IMPORTANCE OF ADDRESSING STRUCTURAL BREAK WHILE ESTIMATING FISHER EFFECT HYPOTHESIS: A TIME SERIES ANALYSIS OF BANGLADESH

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Abstract:

Fisher Equation, asserted by Irving Fisher in his celebrated book 'The Theory of Interest', reveals that nominal interest rate adjusts with the inflation rate at the same rate in order to keep real interest rate constant. Using yearly time series data from Bangladesh for the period 1987 – 2020, this paper tested the validity of the Fisher effect considering the variables- Nominal Interest Rate (Advance Rate), Real Interest Rate and Inflation Rate. With a view to rationalizing the existence of structural break, Clemente - Montanes – Reyes (1998) unit root test was performed to identify the integration order of the variables of interest. After controlling structural break, Gregory- Hansen (1996) cointegration test applied for detecting the long run relationship by adopting ARDL framework. As the results revealed, Partial Fisher effect prevails for Bangladesh in short run. More specifically, keeping the real interest constant the impact of inflation rate on nominal interest rate is 0.16 percent with a lag effect in both ARDL model but parameters are stable only when we address structural break in the model. Thus, establishing that empirical identification of short run relationship among variables and existence of Fisher effect is subject to proper consideration of structural break.

Keywords: Fisher Ef k, Gregory Hansen Cointegration Test, ARDL, Time Series, Bangladesh.

1. Introduction

For an economy, a very crucial issue relating to monetary policy is to set the rate of interest, in both short and long-run, considering the inflation expectations. Usually,

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the issue is addressed, in monetary economics, by testing the validity of the Fisher effect or hypothesis with the help of empirical evidence. The Fisher hypothesis, proposed by American Economist Irving Fisher in 1930, assumed that the nominal interest rate is basically the sum of the real rate of interest and a possible decline in the purchasing power of money. To phrase it differently, the real interest rate and expected inflation rate together compute the nominal interest rate of an economy. The implication is that 1 percent increase in inflation rate will automatically increase the nominal interest rate by 1 percent. Irving Fisher, in his theory, postulated that changes in expected inflation rate creates equal changes in the nominal interest rate by leaving the real interest rate unchanged. Thus, Fisher effect, alternatively, is considered as the one for one adjustment of the two major variables- the nominal interest rate and the expected inflation rate (Uddin et. al., 2008). In practical sense, high inflation creates the loss in welfare by causing the demand for real balances to fall. As a result, the overall economic performance gets hindered by reducing the total investment and aggregate consumption (Uyaebo et. al. 2016).

This paper is an effort to find empirical evidence for the Fisher effect in Bangladesh and consider the importance of addressing structural breaks while estimating the hypothesis. The time series data on different variables, employed by Fisher, has been adopted for almost the last four decades and a rigorous time series econometric analysis has also been applied to test the hypothesis. The issue of structural breaks is central to the discussion. Thus, the major question that this study deals with is-

How important is to address structural break while estimating fisher effect hypothesis in Bangladesh?

To get the answer of the question and to know the further broader implications of the findings, this study has set the following objectives-

1. To test the Fisher hypothesis both in the short and long- run in the economy of Bangladesh
2. To shed lights on the importance of addressing structural break, single or multiple, while estimating Fisher hypothesis in Bangladesh
3. To set the policy implications for fostering economic growth in a sustainable manner in the economy

As there are very few studies in Bangladesh that test Fisher hypothesis using such long span data, this study has a hope to contribute much to the existing knowledge through its academic vigour. However, the paper is structured into five distinct sections. The first part is the continuation of the current discussion under

the heading- Introduction. After this introduction, a handful review of relevant literature is presented in section two. The third section is the methodology and data which discusses the relevant econometric procedures adopted for estimating the hypothesis. Since the issue of structural change is central to the discussion, the bulk of our discussions in section three focuses on detection of breakpoints. Section four employs the detailed results of the tests under the heading- Empirical Findings and Interpretations. Finally, the last section- Conclusion and Policy Implication, puts forward the implication of the findings in the economy.

2. Literature Review

In monetary economics, the Fisher hypothesis is a fiercely debated concept and has attracted immense attention of researchers and policy makers. Many researchers have conducted studies using data from different developed and developing countries and tested the Fisher hypothesis. Generally, in empirical studies, there has noticeably been found mixed findings. Among different studies, most of the findings support existence of a long run relationship between expected inflation rate and nominal interest rate, some findings conclude partial Fisher effect, and few others could not establish any kind of long-run relationship between nominal interest rates and inflation expectations. Besides, some of the studies shed lights on the importance of presence of structural breaks, both single and many, while testing Fisher hypothesis, while some did not.

As mentioned earlier, there has been found mixed results which includes Fisher effect in the long run, partial fisher effect or, even, no kind of association among the variables while testing Fisher hypothesis. A range of studies have been done on this particular theory. For instance, Adil et. al. (2020), Asari et. al. (2011), Benazić (2013), Booth and Ciner (2001), Glasner (2018), GÜRİŞ et. al. (2016), Sathye et. al. (2008), Beyer et. al. (2009), He (2018), Bahmani-Oskooee et. al. (2016) and many others found existence of a long-run association between nominal interest rates and inflation expectations.

The Fisher hypothesis can be applied in emerging economies like India. In a very recent study, Adil et. al. (2020) examined the Fisher's hypothesis by using the dataset on India with a view to checking whether there exist any long-run empirical association between the nominal interest rate and expected inflation rate. They used monthly data from January1993 to March 2015 and applied the ARDL model or bounds testing approach, which was developed by Pesaran, Shin, and Smith (2001). To test the short run and long run association and co-integration

among variables, the bounds testing approach was applied. Their study confirms the presence of a long-run association between Treasury bill and expected inflation rate. By using monthly data of nominal interest rates and inflation rates, for the period from April 1996 to August 2004, Sathye et. al. (2008) found that, in Indian economy, there exist a correlation between expected inflation and nominal short-term interest rate.

Asari et. al. (2011) attempted to analyse the relationship between inflation rate, interest rate and exchange rate volatility for Malaysian economy from the period 1999 to 2009. By employing time-series VECM approach of stationarity test, stability test, cointegration test and Granger causality test, they found that the inflation rate has an impact on the interest rate. Moreover, the interest rate has an influence on the exchange rate as well. Their study concludes that, in Malaysia, interest rate is positively associated while inflation rate is negatively associated with exchange rate volatility in the long-run.

Another study, conducted by Benazić (2013), found full Fisher effect in the long-run using VEC model in Croatia. In 2000, Booth and Ciner took the short-term Eurocurrency interest rate and the inflation rate for nine European countries and the US and examined the long-run bivariate relationship between them. By applying cointegration methods, their study confirms the existence of relationship between Eurocurrency rates and expected inflation rates. A similar study was done by Glasner in 2018 where he found strong, positive and consistent correlation between stock prices and expected inflation.

In 2016, GÜRİŞ et. al. investigated the validity of the Fisher hypothesis in Turkey covering the period 2003- 2012. An ARDL test for threshold cointegration was used to test the validity of Fisher hypothesis. The empirical result of his study indicates that Fisher hypothesis is valid for Turkey which implies that nominal interest rates are an important leading indicator for inflation.

Using both annual and monthly data for the country South Korea and China, He (2018) aimed to verify whether the Fisher effect is significant between South Korea and China both in the long and short run. Their results exhibit that in the long or short run, the Fisher effect exists in China and South Korea, though the effect is more significant in South Korea than that of in China.

Bahmani-Oskooee et. al. (2016) tested the Fisher effect by using monthly data of BRICS countries (i.e., Brazil, Russia, India, China, and South Africa). They applied threshold cointegration method and asserted that, except South Africa,

Fisher effect is valid in all other countries. This implies that, in the long run, nominal interest rates adjust to inflation.

During the period 1999-2001, Piccinino (2011) examined the presence of the Fisher effect in Euro area. As he found the existence of a cointegration between the variables, he then estimated an ECM to obtain the Fisher coefficient. The data set supported the full Fisher hypothesis with a failure to provide enough evidence for a linear relationship between the two variables from the period September 2008 to March 2011.

However, again, there are many studies which failed to establish any kind of long-run association or found weak form of association between expected inflation rate and nominal interest rate in the economy. Among these studies, there are some which found partial Fisher effect. The findings of Weidmann (1997), Hasan (1999), Abubakar and Sivagnanam (2017) can be notable here.

In 1997, using quarterly data from 1957- 1991, Weidmann tested the Fisher hypothesis in Germany and found a partial Fisher effect. He concluded that the nominal interest rate moved less than point-for-point with inflation. A similar study was conducted by Hasan (1999) using data from Pakistan where he did not reject the partial Fisher Hypothesis. Hasan's result implies that interest rate does not perfectly anticipate inflation, which again implies that, over time, bank deposits deteriorate.

Abubakar and Sivagnanam (2017) used monthly time series data on interest rate (lending rate) and CPI growth rate (inflation) from the period 1990M01 to 2015M03 and did not find the presence of long run steadiness between nominal interest rate and inflation which does not support Fisher's proposition.

Another group of researchers have considered the importance of adjusting structural break while testing Fisher hypothesis. In a recent study, Uyaebo et. al. (2016) tested the Fisher hypothesis in the presence of structural breaks for the economy of Nigeria during the period 1970 – 2014. The existence of a weak form of association between nominal interest rates and inflation rate is confirmed by the Gregory and Hansen Co-integration test, albeit with a structural break in October 2005.

In 2017, Clemente et. al. found structural changes in the Fisher equation while they were working on the G7 countries' economies. They found very limited evidence of a total Fisher effect. Interestingly, Beyer et. al. have conducted a study

in 2009 where they argued that the rejection of cointegration is basically due to the existence of a spurious unit root. As a result, new break tests were applied for testing the nonlinearity in the cointegrating relation. After accounting for breaks, their empirical results support cointegration and a linear Fisher relation in the long run which is the opposite of several recent studies that did not find support for linear cointegration.

However, while searching for academic studies that attempt to trace the relationship between interest rates and rates of inflation in the economy of Bangladesh, very few studies were found. In 2008, Uddin et. al. tested Fisher hypothesis for the economy of Bangladesh using monthly data for the period of August 1996 to December 2003. Their empirical results do not support any co-movement of inflation with interest rates, thus, there does not exist any long-run association among the variables of Fisher hypothesis for the economy of Bangladesh (Uddin et. al., 2008). In this spectrum present study tests the Fisher Hypothesis in the presence of Structural Breaks for a longer period of time, 1987 -2020, for the economy of Bangladesh.

3. Methodology

This paper aims to find out the importance of addressing Structural break/s in case of estimating Fisher Effect hypothesis for Bangladesh. We perform unit root test both with structural break and without structural breaks. ADF and KPSS test are used where structural breaks were not considered. Based on the result of CUSUM squared stability test, Clemente, Montanes and Reyes (1998) tests are performed addressing multiple structural breaks. Finally, using the methodology of Gregory and Hansen, existence of Fisher Effect Hypothesis will be checked in the long run addressing structural break. (Yeboah, 2020). We follow broadly the paper written by Uyaebo et al in 2016 who tested Fisher hypothesis for Nigeria. (Uyaebo et. al. 2016) for estimating Fisher Effect hypothesis with structural break in Bangladesh.

3.1: Construction of Variables

Present study takes account of the data set containing variables Nominal Interest Rate (nira) Advance Rate, Real Interest Rate (rir) and Inflation Rate (irt) of Bangladesh over the year 1987 to 2020. It's a 34 years' annual time series data set of Bangladesh. Here we consider rate of interest (Advance Rate) on scheduled Banks that is weighted average as at end of month. For nominal interest rate, advance rate has been considered as it is directly related to the cost of investment of the investors. If banks offer expected inflation adjusted nominal interest rate that is kind of certain based on the past values, investors become more interested

to take loans from banks and invest further. More investment has positive impact on the economy.

CPI based Inflation rate is taken under consideration for this study. Following Fisher, this study employed distributed lag structure in the formation of inflationary expectation (Wit, 1998). The idea of distributed lag implies that any change may not have an immediate effect. Rather it may take some lag in time, meaning the effect is distributed over a number of periods. In a nutshell, economic variables do not always have only static effect, most of the time it captures dynamic effects as well. In this regard, distributed lag supports to capture dynamic effects. Bangladesh Bank has been used as the source of our dependent variable, nira while WDI (World Development Indicator) is the source of variables, rir and irt. STATA 14 has been used to perform all time series tests here. Functional form of the multiple variable regression equation is-

$$nira_t = f(rir_t, irt_t)$$

$$nira_t = \alpha + \beta rir_t + \gamma irt_t + \varepsilon_t$$

In this equation, both independent variables, Real Interest Rate (rir) and Inflation Rate (irt) are positively related with the dependent variable, Nominal Interest Rate (nira). Obviously, there are some other factors that can affect nominal interest rate of any country but because of the relevance of Fisher Effect hypothesis, we have selected two important independent variables, rir and irt. Here nira and irt are considered as main variables as it is said in Fisher Equation that rir can be obtained if we subtract irt from nira. Value of the coefficient of inflation rate (γ) will be exactly one according to the Fisher Effect Hypothesis. If its value remain one then it is called full Fisher Effect and because of any value of γ less than one but greater than zero, it is called partial Fisher Effect. There will be no existence of Fisher Effect if the coefficient of inflation rate is zero. Any kind of negative value of the coefficient will give the misleading result that need more correction of the system or something relevant. Validity of all results will depend on the statistical significance test.

3.2: Unit Root Tests- ADF and KPSS: Stationarity check of variables

In any OLS regression it is assumed that all the variables are stationary that may not be true always. Non stationary variables can make the regression spurious due to the trending nature of variables, hence, unit root test became popular in time series data for last few decades. There are some established methods available to test stationarity of variables where selection of lag length is an important criterion. In our exercise we have selected lag length by using Akaike Information Criteria

(AIC) and Schwarz Bayesian Information Criteria (SBIC). Maximum lag of nira, rir and irt are (3,1,1) according to AIC. All the details of lag length selection are enclosed in the appendix, Annex Table 1 and Annex Figure 1. ADF (Dickey and Fuller, 1979) and KPSS (Kwiatkowski, Phillips, Schmidt and Shin, 1992) tests have been performed to check the validity of stationarity of variables followed by proper lag selection.

3.3: Testing for the Existence of Structural Break:

As ADF and KPSS assume that the parameters in the models are stable, we checked the validity of structural break in the series, if exists, before testing the existence of Fisher Effect Hypothesis for Bangladesh.

CUSUM and CUSUMSQ Stability Test:

Model stability is an important requirement for convenient econometric estimation and interpretation to investigate the techniques enabling the researchers to estimate the unknown parameters of a specific model (Talas et. al., 2013). Both CUSUM and CUSUMSQ test have been used to check parameter stability in the model. Individually variables are regressed on time here and parameter stability has been checked by CUSUM stability test (Brown, Durbin, and Evans, 1975). It plots the cumulative sum together with the 5% critical lines. Parameter becomes unstable if the cumulative sum line does not remain within the area between the two critical lines.

3.4: Unit Root Test Addressing Break:

Once we address structural break adjusted unit root test, it may rise question of considering break in the cointegration analysis (Glynn et. al., 2007). Thus, Clemente, Montañés and Reyes (1998) unit root test has been used to check the availability of multiple breaks in the series (Byrne & Perman, 2006).

Clemente – Montañés – Reyes Unit Root Test: Allowing for Multiple Break

Clemente, Montañés and Reyes (1998) developed a test to address this problem which allows for the existence of double break in the series. Depending upon the structural break dynamics, the test uses two different models; one is called the Additive Outlier (AO) model (here, a sudden structural change is considered), the other is Innovative Outlier (IO) model (here, the shift of the mean of the series is assumed to be gradual).

3.5: Gregory- Hansen Cointegration test controlling structural break: ARDL framework

Cointegrating relationship will not be appropriate that is done based on the ADF test (Gregory et. al., 1996). Thus, the method of Gregory and Hansen (1996) cointegration test takes no cointegration with structural break as null hypothesis while opposite as alternative hypothesis. Three models with different assumptions about structural breaks proposed by Gregory and Hansen (GH) are estimated here in the following way:

Model 1: $nira_t = \theta_1 + \theta_{11} D_{td} + \theta_2 rir_t + \theta_3 irt_t + \varepsilon_t$ (Level Shift)

Model 2: $nira_t = \theta_1 + \theta_{11} D_{td} + \vartheta_t + \theta_2 rir_t + \theta_3 irt_t + \varepsilon_t$ (Level Shift with Trend)

Model3: $nira_t = \theta_1 + \theta_{11} D_{td} + \theta_2 rir_t + \theta_{22} rir_t D_{td} + \theta_3 irt_t + \theta_{33} irt_t D_{td} + \varepsilon_t$ (Regime Shift)

In the above three models, $nira_t$ is the dependent variable, rir_t, irt_t are the independent variables, θ_1 is the intercept without structural break,θ_2, θ_3 are the slope coefficient without structural break,θ_{11} is the intercept with structural break,θ_{22} and θ_{33} are the slope coefficients with structural break, t is used as trend variable. D_{td}, dummy variable where $D_{td}=1$ for $t > d$ and zero for otherwise. Lag selection under the above method is taken based on the t statistics parallel to Perron and Vogelsang, 1992 (Banafea, 2012).

Three test statistics are used in the Gregory Hansen Cointegration test, say ADF*, Z_t*, Z_a* among which the smallest value will be considered as the break point. Modified Mackinnon (1991) critical values are used in this method that is different from the critical values used for the Engle and Granger approach (Banafea, 2012).

3.6: Autoregressive Distributed Lag (ARDL) Model:

Cointegration test is mandatory in the time series studies if there long run relationship exists. Pesaran and Shin (1995) and Pesaran et al (1996b) proposed ARDL approach to cointegration or bound procedure for same affiliation, regardless of the integrated order of the variables (Nkoro and Uko, 2016). Above noticed models strength is subject to the Statistical significance of the slope coefficients and residuals (Hatmanu et. al., 2020).

In this paper our ARDL (p.q,m) model without break variable is-

$nira_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i nira_{t-i} + \sum_{j=1}^{q} \beta_j rir_{t-j} + \sum_{k=1}^{m} \gamma_t irt_{t-k} + \varepsilon_t$

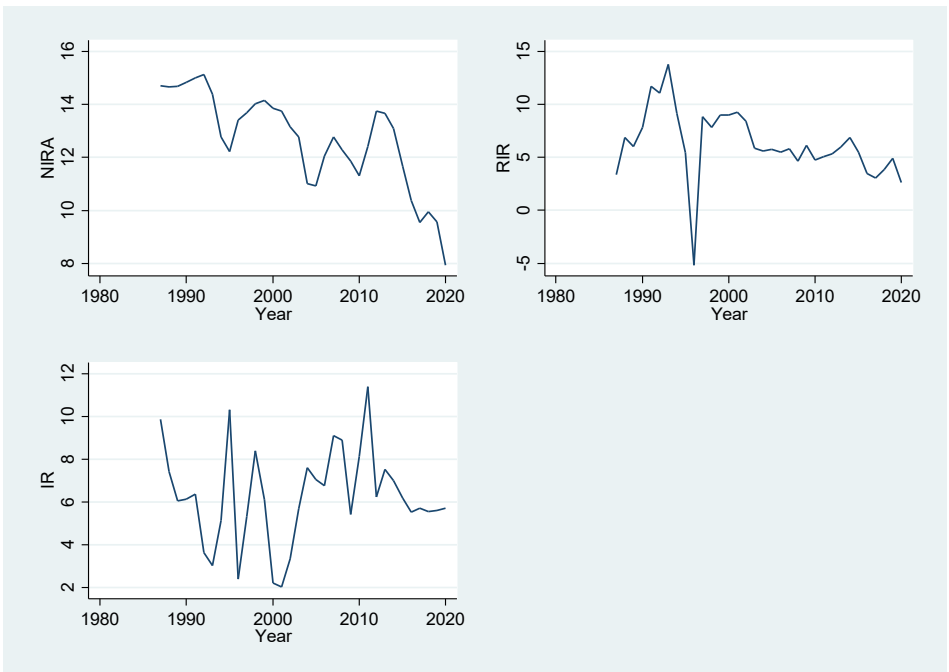
And our ARDL (p.q,m) model with break variable is-

$nira_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i nira_{t-i} + \sum_{j=1}^{q} \beta_j rir_{t-j} + \sum_{k=1}^{m} \gamma_t irt_{t-k} + \varepsilon_t + z_t + z_t * rir_t + z_t * irt_t$

Where optimal lag order of variable nira, rir and irt is p, q and m respectively. In the above two regression equations, if the estimated value of slope coefficient, is positive and significant, short run relationship between nira and irt will exist. Here is our break variable and are break adjusted Real Interest Rate and Inflation Rate. Significance of these variables has also some important implication in this model.

4. Empirical Results and Interpretation

4.1: Unit Root Tests- Stationarity and Non Stationarity Null:



This graphical representation shows all the variables may not be stationary at the level form as well as it may have structural break. To make these confusions clear we performed ADF and KPSS test. Test results are shown below in the table:

Table 1: Results of ADF and KPSS Tests

Table 1 A: Stationarity test results by ADF test: Null of non -stationarity of variables

Variables	Level Form			First Difference		
	Constant	Nonconstant	With Constant and Trend	Constant	Nonconstant	With Constant and Trend
Nominal Interest Rate(nira)	0.22	- 1.563	-1.459	- 3.681*	-3.251*	-3.816**
Real Interest Rate (rir)	-2.825*	-1.168	3.635**	-4.410*	-4.483*	-4.362*
Inflation rate, CPI (irt)	-3.800*	-1.075	-3.938**	-7.454*	-7.577*	-7.320*
*Note: *, **, *** denote rejection of the null hypothesis of a unit root at 1%, 5% and 10% level of significance respectively. No asterisk indicates that it was not possible to reject the null hypothesis of unit root and the series is non stationary.*						

Source: Author's Own Calculation

ADF test results show that variables are nonstationary in a particular nonconstant specification irrespective of the level of significance. Except nira, other two variables are stationary in level form in constant and with constant and trend variants at 1% and 5% level of significance respectively. So, we perform ADF test again in first difference level for all variables. Result indicates that all the variables are stationary in all three variants at 5% and 10% level of significance. So ADF test suggests that all the variables in this model are integrated at order one i.e. I (1) irrespective of any variant.

Table 1 B: Stationarity test results by KPSS test: Null of stationarity of Variables

Variables	Level Form		First Difference	
	No Trend	With Constant and Trend	No Trend	With Constant and Trend
Nominal Interest Rate(nira)	.738	.0695*	.126*	.062*

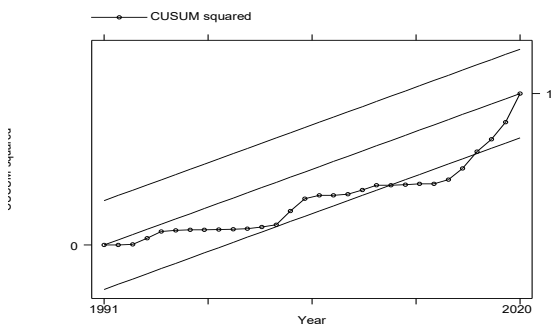
Real Interest Rate (rir)	.429*	.045*	N/A
Inflation rate, CPI (irt)	.195*	.11*	N/A
*Note: *, **, *** denote rejection of the null hypothesis of a unit root at 1%, 5% and 10% level of significance respectively. No asterisk indicates that it was not possible to reject the null hypothesis of unit root and the series is non stationary.*			

Source: Author's Own Calculation

Results show that our main variable Nominal Interest Rate is stationary in the level form with constant and trend specification while it is found nonstationary with no trend variant irrespective of any level of significance. Taking First difference indicates the variable is stationary in both variant at any level of significance. Another important variable Inflation rate is found stationary in level form at both no trend and with constant and trend variants at 1% and 5% level of significance. Same result has been found for Real Interest Rate. That means according to the KPSS test, these three variables are integrated at order zero and one i.e. combination of I(0) and I(1).

4.2: Check Stability test of the Variables: CUSUM squared Stability Test

As our main target was to check the importance of structural break, here we go for CUSUM squared stability test of all variables based on what we would be able to our further discussion regarding unit root test addressing structural break.



In the CUSUM and CUSUMSQ stability test, null hypothesis is that all the coefficients are stable. If the above test statistics remain within the boundary of five per cent level of significance, we cannot reject null. (Srinivasan et al, 2012). This

graph indicates that there is instability of parameter in the model as the CUSUM squared statistics line is outer the zone in the middle of the two critical lines.

4.3: Unit Root Test Addressing Structural Breaks

4.3.1: Clemente – Montanes – Reyes (1998) Unit Root Test: Multiple Endogenous Structural Breaks:

In order to address multiple breaks, Clemente-Montañés-Reyes (1998) Unit Root Test allows two endogenously determined breaks instead of one. Additive and Innovative Outlier approaches are used here to show the rapid and gradual mean change. The results for the three variables are formulated in the following table.

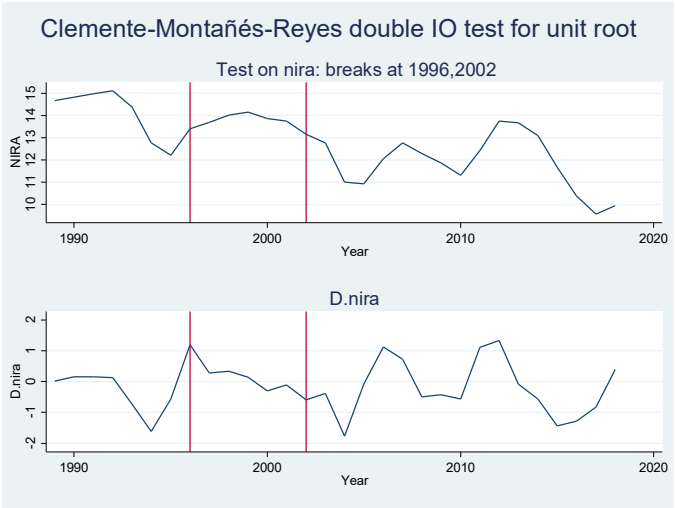
Table 3: Results of the Clemente-Montañés-Reyes (1998) Unit Root Test with Double Mean Shift

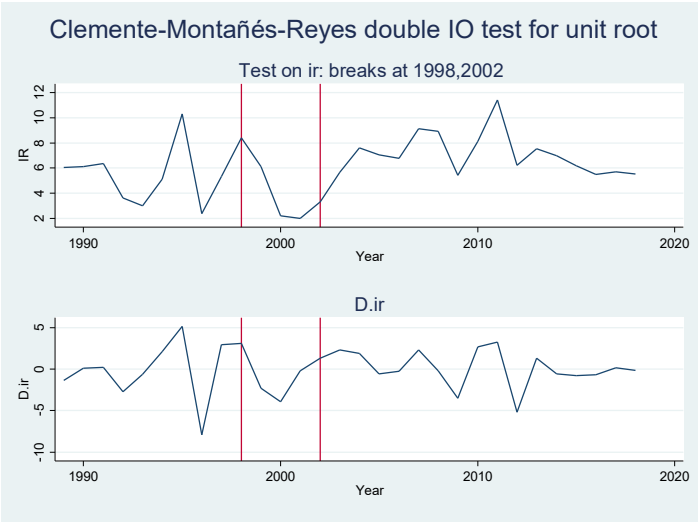
Name of Variables	Additive Outlier (AO)		Innovative Outlier (IO)	
	t-statistic	Break Dates	t-statistic	Break Dates
Nominal Interest Rate (nira)	-.418 (5.49) -7.273*[f] (5.49)	1995 and 2003	-2.107 (5.49) -7.329*[f] (5.49)	1996 and 2002
Real Interest Rate (rir)	-5.447 (5.49)	1994 and 2003	-7.836* (5.49)	1995 and 2003
Inflation Rate(irt)	-5.555* (5.49)	2004 and 2013	-5.562* (5.49)	1998 and 2002

*Note: Value within the bracket indicates critical value at 5% level of significance. * denotes rejection of the null of unit root. No asterisk indicates that it was not possible to reject the null hypothesis of unit root and the process is non-stationary. *f indicates significant value result at first difference level.*

Source: Author's Own Calculation

Both Additive and Innovative Outlier said that our main variable nira has two optimal breaks, but it is significant at first difference form not in level. On the other hand, another important variable irt is significant with two optimal breaks in level form. Both variables are significant at 5% level of significance. Two optimal breaks according to two outliers (AO and IO) are 1995, 2003 and 1996, 2002 respectively for nira while breaks are 2004, 2013 and 1998, 2002 for another variable, irt. That means variable nira and irt is stationary at 5 % level of significance in both AO and IO approach first difference form and in level form respectively.





In a nutshell Clemente-Montañés-Reyes test results show that variables in this series are sometimes stationary in the level form either sudden or gradual mean shift, on the other hand some variables became stationary addressing multiple structural breaks in first difference form. It proves the mean reverting property of the series either in level form or first difference form. So innovative outlier said variables are stationary with break at the combination of integrated at order one and zero i.e. I(0) and I(1). Common break date for two variables is 2002 that is

considered while constructing our break variable, z_t Difference between the results of ADF (without break) and Clemente-Montañés-Reyes test (with break) is clear i.e., ADF test result shows that variables are integrated at order one but addressing break shows combination of I(0) and I(1). It is the significance of addressing structural break while testing stationarity of the series. Graphs in Additive Outlier variant are enclosed in the appendix, Annex Table 2.

4.4: Gregory Hansen Cointegration Test with Structural Breaks:

Addressing structural break variables are stationary at combination of I (o) and I (1). So, we perform "Gregory- Hansen Cointegration test controlling structural break" that is examined in ARDL framework. This test has been done on the basis of no cointegration at break point as null hypothesis. Decision rule is the rejection of null hypothesis if $Z_t >$ critical value at 5% level of significance while tested in three different variants.

Table 4: Results of Gregory – Hansen Cointegration Test with No cointegration Null:

Test Statistics	Level Shift	Break Dates	Level Shift with Trend	Break Dates	Regime Shift	Break Dates
ADF*	-3.11 (-4.92)	2015	-2.85 (-5.29)	2015	3.88 (-5.50)	2002
Z_t*	-3.16 (-4.92)	2002	-3.33 (-5.29)	2015	-3.95 (-5.50)	2002
Z_a*	-16.28 (46.98)	2002	-16.89 (-53.92)	2015	-21.81 (-58.33)	2002
Note: Value within the bracket is the critical value at 5% level of significance						

Source: Author's Own Calculation

The three models in Gregory Hansen cointegration test show that there is no cointegration in this model that means no presence of long run relationship concerning nira with rir and irt. In three variants two years are reported as break dates like 2002 and 2015 and we consider 2002 as the break point as it is the smallest value among three statistics. In order to find out the short run relationship in level form, this study performed the ARDL model with break and without break ignoring error correction model. If we run ARDL model without break and error correction option, lag of inflation rate has positive impact on current year's interest rate, and it is statistically significant. This result shows that partial Fisher Effect exists in Bangladesh. As a diagnostic test, this model has no autocorrelation, no heteroscedasticity but parameters are unstable by CUSUM squared stability test.

On the other hand, when we consider break without error correction option in ARDL model, result remain same along with diagnostic test except parameter stability. So important thing is that partial Fisher Effect exists in both model but if we consider break parameters became stable as well.

The result shows that nominal interest rate increases by 0.16% if inflation rate increases by 1 percent in the previous year. So, fisher effect is partially satisfied in Bangladesh. Our result is not in line of some other conclusions say Abubakar and Sivagnanam (2017), Manuel Benazić (2013), Selahattin (2016) etc but obviously in favour of some others paper like Adil et. al. (2020), Clemente et al (2017), Edirisinghe et al (2015), though long run partial fisher effect has been found by Uyaebo et al. (2016).

Table 5: Results of ARDL model with Break and without Break

Dependent Variable: $nira_t$

Variables	**With Break**			**Without Break**		
	Coefficient	t-stat	P value	Coefficient	t-stat	P value
$L_1 rir_t$	-.0118007	-0.26	0.799	-.0131167	-0.27	0.788
$L_1 irt_t$	.1614088*	2.63	0.016	.1661042 *	2.60	0.016
z_t	-3.601558*	-2.31	0.032			
$z_t * rir_t$	.3634009 *	2.28	0.034			
$z_t * irt_t$	.1281929	1.12	0.278			
Constant	29.51608	0.41	0.684	104.7463	2.05	0.052
*Note: * indicates coefficient is statistically significant at 5% level of significance*						

Source: Author's Own Calculation

In order to check the validity, we Run ARDL model with and without break and result shows that short run Fisher coefficient in one period lag are .161 and .166 respectively those are statistically significant as well. It indicates that nominal interest rate increases by .16% if inflation rate increases by 1 percent in the previous period. So weak Fisher Effect is partially satisfied in Bangladesh. So, there is no existence of long run relationship but in order to detect short run relationship properly, structural break must be addressed for the stable parameter in the model that is the most important characteristics of any model. Our break variable z_t is also significant at 5% level of significance.

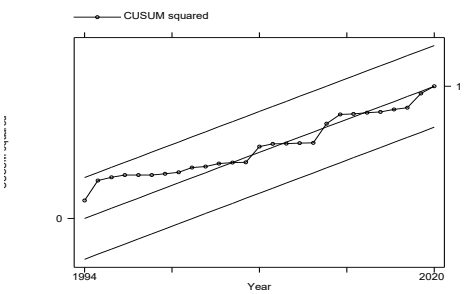
Other Diagnostic Test:

Breusch–Godfrey LM test for autocorrelation (chi^2 = 1.803, p value = 1.793) shows no autocorrelation exists in this model. We used Cameron and Trivedi's decomposition of IM test and result shows that no heteroscedasticity (chi^2 = 31.00, p value = .4754) is there in the model. Ramsey RESET test F (3, 19) = 0.57, p value = .6392) for omitted variables check in this model gives no omitted variables available in this model. These three results are same for the two model i.e., ARDL with break and ARDL without break but parameters of the model are found stable only when we address structural break in the model. Adjusted R-squared and F statistics are also better in this model.

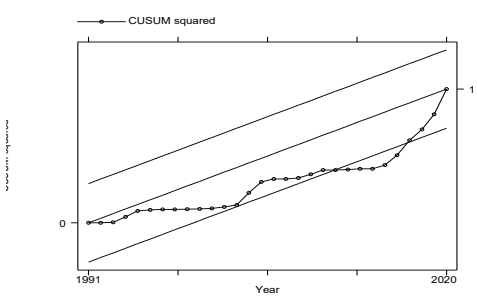
Diagnostic Tests	With break		Without Break	
Adj R^2	0.8707		0.8707	
F Statistics	F(8,22) =26.26		F(8,22) =26.26	
Heteroscedasticity H_0: Homoscedasticity	chi2(30) = 31.00	Prob > chi2 = 0.4154	chi2(30) = 31.00	Prob > chi2 = 0.4154
Autocorrelation H_0: no serial correlation	chi2 = 1.803	Prob > chi2= 0.1793	chi2 = .513	Prob > chi2 = 0.4738
Omitted Variables Bias H_0: Model has no omitted variables	F(3, 16) = 0.31	Prob > F = 0.8147	F(3, 19) = 0.57	Prob > F = 0.6392
Parameter Stability	Parameters are stable		Parameters are unstable	

Source: Author's Own Calculation

In order to check parameter stability, we performed CUSUM squared stability test with break and without break, the result shows that parameters are stable if we consider structural break in the model while opposite result has been found without structural break. It proves the importance of addressing structural break in the model that was our aim to find out throughout this paper.



CUSUM Stability test with break



CUSUM Stability test without break

5. Conclusion and Policy Implication

Considering 34 years' time series data during 1987 to 2020, our focus was to find out the relationship flanked by nominal interest rate (nira) and inflation rate (irt), thus the existence of Fisher Hypothesis. Gregory- Hansen Cointegration test shows no existence of long run relationship, but short run relationship found by applying short run ARDL model with and without structural break. Evidence showed that validity of Fisher Effect is partial in Bangladesh that means Nominal Interest rate increases by .16% if inflation rate increases by 1% with one period lag. The year 2002 has been considered as the break year based on the tests performed in the study.

This paper shows that Nominal Interest Rate is very weakly influenced by the Inflation Rate with lag effect. Concerned Monetary Authority/s may play the significant role in case of fixing interest rate in Bangladesh while inflation rate can be considered as the secondary factor as it has lag effect in this regard. 9% (maximum lending rate) - 6% (maximum deposit rate) interest rate in Bangladesh can be used here as an example of imposition of interest rate on the commercial banks by the Government. Expected Inflation adjusted interest rate may work as an inspiring factor to the investor for further investment to make sure their rate of future return. More investment has positive effect on less unemployment, more income, stability of price and finally sustainable economic growth. As one of the important goals of monetary policy of any country is to stabilize interest rate, the Monetary Policy Department (MPD) of Bangladesh Bank may come up with a monetary policy rule that will preserve one to one relation between country's nominal interest rate with inflation rate considering economic agent's inflationary expectation. Real interest rate will remain constant eventually in the long run that is one of the implications of Fisher equation. However, adopting endogenous structural break for detecting multiple breaks (more than two) or existence of Fisher hypothesis under different policy regimes could be the further scope of research in this field.

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Appendix:

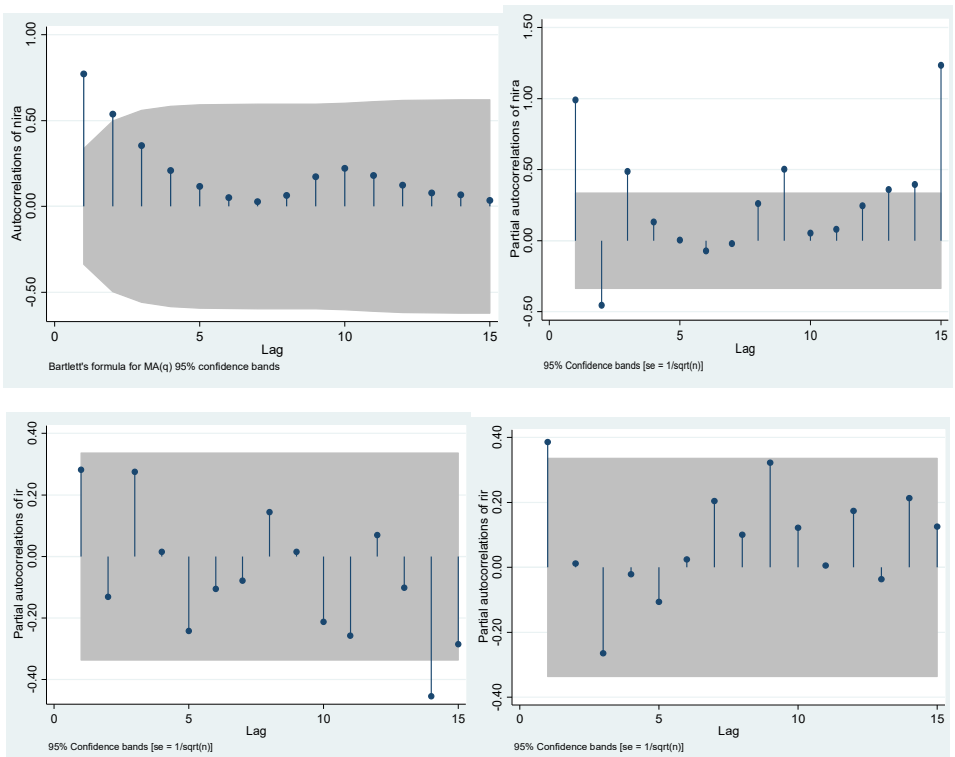
Annex Table 1: Selection of Lag Length for Different Variables

Lag Order	SBIC	AIC	Probability
Nominal Interest Rate (nira)			
0	4.02133	3.97463	
1	2.67699	2.58357	0.000
2	2.59986	2.45974	0.017
3	2.5256*	2.33878*	0.018
4	2.62685	2.39332	0.546

Real Interest Rate (rir)			
0	5.31572	5.36243	
1	5.2102*	5.30361*	0.023
2	5.27686	5.41698	0.986
3	5.27949	5.46632	0.166
4	5.34574	5.57927	0.911
Inflation Rate (irt)			
0	4.56703*	4.52032	
1	4.59913	4.50572*	0.118
2	4.69464	4.55452	0.464
3	4.71905	4.53222	0.102
4	4.83217	4.59864	0.930

*Note: * indicates significant at the 5% level of significance*

Annex Figure 1: Correlogram for Different Variables



Annex Table 2: Clemente – Montanes – Reyes (1998) Unit Root Test