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An Empirical Study of the Fisher Effect and the Dynamic Relationship between Inflation and Interest Rate in Sri Lanka

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ABSTRACT

Maintaining price stability is one of the primary objectives of monetary policy in any economy as price instability, particularly high inflation, will cause to reduce economic growth by reducing investments and productivity growth. Therefore, investigating the existence of Fisher Effect and Price Puzzle is a necessary requirement in order to understand the nature, extent and dynamics of effective monetary policies in Sri Lanka. The main objective of this study is to investigate the existence of short run and long run Fisher Effect and Price Puzzle in Sri Lanka. The results from co-integration technique, Error Correction Model (ECM) which employed in the study suggest that in Sri Lanka, nominal interest rates fully adjust for expected inflation in long-run. But in short-run, a significant positive association between nominal interest rates and expected inflation is there with absence of full Fisher Effect. Moreover the analysis has been extended and identified the existence of the Price Puzzle both in a short run and long run. Therefore, changes in monetary instruments do not appear to be completely effective in meeting the goal of low inflation. In order to solve this problem what we can recommend is, Sri Lanka should move towards inflation-targeting monetary policy system.

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1.0 INTRODUCTION

Interest rate and Inflation are two major central issues in the study of financial markets. (Irving Fisher, 1930) postulates that there is a one-to-one relationship between nominal interest rate and expected inflation. The Fisher effect assumes that the real interest rate is constant over the long-run. Irving Fisher

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affirms that a permanent change in the rate of inflation will cause an equal change in the nominal interest rate so that the real interest rate is not affected by monetary shocks in the long run. This Fisher hypothesis continued to generate series debates among economists recently. In Fisher hypothesis the real interest rate is basically determined by real factors of the economy. This implies that the monetary policy measures cannot influence the real interest rate (Jayahinghe and Udayaseelan, 2008). The presence of the Fisher effect in the financial markets has been a widely discussed topic. In developed countries, there are significant numbers of empirical studies based on the Fisher effect (Bajo-Rudio, Daiaz-Roldan and Esteve, 2005; Fuei, 2007; Ling, Liew and Wafa, 2008; Horn, 2008; and Toyoshima and Hamori, 2011). But in developing countries, especially in countries like Sri Lanka, there are only few studies based on the Fisher effect (Hewarathna, 2000; Cooray, 2002; Ahmad, 2010; and Jayahinghe and Udayaseelan, 2008). When considering the above studies, it is proving that despite the general acceptance of the theory of the Fisher Effect, empirical support for its existence in the real world has been rather mixed.

On the other hand, Price puzzle simply states the positive relationship between nominal interest rate and inflation. According to the conventional view of monetary policy transmission mechanism there should be a positive association between nominal interest rates and inflation (A tightening of monetary policy generally is expected to increase nominal interest rates and reduce the output and prices).This dynamic relationship between nominal interest rate and inflation will enable policy makers to conceive the nature, extent and dynamics of effective monetary policy. Fisher hypothesis has maintained a key position in economic literature because it is considered as one of the cornerstones in monetary economics (Hewarathna, 2000; Fuei, 2007). There are a number of reasons for that. Firstly, standard theoretical consumption-based asset pricing models depend critically on the necessary condition of constant real interest rates, which are implied by the notion of the super-neutrality of money in the Fisher effect. Secondly, the critical assumption of a constant real interest rate in the steady state is also found in neoclassical growth theory that is based on the dynamic optimization of the representative economic agent. Thirdly, real interest rate plays an important role in any economy's economic growth, savings and investment while affecting the trade and capital flows, through influencing exchange rates (Fuei, 2007). At the same time, investigating the dynamic relationship between nominal interest rates and inflation, and identifying the existence of the Price Puzzle are important for monetary authorities to implement most suitable policies for the economy.

When considering the literature review of this paper, it is proving that none of the studies related to Sri Lanka have conducted an analysis of Fisher Effect both in Short run and Long run. Moreover, none of the studies related to Sri Lanka have extended the analysis to evaluate the dynamic relationship between inflation and interest rates, in other words, none of the studies related to Sri Lanka have identified the existence of price puzzle in Sri Lankan economy. Other than above gaps there is a small time gap in 2007 to 2011, where there are no any researches about Fisher effect in Sri Lanka. Based on the above research gaps, the primary objective of this study is to analyze the existence of Fisher effect and the Price Puzzle in Sri Lanka. And the secondary objectives are: Investigate the short run and the long run dynamic relationship between nominal interest rates and inflation, examine the causal relationship between nominal interest rates, inflation and expected inflation and finally suggest policy implications. In the process of achieving the above objectives this study mainly employs co-integration approach, error correction model, Granger causality method.

The paper is structured as follows. The Section 2 brief out the theoretical framework and review of literatures on Fisher's hypothesis and the price puzzle in order to create a solid foundation for the study. Section 3 illustrates the methodology and econometric models employed in the study. Empirical findings of this study are presented in Section 4. Finally, Section 5 consist the concluding remarks and policy recommendations.

2.0 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.01 THE FISHER EFFECT

For nearly forty years, both before and after the turn of the 20th Century (1867 – 1947), an American economist, Irving Fisher, contributed heavily to the topic of money, inflation and interest rates. His ideas are reflected in the development of the concept of Purchasing Power Parity. (Fisher, 1930) hypothesized that the nominal rate of interest (i_t) is made up of two components: the expected rate of inflation (π_t^e) and the real rate of interest (r_t).

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

He claimed a one-to one relationship between the rate of interest and expected inflation, with the real rate being independent of the rate of inflation.

According to (Fisher, 1930), mathematically the intuitive notion of the Fisher equation can be decomposed as follows:

$$(1 + i_t) = (1 + r_t)(1 + E_{t-1}\pi_t)$$

Where:

i_t= nominal interest rate
r_t= real interest rate
π_t= rate of inflation
E_{t-1} = expectation operator conditional on information at time t-1

After simplifying the above equation following formula will arrive:

$$i_t = r_t + E_{t-1}\pi_t + r_t E_{t-1}\pi_t$$

Fisher has assumed that the last term on the right hand side is very small. So that he has omitted this term and obtained the following equation:

$$i_t = r_t + E_{t-1}\pi_t$$

It also can be written as:

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

This forms the basis for Fisher's postulation that the nominal interest rate is the sum of real interest rate and expected inflation. Fisher's hypothesis further state that the real interest rate is constant over time and only determined by the real factors. The stochastic version of the Fisher's postulation is:

$$i_t = \beta_o + \beta_1 \pi_t^e + u_t$$

In his analysis he used inflation and nominal interest rate data from Great Britain and the United States for the periods 1820-1924 and 1890-1927 respectively. (Fisher, 1930) found "no apparent relationship" between price changes and interest rates in these countries in the short-run, where a correlation coefficient of -0.459 was obtained from the British data and -0.289 for the United States data without lagging the data. In contrast, when a distributed lag of past inflation was used as a proxy of expected inflation, the correlation coefficients increased substantially. When expected inflation was used instead of inflation, (Fisher, 1930) obtained correlation coefficients of 0.98 and 0.857 for Great Britain and the United States, when price changes were spread over 28 years and 20 years respectively. From these findings (Fisher, 1930, p. 451) concluded:

> *...We have found evidence general and specific, from correlating P' with both bond yields and short term interest rates, that price changes do, generally and perceptibly affect the interest rate in the direction indicated by a priori theory. But since forethought is imperfect, the effects are smaller than the theory requires and lagged behind price movements, in some periods, very greatly. When the effects of price changes in interest rates are distributed over several years, we have found remarkably high coefficients of correlation, thus indicating that interest rates follow price changes closely in degree, though rather distantly in time.*

According to Fisher's conclusion we can state that nominal interest rates should follow expected inflation. In other words, causality should run from expected inflation to nominal interest rates. Accordingly, in order to fully corroborate the Fisher Effect other than the one to one relationship between nominal interest rates and expected inflation, causality also should run from expected inflation to nominal interest rates.

2.02 PRICE PUZZLE

The simplest explanation for the price puzzle is the positive relationship between the nominal interest rates and inflation (Balke and Emery, 1994). According to monetary theory, there is a negative relationship between nominal interest rate and inflation (Castelnuovo and Surico, 2010). When the Central Bank adopts an expansionary monetary policy, it will reduce interest rates. Because, when the money supply increases, it will increase the demand for financial assets. When demand financial assets increase, prices of the financial assets also will increase and as a result of that interest rates will drop. Finally, this will lead to increase in inflation. It happens because when there are low interest rates individuals will not deposit their money in banks. They will use more money for their consumption purposes which reflect higher demand for goods and services. When demand for goods and services increase, subsequently the prices of goods and services also will increase, which is higher inflation.

In the next segment this paper will briefly explore some empirical studies which are done based on the Sri Lankan economy and other economies. It is better to keep in mind that there are only a few studies based on Fisher Hypothesis in Sri Lanka and this paper will outline only the most recent studies. And when it comes to Price Puzzle, there are no any studies based on Sri Lanka. First, if we move to the empirical studies in Sri Lanka, (Hewarathna, 2000), (Coorey, 2002), and (Jayasinghe and Udayaseelan, 2008) have done some empirical examinations of fisher hypothesis in Sri Lanka and they have obtained mixed results regarding Fisher Effect. (Hewarathna, 2000) found that Sri Lanka's nominal interest rates do not fully adjust for expected inflation, which in turn indicates that real variables are not completely insulated from monetary changes. According to (Coorey, 2002) study, results provide some evidence for a Fisher relationship in Sri Lanka under the both Rational and Adaptive Expectation Approaches. And when it comes to (Jayasinghe and Udayaseelan's, 2008) study, they found that monthly and quarterly data clearly display the absence of a long-term relationship between nominal interest rate and inflation in Sri Lankan financial markets and annual data during the period 1953-1977 provide some evidence for such a relationship at 95% confidence level.

Next, the paper will give a concentration to studies based on other countries. There we can identify a large number of studies on the Fisher Effect, which have used different analytical tools. In the consideration of these studies the common fact that can identify is, most of the studies based on developed economies (Castelnuovo and Surico, 2010; Ling, Liew and Wafa, 2008; Toyoshima and Hamori, 2011 and Fuei, 2007) have obtained presence of Fisher Effect and absence of Price Puzzle. On the other hand, most of the studies based on developing economies (Solomon and Ruiz, 2006; Uddin, Alam and Alam, 2008; Obi, Nurudeen and Wafure, 2009; Javid and Munir, 2011; Awomuse and Alimi, 2012; and Fatima and Sahibzada, 2012) have found the absence of Fisher Effect and presence of Price Puzzle.

In this track of the literature review, it is proving that all of these studies have used different econometric tools (Autoregressive Distributed Lag-bounds testing approach, Engle and Granger's cointegration method, Johansen's cointegration method, adoptive and rational expectation approaches, error correction model, impulse response functions and panel cointegration method) to identify the existence of Fisher effect and Price puzzle, and they have obtained different results. Furthermore, there are comparatively limited number studies related to Sri Lanka based on Fisher Effect and there are no studies pertinent to price puzzle in Sri Lanka.

3.0 METHODOLOGY

The following section will cover data source, time horizon, justification of main variables, formation of inflation expectations, and all econometric tools that are being used to analyze the research issue. The study has used annual data for the analysis and the data are being collected by using Central Bank annual reports and International Financial Statistics (IFS) data base. While considering the data availability, 1959 to 2011 has been decided as the sample period of the study.

This study employs three main variables, which are Treasury bill rate, Colombo Consumer Price Index (CCPI) and Expected Inflation. The annual Colombo Consumer Price Index is used to derive inflation rate[2] and 91-days Treasury bill rates are used as nominal interest rates. Subsequently, the formation of expected inflation will illustrate in the next section.

- *Treasury Bill Rate*

This study employs 91-day Treasury bill rates (annual) for the nominal interest rate[3]. To represent the nominal interest rate, Treasury bill rates are used because the yield rate determined at the weekly Treasury bill auctions serve as a benchmark rate for the determination of other interest rates (Hewarathna, 2000).

- *Colombo Consumer Price Index*

This study uses annual Colombo Consumer Price Index (2002=100) to measure the inflation rate (actual) and it will be used calculate expected inflation rate[4]. The method of calculating expected inflation is broadly discussed below.

3.01 INFLATION EXPECTATIONS FORMATION

The first challenge face by any empirical Fisherian study is to derive inflation expectations proxy, or in other words "how to measure inflationary expectations". (Fisher, 1930) obtained an accurate proxy for inflationary expectations which remained one of the primary problems faced by the researchers. Over the years, a number of approaches have been used to derive proxies for inflationary expectations. For example, distributed lag on past inflation, rational expectations with the efficient market hypothesis, Livingston survey data and etc.

This study employs a model to estimate inflation predictions and (Cooray, 2002) also has used the following inflation-forecasting model to proxy inflation expectations. The model follows the monetarist view of inflation[5] and is extended to include the effects of import prices and the exchange rate (Cooray, 2002). It assumes that inflation forecasts are made using the following variables: Money Supply (M2)[6], real Gross National Product, the Import Price Index, the Exchange Rate and 91-days Treasury Bill Rate. The model that uses to estimate expected inflation is:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + u_i$$

Here:

Y_i = Actual Inflation
X_i = Money Supply
X_2 = GNP
X_3 = Import Price Index
X_4 = Nominal Exchange Rate
X_5 = 91-days Treasury Bill Rate

[2] Inflation rate (π_t) = Ln[$ccpi_t$ / $ccpi_{t-1}$]*100

[3] Nominal interest rate is the rate of interest that a borrower has to pay for borrowing money (Horn 2008)

[4] Expected inflation rate is the expected rate of change of price level in the future (Horn 2008).

[5] In the monetarist view of inflation money supply view as the sole source of shit in the aggregate demand curve; therefore money growth is consider as the only cause of inflation (Cooray, 2002).

[6] In this study broad money supply (M2) has used to estimate expected inflation because, according to (CBSL, 2010) broad money supply is the most appropriate monetary variable analysis. And, in the Sri Lankan monetary framework, the final target, price stability, is achieved by influencing broad money supply which is linked to reserve money through a multiplier (Ananda, Ding and Peiris, 2011).

By estimating the above model expected rate of inflation can be obtained. In other words, $\hat{Y}$ value is considered as the expected rate of inflation.

3.02 GRAPHICAL PRESENTATION

Line Graph and Confidence Ellipse are employed to illustrate the basic features and the underlying trending behavior of the variables. Before pursuing formal econometric tools, it is always advisable to conduct a graphical analysis of the time series because; it will give initial clues about the behavior of variables.

3.03 UNIT ROOT TESTS

Before engaging in further analysis, it is important to test whether interest rate, inflation and expected inflation series are stationary or non-stationary. Many economic and financial time series exhibit trending behavior or non-stationary in the mean. It is the general practice to test for stationarity of the time series prior to any estimation. If the time series are non-stationary, the standard OLS approach will produce a spurious regression, thus rendering standard testing techniques invalid (Fuei, 2007).

This paper employs the Augmented Dickey-Fuller (ADF) procedure to test for stationarity and the order of integration of i_t, π_t and π^e_t. This test requires both the data generating process of the series under study as well as the appropriate lag length be chosen (Gujarati, 2003). Three different data generating processes can be chosen from the Augmented Dickey-Fuller test. They are:

A pure random walk

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

A random walk with drift

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

A random walk with drift and stochastic trend

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

Here;

Δ = the difference operator
β_1 = the drift term
t = the time trend
ε = the white noise error term

Hypothesis:

H_o: $\delta = 0$
H_1: $\delta < 0$

If the null hypothesis is not rejected then the time series is non-stationary or in other words the data series has a unit root. If the null hypothesis is rejected, then time series is stationary.

This study also will employ KPSS procedure to test for stationarity. This alternative unit root test was introduced in 1992 by Kwiatkowski, Phillips, Schmidt and Shin KPSS and it differ from the previous one in the sense that the time series is assumed to be stationary under the null hypothesis (Syczewska, 2010).

In the *KPSS* model, a series of observations is represented as a sum of three components: deterministic trend, a random walk, and a stationary error term. The model has the following form:

$$y_t = \xi t + r_t + \varepsilon_t$$
$$r_t = r_{t-1} + u_t$$

Where, $y_t, t = 1,2,3, \ldots$. denotes series of observations of the variable of interest, t- deterministic trend, r_t– random walk process, ε_t - error term of the first equation, by assumption is stationary, u_t denotes an error term of the second equation, and by assumption is a series of identically distributed independent random variables of expected value equal to zero and constant variation . By assumption, an initial value of the second equation is a constant; and it corresponds to an intercept (Syczewska, 2010).
Hypothesis:

H_o: $\sigma_u^2 = 0$
H_1: $\sigma_u^2 > 0$

Where, the null hypothesis is accepted, then the time series is stationary or in other words the data series does not have a unit root. If the null hypothesis is rejected, then time series is non-stationary.

3.04 ENGLE-GRANGER COINTEGRATION APPROACH

When considering earlier literature, it is proving that many researchers have adopted Engle-Granger technique to test the existence of the Fisher Effect (for instance: Hewarathna, 2000 and Mishkin & Simon, 1994).

According to Engle and (Granger, 1987), if the variables are integrated of the same order, say I(1), the test for co-integration can be done by estimating the following OLS regressions and then conducting unit root tests for regression residuals $\hat{u}_t$ and $\hat{\varepsilon}_t$

- To test the existence of the long run Fisher Effect:
  $i_t = \beta_o + \beta_1 \pi_t^e + u_t$
- To test the long term relationship between nominal interest rates and inflation
  $\pi_t = \alpha_o + \alpha_1 i_t + \varepsilon_t$

3.05 ERROR CORRECTION MODEL (ECM)

The second foremost objective of this study is, investigate the existence of the short term Fisher Effect and dynamic relationship between inflation and interest rates. In this case Error Correction Model (ECM) is employed to achieve the above objective.
Error correction model is important due to two reasons:

- It can be used to estimate the short term effect of the variables.
- Estimate the speed of response that variable returns to its equilibrium after a change in independent variable(s).

Under the ECM the study runs a simple regression and analyzes the unit root property of the estimated residual ($\hat{u}_t$ and $\hat{\varepsilon}_t$). The structures of ECM, to investigate the existence of short term Fisher Effect and Price puzzle are as follows respectively:

$$\Delta i_t = \beta_2 + \beta_3 \Delta \pi_t^e + \beta_4 \hat{u}_{t-1} + \epsilon_t$$

Where, β_3 represents the short term reaction of nominal interest rate to changes in expected inflation, β_4 shows the speed of return in the direction of the long run relationship in case of a shock and ϵ_t is the error term. Here, $\hat{u}_{t-1} = i_{t-1} - \hat{\beta}_2 - \hat{\beta}_3 \pi_{t-1}^e$ and it is known as the error correction component of the model.

$$\Delta \pi_t = \alpha_2 + \alpha_3 \Delta i_t + \alpha_4 \hat{\varepsilon}_{t-1} + \nu_t$$

Where, α_3 represents the reaction of inflation to changes in nominal interest rate, α_4 shows the speed of return in the direction of the long run relationship in case of a shock and v_t is the error term. Here, $\hat{\varepsilon}_{t-1} = \pi_{t-1} - \hat{\alpha}_2 - \hat{\alpha}_3 i_{t-1}$ and it is known as the error correction component of the model.

3.06 GRANGER CAUSALITY METHOD

Investigating the existence of a one-to-one relationship between nominal interest rates and expected inflation partially validates the Fisher hypothesis. In order to fully confirm the hypothesis, causality must run from the expected inflation rate to interest rates (Ahmad, 2010). Moreover, it is also an essential requirement to check the causal relationship between nominal interest rates and inflation. In that manner, the study employs Granger Causality method to investigate any causal relationship between nominal interest rates and expected inflation, nominal interest rates and inflation. In the application of Granger Causality method it is important to use the first difference data if the data series are non stationary. Granger causality method involves two models:

$$\Delta Y_t = \sum_{i=1}^{n} \alpha_i \Delta X_{t-i} + \sum_{j=1}^{n} \beta_j \Delta Y_{t-j} + u_t$$
$$\Delta X_t = \sum_{i=1}^{n} \lambda_i \Delta X_{t-i} + \sum_{j=1}^{n} \delta_j \Delta Y_{t-j} + v_t$$

From the above equations, if α_i's are significant and δ_j's are not significant, then we conclude that there is a unidirectional causality between Y variable and X variable (X causes Y). If α_i's are not significant and δ_j's are significant, then we conclude that there is a unidirectional causality between Y and X (Y causes X). If α_i's and δ_j's are not significant, then we conclude that the variables are independent, which means there is no causal relationship between X and Y. And finally, if α_i's and δ_j's are significant, then we conclude that there is a bilateral causality between X and Y (Gujarati, 2003).

3.07 THE WALD TEST

As a secondary requirement, the study contrives the Wald test to fully corroborate the existence of Fisher Effect. After identifying the existence of the Fisher Effect with both Engle-Granger cointegration approach and ECM, the study employs the Wald test to fully validate the obtained results.

The Wald test is a way of testing the significance of particular explanatory variables in a statistical model. Whenever a relationship within or between data items can be expressed as a statistical model with parameters to be estimated from a sample, the Wald test can be used to test the true value of the parameter based on the sample estimate (Engle, 1984).

Here, the testing hypothesis is: H_o: $\beta_1 = 1$
And, the test statistic is: $W = \hat{\beta}_1'[var^{-1}(\hat{\beta}_1)]\hat{\beta}_1$

4.0 RESULTS AND DISCUSSION

The entire study is based on three main variables which are nominal interest rates (91-days T-bill rates), inflation (CCPI) and expected inflation. Here, the descriptive analysis includes mean, median, standard deviation, maximum and minimum values of above three variables, and the outcomes are presented in Table 1. The results indicate that that the values of summary statistics are more or less similar.

Table 1: Descriptive statistics of the series

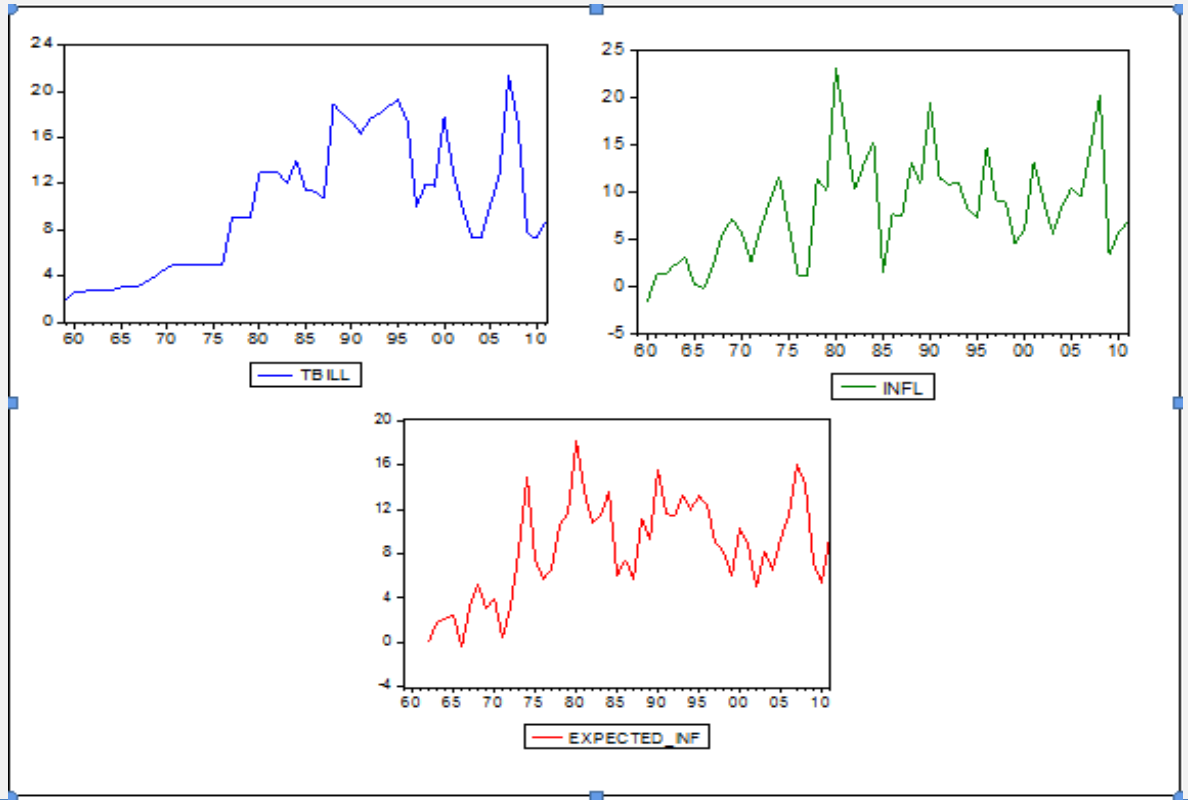
Series	Obs	Mean	Median	Std. Dev.	Max	Min
91-days T-bill rates	53	9.981	9.920	5.640	21.30	2.020
Inflation	52	8.125	7.896	5.509	23.21	-1.629
Expected inflation	50	8.458	8.619	4.469	18.12	-0.458

Sources: author's calculation

Figure 1 provides the visual presentation of three variables in level form. Here, one noticeable feature is the comparatively similar peak points during the 2007/2008 time period. The main reason for this was the tight monetary policy which was adopted by the CBSL during that period. The line graph of inflation (INFL) declares that, since 2009 CBSL was able to hold inflation at single digit levels but during that time period annual average rate of inflation shows an increasing trend. When considering these trending behaviors, it shows high volatility in the annual average inflation rate, which is not a good indicator of the economy. In 2011 the DCS revised the base year of CCPI to 2006/07 = 100 in order to reflect the changes in consumer performances over time (Central Bank of Sri Lanka, 2011). Nevertheless, this study is based on CCPI (2002=100).

In 2011 CBSL has reduced Policy Rates[7] (Repo and Reverse Repo) in order to facilitate investments and to support continuous economic expansion. Subsequently, due to the reduction in excess liquidity in the domestic money market, an upward movement in market interest rates and yields on government securities can be seen in 2011. These movements are shown in the line graph of 91-days T-bill rates (TBILL). Eventually, all three line graphs of variables show some trending behavior, which indicates that the three series are non-stationary in level form. Later, two unit root procedures (ADF and KPSS) will be used to verify the unit root properties of the three variables.

Figure 1: Line graphs of three variables in level form

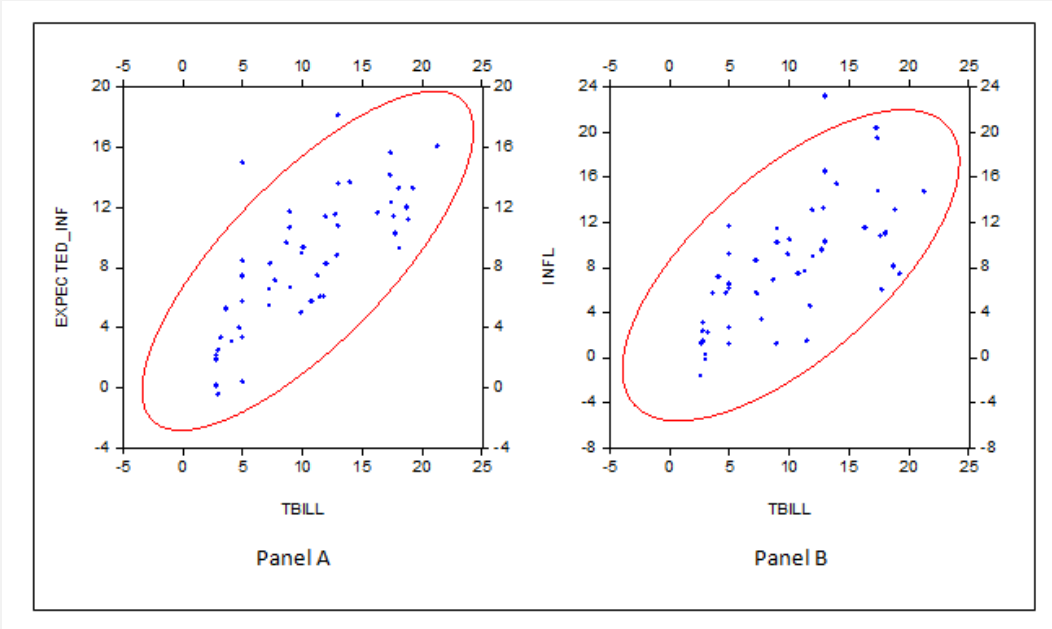


Furthermore, the study is applied confidence ellipses to graphically illustrate the correlation between main variables. Figure 2 presents the 95% confidence ellipses, which show the correlation between expected inflation and T-bill rates, and the correlation between inflation and T-bill rates.

In Figure 2, panel A shows the 95% confidence ellipse which indicates a comparatively strong positive association or correlation between expected inflation and T-bill rates. At the same time, panel B indicates a comparatively weak positive association between inflation and T-bill rates.

[7] In 2010, Repo rate- 7.25% and Reverse Repo- 9.00%. In 2011, Repo rate- 7.00% and Reverse Repo- 8.50% (Central Bank of Sri Lanka, 2011).

Figure 2: Confidence ellipses of main three variables



4.01 UNIT ROOT TESTS

The study has employed two unit root testing procedures: Augmented Dickey-Fuller (ADF) test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test to observe stationarity and the order of integration of three main variables (T-bill rates, inflation and Expected inflation). Table 2 and Table 3 show the results ADF and KPSS tests with intercept, and with intercept and trend, under level form.

Table 2: Unit root test results of ADF test (at level)

Series	Level with intercept		Level with intercept and trend	
	Test statistics	Prob.*	Test statistics	Prob.*
T-bill	-2.21	0.21	-2.29	0.43
Inflation	-4.22	0.00	-4.39	0.00
Exp- inflation	-3.35	0.02	-3.55	0.05
Critical value (5%)	-2.92		-3.5	

*MacKinnon (1996) one-side p-value

Table 3: Unit root test results of KPSS test (at level)

Series	Level with intercept		Level with intercept and trend	
	Test statistics	Critical value (5%)	Test statistics	Critical value (5%)
T-bill	0.65	0.46	0.23	0.15
Inflation	0.50	0.46	0.22	0.15
Exp: inflation	0.50	0.46	0.20	0.15

Test results presented in Table 2 indicate that only T-bill rates are non-stationary and other two variables (inflation and expected inflation) are stationary under level form. In ADF test the MacKinnon (1996) critical values are used for the test. Nevertheless, KPSS test results indicate that all three variables are non-stationary. According to these two unit root tests, the study has obtained some contradictory results for T-bill rates. Since the power of KPSS test is greater than ADF test, the final judgment of the study is, all three variables are non-stationary.

Subsequently, in order to determine the order of integration of non-stationary time series, the same tests were employed under first difference, and those results are shown in Table 4 and Table 5.

Table 4: Unit root test results of ADF test (after 1st difference)

Series	1st difference with intercept		1st difference with intercept and trend	
	Test statistics	Prob.*	Test statistics	Prob.*
T-bill	-6.53	0.00	-6.64	0.00
Inflation	-9.45	0.00	-9.44	0.00
Exp: inflation	-8.08	0.00	-6.41	0.00
Critical value (5%)	-2.92		-3.5	

*MacKinnon (1996) one-side p-value

Table 5: Unit root test results of KPSS test (after 1st difference)

Series	1st difference with intercept		1st difference with intercept and trend	
	Test statistics	Critical value (5%)	Test statistics	Critical value (5%)
T-bill	0.18	0.46	0.07	0.15
Inflation	0.14	0.46	0.04	0.15
Exp: inflation	0.12	0.46	0.05	0.15

The test results indicate that, after first difference all three variables are stationary at 5% level, with respect to both tests (ADF and KPSS). This implies that three time series are integrated in the same order I(1).

4.02 ENGLE-GRANGER CO-INTEGRATION APPROACH

Since the variables are integrated of the same order, as the next step of the study Engle-Granger approach is employed to analyze the long run relationship between variables. First, let's consider about the persistence of long term Fisher Effect and the Engle-Granger test results are presented in Table 6.

Table 6: Engle-Granger test results (long term Fisher Effect)

Fisher Effect (Independent-Expected Inflation)				
Variable	Coefficient	Prob.	KPSS Test (Level with intercept)	
			Test statistic	CV (5%)
T-Bill rate	0.9397	0.0000	0.42	0.46

Null hypothesis- Residual series is stationary

Engle-Granger test result indicates that the residual term is stationary, which means, even though expected inflation and T-bill rates are individually integrated in order one (non-stationary), but their linear combination is stationary. It concludes that the two variables are cointegrated. Next, the coefficient of expected inflation is 0.9397 and it is positive. Since the coefficient of expected inflation is close to one, we can anticipate the existence of the Fisher Effect in the long run. This proclaims that monetary policy does not affect the real side of economic activities in the long run. In order to fully corroborate the result, the study has employed the Wald test which will be discussed in the next section.

Table 7 demonstrates the output of Engle-Granger approach with respect to inflation and T-bill rates. In this case also the residual term is stationary, which signify the cointegrating relationship between inflation and T-bill rates. Furthermore, the coefficient of T-bill rates is 0.6603 which is again positive.

Therefore, the study concludes existence of the Price Puzzle in the long run (due to the positive relationship between inflation and nominal interest rates).

Table 7: Engle-Granger test results (long term Price Puzzle)

Price Puzzle (Independent-Treasury Bill Rate)				
Variable	Coefficient	Prob.	KPSS Test (Level with intercept)	
			Test statistic	CV (5%)
Inflation	0.6603	0.0000	0.16	0.46
Null hypothesis- Residual series is stationary				

4.03 THE WALD TEST

As mentioned earlier the study has applied the Wald test, in order fully confirm the presence of the Fisher Effect in the long run. Table 8 illustrates the Wald test results. In the Wald test the null hypothesis states that $\beta = 1$. Since that probability value under all three test statistics is greater than 0.05, that study accepts the null hypothesis, which is $\beta = 1$, at 95% significance level. Accordingly, the study fully confirms the existence of the Fisher Effect in the long run.

Table 8: The Wald test results
Null hypothesis: $\beta = 1$

Test Statistic	Value	df	Probability
t-statistic	1.588286	48	0.1188
F-statistic	2.522652	(1, 48)	0.1188
Chi-square	2.522652	1	0.1122

4.04 ERROR CORRECTION MODEL (ECM)

In the process of achieving the second foremost objective, which is investigating the existence of the Fisher Effect and the Price Puzzle in a short run, the study has employed ECM. First, the study has examined the validity of the short term Fisher effect and the results are represented in Table 9.

Table 9: ECM results (short term Fisher Effect)

Dependent Variable: D(T-bill rates)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EXPECTED_INF)	0.536084	0.098920	5.419348	0.0000
C	0.032900	0.342623	0.096024	0.9239
RESID01(-1)	-0.278880	0.099552	-2.801364	0.0074

Here, coefficient of expected inflation 0.536084 and it represents the short term reaction of T-bill rates to changes in expected inflation. Moreover, the minimum probability value (0.0000) of expected inflation indicates a significant positive relationship with T-bill rates. Next, the coefficient of the one year lagged residual series is -0.278880 and it shows the speed of adjustment of deviation from a long run equilibrium relationship in case of a shock. This also indicates that 27% of deviation is adjusted every year. Since the coefficient of expected inflation is not even close to one, the study concludes absence of the Fisher Effect in a short run and the presence of positive nexus between expected inflation and nominal interest rates.

Subsequently, the study has moved to investigate the dynamic relationship between nominal interest rates and inflation in the short run and the results are shown in Table 10.

Table 10: ECM results (short term Prize Puzzle)

Dependent Variable: D(INF)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TBILL)	0.614331	0.190606	3.223046	0.0023
RESID02(-1)	-0.738149	0.139702	-5.283725	0.0000
C	0.079413	0.561715	0.141376	0.8882

In this case the coefficient of T-bill rates is 0.614331. Moreover, the minimum probability value (0.0023) indicates a significant positive association between T-till rates and inflation. Meanwhile, the coefficient of one year lagged residual series is -0.738149 and this represents how quickly the system will move to a long run equilibrium position in case of a shock. It also proclaims that 74% of deviation is adjusted every year. ECM clearly displays a positive association between nominal interest rates and inflation. Therefore, the study concludes existence of the price puzzle in a short run as well.

4.05 GRANGER CAUSALITY TEST

As an accessory requirement the study explores the causal relationship between variables. Table 11 presences the results of pair wise Granger causality tests which were obtained with two lags of each variable.

Table 11: Pair wise Granger causality test

Null Hypothesis:	Obs	F-Statistic	Probability
DTBILL does not Granger Cause DEXPECTED_INF	47		
		0.23807	0.78920
DEXPECTED_INF does not Granger Cause DTBILL			
		0.04860	0.03961
DINFL does not Granger Cause DTBILL	49		
		2.01756	0.14510
DTBILL does not Granger Cause DINFL			
		2.65863	0.04128
* Lags: 2			

The Granger causality test results indicate that expected inflation Granger causes T-bill rates, while the converse is not true at 95% significance level. Moreover, T-bill rates Granger cause inflation, but not vice versa at 95% significance level. The entire Granger causality test results conclude that the causality runs from expected inflation to T-bill rates and T-bill rates to inflation.

5.0 CONCLUSION AND POLICY RECOMMENDATION

Initially, the Engle-Granger cointegration approach and the Wald fully confirmed and assured the existence of the Fisher Effect in the long run. This proclaims that real interest rates remain constant over time, which supports the proposition that monetary policy does not affect the real side of economic activities. Since pair wise Granger causality also runs from expected inflation to nominal interest rates, the study concluded that in long run nominal interest rates fully respond to inflation expectations of Sri Lankan economy.

In the short run situation, the study discovered the absence of Fisher Effect and the presence of significant positive association between expected inflation and nominal interest rates. The most likely explanation for the absence of short run Fisher effect is, the short term nominal interest rates are not formed by market forces, which means the short term interest rates are not influenced by inflation expectations (Cooray, 2003). They are artificially determined by monetary authorities as a part of the monetary policy framework. Once policy action has been implemented, the short term real rate of interest is affected and as a result it does not remain constant. Therefore the monetary transmission

mechanism causes the short-term real rate of interest to fluctuate contrary to the hypothesis which was put forward by Irving Fisher.

Furthermore, the study identified the existence of the Price Puzzle both in the long run and short run by analyzing the dynamic relationship between nominal interest rates and inflation throughout the study period. This is not a good indicator of the economy. Because this phenomenon convince that monetary changes do not lead to anticipated outcomes in the economy. In this kind of circumstance, the study suggested that a positive interest rate shocks (Contractionary monetary policy) will lead to a persistent rise in the price level. The positive association between nominal interest rates and inflation can be caused by many reasons and this study identified two reasons which are cost channel and exchange rate channel of monetary transmission mechanism.

As mentioned earlier, Sri Lanka operates within a monetary targeting framework, which is based on information conveyed by monetary aggregates to conduct monetary policy, announcement of targets for monetary aggregates and an accountability mechanism to preclude significant deviations from the monetary targets (Wimalasuriya, 2008). Due to the existence of the Price Puzzle both in a short run and long run the study concluded that monetary policy can be ineffective in both cases. In the graphical representation also inflation displayed high volatility and this is another weak point of the monetary targeting framework. Due to all these analytical outcomes and circumstances, the study recommends that Sri Lanka should move away from monetary targeting framework to inflation targeting framework in order to have an effective monetary system. In the next section, let's further discuss the justification of above policy recommendation.

The monetary targeting framework sets quantitative targets for the rate of growth of the money supply as the basis of monetary policy. This system came into action in 1970s in industrialized countries, which was adopted as a mechanism to bring the chronically high inflation and fluctuations in output under control by controlling interest rates and credit conditions (Wimalasuriya, 2008). Due to the inability of achieving target objectives, many central banks of different countries (industrialized and developing countries) have started to adopt inflation targeting framework since early 1990s. According to (Wimalasuriya, 2008) monetary targeting seems to lack the institutional features which are needed to achieve low and stable inflation in the long run. Another feeble feature of monetary targeting is lack of consideration about inflation expectations. Since monetary targeting framework put more weight on monetary aggregates, expected inflation does not play a vital role in the monetary policy determination.

On the other hand, in the inflation targeting framework, monetary authorities will conduct public announcements of official quantitative targets (or target ranges) for the inflation rate over a specific time horizon. As stated by (Wimalasuriya, 2008) there are three important characteristics of inflation targeting framework:

a. An explicit quantitative inflation target (interval or point target).
b. The use of an internal conditional inflation forecast as an intermediate target variable.
c. High degree of transparency and accountability.

Here, the second feature of inflation targeting framework proclaims that inflation expectations play a vital role in this framework. Accordingly, since the study identified the existence of long term Fisher Effect, we can anticipate inflation targeting framework might operate more effectively and successfully in Sri Lanka.

Moreover, inflation targeting framework is successful in limiting not only volatility of inflation but also the variability of the output gap and real exchange rate (Wimalasuriya, 2008). According to IMF, inflation targeting framework is an appropriate regime for both emerging and developing economies (Anand, Ding and Peiris, 2011). These facts also perceive the appositeness of inflation targeting

monetary policy to Sri Lankan economy. Due to all these reasons the study suggests that Sri Lanka should move away from monetary targeting framework to inflation targeting framework in order to have an effective monetary system.

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