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The Fisher Hypothesis within the Framework of Long-Run Covariability: The Case of the United Kingdom

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Uzun Dönemli Ortak Değişkenlik Çerçevesinde Fisher Hipotezi: İngiltere Örneği

Abstract

This paper aims to present the long-run covariability between inflation and the interest rate of the United Kingdom by using a new method developed by Müller and Watson (2018) that eliminates the low-frequency problems. In this study, the validity of the Fisher hypothesis is investigated under structural break periods for the UK's economy. The analysis is carried out with monthly inflation and interest rate for six periods: Full sample (1920:1-2019:12), interwar years (1920:1-1939:8), fixed exchange rate (1952:1-1973:2), Post War II (1952:1-1992:9) and two different inflation targeting periods (1992:10-2008:8 and 1992:10-2019:12). The empirical finding suggests that the Fisher hypothesis holds for the United Kingdom in the long-run.

Keywords : Fisher Hypothesis, Long-Run Covariability, United Kingdom.

JEL Classification Codes : C22, E31, E47.

Öz

Bu çalışmanın amacı, literatürde Müller ve Watson (2018) tarafından geliştirilen ve düşük frekanslı serilerin tahmin problemine çözüm getiren yeni bir yöntem olan uzun dönemli ortak değişkenlik ile İngiltere'nin enflasyon ve faiz oranı arasındaki ilişkiyi ortaya koymaktır. Bu çalışmada, İngiltere ekonomisi için kritik dönemler ele alınarak Fisher hipotezinin geçerliliği araştırılmış ve aylık enflasyon ve faiz oranı ilişkisi tüm dönem (1920:1-2019:12), savaş yılları arası dönem (1920:1-1939:8), sabit kur yılları (1952:1-1973:2), II. Dünya Savaşı sonrası dönem (1952:1-1992:9), birinci ve ikinci enflasyon hedeflemesi (1992:10-2008:8 ve 1992:10-2019:12) olmak üzere altı farklı döneme ayrılarak incelenmiştir. Fisher hipotezinin İngiltere için uzun dönemde geçerli olduğu sonucuna ulaşılmıştır.

Anahtar Sözcükler : Fisher Hipotezi, Uzun Dönemli Ortak Değişkenlik, İngiltere.

1. Introduction

Fisher (1930) suggests that nominal interest rates have a movement one-for-one with expected inflation. The real interest rates level has important implications for macroeconomic and financial models and politics (Caporale & Grier, 2000: 320). After Fisher's hypothesis, the co-movement of inflation and nominal interest rate has been studied extensively by different periods, countries, and time series techniques. After Fama's (1975) controversial finding in the literature that real interest rates are constant, Mishkin (1981) found evidence to the contrary. Mishkin (1992) investigated that while the Fisher effect, also known as the Fisher hypothesis, is valid in particular periods but not in others, he determined that the inflation-interest relationship changed according to the length of the periods, the short and the long-term. Therefore, potential nonstationarities of interest rate and inflation have important implications for determining the Fisher effect. Some studies use traditional techniques like unit root or cointegration tests (Huizinga & Mishkin, 1986; Bonser-Neal, 1990; Mishkin, 1992; Rose, 1998; Koustas & Serletis, 1999). On the other hand, Perron (1990), Garcia and Perron (1996), Bai and Perron (1998 and 2003), Atkins (2002), and Clemente et al. (2017) consider that neglecting the existence of structural breaks in the series, unit root or cointegration results are not valid.

In this paper, it is used the method developed by Müller and Watson (2018) (hereinafter referred to as MW) to examine the effect of inflation targeting or regime change in determining the Fisher effect for the United Kingdom (UK). MW method has the advantage of providing us with more robust confidence intervals for long-run variability and covariability in different orders of integration that do not need the stationarity assumption.

Low-frequency of the long-horizon data is often a problem for economic research, especially in asymptotic approximations (Müller and Watson, 2008), because there may not be many long-run observations. After that, Müller and Watson develop the method that uses time series estimates for low-frequency problems as a robust tool. The method is based on again band spectrum regression developed by Engle (1974). MW method captures the long-run variability between the two variables with a small amount of low-frequency data (Tokatlioglu, 2021: 267). Moreover, this method relies on low-frequency transformations to isolate the economic shock and variation in the series by using more than ten years of subsamples. MW has solved the inference problems that are inadequate for sample inference and related to long-run data persistence. Even a small sample can be informative by focusing on only a few low-frequency data.

The main contribution of this study to the literature is that it is the first study to investigate the validity of the Fisher hypothesis for the UK using Müller and Watson's (2018) method. In the framework of literature investigating whether the Fisher effect is valid in the UK, analysis is performed in the full sample and sub-samples. While the full sample covers the period between 1920:1-2019:12, the sub-sample includes interwar years (1920:1-1939:8), fixed exchange rate (1952:1-1973:2), Post War II (1952:1-1992:9) and two different inflation targeting periods (1992:10-2008:8 and 1992:10-2019:12), so this allows to assess the existence of the Fisher effect for structural and regime changes. Section 2 is the related literature, and Section 3 introduces the MW method used to test the Fisher hypothesis for the UK. The empirical results are presented in Section 4; the conclusion is in the last section.

2. Literature Review

Economic policymakers of countries must understand the reasons for the change in interest rates and the effect of these changes on other macroeconomic variables. The Fisher hypothesis has frequently been the subject of studies and has vast literature. Many studies argue whether the Fisher hypothesis is valid for different periods of different countries, but there needs to be more consensus about the Fisher effect. Mishkin (1992) revealed the presence of a long-term Fisher effect in specific periods examined, while its existence is absent in others, and concluded that the Fisher effect existed in the United States in the long-run but not in the short run. In his study, Mishkin (1992) proved that the relation of the inflation-interest rates is strong in the long-run, but these series do not trend together in the short run, and there is no short-run Fisher effect. Boudoukh and Richardson (1993) indicate that the expectation of the Fisher model is valid at all horizon lengths in the United States and the United Kingdom. Wong and Wu (2003) provided evidence to support Boudoukh and Richardson's study for G7 and eight Asian countries. Yuhn (1996) indicated that the Fisher hypothesis is valid only for particular periods, not all. Also, Yuhn found that the Fisher hypothesis is valid United States, Germany, Japan, the United Kingdom, and Canada in the long-run; but the Fisher effect is only observed in Germany in the short run. Some studies also show that the Fisher hypothesis is invalid for short-horizon lengths and that the relationship between the variables is negative (Fama, 1975; Nelson, 1976; Fama & Schwert, 1977).

Some studies have considered the monetary policy regimes and time-variation in inflation (Cogley & Sargent, 2002 and 2005; Benati, 2004; Levin & Piger, 2004; Groen et al., 2013; Cogley et al., 2015; Berument & Froyen, 2021). Benati (2004) used band-pass filtering for the UK and indicated economic stability in the inflation-targeting period (in October 1992) compared to the post-war period. Also, he found that inflation volatility is lower than in Bretton Woods and over the 1971-92 period, compared to the post-1992 period. Granville and Mallick (2004) found evidence favouring the Fisher effect for the UK. They used to long-run data from 1900 to 2000 and employed Johansen cointegration tests. Toyoshima and Hamori (2011) employed panel cointegration tests for the United States, the United Kingdom, and Japan. They found that the Fisher effect holds for the 1990-2010 period. Cogley et al. (2015) found evidence that there was not much volatility in price levels before World War I and peaked in 1976 for the UK. Also, they classified the structural break periods for the UK's economy as silver and gold standard, Bretton Woods, money and exchange-rate targeting, and inflation targeting. A recent study by Berument and Froyen (2021) studied the Fisher effect for different regimes in the United Kingdom, and they concluded that structural changes are essential to the validity of the Fisher hypothesis. The sub-sample periods in this study are chosen based on Benati's (2004), Cogley et al. (2015), and Berument and Froyen's (2021) study.

MW method is used in other fields as well: Real interest rates (Lunsford, 2017; Lunsford & West, 2019); real stock and nominal bond yields (Gozluklu & Morin, 2019); energy sector (Atil et al., 2020; Shahbaz et al., 2023), long-run purchasing power parity (Papell & Prodan, 2020); loan-to-value ratios (Jensen et al., 2020); real exchange rates and economic fundamentals (Grisse & Scheidegger, 2021); measuring the relationships among long-run trend-cycle (Kunitomo & Sato, 2021); relationship between total factor productivity and the relative investment price (Moura, 2021); long-run correlation of inflation with money growth and nominal interest rates (West & Cao, 2022); and comparison with other methods (Chen et al., 2022; Yamada, 2020 and 2022).

3. Methodological Framework

The methodological part of this study relies on the MW method. The authors utilised the cosine functions for the long-run covariability model for two-time series, and in the application, they used a variety of series of US economic data. Also, they give asymptotic approximations in the paper.

Let $x_t, t = 1, ..., T$ denotes the time series, and the MW method uses cosine functions. By using low-pass transformations of x_t, low-frequency projections are obtained. The cosine functions are represented by:

$$\Psi_j(s) = \sqrt{2}\, cos(js\pi) \qquad j = 1, 2, ..., q \tag{1}$$

with period $2/j$ where j denotes the period of the cosine wave. $\Psi(s) = [\Psi_1(s), \Psi_2(s), ..., \Psi_q(s)]'$ denote the vector of functions. The $\Psi(.)$ function is obtained by evaluating $s = (t - 1/2)/T$. Ψ_T symbolizes the $T\ X\ q$ matrix with the t^{th} row specified by $\Psi((t - 1/2)\ /\ T)'$. The projection of x_t is $\widehat{x_t} = X_T'\ \Psi\left((1 - \frac{1}{2})/\ T\right)$. The rearranged values from these projections are denoted by $(\hat{x}_t, \hat{y}_t)$, and y is the variable to be examined the covariability with x. X_T denotes the projection coefficients of linear regression. $X_T = (\Psi_T'\Psi_T)^{-1}\Psi_T' x_{1:T}$ and $x_{1:T}$ is the $T\ X\ 1$ vector with the t^{th} part given by $x_t.\bar{x}_{1:T}$ denote the sample mean and $T^{-1}\Psi_T'\Psi_T = I_q$, so X_T is the cosine transform of x_t and calculated as $X_T = T^{-1}\Psi_T' x_{1:T}$

Ψ_T is the cosine regressor, and it presents the long-run projections of variability and covariability $(\hat{x}_t, \hat{y}_t)$; the long-run covariability can be estimated using long-run projections. Cosine transforms (X_{jT}, Y_{jT}) as follows:

$$T^{-1} \sum_{t=1}^{T} \binom{\hat{x}_t}{\hat{y}_t} (\hat{x}_t\ \hat{y}_t) = T^{-1} \binom{X_T'}{Y_T'} \Psi_T'\Psi_T\ (X_T\ Y_T) = \begin{pmatrix} X_T'\, X_T & X_T'\, Y_T \\ Y_T'\, X_T & Y_T'\, Y_T \end{pmatrix} \tag{2}$$

The long-run covariability is based on the second moment matrices in Eq. (2). Ω_T is the $2X2$ covariance matrix, yielding long-run projections of variability and covariability of subsamples.

$$\Omega_T = T^{-1} \sum_{t=1}^{T} E\left[\begin{pmatrix}\hat{x}_t\\ \hat{y}_t\end{pmatrix}(\hat{x}_t \; \hat{y}_t)\right] = \sum_{j=1}^{q} E\left[\begin{pmatrix}X_{jT} & X_{jT}\\ Y_{jT} & Y_{jT}\end{pmatrix}'\right] = \begin{pmatrix}tr\,(\Sigma_{XX,T}) & tr\,(\Sigma_{XY,T})\\ tr\,(\Sigma_{YX,T}) & tr\,(\Sigma_{YY,T})\end{pmatrix} \quad (3)$$

$\Sigma_{XX,T}, \Sigma_{XY,T}, \Sigma_{YX,T}, \Sigma_{YY,T}$ denote the covariance matrix of $(X_T', Y_T')'$. The formulations of the long-run correlation and regression coefficient of the linear regression are as follows:

$$\rho_T = \frac{\Omega_{xy,T}}{\sqrt{\Omega_{xx,T}\,\Omega_{yy,T}}}, \beta_T = \frac{\Omega_{xy,T}}{\Omega_{xx,T}}, \sigma^2_{y|x,T} = \frac{\Omega_{yy,T} - (\Omega_{xy,T})^2}{\Omega_{xx,T}} \quad (4)$$

β_T can obtain by solving the least-square problem as follows:

$$\beta_T = \underset{b}{\text{argmin}}\, E[T^{-1} \sum_{t=1}^{T} (\hat{y}_t - b\hat{x}_t)^2] = \underset{b}{\text{argmin}}\, E\left[\sum_{j=1}^{q} (Y_{jT} - bX_{jT})^2\right] \quad (5)$$

β_T denotes the coefficient of the linear regression, $\sigma^2_{y|x,T}$ denotes the variance of the error, and ρ_T^2 denotes the determination coefficient, and they are the long-run parameters. These parameters are the core of this method and depend on the periods (q) defined as long-run projections.

4. Data and Empirical Results

The purpose of this paper is to investigate whether the Fisher hypothesis is valid or not for the UK. A long-run covariability model is established between monthly inflation (CPI) (yearly percentage change) and monthly interest rate (INR). Data were collected from the Federal Reserve Bank of St. Louis, Bank of England, UK Office for National Statistics, National Bureau of Economic Research and Statistical Abstract of the United Kingdom[1]. Data consists of monthly observations from 1920:1 to 2019:12. To provide evidence of structural and regime changes, estimations are reported over the full sample (1920:1-2019:12) and for six sub-samples: interwar years (1920:1-1939:8), fixed exchange rate years (1952:1-1973:2), Post War II (1952:1-1992:9) and two inflation targeting periods (1992:10-2008:8 and 1992:10-2019:12).

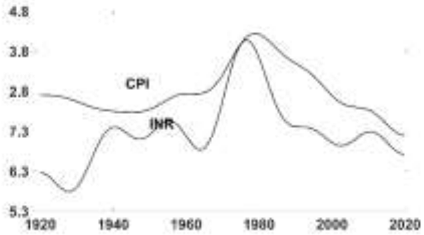
Figure 1 shows the long-run inflation and interest rate projections over 11 years. As mentioned, projection coefficients are calculated using cosine functions on low-frequency periodic functions[2]. Figure 1 presents that there is no significant long-run covariability over the interwar years (panel (b)), fixed exchange rate years (panel (c)), Post War II period (panel (d)), and two inflation targeting periods (panel (e) and panel (f)). Compared to the other

[1] *Different data sources were used to access the series's historical data, and the data's consistency was checked.*

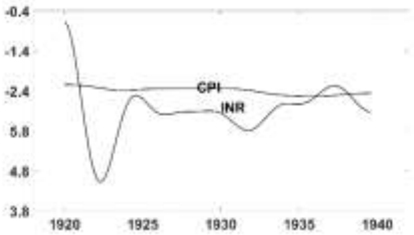
[2] *The number of 11 years subsamples in these six different periods naturally differ depending on the length of each period.*

periods, as seen from panel (a), there is a long-run covariability for inflation and interest rate in the full sample.

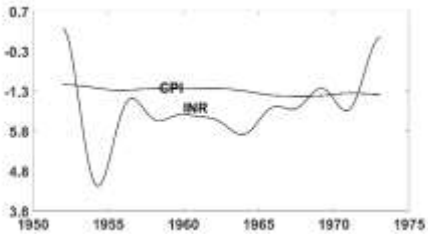
Figure: 1
Long-run Correlations for Interest Rate and CPI for Different Periods



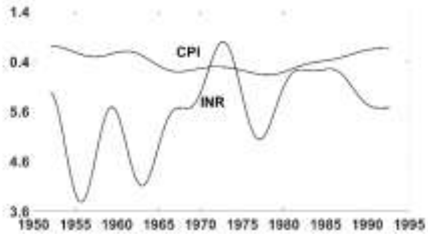
(a) 1920:1-2019:12



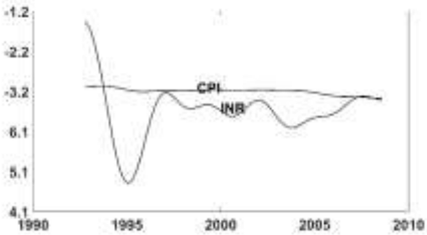
(b) 1920:1-1939:8



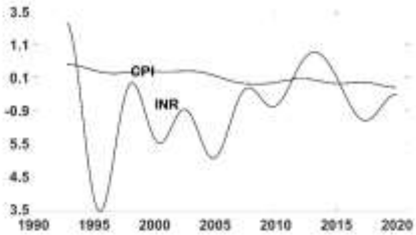
(c) 1952:1-1973:2



(d) 1952:1-1992:9



(e) 1992:10-2008:8



(f) 1992:10-2019:12

** CPI and INR donate the inflation and interest rate, respectively.*

Table: 1
Long-Run Covariation of Interest Rate and CPI: Periods Longer Than 11 Years

	Period	$\hat{\rho}$	%67	%90	$\hat{\beta}$	%67	%90	$\hat{\sigma}_{y,x}$	%67	%90
Full	1920:1-2019:12	0.42	(0.27,0.75)	(-0.05,0.85)	0.34	(0.20,0.71)	(-0.02,0.84)	2.34	(1.95,3.64)	(1.73,4.13)
Interwar	1920:1-1939:8	-0.59	(-0.88,-0.08)	(-0.96,0.28)	-0.28	(-0.47,-0.02)	(-0.72,0.22)	0.54	(0.33,1.05)	(0.26,1.97)
Fixed ER	1952:1-1973:2	-0.35	(-0.80,0.12)	(-0.93,0.48)	-0.10	(-0.23,0.07)	(-0.42,0.24)	0.74	(0.46,1.41)	(0.36,2.65)
Post War	1952:1-1992:9	-0.27	(-0.70,0.05)	(-0.85,0.40)	-0.08	(-0.26,0.02)	(-0.37,0.14)	0.83	(0.61,1.42)	(0.53,1.89)
1st IT*	1992:10-2008:8	-0.50	(-0.88,0.06)	(-0.97,0.50)	-0.79	(-1.75,0.13)	(-4.35,2.63)	0.71	(0.34,2.18)	(0.25,7.68)
2nd IT	1992:10-2019:12	-0.30	(-0.80,0.10)	(-0.93,0.44)	-0.11	(-0.24,0.04)	(-0,39,0.14)	0.72	(0.49,1.16)	(0.37,1.86)

** IT denotes the inflation targeting periods.*

Table 1 reports the estimation of long-run correlation coefficients ($\hat{\rho}$) between interest rate and inflation, long-run regression parameters ($\hat{\beta}$) of interest rate onto inflation, standard deviations of residuals ($\hat{\sigma}_{y,x}$), and their 67%[3] and 90% confidence intervals[4]. It is clear from the table the estimated long-run Fisher effect correlation coefficients and regression parameters are negative at all sub-samples while positive at the full sample. However, all long-run correlation coefficients and regression parameters contain zero in the 90% confidence interval. Statistical significance at the %67 confidence interval is measured in only the full sample and the interwar years. Monthly inflation and interest rate are positively correlated in the long-run ($\hat{\rho}$=0.42 and 67% confidence interval: 0.27 ~ 0.75) long-run slope coefficient is 0.34 (67% confidence interval: 0.20 ~ 0.71). A positive slope suggests a bias or volatility in interest rates during high inflation.

Note that the correlation and regression coefficients of interwar years are not involved zero in the %67 confidence interval, as observed in the full sample, but the coefficients are negative. For interwar years, the long-run regression parameter of interest rate on inflation is estimated at -0.28 (with a 67% confidence interval: -0.47 ~ -0.02). The estimated long-run correlation between inflation and interest rate is -0.59 (67% confidence interval: -0.88 ~ -0.08). Among all these periods, interest rate and inflation are more highly correlated in interwar years.

67% and 90% confidence intervals are wide for statistical significance for fixed exchange rate years, Post War II, and two inflation targeting periods. There is a much weaker relation between inflation and interest rate in the second inflation targeting period ($\hat{\rho}$=-0.30, $\hat{\beta}$=-0.11) than in the first inflation targeting period ($\hat{\rho}$=-0.50, $\hat{\beta}$=-0.79). For fixed exchange rate years, the long-run correlation between inflation and interest rate is -0.35, and the long-run regression coefficient of interest rate on inflation is -0.10. In the Post War II period, the estimated long-run correlation and regression coefficient were -0.27 and -0.08, respectively.

Table: 2
Long-Run Covariation of Interest Rate and CPI: Periods Longer Than 20 Years

		$\boldsymbol{\rho}$			$\boldsymbol{\beta}$			
	Period	$\hat{\boldsymbol{\rho}}$	**%67**	**%90**	$\hat{\boldsymbol{\beta}}$	**%67**	**%90**	$\hat{\boldsymbol{\sigma}}_{y,x}$
Full	1920:1-2019:12	0.53	(0.27, 0.80)	(-0.15,0.92)	0.45	(0.25, 0.86)	(-0.04,1.1)	2.5
Interwar	1920:1-1939:8	-0.53	(-0.89, 0.04)	(-0.98,0.49)	-0.32	(-0.68, 0.05)	(-1.58,0.96)	0.74
Fixed ER	1952:1-1973:2	-0.43	(-0.84, 0.13)	(-0.96,0.54)	-0.15	(-0.37, 0.08)	(-0.92,0.66)	0.88
Post War	1952:1-1992:9	-0.36	(-0.70, 0.05)	(-0.85,0.45)	-0.18	(-0.42, 0.03)	(-0.68,0.29)	0.95
1st IT	1992:10-2008:8	-0.50	(-0.88, 0.06)	(-0.97,0.50)	-0.79	(-1.75, 0.13)	(-4.35,2.63)	0.71
2nd IT	1992:10-2019:12	-0.88	(-0.99,-0.33)	(-0.99,0.21)	-0.34	(-0.45,-0.22)	(-0.79,0.12)	0.26

** IT denotes the inflation targeting periods.*

3 *Following Müller and Watson's (2018) study, we also included 67% confidence intervals in the results. By using 67% confidence intervals, we decrease the beta of the test failing to reject H_0 even though it is not right, so we strictly penalize accepting the Fisher hypothesis when it does not hold.*

4 *Matlab codes are obtained from Mark W. Watson's website: <http://www.princeton.edu/~mwatson/publi.html>, 23.08.2022.*

Table 2 reports similar results to Table 1 but uses periods longer than 20 years[5]. The full sample long-run correlation coefficient and long-run regression parameter are statistically significant at the 67% confidence interval, but the 90% confidence interval is wide. The estimated long-run regression coefficient for the full sample is 0.45 (67% confidence interval: 0.25 ~ 0.86). Moreover, the interest rate positively correlates with inflation and is estimated at 0.53 (67% confidence interval: 0.27 ~ 0.80). Only the second inflation targeting period is statistically significant at the 67% confidence interval. Interest rate and inflation are negative and highly correlated ($\hat{\rho}$=-0.88) over the long-run in this period (67% confidence interval: -0.99 ~ -0.33). The long-run regression parameter of interest rate on inflation is estimated at -0.34 (67% confidence interval: -0.45 ~ -0.22). A positive regression coefficient means volatility in interest rates during periods of high inflation or vice versa.

Regression parameters of interest rate onto inflation and the correlation coefficient between them are negative but statistically insignificant in the interwar years, fixed exchange rate years, Post War II period, and the first inflation targeting period. The %67 confidence interval involves zero in these periods, but the upper bounds of the 67% confidence interval are close to zero.

Estimated long-run correlation coefficients and long-run regression parameters suggest that the Fisher hypothesis is valid in the UK in the long-run (1920:1-2019:1). However, during critical periods for the UK's economy considered, it is observed that the Fisher hypothesis is no longer valid and the relationship between interest rates and inflation is reversed.

5. Conclusion

This study concludes that the Fisher hypothesis is valid in the UK in the long-run (1920:1-2019:1) by applying Müller and Watson's (2018) methodology. The long-run correlation coefficients between interest rates and inflation and the long-run regression parameters of interest rates onto inflation are both positive and statistically significant within a 67% confidence interval. These findings hold for periods longer than 11 and 20 years for the full sample. However, in the short run, during the critical periods for the UK's economy, such as the interwar years, fixed exchange rate years, Post War II period, and two inflation targeting periods, it is observed that the Fisher hypothesis is no longer valid and the relationship between interest rates and inflation is reversed. The estimated correlation coefficients and regression parameters have become negative and statistically insignificant in the sub-samples.

The Fisher hypothesis has been comprehensively examined across different countries, techniques, and datasets. The early literature also highlights that the Fisher effect

[5] *For subsamples less than 20 years, the empirical results relied on longer than the maximum period that can be taken.*

is predominantly observed in the long-run, and there is evidence that it loses its validity during periods of regime and policy change (Fama, 1975; Nelson, 1976; Fama & Schwert, 1977; Mishkin, 1992; Yuhn, 1996). There is no consensus on this issue in the contemporary literature; while some studies support these (Granville and Mallick, 2004; Berument & Froyen, 2021) these findings, others do not support them (Wong & Wu, 2003; Toyoshima & Hamori, 2011). This study sheds light on the issue, frequently discussed in the literature and contains controversial findings, by analysing it with new methods rather than more traditional approaches. In addition, this study uses a comprehensive data set from 1920 to 2019 and, as a result, obtained findings that support the early literature.

In light of the findings, two main conclusions have been reached. First, the Fisher effect loses its validity in the event of policy and regime changes; second, there is evidence that the Fisher effect holds in the long-run for the United Kingdom. In future studies, Covid-19 can be a crucial period to figure out the Fisher effect for countries.

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