical value at all three levels of significance, it can be noticed that stationarity was achieved after the first differencing, i.e. both series were integrated of order one. Consequent analysis was therefore carried out on the first differences.

5.4 Selection of Optimal Lag Order

Having established that both series were integrated of order one, the next step was to select the optimal lag order for the research data. The research utilized four information criteria in optimal lag selection, i.e. Akaike's Final Prediction Error, Akaike Information Criterion, Hanna Quinn Information Criterion, and the Bayesian information criterion. Table 4 below shows the values of the statistics of the each of the four information criteria for up to five lags.

Table 4. Optimal Lag order Selection

Lag	FPE	AIC	HQIC	BIC
0	169.08	10.806	10.831	10.868
1	1.270	5.915	5.989	6.100
2	0.731	5.363	5.486	5.672
3	0.635*	5.220*	5.393*	5.653*
4	0.652	5.246	5.468	5.802
5	0.653	5.246	5.517	5.926

There was unanimous consensus that the optimum lag length was three since the least statistic for each criterion was achieved using three lags.

5.5 Testing for Cointegration

In order to decide on whether to use a VAR or a VEC model to evaluate the interactions between the study variables and their lags, It was essential to test the research data for cointegration. If there is at least one cointegrating equation, a VEC model should be fitted. On the other hand, Vector Autoregression is used if the data does not have any cointegrating relations. The Johansen cointegration test was applied on the research data and its results were reported in table 5.

Table 5. Johansen Cointegration Test

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	38	-160.336	.	10.885*	15.41
1	41	-156.427	0.106	3.067	3.76
2	42	-154.893	0.0429		

The results show that the null hypothesis that there were no more than r cointegrating relations at r = 0 should not be rejected. The implication of this result is that there was no long run relationship between inflation and interest rates and therefore there was no evidence of Fisher effects in Kenya over the study period.

5.6 Vector Autoregressive Model Estimation

Since there were no cointegrating relations in the data, a vector autoregressive model was fitted on the first differences of the initial time series for upto three lags. The model fitting results are indicated in table 6 below.

Table 6. VAR Estimation Results

		Coef.	Std. Err.	z	P>|z|
dtbill					
	dtbill				
	L1.dtbill	1.203	0.104	11.580	0.000
	L2.dtbill	-0.677	0.158	-4.280	0.000
	L3.dtbill	0.391	0.103	3.800	0.000
	dinflation				
	L1.dinflation	0.522	0.156	3.340	0.001
	L2.dinflation	-0.237	0.268	-0.880	0.378
	L3.dinflation	-0.164	0.155	-1.060	0.290
	constant	-0.166	0.311	-0.530	0.593
dinflation					
	dtbill				
	L1.dtbill	0.143	0.077	1.860	0.063
	L2.dtbill	-0.108	0.117	-0.920	0.356
	L3.dtbill	-0.078	0.076	-1.020	0.308
	dinflation				
	L1.dinflation	1.436	0.116	12.390	0.000
	L2.dinflation	-0.441	0.199	-2.220	0.027
	L3.dinflation	-0.049	0.115	-0.430	0.669
	constant	0.725	0.230	3.150	0.002

The results imply that lead-lag effect was stronger for the ‘dtbill’ series than for the ‘dinflation’ series. In the ‘dtbill’ equation, it is only the second and third lags of ‘dinflation’ which were not significant. However, in the 'dinflation' equation, these two variables, i.e. second lag and third lags of 'dinflation' are the only ones that were significant.

The implication here is that holding other factors constant, information from lagged values of the T-Bill series data and inflation data was reflected more in the current value of the T-Bill rate than in the inflation rate.

Table 7 below shows the R – Squared statistics for both equations.

Table 7. R - Squared

Equation	R-sq	chi2	P>chi2
dtbill	0.575	1113.841	0.000
dinflation	0.487	2545.280	0.000

The values of the R-Squared imply that the VAR model explains for 57.5% and 48.7% of variation in "dinflation" and "dT-Bill" respectively.

5.7 Testing for Granger Causality

The granger causality tests results were reported in table 8 below. A bi-directional granger causality was implied since the p-values of both equations were less than 5%.

Table 8. Granger Causality Tests

Equation	Excluded	chi2	df	Prob>chi2
dtBill	dinflation	37.981	3	0.000
dtBill	ALL	37.981	3	0.000
dinflation	dtBill	9.397	3	0.024
dinflation	ALL	9.397	3	0.024

Consequently, we rejected the two null hypotheses of the granger causality tests:

H_{0a}: T-Bill rate does not grange cause the inflation rate

H_{0b}: Inflation rate does not grange cause the T-Bill rate

However, we can infer that granger causality of the inflation rate on the T-Bill rate was stronger that the reverse granger causality from the T-Bill rate to the inflation rate since the p-value of the former was at the absolute minimum.

6. Conclusion

This paper empirically investigated the relationship between inflation and interest rates in Kenya using monthly data from January 2009 to September 2015. Both time series were found to be integrated of order one and hence consequent analysis was carried out on the first differences of the original data. Cointegration tests suggested that the inflation rate and interest rates in Kenya did not have did not have a long run relationship, and hence the Fisher effects hypothesis did not hold in Kenya over the study period. Next, a vector autoregressive model was fitted on the study data to evaluate the lead – lag interactions of the study variables. The results of VAR model fitting showed a strong lead-lag effect in the 'dtbill' series as compared to the 'dinflation' series. Granger causality testing suggested a bidirectional relationship between call interest rates and inflation. Nevertheless, granger causation of the inflation rate on the T - Bill rate was found to be stronger than the reverse granger causality from the T – Bill rate to the inflation rate.

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