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NOTES

A note on the neutrality of interest rates

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Abstract

We test the neutrality of nominal interest rates taking advantage of recent advances in quantitative financial history using the Schmelzing (2022) global nominal interest rate and inflation rate series (across eight centuries), for France, Germany, Holland, Italy, Japan, Spain, the United Kingdom, and the USA. We pay attention to the integration and cointegration properties of the variables and use the bivariate autoregressive methodology proposed by King and Watson (1997). We argue that meaningful long-run neutrality tests can be performed only for three countries—Japan, Spain, and the United Kingdom—and we find no evidence consistent with the neutrality of nominal interest rates.

Keywords: Inflation; monetary policy; monetary neutrality

1. Introduction

As Robert E. Lucas Jr. (1996, p. 661) put it in his Nobel Lecture, "[t]he work for which I have received the Nobel Prize was part of an effort to understand how changes in the conduct of monetary policy can influence inflation, employment, and production. So much thought has been devoted to this question and so much evidence is available that one might reasonably assume that it had been solved long ago. But this is not the case. It had not been solved in the 1970s when I began my work on it [referring to Lucas (1972)], and even now this question has not been given anything like a fully satisfactory answer."

Over the years, large numbers of studies, including Fisher and Seater (1993), King and Watson (1997), and Serletis and Koustas (1998, 2019), among others, have investigated the long-run neutrality of money proposition using simple-sum and Divisia measures of money and state-of-the-art advances in the theory of nonstationary regressors. The general conclusion is that money is neutral in the long run, consistent with both monetarist and Keynesian macroeconomic theory.

However, Lucas (1972) studied the neutrality (and temporary non-neutrality) of money, but as Cochrane (2023a, pp. 1) recently put it, " our central banks set *interest rates*. The Federal Reserve does not even pretend to control money supply, especially inside money. There are no reserve requirements. Super-abundant reserves pay the same or more interest as short-term treasuries and overnight money markets. The Fed controls interest rates by changing the interest it offers on abundant reserves, not by rationing scarce zero-interest reserves. Other central banks follow similar policies." Cochrane (2023a, b) argues that we need a theory of inflation under interest rate targets.

In a world where central banks set interest rates, long-run monetary neutrality means that higher nominal interest rates eventually produce higher inflation rates, other things constant (particularly fiscal policy). In particular, according to the new Keynesian model that is currently used in the conduct of monetary policy in inflation targeting countries, a higher nominal interest rate leads to a higher real interest rate. The intertemporal substitution effect induces economic agents to reduce current demand and increase future demand. That change in demand puts downward pressure on the price level today and upward pressure on the expected future price level, and this continues until inflationary expectations realize. Thus, in the long run, higher nominal interest rates raise the expected inflation rate and that implies monetary neutrality.

In this paper, we investigate the dynamic effects of interest rates on inflation. In doing so, we use the bivariate autoregressive methodology proposed by King and Watson (1997), also used by Serletis and Koustas (1998, 2019) and Koustas and Serletis (1999), paying explicit attention to the univariate time series properties of the variables. According to this approach, meaningful long-run neutrality tests can be constructed only if the variables satisfy certain nonstationarity conditions. In particular, neutrality tests are possible if both variables, the nominal interest rate and the inflation rate, are at least integrated of order one and are of the same order of integration. We also take advantage of recent advances in quantitative financial history and use the Schmelzing (2022) global interest rate and inflation rate series (over the past 700 years), for France, Germany, Holland, Italy, Japan, Spain, the United Kingdom, and the USA.

The paper is organized as follows. In the next section, we discuss the Schmelzing (2022) interest rate and inflation rate data and their time series properties. In section 3, we discuss the King and Watson (1997) methodology and present the evidence regarding the long-run neutrality of nominal interest rates. The final section concludes.

2. The data

We take advantage of a new data set on advanced economy long-maturity interest rates (comparable to interest rates on modern 10-year Treasury bonds), constructed by Schmelzing (2022) and further investigated by Rogoff et al. (2022). The series are for eight countries—France, Germany, Holland, Italy, Japan, Spain, the United Kingdom, and the USA—across eight centuries (starting in 1311). Schmelzing (2022) and Rogoff et al. (2022) provide details regarding the series and their construction. It is to be noted that although monetary policy is conducted in terms of a short-term nominal interest rate, we use a long-term interest rate under the assumption that changes in the policy rate propagate to the long-term yield curve.

As noted in the Introduction, according to the King and Watson (1997) approach, meaningful neutrality tests are possible if both variables, the nominal interest rate and the inflation rate, are at least integrated of order one and are of the same order of integration. In this regard, we test the null hypothesis of a unit root in the nominal interest rate and inflation rate series for each of the eight countries. Table 1 presents the augmented Dickey-Fuller (ADF) unit root test [see Dickey and Fuller (1981)], the KPSS stationarity test [see Kwiatkowski et al. (1992)], and the Johansen (1988) maximum likelihood (ML) cointegration test [see Johansen (1988)]. As can be seen, the ADF and KPSS tests give mixed results, suggesting that the series are not very informative about their univariate time series properties. In the case of France, for example, the ADF test rejects the null of a unit root in the inflation rate and the KPSS test rejects the null of level stationarity.

To decide on the order of integration of each of the nominal interest rate and inflation rate series, we also report the Johansen ML cointegration test to get some additional information. As can be seen, in the case of France, the Johansen test shows two cointegrating vectors, suggesting that both series are stationary. Thus, combining the results of the ADF, KPSS, and Johansen tests, we conclude that the inflation rate and nominal interest rate series for France are individually integrated of order zero or I(0). We follow the same strategy for the rest of the countries and summarize the integration order of the inflation rate and nominal interest rate series for each country in the last column of Table 1. As can be seen, meaningful neutrality tests are possible only in the case of Japan, Spain, and the United Kingdom.[1]

Table 1. Integration and cointegration tests

Country	Series	Test ADF (*t* statistic)	 KPSS ($\hat{\eta}_\mu$ statistic)	 Johansen (rank)	Order of integration
France	Inflation rate	-8.351^{**}	1.306^{**}	2	I (0)
	Interest rate	-2.658	7.306^{**}		I (0)
Germany	Inflation rate	12.891^{**}	0.253	2	I (0)
	Interest rate	-2.886^{*}	6.115^{**}		I (0)
Holland	Inflation rate	-17.494^{**}	0.179	2	I (0)
	Interest rate	-2.828	4.999^{**}		I (0)
Italy	Inflation rate	-20.630^{**}	0.736^{*}	2	I (0)
	Interest rate	-3.275^{*}	1.356^{**}		I (0)
Japan	Inflation rate	-4.876^{**}	0.110	1	I (1)
	Interest rate	-1.079	0.668^{*}		I (1)
Spain	Inflation rate	-10.337^{**}	0.536^{*}	1	I (1)
	Interest rate	-2.356	1.004^{*}		I (1)
United Kingdom	Inflation rate	-12.403^{**}	0.722^{*}	1	I (1)
	Interest rate	-0.766	5.787^{**}		I (1)
USA	Inflation rate	-7.775^{**}	0.565^{*}	2	I (0)
	Interest rate	-3.030^{*}	0.414		I (0)

Notes: The null hypothesis in the ADF test is a unit root and in the KPSS test is stationarity.
ADF critical values 1% (**) -3.467, 5% (*) -2.877.
KPSS$\hat{\eta}_\mu$ critical values 1% (**) 0.739, 5% (*) 0.463.

3. The neutrality of interest rates

We follow King and Watson (1997) and consider the following bivariate structural vector-autoregressive model of order p

$$\Delta R_t = \lambda_{R\pi}\,\Delta\pi_t + \sum_{j=1}^{p} \alpha_{R\pi}^{j}\,\Delta\pi_{t-j} + \sum_{j=1}^{p} \alpha_{RR}^{j}\Delta R_{t-j} + \varepsilon_t^R \tag{1}$$

$$\Delta\pi_t = \lambda_{\pi R}\Delta R_t + \sum_{j=1}^{p} \alpha_{\pi\pi}^{j}\,\Delta\pi_{t-j} + \sum_{j=1}^{p} \alpha_{\pi R}^{j}\Delta R_{t-j} + \varepsilon_t^\pi \tag{2}$$

where R_t is the nominal interest rate and π_t the inflation rate. ε_t^R and ε_t^π represent exogenous unexpected changes in the interest rate and inflation rate, respectively, and $\lambda_{R\pi}$ and $\lambda_{\pi R}$ represent the contemporaneous effect of the inflation rate on the interest rate and the contemporaneous response of the inflation rate to the interest rate, respectively. We are interested in the dynamic effects of the nominal interest rate shock, ε_t^π, on R_t.

The matrix representation of the model is

$$\boldsymbol{\alpha}(L)\mathbf{z}_t = \boldsymbol{\varepsilon}_t \tag{3}$$

where

$$\boldsymbol{\alpha}(L) = \sum_{j=0}^{p} \boldsymbol{\alpha}_j L^j,$$

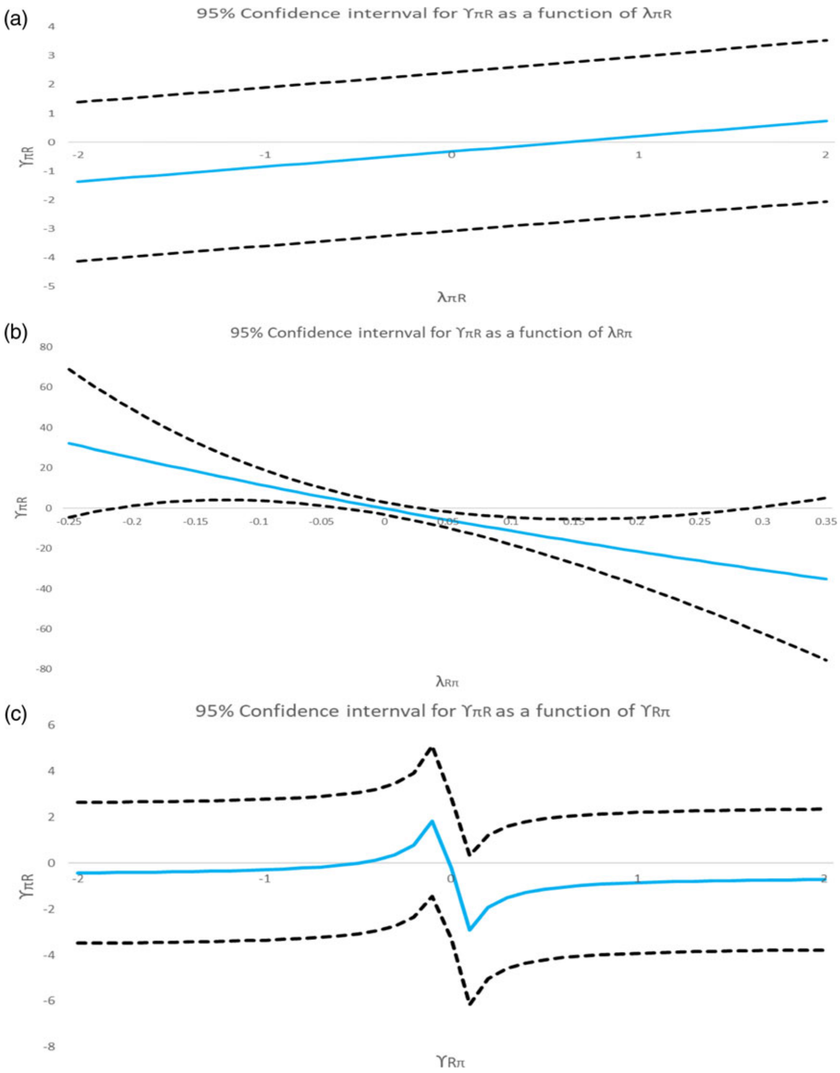

Figure 1. The long-run impact of the interest rate on inflation in Japan.
Note: annual data 1397–2018; the dashed lines represent the two-standard error bands.

$\mathbf{z}_t = (R_t, \pi_t)$, L is the lag operator $\left(\text{i.e., } L^j \mathbf{z}_t = \mathbf{z}_{t-j}\right)$, and

$$\mathbf{z}_t = \begin{bmatrix} \Delta R_t \\ \Delta \pi_t \end{bmatrix}; \boldsymbol{\varepsilon}_t = \begin{bmatrix} \varepsilon_t^R \\ \varepsilon_t^\pi \end{bmatrix}; \boldsymbol{\alpha}_0 = \begin{bmatrix} 1 & -\lambda_{R\pi} \\ -\lambda_{\pi R} & 1 \end{bmatrix}; \boldsymbol{\alpha}_j = -\begin{bmatrix} \alpha_{RR}^j & \alpha_{R\pi}^j \\ \alpha_{\pi R}^j & \alpha_{\pi\pi}^j \end{bmatrix}, \quad j = 1, \ldots, p.$$

Thus, in this notation the long-run multipliers are $\gamma_{\pi R} = \alpha_{\pi R}(1)/\alpha_{\pi\pi}(1)$ and $\gamma_{R\pi} = \alpha_{R\pi}(1)/\alpha_{RR}(1)$, where $\alpha_{\phi\psi}(1) = \sum_{j=1}^{\infty} \alpha_{\phi\psi}^j$. Hence, $\gamma_{\pi R}$ measures the long-run response of the inflation rate to a permanent unit increase in R, and $\gamma_{R\pi}$ measures the long-run response to R to a permanent unit increase in the inflation rate.

The endogeneity of the nominal interest rate, however, makes equation (3) econometrically unidentified, as noted by King and Watson (1997). To see this, write the primitive system (3) in

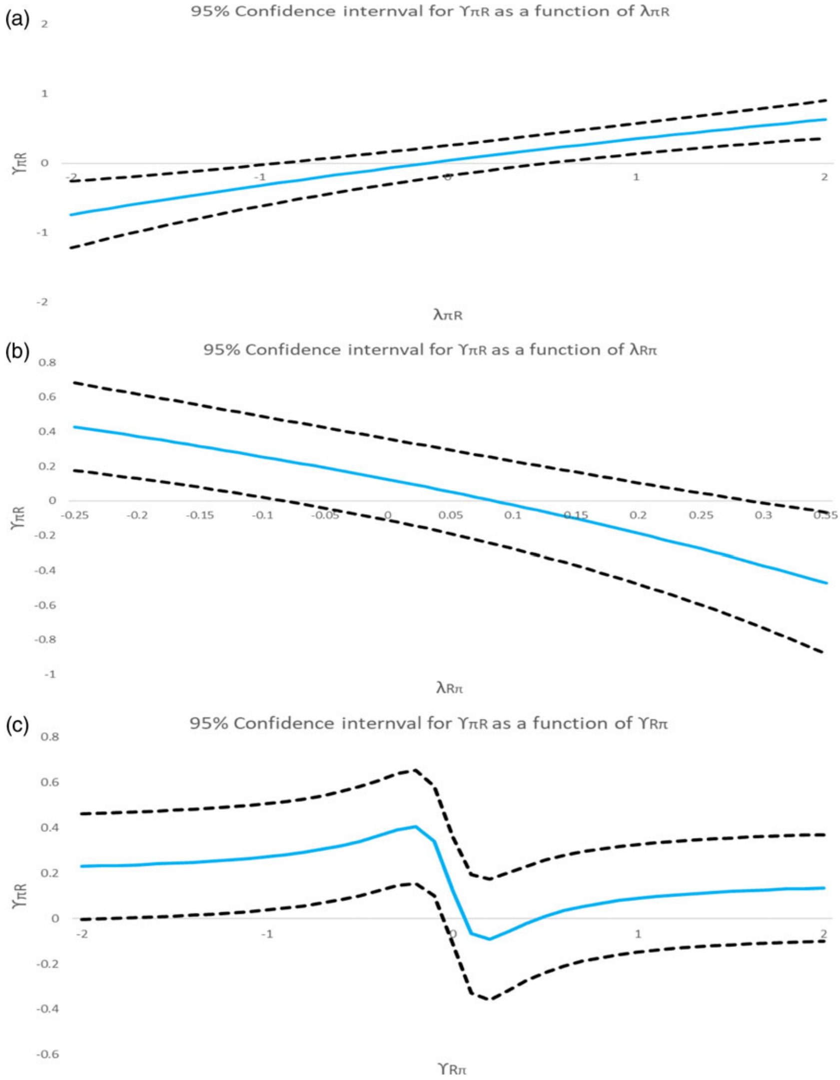

Figure 2. The long-run impact of the interest rate on inflation in Spain.
Note: annual data 1800–2018; the dashed lines represent the two-standard error bands.

standard form as

$$\mathbf{z}_t = \sum_{j=1}^{p} \boldsymbol{\Phi}_j \mathbf{z}_{t-j} + \mathbf{e}_t$$

where $\boldsymbol{\Phi}_j = -\boldsymbol{\alpha}_0^{-1}\boldsymbol{\alpha}_j$ and $\mathbf{e}_t = \boldsymbol{\alpha}_0^{-1}\boldsymbol{\varepsilon}_t$. The following equations determine the matrices $\boldsymbol{\alpha}_j$ and $\sum_{\boldsymbol{\varepsilon}}$:

$$\boldsymbol{\alpha}_0^{-1}\boldsymbol{\alpha}_j = -\boldsymbol{\Phi}_j, \quad \text{where } j = 1, \ldots, p \tag{4}$$

$$\boldsymbol{\alpha}_0^{-1} \sum\nolimits_{\boldsymbol{\varepsilon}} \left(\boldsymbol{\alpha}_0^{-1}\right)' = \sum\nolimits_{\boldsymbol{\varepsilon}}. \tag{5}$$

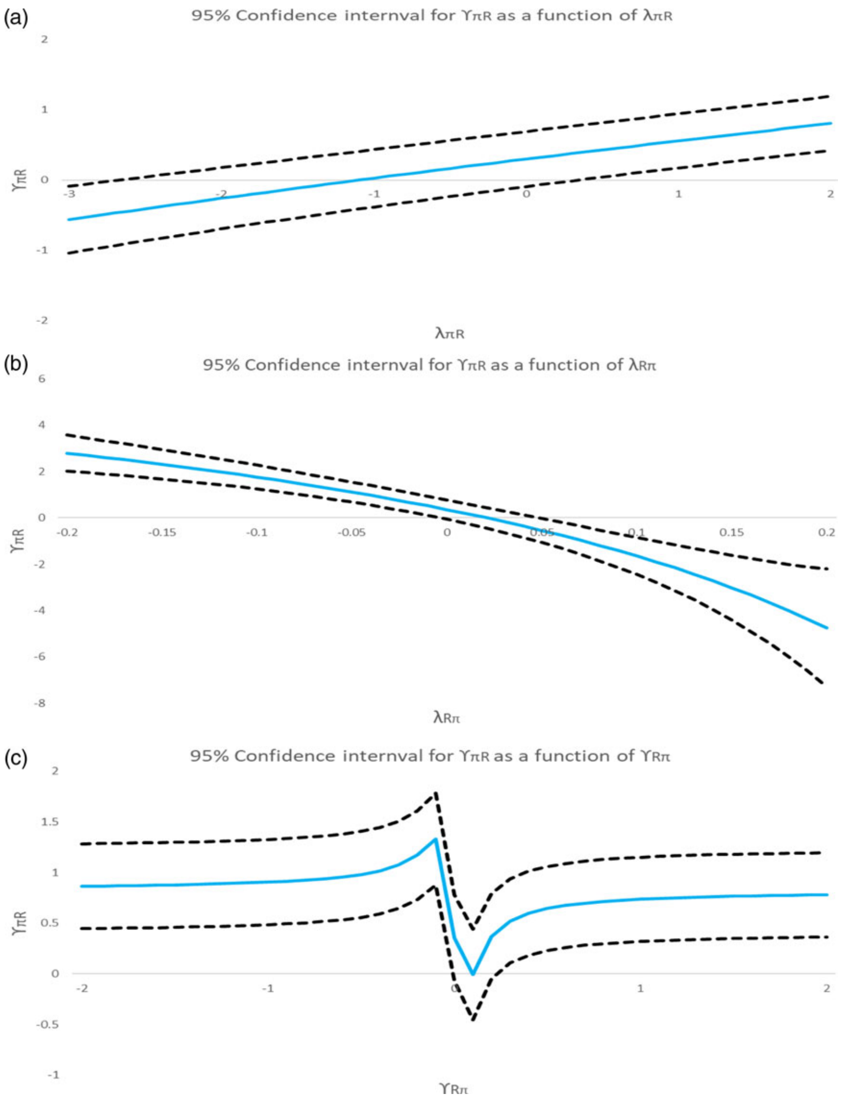

Figure 3. The long-run impact of the interest rate on inflation in UK.
Note: annual data 1310–2018; the dashed lines represent the two-standard error bands.

Equation (4) determines $\boldsymbol{\alpha}_j$ as a function of $\boldsymbol{\alpha}_0$ and $\boldsymbol{\Phi}_j$. Equation (5) cannot determine both $\boldsymbol{\alpha}_0$ and $\sum_{\boldsymbol{\varepsilon}}$, given that $\sum_{\boldsymbol{\varepsilon}}$ is a 2×2 symmetric matrix with only three unique elements. Therefore, only three of the four unknown parameters—$\lambda_{R\pi}$, $\lambda_{\pi R}$, $\mathrm{var}(\varepsilon_t^{\pi})$, $\mathrm{var}\left(\varepsilon_t^{R}\right)$—can be identified, even under the assumption of independence of ε_t^R and ε_t^{π}. Clearly, one additional restriction is required to identify the model and test the long-run neutrality restrictions.

We follow King and Watson's (1997) eclectic approach, and instead of focusing on a single identifying restriction, we report results for a wide range of identifying restrictions. In particular, we iterate each of $\lambda_{R\pi}$, $\lambda_{\pi R}$, $\gamma_{R\pi}$, and $\gamma_{\pi R}$ within a reasonable range, each time obtaining estimates of the remaining three parameters and their standard errors. This testing strategy is clearly more informative in terms of the robustness of inference about the long-run neutrality of interest rates to specific assumptions about $\lambda_{\pi R}$, $\lambda_{R\pi}$, or $\gamma_{R\pi}$. All of the models include lags of the relevant variables, which are determined by the AIC.

To deal with the identification problem mentioned earlier, we estimate equation (3) under appropriate identification restrictions. Following King and Watson (1997), we can always get an estimate of $\gamma_{\pi R}$ based on a wide range of any of $\lambda_{R\pi}$, $\lambda_{\pi R}$, and $\gamma_{R\pi}$. Therefore, we report the results in the following way. The figure for each country includes three panels. The upper panel shows the variation of $\gamma_{\pi R}$ conditional on ranges of values on the short-run impact of the nominal interest rate on the inflation rate, $\lambda_{\pi R}$. The middle panel provides the possible values of $\gamma_{\pi R}$ conditional on ranges of values on the short-run impact of inflation on the nominal interest rate, $\lambda_{R\pi}$. The lower panel gives the value of $\gamma_{\pi R}$ which changes as the changes in the long-run impact of inflation on the nominal interest rate, $\gamma_{R\pi}$. Please note $\gamma_{R\pi}$ will be unit if the Fisher link holds in the long run.

The estimates are reported in Figures 1–3 for Japan, Spain, and the United Kingdom, respectively. In panel A of Figure 1, we find no evidence supporting a long-run effect of the nominal interest rate on inflation in Japan conditional on the short impact of the interest rate on inflation. However, as can be seen in panel A of Figure 2 (and to a lesser extent in Figure 3), we can identify a long-run effect of the nominal interest rate on the inflation rate, but the identification requires a more than a unit short-run effect of the interest rate on inflation. In particular, a large enough positive (negative) $\lambda_{\pi R}$ value implies a positive (negative) $\gamma_{\pi R}$ value. What makes more sense between the two cases is that an increase in the nominal interest rate may reduce inflation.

Panel B of Figures 1–3 supports a negative long-run effect of the nominal interest rate on the inflation rate in each of the countries. In particular, a short-run effect of inflation on the nominal interest rate (typically $0.05 < \lambda_{R\pi} < 0.3$ for Japan, $\lambda_{R\pi} > 0.3$ for Spain, and $\lambda_{R\pi} > 0.05$ for the United Kingdom), identifies a negative long-run effect of the nominal interest rate on the inflation rate ($\gamma_{\pi R} < 0$). Turning to panel C of Figures 1–3, we see a significantly positive $\gamma_{\pi R}$ value for the United Kingdom when $\gamma_{R\pi} > 0$. There are no significant $\gamma_{\pi R}$ values in the case of Japan, and the positive $\gamma_{\pi R}$ values in the case of Spain correspond to a negative long-run effect of inflation on the nominal interest rate ($\gamma_{R\pi} < 0$) which is inconsistent with macroeconomic theory.

Overall, the interest rate has a long-run effect on inflation. The most robust identified impact is that an increase in the interest rate will reduce inflation in the long run if we believe an increase in inflation leads to an increase in the interest rate in the short run.

4. Conclusion

In the context of the bivariate autoregressive methodology proposed by King and Watson (1997), we test the long-run neutrality of nominal interest rates using the Schmelzing (2022) global nominal interest rate and inflation rate series (over 700 years), for France, Germany, Holland, Italy, Japan, Spain, the United Kingdom, and the USA. We cannot test the neutrality proposition for five of the countries—France, Germany, Holland, Italy, and the USA—because their nominal interest rate and inflation rate series do not satisfy the time series properties for meaningful neutrality tests. For the remaining countries—Japan, Spain, and the United Kingdom—we do not find evidence consistent with the neutrality of nominal interest rates.

Competing interests. We have no conflicts of interest to report.

Declaration of Generative AI and AI-assisted technologies. We have not used Generative AI and AI-assisted technologies in the writing process.

Note

1 In the case of Japan, inflation is stationary based on the ADF and KPSS tests. On the other hand, both tests confirm that the interest rate is nonstationary. However, one cointegrating vector is suggested by the Johansen test. Therefore, the results for Japan should be interpreted with caution.

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