The Fisher Effect Using Differences in The Deterministic Term

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Note: This is the accepted version.

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ABSTRACT

The Fisher effect posits that nominal interest rates move one for one with inflation. This hypothesis has become an important concept in Financial Economics and has become the mainstay of inflation and interest rate targeting. Previous studies used cointegration tests particularly the Johansen cointegration test and the Johansen and Juselius cointegration methods to determine long run affiliations between nominal interest rates and inflation. The glitch is, the recent cointegration methodology proposed by Saikkonen and Lütkepohl has not been applied in the investigation of cointegrating vectors between nominal interest rates and inflation. Following Saikkonen & Lü ikepohl, this study estimates deterministic terms of the time series under investigation and then proceeds with the cointegration process. The study tests for the Fisher effect for 20 selected countries and examines interest rates and inflation figures for the period 1982 to 2013 as provided by the World Bank and the International Monetary Fund (IMF). Conformingly, the results of the Saikkonen & Lütkepohl cointegration test show that the Fisher effect holds in all countries under examination. Comparatively, the Johansen cointegration procedure evidenced that the Fisher effect holds in all economies except the US, South Africa, Chile, Switzerland and Australia.

JEL: E43; E31

INTRODUCTION

Interest rates, inflation rates as well exchange rates are key factors in Financial Economics. These aforementioned factors affect how financial institutions conduct their lending to the public and borrowings from the central bank. At a macroeconomic level, interest rates and inflation also affect investment spending thus impinging on economic growth. The relationship between interest rates and inflation was not self-evident until the American economist Irvin Fisher, proposed that nominal interest rates trend positively with inflation in the long run. Ever since then, numerous studies have been conducted following Fisher's (1930) proposition and many studies generally supported the long run Fisher effect. The long run Fisher effect appears to surface more in numerous studies simply because in the short run, interest rates are highly volatile hence they have no significant bearing in predicting inflation. Currently, most central banks are operating under inflation targeting regimes. Under this regime, the Fisher hypothesis is the lifeblood of this operation because interest rates can be used to target and control inflation dynamics.

The Fisher effect is a breakthrough in Financial Economics because it is not for particular interest rates such as prime interest rates, interest on a central bank bond or certificate but is a broad phenomenon that merely states the relationship between any interest rate figure and inflation. Financial institutions such as commercial banks account for inflation when conducting loans in order to avoid the prospect of eroding interest rate income. The Fisher (1930) proposition assumes that real interest rates remain indifferent in the long run relationship between nominal interest rates and inflation. In practical terms, real interest rates are never completely stationary unless you are talking about a fixed income security such as a central bank bond or certificate. The other option is when you are operating under an interest rate targeting regime such that any volatility or movements will only be attributed to inflation subsequently nominal interest rates. This will in consequence, result in the long run relationship between the variables.

Previous studies generally affirmed the existence of the Fisher effect. Since the Fisher effect posits long run comovement between nominal interest rates and inflation, cointegration tests have been applied manifold in previous studies. The glitch with the extant literature is that the Johansen cointegration test seems to be the most applied cointegration technique while other cointegration procedures have been sidelined drawing from previous studies such as Pelaez (1995); Fahmy & Kandil (2003); Incekara et al., (2012); Hawtrey (1997); Granville & Mallick (2004); and Daniels et al. (2006). This paper contributes to the literature by applying a cointegration technique proposed by Saikkonen & Lütkepohl to test for the long run relationship between nominal interest rates and inflation for twenty countries as from 1982 to 2013. The Johansen cointegration test is further applied to make a comparative analysis between the two cointegration tests. The rest of this paper is structured as follows. Next will be a literature review on the Fisher effect. This will be followed by data description and unit root tests. Next will be empirical test results of the cointegration tests. To sum up, a discussion and conclusion follows with practical implications of the study.

LITERATURE REVIEW

The Fisher effect has often been viewed as long run phenomena. Studies presenting evidence of the short run Fisher effect have been limited as opposed to evidence on the long run Fisher effect. Tsong & Lee (2013) intended to provide possible explanations for the empirical failure of the Fisher hypothesis in terms of economic shocks by employing quantile cointegration methodology proposed by Xiao (2009) for the period 1957Q1-2012Q2. The results of the study for six OECD countries (Australia, Belgium, Canada, Sweden, UK, and US) suggest that though nominal interest rates and inflation move together in the long run, the cointegrating coefficients between the two variables displayed an asymmetric pattern depending on the sign and the size of the shock in contrast to their counterparts with conventional cointegration methods (Tsong & Lee, 2013). The authors further noted that even though the Fisher effect is easy to justify theoretically, the Fisher parity is quite difficult to vindicate empirically. Thus evidence provided by Tsong & Lee (2013) showed that the Fisher hypothesis holds in the six OECD countries in a quantile sense.

Pelaez (1995) aimed to test for a long run equilibrium relationship between nominal interest rates and inflation by employing cointegration concepts developed by Granger (1981); Granger & Weiss (1983) and Engel & Granger (1987). Pelaez (1995) noted that the non-stationarity of the real interest rates implied that the Fisher effect should be recast as a long run equilibrium relationship between expected inflation components of the nominal interest rates and actual inflation for the period 1959-1993. Furthermore, Pelaez (1995) tested for cointegration between quarterly inflation and expected inflation for a 3-month Treasury bill. The results indicated that the variables were cointegral during the material period. Panapoulou & Pantelidis (2015) observed interest rates and inflation for 19 OECD members using time varying coefficients. It was found out that when employing simulated critical values instead of asymptotic ones, the results provide ample evidence supporting the existence of a long run Fisher effect in which interest rates move one for one with inflation except for Ireland and Switzerland. This study is consistent with previous studies which used coefficient estimation procedures and generally found support for a long run Fisher effect in the US (Evans & Lewis, 1995; Crowder & Hoffman, 1996; Atkins & Coe, 2002; Fahmy & Kandil, 2003). Lanne (2001) tested for the Fisher effect by using US data covering the period 1953:1 to 1990:12. Taking appropriate account of the near unit problem, the Fisher effect was confirmed. The study supported the Fisher effect in the Federal Reserve interest rate targeting period of 1953-1979.

Jareno & Tolentino (2013) found a positive and significant relationship between variations in the current expected inflation rate and variations in the nominal interest rates for the whole of Europe. The Fisher effect covered Germany, Spain and Finland. Similarly, Incekara et al. (2013) used seasonal series data between 1989:Q1 and 2011:Q4 to test the validity of the Fisher effect in the Turkish economy by using Johansen cointegration analysis and VAR methods. It was concluded that in the long run, the Fisher effect holds in Turkey. Granville & Mallick (2004) contributed by applying Johansen cointegration tests to validate the existence of the Fisher effect in the UK thus implying a significant long run equilibrium relationship between the variables. Malliaropolus (2000) proposed an alternative test of the Fisher effect based on VAR representations. The study revealed a strong support of the Fisher effect both in the medium term and in the long run as from 1960:Q1 to 1995:Q3. In contribution, Daniels et al. (1996) noted that the literature is concerned with whether there is a stable long run equilibrium relationship between nominal interest rates and inflation. The study found that in the long run, there is unidirectional causality from inflation rates to interest rates. Berument & Jelassi (2002) tested whether the Fisher hypothesis holds for a sample of 26 countries by assessing the long run relationship between nominal interest rates and inflation rates taking into consideration the short run movements of interest rates. The study covered the period 1957 to 1998 and applied robustness checks as well as ARCH techniques. Evidence brought forward supported the Fisher effect for several economies under examination.

It is worth noting that the Fisher effect has also been nullified in some studies. Olekalns (1996) for example, used data from 1964:4-1993:3 and vector autoregressive indicator estimates of the Fisher equation rejected the Fisher hypothesis. However, an analysis conducted on post deregulation data alone showed that complete adjustment of the Fisher effect is achieved. Hawtrey (1997) also tested for the Fisher effect in Australia for the period 1969 to 1994 using the Johansen methodology and found that while the Fisher effect fails prior to the financial deregulation in the 1980's, there is ample evidence following deregulation that the relationship is restored. Hasan (1997) applied the Adaptive Expectation Approach, Diagnostic checks and Wald tests to reveal that the effectiveness of monetary policy and efficiency in the banking sector had direct bearing on the long run relationships between nominal interest rates and expected inflation. The study further revealed the failure of interest rates as a hedge against inflation as a predictor of inflation as from 1957-1991. In addition, Ghazalli & Ramlee (2003) used an Autoregressive Fractionally Integrated Moving Averages model (ARFIMA) to test for the Fisher effect in G7 countries. Using data from 1974-1996 the study revealed that interest rates in the G7 countries were not linked to inflation in the long run. Further evidence on the rejection of the Fisher effect was provided by Coppock & Poitras (2000) using bounded influence estimations. It was found out that interest rates failed to adjust to inflation due to variations in implicit liquidity premiums on financial assets.

The extant literature has thus affirmed the existence of the Fisher effect drawing from the works of Tsong & Lee (2013); Pelaez, (1995); Panapoulou & Pantelidis, (2015); Lanne, (2001); Jareno & Tolentino, (2013); Incekara et al. (2013); Granville & Mallick, (2004); Daniels et al. (1996); Jareno & Tolentino, (2013) and Berument & Jelassi (2002). Even so, there are a number of studies nullifying the Fisher effect phenomena following studies carried out by Olekalns (1996); Hawtrey (1997); Hasan (1997); Ghazalli & Ramlee (2003); and Coppock & Poitras (2000). By implication, the Fisher effect has been incongruent. In general, most studies pertaining to this hypothesis used the Johansen cointegration test to validate the Fisher effect without applying other cointegration techniques such as Phillips and Hansen or the Gregory-Hansen cointegration tests. This study uses data from 1982 to 2013 for 20 countries to test for the Fisher effect by applying the recent

Saikkonen & Lütkepohl cointegration method. This study further carries out the Johansen cointegration test to make a comparative analysis of the results of the cointegration techniques. The primary reason why the two tests are employed is to validate if their inherent differences in the estimation of the deterministic term plays any profound role in the validity of the Fisher effect.

DATA DESCRIPTION AND UNIT ROOT TESTS

The data covers the period 1982 to 2013 and was sourced from the World Bank. Comparatively, real interest rates and inflation correspond with those from the International Monetary Fund (IMF). According to the World Bank, real interest rates were measured as a percentage of the country's annual lending rate adjusted for inflation as measured by the GDP deflator. Moreover, inflation was measured by the annual growth rate of the GDP implicit deflator. Following the World Bank definition, GDP implicit deflator was defined as the ratio of GDP in current local currency to GDP at local constant currency. Before proceeding with the cointegration technique, the data has to be examined for unit roots. The Augmented Dickey Fuller (ADF) test is one of the most applied stationarity tests for determining the order of integration of macroeconomic time series following Asemota & Bala (2011). The testing technique for the ADF test is based on the model:

$$\Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t.$$

The following model was used to examine unit roots for the time series

$$\therefore \Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-1} + \varepsilon_t.$$

Statistically, α was allowed to be a constant, β the coefficient on a time trend following Asemota & Bala (2011). By implication ε_t was allowed to be a white noise error term and Δy_{t-1} was then equated to $\Delta y_{t-1} - \Delta y_{t-2}$. The Philips Perron test was further applied to test the stationarity of the real interest rates. The model took the form $\Delta \hat{y}_t = \mu_t + p\hat{y}_{t-1} + \varepsilon_t$. Table 1 to 4 presents stationarity test results of the time series.

Table 1: Inflation Rates Stationarity

Augmented Dickey Fuller (ADF) test			
Country		π_t^e	
Bangladesh	-3.8158$_{-[4.2967]}$	-3.8158 $_{–[3.583]}$	-3.8158 $_{–[3.2183]}$
Bhutan	-3.0510$_{-[4.2967]}$	-3.0510$_{-[3.583]}$	-3.0510$_{-[3.2183]}$
Bolivia	-4.1153$_{-[4.2967]}$	-4.1153$_{–[3.583]}$	-4.1153$_{–[3.2183]}$
Australia	-3.8135$_{-[4.2967]}$	-3.8135$_{-[3.583]}$	-3.8135$_{-[3.2183]}$
Botswana	-3.8070$_{-[4.2967]}$	-3.8070$_{-[3.583]}$	-3.8070$_{-[3.2183]}$
Canada	5.2862$_{-[4.2967]}$	5.2862$_{-[3.583]}$	5.2862$_{-[3.2183]}$
Switzerland	-1.8529$_{-[4.2967]}$	-1.8529$_{–[3.583]}$	-1.8529$_{–[3.2183]}$
Chile	4.3556$_{-[4.2967]}$	4.3556$_{-[3.583]}$	4.3556$_{-[3.2183]}$
China	5.5321$_{-[4.2967]}$	5.5321$_{–[3.583]}$	5.5321$_{–[3.2183]}$
Carbo Verde	-3.4390$_{-[4.2967]}$	-3.4390$_{-[3.583]}$	-3.4390$_{-[3.2183]}$
Costa Rica	8.5476$_{-[4.2967]}$	8.5476$_{-[3.583]}$	8.5476$_{-[3.2183]}$
Dominica	12.6031$_{-[4.2967]}$	12.6031$_{-[3.583]}$	12.6031$_{[3.2183]}$
UK	5.9229$_{-[4.2967]}$	5.9229$_{-[3.583]}$	5.9229$_{-[3.2183]}$
Japan	4.2073$_{-[4.2967]}$	4.2073$_{-[3.583]]}$	4.2073$_{-[3.2183]}$
Kenya	-0.9992$_{-[4.2967]}$	-0.9992$_{–[3.583]}$	-0.9992$_{–[3.2183]}$
Lesotho	-2.7612$_{-[4.2967]}$	-2.7612$_{-[3.583]}$	-2.7612$_{[3.2183]}$
Nigeria	-3.8510$_{-[4.2967]}$	-3.8510$_{–[3.583]}$	-3.8510$_{–[3.2183]}$
SA	4.5043$_{-[4.2967]}$	4.5043$_{-[3.583]}$	4.5043$_{-[3.2183]}$
USA	-2.7963$_{-[4.2967]}$	-2.7963$_{–[3.583]}$	-2.7963$_{–[3.2183]}$
Singapore	5.0140$_{-[4.2967]}$	5.0140$_{-[3.583]}$	5.0140$_{-[3.2183]}$

$_{-[4.2967]}$ critical value at 1% level

$_{-[3.583]}$ critical value at 5% level

$_{-[3.2183]}$ critical value at 10%

Table 2: Nominal Interest Rates Stationarity

	Augmented Dickey Fuller (ADF) test		
Country		i_t	
US	-3.2230$_{-[4.2967]}$	-3.2230$_{-[3.583]}$	-3.2230$_{-[3.21832]}$
Australia	2.8183$_{-[4.2967]}$	2.8183$_{-[3.583]}$	2.8183$_{-[3.21832]}$
Botswana	4.5543$_{-[4.2967]}$	4.5543$_{-[3.583]}$	4.5543$_{-[3.21832]}$
Canada	4.6740$_{-[4.2967]}$	4.6740$_{-[3.583]}$	4.6740$_{-[3.21832]}$
Bangladesh	-2.0943$_{-[4.2967]}$	-2.0943$_{-[3.583]}$	-2.0943$_{[3.21832]}$
Bolivia	-1.9941$_{-[4.2967]}$	-1.9941$_{-[3.583]}$	-1.9941$_{-[3.21832]}$
Bhutan	4.9811$_{-[4.2967]}$	4.9811$_{-[3.583]}$	4.9811$_{-[3.21832]}$
Switzerland	-3.2655$_{-[4.2967]}$	-3.2655$_{-[3.583]}$	-3.2655$_{-[3.21832]}$
Chile	1.2086$_{-[4.2967]}$	1.2086$_{-[3.583]}$	1.2086$_{-[3.21832]}$
China	-2.0275$_{-[4.2967]}$	-2.0275$_{-[3.583]}$	-2.0275$_{-[3.21832]}$
Carbo Verde	-3.4398$_{-[4.2967]}$	-3.4398$_{-[3.583]}$	-3.4398$_{-[3.21832]}$
Costa Rica	4.7336$_{-[4.2967]}$	4.7336$_{-[3.583]}$	4.7336$_{-[3.21832]}$
Dominica	-3.1639$_{-[4.2967]}$	-3.1639$_{-[3.583]}$	-3.1639$_{-[3.21832]}$
Kenya	-1.6751$_{-[4.2967]}$	-1.6751$_{-[3.583]}$	-1.6751$_{-[3.21832]}$
Lesotho	-3.7728$_{-[4.2967]}$	-3.7728$_{-[3.583]}$	-3.7728$_{-[3.21832]}$
Japan	-2.9801$_{-[4.2967]}$	-2.9801$_{-[3.583]}$	-2.9801$_{-[3.21832]}$
South Africa	4.4797$_{-[4.2967]}$	4.4797$_{-[3.583]}$	4.4797$_{-[3.21832]}$
Singapore	-2.9760$_{-[4.2967]}$	2.9760$_{-[3.583]}$	2.9760$_{-[3.21832]}$
UK	-4.0008$_{-[4.2967]}$	-4.0008$_{-[3.583]}$	-4.0008$_{-[3.21832]}$
Nigeria	5.5640$_{-[4.2967]}$	5.5640$_{-[3.583]}$	5.5640$_{-[3.21832]}$

$_{-[4.2967]}$ critical value at 1% level

$_{-[3.583]}$ critical value at 5% level

$_{-[3.21832]}$ critical value at 10%

Table 3: Real Interest Rates Stationarity-Phillips Perron Test

Phillips-Perron Test			
Country		r_t	
Bangladesh	-2.6885$_{-[4.2967]}$	-2.6885$_{-[3.583]}$	-2.6885$_{-[3.21832]}$
Bhutan	-3.7009$_{-[4.2967]}$	-3.7009$_{-[3.583]}$	-3.7009$_{[3.21832]}$
Bolivia	-5.0504$_{-[4.2967]}$	-5.0504$_{-[3.583]}$	-5.0504$_{-[3.21832]}$
Australia	-4.5134$_{-[4.2967]}$	-4.5134$_{-[3.583]}$	-4.5134$_{[3.21832]}$
Botswana	-3.0967$_{-[4.2967]}$	-3.0967$_{-[3.583]}$	-3.0967$_{-[3.21832]}$
Canada	-1.2930$_{-[4.2967]}$	-1.2930$_{-[3.583]}$	-1.2930$_{-[3.21832]}$
Switzerland	-5.3816$_{-[4.2967]}$	-5.3816$_{-[3.583]}$	-5.3816$_{-[3.21832]}$
Chile	-4.3144$_{-[4.2967]}$	-4.3144$_{-[3.583]}$	-4.3144$_{[3.21832]}$
China	-6.9537$_{-[4.2967]}$	-6.9537$_{-[3.583]}$	-6.9537$_{-[3.21832]}$
Carbo Verde	-3.4326$_{-[4.2967]}$	-3.4326$_{-[3.583]}$	-3.4326$_{-[3.21832]}$
Costa Rica	-7.1913$_{-[4.2967]}$	-7.1913$_{-[3.583]}$	-7.1913$_{-[3.21832]}$
Dominica	-4.5519$_{-[4.2967]}$	-4.5519$_{-[3.583]}$	-4.5519 $_{[3.21832]}$
UK	-6.4278$_{-[4.2967]}$	-6.4278$_{-[3.583]}$	-6.4278$_{-[3.21832]}$
Japan	-3.8523$_{-[4.2967]}$	-3.8523$_{-[3.583]}$	-3.8523$_{[3.21832]}$
Kenya	-6.2759$_{-[4.2967]}$	-6.2759$_{-[3.583]}$	-6.2759$_{-[3.21832]}$
Lesotho	-6.6562$_{-[4.2967]}$	-6.6562$_{-[3.583]}$	-6.6562$_{[3.21832]}$
Nigeria	-2.8246$_{-[4.2967]}$	-2.8246$_{-[3.583]}$	-2.8246$_{-[3.21832]}$
SA	-3.9675$_{-[4.2967]}$	-3.9675$_{-[3.583]}$	-3.9675$_{[3.21832]}$
USA	-3.1656$_{-[4.2967]}$	-3.1656$_{-[3.583]}$	-3.1656$_{-[3.21832]}$
Singapore	-6.6562$_{-[4.2967]}$	-6.6562$_{-[3.583]}$	-6.6562$_{[3.21832]}$

$_{-[4.2967]}$ critical value at 1% level

$_{-[3.583]}$ critical value at 5% level

$_{-[3.21832]}$ critical value at 10%

Table 4: Real Interest Rates Stationarity- Augmented Dickey Fuller Test

Augmented Dickey Fuller (ADF) test			
Country		r_t	
US	-3.0601-[4.2967]	-3.0601-[3.583]	-3.0601-[3.21832]
Australia	-3.7709-[4.2967]	-3.7709-[3.583]	-3.7709-[3.21832]
Botswana	-5.0014-[4.2967]	-5.0014-[3.583]	-5.0014-[3.21832]
Canada	-4.5562-[4.2967]	-4.5562-[3.583]	-4.5562-[3.21832]
Bangladesh	-3.0977-[4.2967]	-3.0977-[3.583]	-3.0977 [3.21832]
Bolivia	-1.6426-[4.2967]	-1.6426-[3.583]	-1.6426-[3.21832]
Bhutan	-5.3816-[4.2967]	-5.3816-[3.583]	-5.3816-[3.21832]
Switzerland	-4.3350-[4.2967]	-4.3350-[3.583]	-4.3350-[3.21832]
Chile	-3.1637-[4.2967]	-3.1637-[3.583]	-3.1637-[3.21832]
China	-3.4342-[4.2967]	-3.4342-[3.583]	-3.4342-[3.21832]
Carbo Verde	-7.2482-[4.2967]	-7.2482-[3.583]	-7.2482-[3.21832]
Costa Rica	-4.5519-[4.2967]	-4.5519-[3.583]	-4.5519-[3.21832]
Dominica	-5.8273-[4.2967]	-5.8273-[3.583]	-5.8273-[3.21832]
Kenya	-3.8033-[4.2967]	-3.8033-[3.583]	-3.8033-[3.21832]
Lesotho	-6.4552-[4.2967]	-6.4552-[3.583]	-6.4552-[3.21832]
Japan	-4.0237-[4.2967]	-4.0237-[3.583]	-4.0237-[3.21832]
South Africa	-2.8246-[4.2967]	-2.8246-[3.583]	-2.8246-[3.21832]
Singapore	-3.9929-[4.2967]	-3.9929-[3.583]	-3.9929-[3.21832]
UK	-3.2111-[4.2967]	-3.2111-[3.583]	-3.2111-[3.21832]
Nigeria	-5.9841-[4.2967]	-5.9841-[3.583]	-5.9841-[3.21832]

-[4.2967] critical value at 1% level

-[3.583] critical value at 5% level

-[3.21832] critical value at 10%

METHODOLOGY

The Johansen Cointegration Technique

Following Johansen (1988) the idea of using cointegration vectors in the study of non-stationary time series comes from works of Granger (1981); Granger & Weiss (1983); Granger & Engle (1985) and Engle & Granger (1987). Even so, the connection with error correction models has been investigated by a number of authors considering studies of Davidson (1986); and Stock (1987). The foundation of cointegrating vectors using regression analysis was brought to light by Engle & Granger (1987) while cointegration estimates were investigated by Stock (1987); Phillips (1985); Phillips & Durlauf (1986); Phillips & Park (1986); Phillip & Ouilaris (1986); and Stock & Watson (1987). For the Johansen cointegration test, consider vector m of X_t of $I(1)$ variables. If cointegration exists, then there should surface $r(0 \leq r \leq m)$ linear combinations of such variables that are stationary following Mallory & Lence (2012). Vector X_t with cointegrating rank $r(0 \le r \le m)$ can now be represented by the VECM:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + e_t.$$

The Johansen cointegration technique will be used to test cointegration relations between i_t and π_t^e. If Π is allowed to be $m \times m$ matrices denoting long run impacts, Γ will be $m \times m$ lag parameter matrices while e_t an m-vector of residuals. By implication, if there is cointegration between i_t and π_t^e, Π will then be expressed as $\Pi = \alpha\beta^T$. Then α will be matrix $m \times r$ corresponding to the response of adjustment coefficients to the long run relationships. Following Johansen (1988) and Mallory & Lence (2012), there will be r cointegrating relationships among the variables X_t if $r\ (0 \le r \le m)$ whereas there will be no cointegration between i_t and π_t^e if $r = 0$. The trace test statistic for the null hypothesis that there are at most r cointegrating vectors is computed as $-T \sum_{i=r+1}^{m} ln\left(1 - \lambda_i^{'}\right)$ where T will represent the number of dates in the sample (Mallory & Lence, 2012). The maximum eigenvalue tests statistic will be used to test the null hypothesis that there are r cointegrating vectors against the alternative $r + 1$ vectors and will be represented as $-Tln\left(1 - \lambda_{r+1}^{'}\right)$.

Saikkonen & Lütkepohl Approach

Previous studies generally applied the Johansen cointegration procedure while overlooking other cointegration methods. Saikkonen & Lütkepohl (2000a, 2000b) considered an n-dimensional multiple time series of the form $y_t = \left(y_{1t},...,y_{nt}\right)'$. The VAR process for this series will then be:

$$y_t = v + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \qquad t = p+1, p+2, ...,$$

For the Saikkonen & Lütkepohl cointegration test, v is an unknown term and a fixed $n \times 1$ intercept vector. By implication, A_j will then be coefficient matrix $n \times n$ and ε_t an $n \times 1$ stochastic error term assumed to be a martingale difference with $E\left(\varepsilon_t \middle| \varepsilon_{s,} s < t\right) = 0$. The Saikkonen & Lütkepohl test commands the subtraction of y_{t-1} on both sides of the VAR process equation above. The resulting error correction model will then be:

$$\Delta\tilde{y}_t = v + \Pi\tilde{y}_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta\tilde{y}_{t-j} + \varepsilon_t \qquad t = p+1, p+2, ...,$$

The major difference between the Saikkonen & Lütkepohl test and the Johansen procedure is the estimation of the deterministic term first D_t and then subtracting it from the time series observations. This technique will then be used to test long run affiliations between i_t and π^e_t. The test validates if $H(r_0){:}rk(\Pi) = r_0$ and $\Pi = -(I_n - A_1 - \cdots - A_p)$ while $\Gamma_j = (A_{j+1} + \cdots + A_p)$ $(j = 1,\ldots,p - 1)$.

EMPIRICAL RESULTS

The Fisher proposition is that nominal interest rates trend positively with inflation. This study examines 20 countries for cointegration relations between nominal interest rates and inflation for the period 1982-2013. The Saikkonen & Lütkepohl cointegration test was carried out at 90%, 95% and 99% critical levels conducted by first estimating the deterministic term D_t and then subtracting it from the series observations for all the countries under examination. The ρ-values registered were less than the critical levels of 90%, 95% and 99% thus revealing a statistically significant positive relationship between nominal interest rates and inflation for the period 1982-2013. Only Switzerland registered one cointegration equation while all the countries affirmed the Fisher effect over the material period. Table 5 shows results of the Saikkonen & Lütkepohl cointegration test.

Table 5: Results of the Saikkonen & Lütkepohl Cointegration Test

Country	r_0	LR	90%	95%	99%	ρ-value	r_0	LR	90%	95%	99%	ρ-value
Bangladesh	0	9.6700	13.880	15.760	19.710	(0.36950)[1,2,3]	1	3.590	5.470	6.790	9.730	(0.25890)[1,2,3]
Bhutan	0	13.520	13.880	15.760	19.710	(0.11320)[1,2,3]	1	2.180	5.470	6.790	9.730	(0.49710)[1,2,3]
Bolivia	0	30.740	13.880	15.760	19.710	(0.00010)[1,2,3]	1	1.920	5.470	6.790	9.730	(0.55710)[1,2,3]
Australia	0	13.420	13.880	15.760	19.710	(0.01170)[1,2,3]	1	3.480	5.470	6.790	9.730	(0.27330)[1,2,3]
Botswana	0	9.8000	13.880	15.760	19.710	(0.35710)[1,2,3]	1	5.210	5.470	6.790	9.730	(0.11480)[1,2,3]
Canada	0	19.040	13.880	15.760	19.710	(0.01330)[1,2,3]	1	3.170	5.470	6.790	9.730	(0.31710)[1,2,3]
Switzerland	0	15.810	13.880	15.760	19.710	(0.04900)[1,2,3]	1	0.110	5.470	6.790	9.730	(0.99270)
Chile	0	4.1600	13.880	15.760	19.710	(0.93140)[2,3]	1	2.490	5.470	6.790	9.730	(0.43340)[1,2,3]
China	0	10.600	13.880	15.760	19.710	(0.28650)[1,2,3]	1	3.850	5.470	6.790	9.730	(0.22820)[1,2,3]
Carbo V.	0	18.410	13.880	15.760	19.710	(0.07930)[1,2,3]	1	2.190	5.470	6.790	9.730	(0.49610)[1,2,3]
Costa Rica	0	11.200	13.880	15.760	19.710	(0.24050)[1,2,3]	1	6.830	5.470	6.790	9.730	(0.04870)[1,2,3]
Dominica	0	18.400	13.880	15.760	19.710	(0.01740)[1,2,3]	1	0.890	5.470	6.790	9.730	(0.82230)[1,2,3]
UK	0	16.100	13.880	15.760	19.710	(0.04380)[1,2,3]	1	2.970	5.470	6.790	9.730	(0.34760)[1,2,3]
Japan	0	12.250	13.880	15.760	19.710	(0.17340)[1,2,3]	1	5.910	5.470	6.790	9.730	(0.07970)[1,2,3]
Kenya	0	13.940	13.880	15.760	19.710	(0.09790)[1,2,3]	1	1.380	5.470	6.790	9.730	(0.68990)[1,2,3]
Lesotho	0	24.600	13.880	15.760	19.710	(0.00110)[1,2,3]	1	1.980	5.470	6.790	9.730	(0.54280)[1,2,3]
Nigeria	0	20.960	13.880	15.760	19.710	(0.00570)[1,2,3]	1	2.860	5.470	6.790	9.730	(0.36620)[1,2,3]
SA	0	12.860	13.880	15.760	19.710	(0.14190)[1,2,3]	1	2.900	5.470	6.790	9.730	(0.36050)[1,2,3]
USA	0	11.990	13.880	15.760	19.710	(0.18550)[1,2,3]	1	1.040	5.470	6.790	9.730	(0.78050)[1,2,3]
Singapore	0	12.570	13.880	15.760	19.710	(0.15620)[1,2,3]	1	1.500	5.470	6.790	9.730	(0.65920)[1,2,3]

*(a)[1,2,3] shows statistical significance at 90%, 95% and 99% critical levels

In extension to the Saikkonen and Lütkepohl test, the Johansen cointegration test also carried out. The trace test affirmed cointegration between nominal interest rates and inflation for Singapore, Nigeria, Lesotho Kenya, Japan, Costa Rica, China, Canada, Botswana, Bolivia, Dominica, Carbo Verde, and Bangladesh. The maximum eigenvalue test also confirmed cointegration for the aforementioned countries each registering cointegration at a critical level of 5%. Only the US, South Africa, UK, Switzerland, Australia, and Bhutan rejected the Fisher parity. Table 6 shows results of the Johansen cointegration test.

Table 6: Results of The Johansen Cointegration Test

Country	r_0	Eigenv.	Tr. St	5%	ρ-value	r_0	Eigenv.	MES	5%	ρ-value
	TRACE TEST					MAXIMUM EIGENVALUE TEST				
Singapore	0	0.3100	20.9130	15.494	(0.00069)[1]	0	0.3100	11.1400	14.264	(0.14730)
	1	0.2780	9.7720	3.8410	(0.00180)[1]	1	0.2780	9.77200	3.8410	(0.00180)[1]
US	0	0.2380	11.2660	15.494	(0.19560)	0	0.2380	8.1820	14.264	(0.36050)
	1	0.0970	3.0840	3.8410	(0.07910)	1	0.0970	3.0840	3.8410	(0.07910)
South Africa	0	0.2410	9.5350	15.494	(0.31820)	0	0.2410	9.5350	14.264	(0.35160)
	1	0.0410	1.2620	3.8410	(0.26120)	1	0.0410	1.2620	3.8410	(0.26120)
Nigeria	0	0.4020	23.510	15.494	(0.00250)[1]	0	0.4020	15.438	14.264	(0.03250)[1]
	1	0.2360	8.0760	3.8410	(0.00450)[1]	1	0.2360	8.0760	3.8410	(0.00450)[1]
Lesotho	0	0.2370	13.6110	15.494	(0.09420)	0	0.2370	8.1390	14.264	(0.36470)
	1	0.1660	5.4720	3.8410	(0.01930)[1]	1	0.1660	5.4720	3.8410	(0.01930)[1]
Kenya	0	0.3750	16.1220	15.494	(0.04020)[1]	0	0.3750	14.110	14.264	(0.05280)[1]
	1	0.0640	2.0110	3.8410	(0.15160)	1	0.0640	2.0110	3.8410	(0.15160)
Japan	0	0.4180	19.0810	15.494	(0.01380)[1]	0	0.4180	16.244	14.264	(0.02400)[1]
	1	0.0090	2.8360	3.8410	(0.09210)	1	0.0900	2.8360	3.8410	(0.09210)
UK	0	0.2120	7.8290	15.494	(0.48380)	0	0.2120	7.1480	14.264	(0.47170)
	1	0.0220	0.6680	3.8410	(0.40940)	1	0.0220	0.6800	3.8410	(0.40940)
Costa Rica	0	0.7510	45.9930	15.494	(0.00000)[1]	0	0.7510	41.809	14.264	(0.00000)[1]
	1	0.1300	4.1840	3.8410	(0.04080)[1]	1	0.1300	4.1840	3.8410	(0.00400)[1]
China	0	0.5690	27.8440	15.494	(0.00040)[1]	0	0.5690	25.281	14.264	(0.00060)[1]
	1	0.0820	2.5670	3.8410	(0.10910)	1	0.0820	2.5677	3.8410	(0.10910)
Chile	0	0.2820	11.3170	15.494	(0.19270)	0	0.2820	9.9530	14.264	(0.21500)
	1	0.0440	1.3640	3.8410	(0.24280)	1	0.0400	1.3640	3.8410	(0.24280)
Switzerland	0	0.3200	14.2170	15.494	(0.07720)	0	0.3200	11.582	14.264	(0.12740)
	1	0.0080	2.6350	3.8410	(0.10450)	1	0.0080	2.6350	3.8410	(0.10450)
Canada	0	0.4590	20.6170	15.494	(0.00770)[1]	0	0.4590	18.843	14.264	(0.01030)[1]
	1	0.0070	2.18440	3.8410	(0.13940)	1	0.0700	2.1844	3.8410	(0.13940)
Botswana	0	0.3980	17.667	15.494	(0.02320)[1]	0	0.3980	15.252	14.264	(0.03470)[1]
	1	0.0770	2.4080	3.8410	(0.12070)	1	0.0770	2.4010	3.8410	(0.12070)
Australia	0	0.3160	14.152	15.494	(0.07880)	0	0.3160	11.4110	14.264	(0.13480)
	1	0.6080	2.7410	3.8410	(0.00978)	1	0.0873	2.7410	3.8410	(0.09780)
Bolivia	0	0.8230	60.834	15.494	(0.00000)[1]	0	0.8230	52.021	14.264	(0.00000)[1]
	1	0.2540	8.8130	3.8410	(0.00030)[1]	1	0.2540	8.8130	3.8410	(0.00300)[1]
Bhutan	0	0.3390	14.161	15.494	(0.06760)	0	0.3390	12.450	14.264	(0.09460)
	1	0.0690	2.1560	3.8410	(0.14200)	1	0.0690	2.1560	3.8410	(0.14200)
Dominica	0	0.4000	17.659	15.494	(0.02320)[1]	0	0.4000	15.352	14.264	(0.03550)[1]
	1	0.0070	2.3000	3.8410	(0.12890)	1	0.0739	2.2060	3.8410	(0.12890)
Carbo Verde	0	0.4530	27.274	15.494	(0.00060)[1]	0	0.4530	18.108	14.264	(0.01180)[1]
	1	0.2630	9.1660	3.8410	(0.00250)[1]	1	0.2630	9.1664	3.8410	(0.00250)[1]
Bangladesh	0	0.2620	60.834	15.494	(0.02620)[1]	0	0.2620	9.1300	14.264	(0.27540)
	1	0.2540	8.8130	3.8410	(0.00420)[1]	1	0.2390	8.2020	3.8410	(0.00420)[1]

(a)[1] shows statistical significance at 5% critical level

DISCUSSION AND CONCLUSION

The Fisher effect posits that nominal inters rates are predictors of inflation. Even though the hypothesis has been found to hold theoretically, empirically there have been incongruences over the Fisher effect relation. An analysis of previous studies has shown that the Johansen cointegration procedure has been the most applied technique in the analysis of cointegrating vectors. In general, the literature does not apply other techniques numerous times such as the Gregory-Hansen or the Saikkonen and Lütkepohl cointegration methods. This study has validated the presence of the Fisher effect using the Saikkonen & Lütkepohl cointegration test. The major difference between the Johansen and the Saikkonen & Lütkepohl cointegration methods is that under the technique suggested by Saikkonen & Lütkepohl (2000), the estimation of the deterministic term is carried out first and then subtracted from the series observation.

The results of this study have shown that under the Saikkonen & Lütkepohl cointegration technique, the Fisher effect holds for all the counties under examination over the material period 1982-2013. The Johansen cointegration procedure also affirmed cointegration between nominal interest rates and inflation for numerous countries namely: Nigeria, Lesotho, Kenya, Japan, Costa Rica, China, Canada, Botswana, Bolivia, Carbo Verde, and Bangladesh. The results of this study are consistent with Tsong & Lee (2013). The study used quantile cointegration methodology recently proposed by Xiao (2009) and reveled that nominal interest rates and inflation moved together in the long run for selected OECD economies. Previous studies have also supported that existence of the long run Fisher effect (Evans & Lewis, 1995; Crowder & Hoffman, 1996; Atkins & Coe, 2002; Fahmy & Kandil, 2003).

Even though theoretically it is justified to anticipate nominal interest rates to move with inflation, the Fisher effect is only a tip of the iceberg. Tsong & Lee (2013) for instance revealed that the Fisher effect is also affected by factors such as marginal productivity of capital and time preference. Drawing from Hawtrey (1997), financial deregulation also plays a significant role in the magnitude of the Fisher effect. Hawtrey (1997) noted that the Fisher effect failed to surface in Australia prior to financial deregulation of the 1980's however, there is evidence of the Fisher parity following the liberalization of the financial system. In conclusion, this study has affirmed the Fisher effect using the Saikkonen & Lütkepohl approach of cointegrating vectors. The results of his study are conceivable drawing from the extant literature. It is concluded that nominal interest rates and inflation trend together in the long run. Short term interest rates are likely to have an insignificant impact on inflation.

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