Economic Research-Ekonomska Istraživanja

ISSN: 1331-677X (Print) 1848-9664 (Online) Journal homepage: http://www.tandfonline.com/loi/rero20

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To cite this article: Burcu Ozcan & Ayse Ari (2015) Does the Fisher hypothesis hold for the G7? Evidence from the panel cointegration test, Economic Research-Ekonomska Istraživanja, 28:1, 271-283, DOI: 10.1080/1331677X.2015.1041777

To link to this article: http://dx.doi.org/10.1080/1331677X.2015.1041777

Economic Research-Ekonomska Istraživanja, 2015
Vol. 28, No. 1, 271–283, http://dx.doi.org/10.1080/1331677X.2015.1041777

Does the Fisher hypothesis hold for the G7? Evidence from the panel cointegration test

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(*Received 21 June 2013; accepted 6 February 2015*)

The aim of this study is to investigate the validity of the Fisher hypothesis by assessing the relationship between the nominal interest rate and the inflation rate. To this end, we analyse the G7 countries over the period January 2000 to November 2012 by employing the panel unit root and panel cointegration tests. The analysis reveals that the adjustment in nominal interest rates to changes in inflation is significantly lower than unity, which implies the existence of a partial Fisher effect.

Keywords: Fisher hypothesis; monetary policy; inflation rate; interest rate; panel unit root test; panel cointegration test

JEL classifications: E40, E43, E52

1. Introduction

Because it constitutes an important research area in macroeconomics, economists frequently use different methods to test the Fisher hypothesis. Fisher (1930) first described the relationship between the interest rate and the inflation rate as a one-for-one movement between the nominal interest rate and expected inflation. As such, the real interest rate, which establishes the nominal interest rate with expected inflation, is constant.

The co-movement of expected inflation and nominal interest rate is of crucial interest for central banks and investors. If the Fisher hypothesis does hold, the real interest rate must be independent of changes in inflation and monetary shocks at any given time. In other words, evidence in support of the Fisher hypothesis indicates the neutrality of monetary policy, i.e. the ineffectiveness of monetary policies. A constant interest rate also has important implications for investors in financial markets due to its effect on asset prices, savings, and investments; Fisher's hypothesis indicates that real interest rates on financial assets are affected only by the changes within the asset's respective sector (Ray, 2012). Thanks to this knowledge, borrowers can carry out productive investments, which in turn lead to economic growth and a strong banking sector (Ling, Venus, Wafa, & Wafa, 2008). Furthermore, the Fisher hypothesis implies that short-term interest rates can efficiently predict future inflation trends (Mishkin, 1992).

Motivated by interest in the above-mentioned topics, Fisher (1930) researched the full co-movement of the nominal interest rate and the expected inflation rate in the

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United States and the United Kingdom from 1890–1927. He found that long-term inflation and interest rates were correlated with a coefficient of 0.86 in the United States, whereas the coefficient was equal to 0.98 for the United Kingdom over the period 1820–1924 (Phylaktis & Blake, 1993).

Following Fisher, many researchers have examined the extent to which the nominal interest rate reflects changes in expected inflation using different methods in different countries. In this respect, early studies, such as those of Meiselman (1962) and Gibson (1970), used proxies to estimate expected inflation. After Fama (1975), Levi and Makin (1979) incorporated the rational expectation and efficient market hypothesis into the Fisher hypothesis; however, scholars have begun to employ time series analysis to investigate the validity of the Fisher hypothesis. Based on these developments, empirical interest to test for the Fisher hypothesis has increased over time, especially in the late 1980s. However, studies in the related literature obtained conflicting results due to differences in time periods and analysis methods.

These studies can be classified into two areas: time series analysis and panel data analysis. Researchers concentrating on the Fisher hypothesis's validity primarily applied time series analysis via cointegration approach. For instance, Evans and Lewis (1995) analysed the US economy by using quarterly data for the years 1974–1987 and found that the Fisher hypothesis does hold. In this line, Garcia (1993), Thornton (1996), Granville and Mallick (2004), and Gul and Acikalin (2007) are the other researchers who conducted time series studies in Brazil, Mexico, the United Kingdom, and Turkey, respectively and attained results as postulated by Fisher (1930). In contrast, Inder and Silvapulle (1993) observed results contrary to the Fisher hypothesis in an analysis of Australian data for the period 1964–1990. Kandel, Ofer, and Sarig (1996) also obtained results that support the non-neutrality of ex-ante real interest rates toward expected inflation. Another scholar, Peng (1995), analysed the Fisher hypothesis for France, Germany, Japan, the United Kingdom, and the United States by the cointegration test and obtained results in favour of the Fisher hypothesis only for the cases of France, the United Kingdom, and the United States during the period 1957–1994. Similarly, Yuhn (1996) examined the Fisher hypothesis for the United States, Germany, Japan, the United Kingdom, and Canada. The results supported the Fisher hypothesis for the United States, Germany, and Japan over the period 1974–1993. Additionally, in line with Yuhn's (1996) results, Dutt and Ghosh (1995) could not establish a one-to-one movement between Canada's interest rate and inflation rate during the period 1979–1993. Atkins and Coe (2002), however, used monthly data by employing the ARDL bounds testing approach to examine the Fisher hypothesis for the United States and Canada from 1953–1999 and obtained evidence that strongly favoured the validity of the Fisher hypothesis. Lardic and Mignon (2003) and Ghazali and Ramlee (2003) conducted studies that could be given as examples on G7 countries. Using the fractional cointegration test, Lardic and Mignon (2003) found that the Fisher hypothesis is valid for most of the G7 countries. In contrast, Ghazali and Ramlee (2003) tested for the presence of the Fisher hypothesis by employing an autoregressive, fractionally integrated, moving average method for G7 countries and obtained no evidence of the Fisher hypothesis.

The second research strand consists of panel data studies, although few such studies exist in the literature. Badillo, Reverte, and Rubio (2011), Toyoshima and Hamori (2011), and Westerlund (2008) preferred panel data analysis. Westerlund (2008) argued for the benefits of the panel cointegration test over the time series cointegration test and used it to examine the relationship between the nominal interest rate and the inflation rate using quarterly data from 1980–2004 for 20 OECD economies. The results did not reject the existence of the Fisher effect. Badillo et al. (2011) investigated the Fisher hypothesis for the 15 European Union countries via the cointegration test. They found evidence in support of a weak Fisher effect in 1983–2009. Performing panel data analysis of monthly data from the United States, the United Kingdom, and Japan in January 1990–December 2010, Toyoshima and Hamori (2011) obtained strong evidence in favour of the Fisher hypothesis.

In this study, we examined the validity of the Fisher hypothesis, which constitutes one of the cornerstones in neoclassical monetary theory. The empirical results will provide useful knowledge to the monetary authorities about the relationship between the inflation rate, interest rate and money supply. High inflation and interest rates are undesirable factors due to their damage on economic growth by discouraging investment and reducing productivity. In many countries, the main goal of the central bank is the price stability, i.e. controlling the inflation rate. To achieve inflation targets, central banks consider the nominal interest rate as the targeting instrument. Additionally, the central bank controls the money supply through the channel of the interest rate, and for the effectiveness of monetary policy, the relationship between the interest rate and money supply is important (Fatima & Sahibzada, 2012). We carried out the analysis using the panel cointegration test developed by Westerlund (2008). To this aim, we employed monthly data from January 2000 to November 2012 for the G7 countries, including the United States, the United Kingdom, Germany, Canada, Japan, Italy, and France. Monthly data are preferred through the suggestions of Rossana and Seater (1995) and Berument and Jelassi (2002) to avoid the aggregation-biased problem, which can be seen when annual data are used. The contributions of this study to the literature are twofold. First, only a limited number of studies applying the panel cointegration tests exist in the literature. As stated by Westerlund (2008), the panel cointegration test performs better than the time series cointegration test given that it allows researchers to gain more observations by pooling the time-series data across sections. Additionally, this cointegration test solves the problem of modelling the series with different integration orders. Second, we take cross-sectional dependence among G7 countries into account in our testing procedure given the existence of common global shocks that affect interest rates and inflation rates of all G7 countries.

The remainder of the paper is organised as follows. In Section 2, we explain the model and data. Section 3 illustrates the methodology, while Section 4 presents empirical results. Finally, in Section 5, we conclude the study.

2. Data and model

The Fisher hypothesis is tested based on the following equation:

$$i_{it} = \alpha_i + \gamma_i \pi_{it} + \varepsilon_{it} \tag{1}$$

where i_{it} denotes the nominal interest rate; π_{it} is the observed inflation rate at time t for country i; while ε_{it} is the error term, and α_i is a country-specific constant, also representing the mean of the ex-ante real interest rate, which is assumed to be constant over time (Westerlund, 2008).

Based on equation (1), the presence of the Fisher effect is demonstrated by a long-run relationship between inflation and nominal interest rates; in other words, these two factors should cointegrate. Furthermore, a full Fisher effect indicates that γ_i should be equal to 1, representing a nominal interest rate that moves one-for-one with the observed inflation rate in the long term. A partial Fisher effect implies that γ_i should be positive but less than one.

We tested for the validity of the Fisher hypothesis for G7 countries by employing monthly data over the period January 2000 to November 2012, resulting in a total of 155 observations. We used monthly Treasury bill rates as a proxy of the nominal interest rate, except for the case of Germany. Because no data are available on the Treasury bill rate in Germany, we used the government monthly bond rate instead. Additionally, the inflation rate was based on the consumer price index (2005 = 100) and measured as a percentage change over the corresponding period of the previous year. All data were obtained from the International Financial Statistics (IFS). The time period was dictated by data availability.

3. Methodology

3.1. Unit root tests

Before testing for the cointegrating relationship among variables of interest, we must first define the integrational properties of variables. Once they are integrated of order one (i.e. nonstationary), we can proceed to test for a cointegrating relationship among them. To this aim, we employed the panel unit root tests that can be classified into two groups: first-generation unit root tests and second-generation unit root tests. The first group includes unit root tests that do not allow for cross-sectional dependence, such as those proposed by Choi (2001), Hadri (2000), Im, Pesaran, and Shin (2003), Levin, Lin, and Chu (2002), and Maddala and Wu (1999). The second group consists of unit root tests that take cross-sectional dependence into account, including unit root tests developed by Bai and Ng (2004), Moon and Perron (2004), Pesaran (2007), and Phillips and Sul (2003), among others. Among second-generation unit root tests, we selected the unit root test suggested by Phillips and Sul (2003, hereafter PS).

By allowing the common factors to have differential effects on cross-section units, PS (2003) suggest a dynamic factor model, where the factor is independently distributed across time. They eliminate the common factor, which differs from principal components, by proposing a moment-based method, as pointed out by Baltagi, Bresson, and Pirotte (2006). They propose an orthogonalization procedure, based on the iterative method of moments estimation, to remove cross-section dependence and to permit the use of conventional unit root tests with panel data. In addition, they propose two types of test statistics. The first type is based on median unbiased correction once cross-section dependence is eliminated. The second type includes the use of meta-statistics, which seek to avoid small sample biases rather than correct for them (Phillips & Sul, 2003). Here, we report the results of the P test that is called the inverse chi-square test or Fisher test, after Fisher (1932). The test statistic is formulated as

$$P = -2\sum_{i=1}^{N-1} \ln(p_i) \rightarrow_d \chi^2_{2(N-1)} \quad \text{for fixed N} \tag{2}$$

where p_i is the value of a unit root test concerning cross-section unit i.

3.2. Cross-sectional dependence tests

To select the correct type of unit root test, we must first test for cross-sectional dependence for the variables and the cointegrating equation. To that aim, we employ the

Lagrange Multiplier (LM) and bias-adjusted Lagrange Multiplier (LM_{adj}) tests developed by Breusch and Pagan (1980) and Pesaran, Ullah, and Yamagata (2008), respectively. It is well known that when T is larger than N ($T > N$, as is the case in this paper), LM and LM_{adj} tests are favourable to the tests suggested by Frees (1995) and Pesaran (2004). The LM test has a χ^2 distribution with a cross-sectional independence null hypothesis. It is based on the sum of squared coefficients of correlation among cross-sectional residuals obtained through ordinary least squares (OLS). However, the LM test is biased when the group mean is equal to zero and the individual mean is different from zero. Therefore, Pesaran et al. (2008) corrected for bias by including variance and mean in the test statistic. In this way, they obtained the bias-adjusted LM test, which has standard normal distribution.

3.3. Westerlund's (2008) cointegration tests

The next step in our analysis is to apply the cointegration test.[1] The variables should be integrated of order one for the application of most cointegration tests, e.g. Pedroni's (2004) residual based tests for cointegration. In our case, however, the inflation rate was I (0), while the interest rate was I (1).[2] As such, the most suitable cointegration tests were the Durbin-Hausman tests, namely the panel test and group mean test, developed by Westerlund (2008). These tests can be applied under very general conditions because they do not rely heavily on a priori knowledge regarding the integration orders of the variables. Additionally, they allow for cross-sectional dependence modelled by a factor model in which the errors of equation (1) are obtained by idiosyncratic innovations and unobservable factors that are common across units of the panel (Auteri & Constantini, 2005). Thus, the errors in equation (1) are modelled as follows:

$$\varepsilon_{it} = \lambda_i' F_t + e_{it} \tag{3}$$

$$F_{jt} = \rho_j F_{jt-1} + u_{jt} \tag{4}$$

$$e_{it} = \phi_i e_{it-1} + \upsilon_{it} \tag{5}$$

where F_t is a $1 \times K$ vector of common factors and F_{jt} with $j = 1, \ldots, k$ and λ_i is a conformable vector of factor loadings. We ensure that F_t is stationary by assuming that $\rho_j < 1$ for all j. In this case, the integration order of the composite regression error ε_{it} depends only on the integratedness of the idiosyncratic disturbancee_{it}. Thus, in this data-generating process, testing the null hypothesis of no-cointegration is equivalent to testing whether $\phi_i = 1$ in an equation. Two panel cointegration tests exist: the panel test and the group mean test. The panel test is constructed under the maintained assumption that $\phi_i = \phi$ for all i, whereas the group mean test assumes that $\phi_i \neq \phi$ for all i. Both tests are based on two estimators of ϕ_i both of which have different probability limits under the cointegration alternative hypothesis while sharing the property of consistency under the no co-integration null hypothesis. The instrumental variable (IV) and OLS estimators can be used to attain the Durbin-Hausman tests. Thus, the statistics of DH_g and DH_p tests can be formulated as:

$$DH_g = \sum_{i=1}^{N} \hat{S}_i(\tilde{\phi}_i - \hat{\phi}_i)^2 \sum_{t=2}^{T} \hat{e}^2_{it-1} \tag{6}$$

$$DH_p = \hat{S}_n(\tilde{\phi} - \hat{\phi})^2 \sum_{i=1}^{n}\sum_{t=2}^{T} \hat{e}^2_{it-1} \tag{7}$$

where $\hat{\phi}_i$ is the OLS estimator of ϕ_i in equation (5) and $\hat{\phi}$ denotes its pooled counterpart. The corresponding individual and pooled instrumental variable (IV) estimators of ϕ_i, denoted $\tilde{\phi}_i$ and $\tilde{\phi}$, respectively, are obtained by simply instrumenting $\hat{e}_{it-1}$ with $\hat{e}_{it}$.

For the panel test (DH_p), the null and alternative hypotheses are formulated as H_0: $\phi_i = 1$ for all $i = 1,\ldots,N$ versus $H_1^p : \phi_i = \phi$ and $\phi < 1$ for all i. A common autoregressive parameter is assumed both under the null and alternative hypotheses. In contrast, for the DH_g test, H_0 is tested versus the alternative hypothesis defined as $H_1^g : \phi_i \prec 1$ for at least some i. In this case, heterogeneous autoregressive parameters are assumed across panel members. Thus, the rejection of null hypothesis indicates that there is a long-run relationship for at least some of the panel units.

3.4. *The panel ARDL (autoregressive distributed lag) approach*

Because the inflation rate is I(0) and the nominal interest rate is I(1), we could estimate the long-run parameters from the panel ARDL approach developed by Pesaran, Shin, and Smith (1999).[3] We correctly chose the pooled mean group estimator (PMGE) given that the Hausman test result indicated slope homogeneity in the cointegrating vector. In a panel ARDL(p, q)framework, we formulated the Fisher equation as follows:

$$i_{it} = \alpha_i + \sum_{j=1}^{p} \beta_{ij} i_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}\pi_{i,t-j} + \varepsilon_{it} \tag{8}$$

However, as stated by Pesaran et al. (1999), it is more convenient to work with the following re-parameterization of equation (8):

$$\Delta i_{it} = \alpha_i + \phi_i i_{i,t-1} + \gamma_i \pi_{it} + \sum_{j=1}^{p-1} \beta^*{}_{ij}\Delta i_{i,t-j} + \sum_{j=0}^{q-1} \delta^*_{ij}\Delta\pi_{i,t-j} + \varepsilon_{it} \tag{9}$$

for i = 1, 2,..., 7 and t = 2000m1, ..., 2012m11.

where $\phi_i = -(1 - \sum_{j=1}^{p} \beta_{ij})$, $\gamma_i = \sum_{j=0}^{q} \delta_{ij}$, $\beta^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}$ for j = 1, 2, ..., p − 1, and $\delta^*_{ij} = -\sum_{m=j+1}^{q} \delta_{im}$ for j = 1, 2, ..., q − 1.

ε_{it} is an error term which is independently distributed across i and t; φ_i is the error correction coefficient, which is expected to be negative; the term γ_i is the long-run coefficient; while β^*_{ij} and δ^*_{ij} are the short-run coefficients.

Pesaran et al. (1999) propose two estimators: the Mean Group estimator (MGE) and the Pooled Mean Group (PMGE) estimator. The MGE is not restrictive enough, as it does not impose any restriction on the parameters of ARDL specification. It is based on an average of an estimation of the coefficients from each cross-section. However, the MGE does not allow for some of the parameters to be the same across countries, and thus, it is likely to be inefficient, especially in small samples. In light of this problem, Pesaran et al. (1999) developed the PMGE estimator, which allows the intercept, the short-run dynamics, and the error variances to differ across the panel members, while the long-run parameters are constrained to be the same (Belke & Dreger, 2013).

In addition, a Hausman (1978) type test can be used to test the restriction of long-run parameters. In this test, under the null hypothesis of long-run slope homogeneity, both the PMG and MG estimators are consistent; however, only the PMG estimator is efficient. Therefore, non-rejection of the null hypothesis indicates that the PMG estimator is the correct estimator. In other words, the Hausman test is used to compare the PMG and MG estimators.

4. Empirical results

4.1. Results of cross-sectional dependence and unit root tests

We first presented the results of cross-sectional dependence tests in Table 1.

As seen in Table 1, the LM and LM_{adj} tests indicate the presence of cross-sectional dependence at a 1% significance level for the variables and the cointegrating equation regardless of model type. Thus, we can proceed by implementing unit root tests that allow for cross-sectional dependence. For the purpose of comparison, however, we applied the first-generation panel unit root tests developed by Levin et al. (2002, hereafter LLC), Im et al. (2003, hereafter IPS), and Maddala and Wu (1999, hereafter MW).[4] The test results are presented in Table 2.

As shown in Table 2, all unit root tests indicate that the interest rate is integrated of order one, i.e. I(1). However, mixed results were obtained for the inflation rate. The IPS and MW tests imply that the inflation rate is level stationary, whereas the LLC test indicates that it is difference-stationary. However, based on the cross-sectional dependence result, as a next step, we conducted the PS (2003) panel unit root test and its results are illustrated in Table 3.

As seen in Table 3, the results from the PS unit root test support the first generation panel unit root tests given that the inflation rate appears to be integrated of order zero, whereas the interest rate appears to be integrated of order one.

Table 1. Results of cross-sectional dependence tests.

Variables	(Constant case) LM test	(Constant case) LM_{adj} test	(Constant and trend case) LM test	(Constant and trend case) LM_{adj} test
Inflation rate	127.882 (0.000)	19.702 (0.000)	131.091 (0.000)	20.138 (0.000)
Interest rate	203.330 (0.000)	45.379 (0.000)	196.494 (0.000)	46.653 (0.000)
Co-integrating Equation	1174.923 (0.000)	40.120 (0.000)	1302.979 (0.000)	40.120 (0.000)

Notes: *P*-values of test statistics are presented in parentheses.
Source: Authors' calculations.

Table 2. Results of first generation panel unit root tests.

	Inflation rate			Interest rate	
	Constant	Constant and trend		Constant	Constant and trend
Tests	Level		Tests	Level	
IPS		−3.827*** (0.000)	IPS	−0.293 (0.384)	−0.104 (0.458)
LLC	0.421 (0.663)	1.406 (0.920)	LLC	−0.794 (0.213)	−0.639 (0.261)
MW	42.969*** (0.000)	31.809*** (0.004)	MW	9.286 (0.812)	8.093 (0.884)
First difference			First difference		
IPS	−21.215*** (0.000)	−21.289*** (0.000)	IPS	−19.328*** (0.000)	−19.205*** (0.000)
LLC	−19.009*** (0.000)	−20.838*** (0.000)	LLC	−18.881*** (0.000)	−21.255*** (0.000)
MW	501.949*** (0.000)	468.411*** (0.000)	MW	414.378*** (0.000)	382.049*** (0.000)

Notes: *P*-values of test statistics are reported in parentheses. ***indicates rejection of unit root null hypothesis at 1% level of significance.
Source: Authors' calculations.

Table 3. Results of PS test.

Inflation rate		Inflation rate	
Constant		Constant and trend	
Level		Level	
Fisher-Z-test	*p*-value	Fisher-Z-test	*p*-value
23.919	0.021	23.918	0.020
Firs Difference	Firs Difference		
Fisher-Z-test	*p*-value	Fisher-Z-test	*p*-value
38.721	0.000	38.721	0.000
Interest rate		Interest rate	
Constant		Constant and trend	
Level		Level	
Fisher-Z-test	*p*-value	Fisher-Z-test	*p*-value
3.012	0.995	1.742	0.999
Firs Difference		Firs Difference	
Fisher-Z-test	p-value	Fisher-Z-test	*p*-value
33.355	0.000	31.969	0.001

Notes: The maximum order of lag length of ADF regression was set at 10.
Source: Authors' calculations.

Table 4. Results of Westerlund's (2008) cointegration tests.

DH_g	2.047** (0.020)
DH_p	6.108 *** (0.000)

Notes: Probabilities were reported in parentheses. The criterion used in this paper is $IC_2(K)$ with the maximum number of factors (K) set equal to 5. For the bandwidth selection, M was chosen to represent the largest integer less than $4(T/100)^{2/9}$ as suggested by Newey and West (1994). *** and ** indicate the rejection of no co-integration null hypothesis at 1% and 5% levels of significance, respectively.
Source: Authors' calculations.

4.2. Results of panel cointegration test

The results of the DH_g and DH_p tests, developed by Westerlund (2008), are reported in Table 4.

As presented in Table 4, the results of both tests indicate that the null hypothesis of no-cointegration is rejected at 5% and 1% significance levels for the DH_g and DH_p

Table 5. Results of panel ARDL estimation.

Long-run coefficient	PMGE	MGE	Hausman test
$\hat{\gamma}_i$	0.338***	0.729***	2.76
	[0.044]	[0.239]	(0.10)
Error correction	−1.097	−1.113	
coefficient (φ_i)	[0.208]***	[0.212]***	
t-Statistic (H_0:γ_i = 0)	7.681***	3.050 ***	
t-Statistic (H_0:γ_i = 1)	−15.045***	−1.133	

Notes: The maximum number of lags for each variable is set at three, and optimal lag lengths are selected by the AIC. The MG estimates are used as initial estimates of the long-run parameters for the pooled maximum likelihood estimation. The PMG estimators are computed by a 'back-substitution' algorithm. Numbers in brackets are the standard errors. Probability value is reported for the Hausman test. *** indicates 1% level of significance.
Source: Authors' calculations.

tests, respectively.[5] Thus, based on these results, long-run parameters (cointegrating vector) should be estimated. To this end, we applied the panel approach developed by Pesaran et al. (1999).

4.3 Results of panel ARDL approach

The panel ARDL approach assumes cross-sectional independence, implying that disturbances are independently distributed across units and over time with zero mean and constant variances (Arpaia & Turrini, 2008). Therefore, we used cross-section demeaned data. When we estimated equation (9), we followed a maximum likelihood approach and applied the 'back-substitution' algorithm. We also used Akaike Information Criteria (AIC) to select lag length for each individual country regression. We did not report the short-run coefficients because only long-run parameters have importance in the Fisher hypothesis.[6] The long-run results obtained from the PMGE and MGE are tabulated in Table 5.

As shown in Table 5, the Hausman test provides evidence favourable to the PMGE. In other words, the null hypothesis of long-run homogeneity in coefficients of the inflation rate cannot be rejected at a 1% significance level or better. This result confirms that the PMGE is a consistent and efficient estimator under the null hypothesis of long-run homogeneity of slope parameters. According to the results of PMGE, the inflation rate is significant at the 1% significance level, and we can reject the null hypothesis of $\gamma_i = 0$. However, a full or strong Fisher effect does not hold, because the null hypothesis of $\gamma_i = 1$ is rejected at all conventional significance levels. The coefficient of inflation rate (0.338) is significant but still lower than unity. Thus, the results of this study support a partial Fisher effect. Additionally, the negative and significant error correction term indicates the presence of cointegration among variables of interest as well as an adjustment of the interest rate toward equilibrium.

5. Conclusion

In this study, we aimed to test for the Fisher hypothesis for G7 countries; in other words, we investigated whether the nominal interest rate responds fully to changes in inflation. In this respect, we employed the Durbin-Hausman panel cointegration tests, which are applicable irrespective of the integration orders of variables of interest. The results indicated the presence of a long-run relationship between inflation rate and nominal interest rate. The results of the PMGE in the panel ARDL approach supported a weak form of the Fisher hypothesis. These results demonstrated that while there is a long-run relationship between the inflation rate and nominal interest rate, the rise in the nominal interest rate is less than unity in response to a change in the rate of inflation. The findings supported the impact of inflation on the real interest rate, which implies the invalidity of the long-run super neutrality of money. In other words, monetary policies implemented in G7 countries could affect real interest rates in the long-run and changes in expected inflation will not be fully offset by changes in the nominal interest rate, which in turn cause the real interest rate to change. Our results are consistent with the results of Peng (1995) for the cases of Germany and Japan; however, they are contrary to the results of Toyoshima and Hamori (2011) whose findings indicated that the full Fisher effect holds in the United States, the United Kingdom and Japan. As Peng (1995) concluded, causing the less than one-to-one relationship between inflation and nominal interest rate, the strong anti-inflationary policies implemented by the monetary authorities may lead to a weaker Fisher effect and thus a less persistent inflation. As a result, monetary policy will be an important tool to control price stability. Consequently, to achieve production and economic growth targets, governments should implement policies to prevent the rise of inflation due to the non-neutrality of inflation with respect to real spending and saving decisions.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. See Wagner and Hlouskova (2010) for a detailed explanation on the performance of panel cointegration tests.
2. Furthermore, it is possible to distinguish between national and international trends as potential drivers of the long-run equilibrium between the inflation rate (interest rate) and its forcing variables by decomposing each variable into common and idiosyncratic components. However, this issue is beyond the scope of this study. Interested readers may refer to Belke, Dobnik, and Dreger (2011) and Dreger and Reimers (2009).
3. The panel ARDL approach allows for independent variables being of different integration orders, i.e. I(1) or I(0).There are also other estimators, such as dynamic ordinary least squares (DOLS) developed by Mark and Sul (2003) and the panel fully modified ordinary least squares (FMOLS) estimator proposed by Pedroni (2000). However, they necessitate the variables are integrated of order one, i.e. I(1)
4. For an extensive explanation of the methods of the tests, see Levin et al. (2002), Im et al. (2003), and Maddala and Wu (1999).
5. The result of the DH_p test is favourable to the DH_g test since, as will be reported in next section, the Hausman test result from the panel ARDL approach indicates that the homogeneity assumption of slope parameters in long-run equilibrium does hold.
6. Detailed results of the panel ARDL estimation are available upon request from the authors.

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