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Book

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Is Real Interest Rate a Monetary Phenomenon in Advanced Economies? Time-Varying Evidence from Over 700 Years of Data

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ABSTRACT

In this paper we examine the effect of permanent inflation shocks on real interest rates, based on a structural Time-Varying Parameter Vector Autoregression (TVP-VAR) model that account for parameter instability. This is important since we use over 700 years of annual data that covers the entire economic history for France, Germany, Holland (the Netherlands), Italy, Japan, Spain, the United Kingdom (UK) and the United States (US), going as far back as 1310. Based on the responses of real interest rates to an inflation shock, the Fisherian hypothesis of a one-to-one movement of inflation to nominal interest rates can only be rejected episodically, in favour of a Mundell-Tobin effect of less than proportional increase in the nominal interest rate to an inflation shock. In other words, generally speaking, real interest rate in the long-run tends to be unaffected by inflation shocks, as derived from longest possible data samples of real interest rates and inflation for the advanced economies considered. Hence, the results in the existing literature based on post World War II samples, should be treated with caution due to the possibility of sample selection bias. Our findings, that real interest rates might not necessarily be a monetary phenomenon, have important policy implications in the current context of rising global inflation rates.

Keywords: Inflation, Real interest rate, TVP-VAR

JEL Codes: C32, E31, E43

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1. Introduction

The advent of high inflation in the post-COVID-19 period and the following price surge in the wake of Russia's invasion of Ukraine has resuscitated after almost 4 decades the economic discussion around inflation and monetary policy efficiency (Cavallo, 2020). The awakening of the "inflation ghost" of the 70s reminded the lessons from that era; clear mandates for central banks on tight monetary policy, despite the discrepancies with today's inflation. The inflation of the 70s was mainly a result of high oil prices, weak economic growth and monetary expansion in tandem with the release of the Bretton Woods system. Today's inflation originates from a historical jump in commodity prices, with not so relatively high oil prices and a slowing but robust economic growth. As a response to price surges, almost all central banks increased or announced successive increments in their basic interest rates, and this in turn raises an important question about the impact on real interest rate. The real interest rate, defined as an interest rate adjusted for either realized or expected inflation, is the relative price of consuming now rather than later. Hence, it is a key variable in wide array of important theoretical models in finance and macroeconomics, such as the consumption-based asset pricing model, neoclassical growth model, models of central bank policy, and numerous models of the monetary transmission mechanism (Neely and Rapach, 2008).

Theoretically, how an inflation shock ends up impacting the real interest rate is based on two lines: On one hand, as per the Fisher (1930)-effect, real interest rate should be unaffected by inflation shocks, due to the underlying proposition of long-run neutrality, i.e., there is a positive one-to-one relationship between inflation and the nominal rate of interest in the long-run. On the other hand, it is expected that inflation shocks should reduce the real interest rate due to a less than one-for-one adjustment in long-run nominal interest rates to a permanent increase in inflation, as suggested by the theoretical models of Mundell (1963) and Tobin (1965), which in turn is known as the Mundell-Tobin hypothesis. As per Mundell (1963), a permanent increase in inflation lowers the steady-state real interest rate due to the dependence of saving on real money balances. Specifically speaking, a rise in inflation increases the nominal interest rate and thus reduces the demand for real money balances. This decrease in real money balances increases saving via a wealth effect, and the real interest rate must fall to restore the equilibrium in the goods market. As far as Tobin (1965) is concerned, he develops an augmented Solow growth model where agents hold both capital and real money balances. Thus, an increase in steady-state inflation raises the costs of holding real money balances, leading agents to carry out portfolio reallocation whereby they substitute capital holdings for real money balances. This results in increases in the steady-state capital stock which lowers the marginal product of capital, and in turn the real interest rate in equilibrium.

Given the importance of the real interest rate variable, the associated empirical literature is extensive, and more importantly yields a mixed picture in terms of the validation of the two hypotheses: Fisherian and Mundell-Tobin effects (see, Rapach (2003), Rapach and Wohar (2005), Amusa et al. (2013), Das et al. (2014), and Anari and Kolari (2016) for detailed reviews). Against this backdrop of unconvincing evidence, and the direct macroeconomic implications of the matter especially in today's era of increased inflation, we make an attempt to resolve this issue by taking a historical perspective. Specifically speaking, we use the recently available dataset of Schmelzing (2020) on inflation and real interest rates that covers the entire economic history of eight advanced countries (France, Germany, Holland, Italy, Japan, Spain, the United Kingdom, and the United States) staring from the year 1310, to analyze the time-varying impact of a permanent inflation shock on the real interest rate. In this regard, our work draws from the earlier studies of Cogley et al. (2008) and Cogley and Sargent (2002, 2005) in the usage of a Time-Varying Parameter Vector Autoregression (TVP-VAR) framework to investigate the possibility of shifts in the dynamics of the variables under consideration. The usage of the longest possible data samples on inflation and real interest rates allow us to avoid our results suffering from sample selection bias, and the implementation of the TVP-VAR ensures that we incorporate all possible monetary-policy regime changes over the 700 years of country-specific data that we investigate.

To the best of our knowledge this is a first such attempt to provide a comprehensive understanding of the long-run effect of inflation on real interest rates over centuries of data, unlike the existing literature that only looks at the post World War II (WWII) period. While the choice of the eight economies is purely data dependent, their importance in the global setting cannot be ignored, since they account, on average, for the 78% of the real Gross Domestic Product (GDP), associated with the developed world (Schmelzing, 2020). The remainder of the paper is organized as follows: Section 2 outlines the basic methodology of the TVP-VAR along with our identification scheme of the inflation shock. Section 3 presents the data and the empirical findings, while Section 4 concludes the paper.

2. Methodology

The basic model of Cogley and Sargent (2005) assumes a TVP-VAR model trained on Bayesian methods to allow for time-varying VAR coefficients with stochastic volatility of the innovations. Thus, we consider the reduced VAR model:

$$\theta_t(L)x_t = e_t \tag{1}$$

with $x_t = \{\pi_t, r_t\}$ representing a n-vector of endogenous variables (namely inflation (π) and real interest rate (r_t), at each point of time *t*, each θ_{jt} in $\theta_t(L) = I - \theta_{1t}L - \cdots - \theta_{kt}L^k$ a matrix of time-varying coefficients and e_t is a vector of zero mean VAR errors with a time-varying covariance matrix R_t. The coefficients in (1) evolve according to:

$$\theta_t = \theta_{t-1} + u_t \tag{2}$$

with θ_t denoting the vector that stacks all parameters in $\theta_t(L)$ and u_t is a Gaussian white noise process with zero mean and constant covariance matrix Q, independent of ε_t at all leads and lags. We model the time variations of innovations $\mathrm{R}_t = \mathrm{E}(e_t e_t') = F_t D_t F_t'$, where F_t is a lower diagonal matrix with ones in the main diagonal and D_t a diagonal matrix. In order to provide flexibility to our model we drop the typical homoscedasticity assumption and allow for the existence of stochastic volatility on the VAR errors.[1]

Following the literature cited in the introduction, our identification method of structural shocks follows a Blanchard and Quah (1989)-type long-run restrictions on the innovations in order to decompose the responses into permanent and transitory shocks. The imposed restriction is that long-run inflation is only affected by its own shock, by ordering the inflation rate first in the TVP-VAR, followed by the real interest rate. This is consistent with the monetarist hypothesis in which long-run money growth and inflation rates are determined exogenously by the monetary authority and permanent changes in inflation arise solely from permanent changes in money growth. In other words, the central bank can still react to the preference (real interest rate) shock by adjusting the rate of money growth in the short-run.

[1] More information on the model structure can be obtained from Cogley and Sargent (2005).

3. Data and empirical findings

Our dataset consists of annual observations of inflation and real interest rates for the eight advanced economies, derived from Schmelzing (2020).[2] The usage of the ex post real interest rate allows us to sidestep the thorny issue of specifying explicitly how inflationary expectations are formed and should not be crucial for measuring the average real interest rate over relatively long periods. If expectations are rational, actual and expected inflation will only differ by a white-noise error term. The sample period for the eight countries differs based on data availability, and has been reported explicitly in Table 1, along with the descriptive statistics.

[Insert Table 1 here]

As we observe from Table 1, no series is strictly non-stationary and a number of series exhibit structural breaks. To account for this issue, our reliance on the TVP-VAR model is well-warranted. In Figure 1, we plot the data on inflation and real interest rates.

[Insert Figure 1]

Using the identification scheme, outlined in Section 2, of the inflation shock corresponding to central bank monetary policy and the preference shock related to household preferences for present versus future consumption, we compute the response of real interest rates to an inflation shock. The results are depicted in Figure 2 over panels (a) to (h) for the horizons of 1-, 2-, 3-, 5-, and 10-year-ahead, with the first 50 observations used as a training sample.

[Insert Figure 2 here]

As we observe from Figure 2(a), the responses of real interest rates to an inflation shock for France are mostly zero, with small exceptions around 1789 (i.e., the French Revolution) and 1945 (i.e., end of WWII), though the effects are statistically insignificant. The lack of compelling evidence in favor of a significant response suggests a Fisherian effect of one-to-one movement between inflation and nominal interest rate. Our results are quantitatively similar for Germany in Figure 2(b) with an exception on the 3-year-ahead horizon for the period 1495-1618, where we detect a significant negative effect that gives rise to a Mundell-Tobin effect. But the effect is not significant at the shorter-horizons and disappears at longer-runs. We get similar results for Holland in Figure 2(c), whereby we validate the Fisherian hypothesis for all periods, except between 1510 to 1520 at the 3-year-ahead horizon, when it depicts a

[2] The data is available for download from: https://www.bankofengland.co.uk/working-paper/2020/eight-centuries-of-global-real-interest-rates-r-g-and-the-suprasecular-decline-1311-2018.

negative spike. As far as Italy in Figure 2(d) is concerned, the results continue to suggest a unanimous validation of the Fisherian hypothesis, with most of the immense variability of the impulse responses in the 14th and 15th century being insignificant, and then smoothing out as we move towards longer horizons. Japan in Figure 2(e) exhibit a negative response around 1868 (i.e., the Meiji era) at the shorter-horizons that turn positive in longer horizons, with all responses being insignificant over the rest of the sample. Thus, a Mundell-Tobin effect is visible only for a certain period and for shorter horizons, and then turn into insignificant impacts. The case of Spain in Figure 2(f), which is is also one of our longer series, depicts all variability of responses to be limited during the 18th century, but is statistically insignificant. The same applies for the UK in Figure 2(g) where barring the exception of a Mundell-Tobin effect at the 1-year-ahead horizon over 1973-1985, partly coinciding with the period Margaret Thatcher served as the British prime minister, all other responses are indifferentiable from zero. Finally, for the US in Figure 2(h), we observe deviations from the Fisherian hypothesis during the Civil War period for the 1-year-ahead horizon, and during the mid-1980s involving the Great Moderation period, with a Mundell-Tobin effect observed during the time frame at the 5-year-ahead horizon. The responses for the rest of the time period are not statistically significant.

Overall, our results tend to provide strong evidence in favour of the Fisherian hypothesis, which suggests that long-run real interest rates of advanced economies have historically remain unaffected by inflation shocks due to a corresponding one-to-one increase in the nominal interest rate.

4. Conclusions

Against the backdrop of mixed evidence on the effects of a permanent structural inflation shock on the behavior of real interest rate in post WWII data, in this paper we develop a TVP-VAR model to revisit this question by looking at over 700 years of data for eight advanced economies. Our empirical findings primarily suggest the existence of a one-to-one Fisherian relationship between inflation and nominal interest rate co-movements causing no impact of long-term real interest rates. Alternatively put, evidence on a negative effect on long-term real interest rate following an inflation shock due to a less than proportional increase in the nominal interest rate, i.e., the Mundell-Tobin effect, is only episodical and scattered through time and the economies considered. Taking into account the recent surge of prices in global markets, our work has direct policy implications for monetary authorities, deviating from previous sample specific analyses. In particular our results seem to suggest that inflation shocks are likely to have no effect on real interest rates, and hence savings and investment decisions of economic agents in the long-run. In sum, based on longest possible data history on real interest rates and inflation of major advanced economies, we tend to conclude that real interest rate is not a monetary phenomenon. As part of future research, it would be interesting to extend our analysis and consider other possible determinants of real interest rates, for example, technology shocks.

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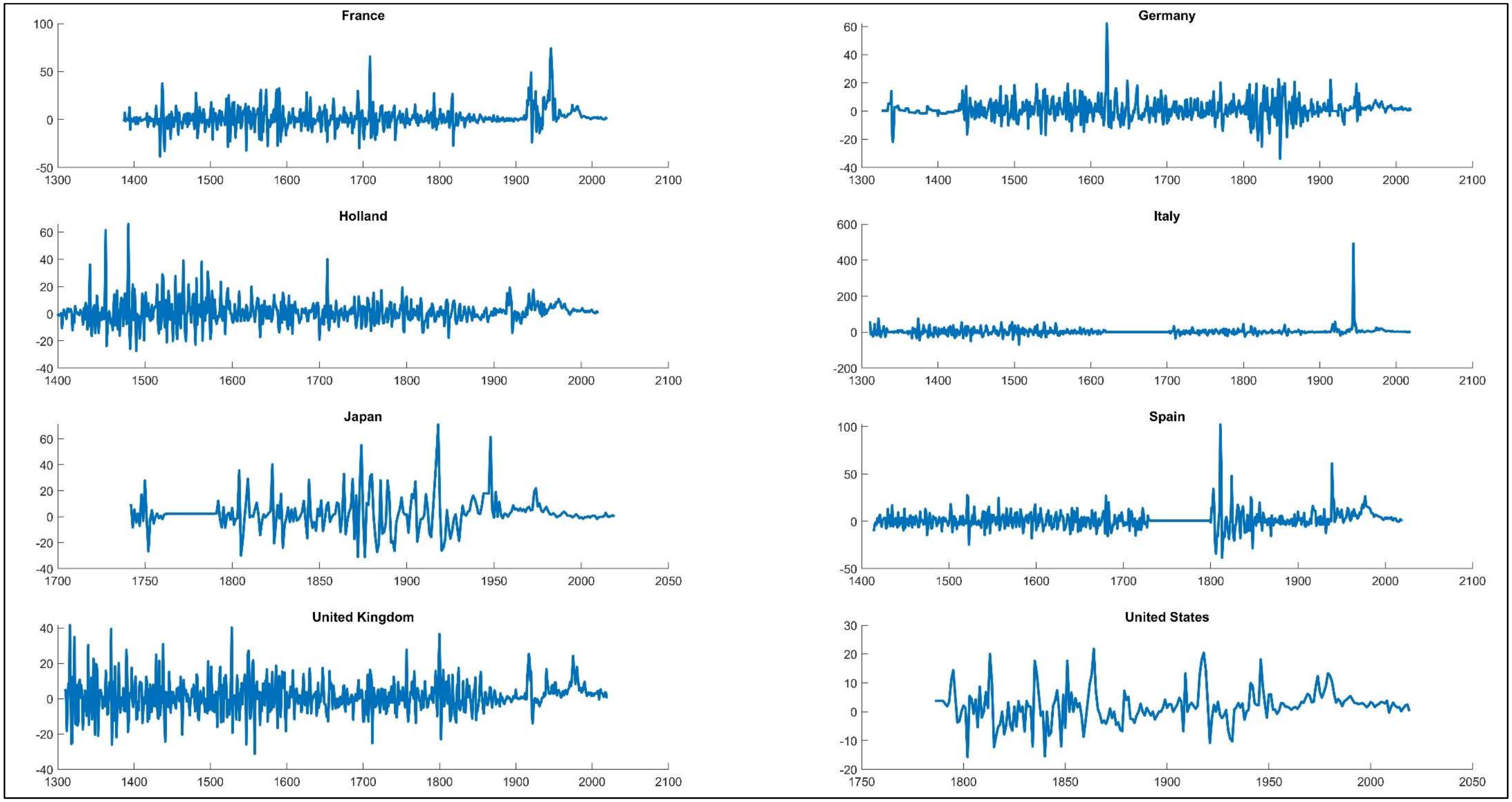
Table 1. Descriptive Statistics

Country	Observations (start – end)	Mean	Maximum	Minimum	Std. Dev.	Jarque-Bera	ADF	BP (breaks)	EL
Panel A: Inflation									
France	633 (1387-2019)	1.97	74.02	-38.36	11.14	1675***	-6.54***	10.79*** (5)	-20.70***
Germany	694 (1326-2019)	1.25	62.03	-33.79	7.29	3098***	-8.62***	2.47* (1)	-20.42***
Holland	620 (1400-2019)	1.27	65.92	-27.42	9.18	1923***	-7.03***	2.65** (2)	-23.99***
Italy	709 (1311-2019)	3.13	491.27	-69.28	23.85	1827***	-7.41***	4.80** (5)	-19.88***
Japan	278 (1742-2019)	2.61	70.87	-31.13	13.04	1247***	-4.65***	3.17* (1)	-13.82***
Spain	606 (1414-2019)	1.63	102.07	-38.45	9.77	1464***	-6.52***	7.83*** (5)	-19.86***
United Kingdom	710 (1310-2019)	1.36	41.85	-31.19	9.13	185.11***	-7.20***	4.28** (5)	-23.66***
United States	234 (1786-2019)	1.97	21.80	-15.73	5.84	39.73***	-4.78***	4.38** (5)	-10.77***
Panel B: Real Interest rate									
France	633 (1387-2019)	7.56	54.89	-70.67	12.79	956***	-6.31***	39.82*** (5)	-19.84***
Germany	694 (1326-2019)	5.24	38.84	-58.07	7.81	2327***	-6.98***	13.61*** (5)	-19.62***
Holland	620 (1400-2019)	5.08	36.48	-56.88	9.99	685***	-5.38***	15.07*** (5)	-22.79***
Italy	709 (1311-2019)	3.47	76.48	-489.13	24.08	1804***	-7.31***	4.96*** (5)	-20.05***
Japan	278 (1742-2019)	0.59	39.11	-65.34	13.18	273.20***	-4.72***	3.96* (2)	-13.57***
Spain	620 (1400-2019)	6.36	76.84	-61.00	11.36	2854***	-3.67***	26.67*** (5)	-17.25***
United Kingdom	710 (1310-2019)	10.76	58.21	-31.79	10.75	69.87***	-3.59***	166.78*** (5)	-23.42***
United States	234 (1786-2019)	2.89	20.76	-16.65	5.97	41.45***	-4.66***	4.67** (5)	-10.27***

Note: ADF denotes the augmented Dickey-Fuller test (Dickey and Fuller, 1979). The test assumes the inclusion of a trend in the regression. BP denotes the Bai and Perron (1998) structural breaks test. EL denotes the Enders and Lee (2012) Fourier unit root test that accounts for an infinite number of structural breaks in the timeseries. *, ** and ***indicate statistical significance at 1%, 5% and 10% respectively.

1(a). Inflation rates



1(b). Real interest rates

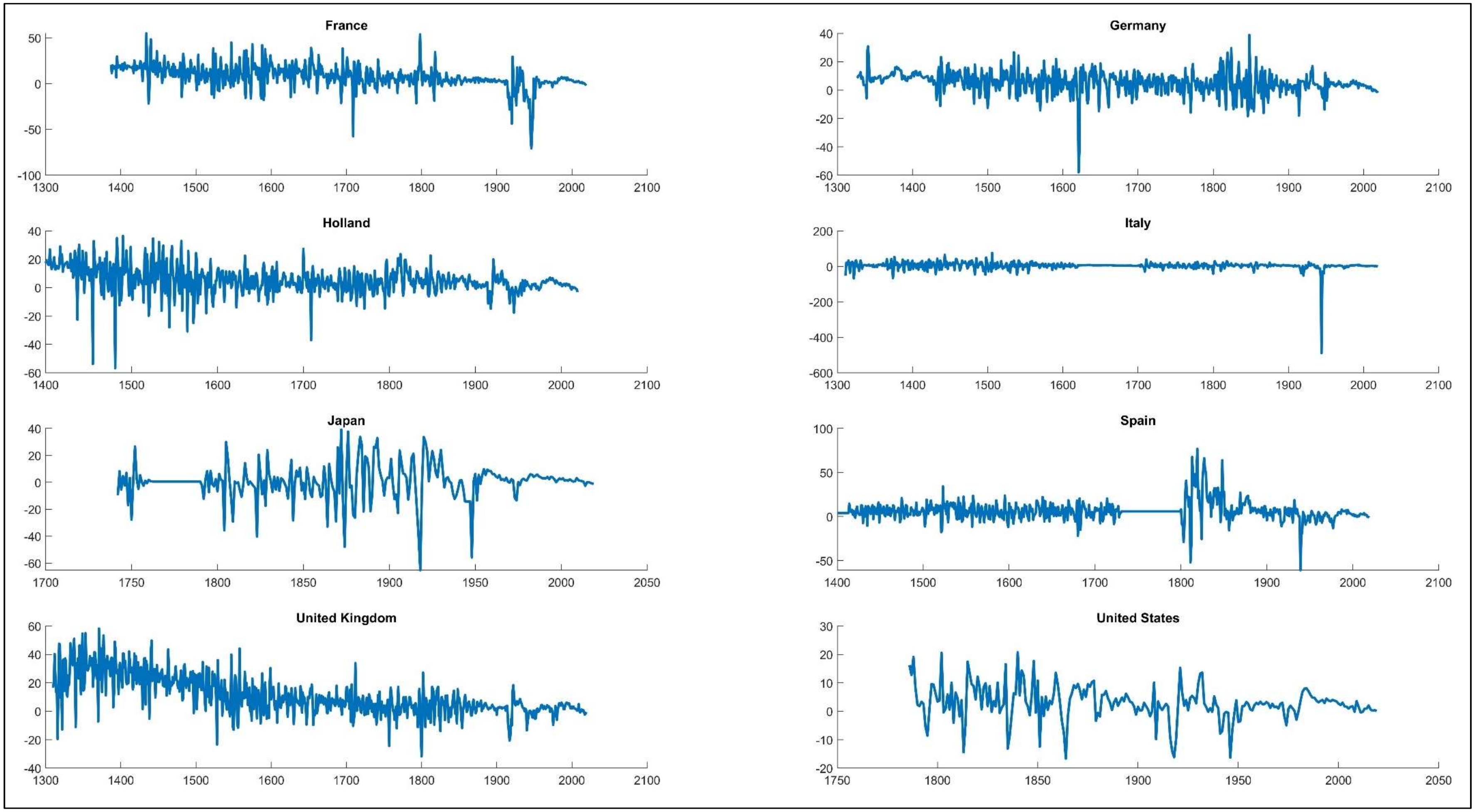
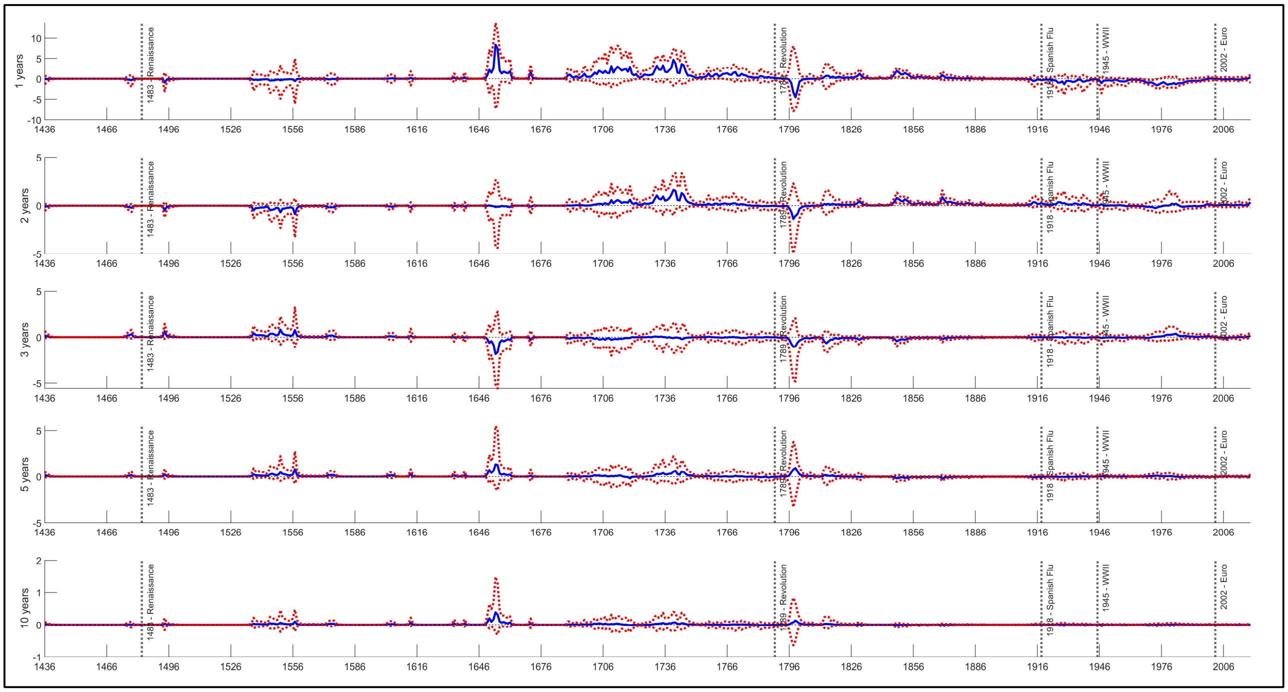
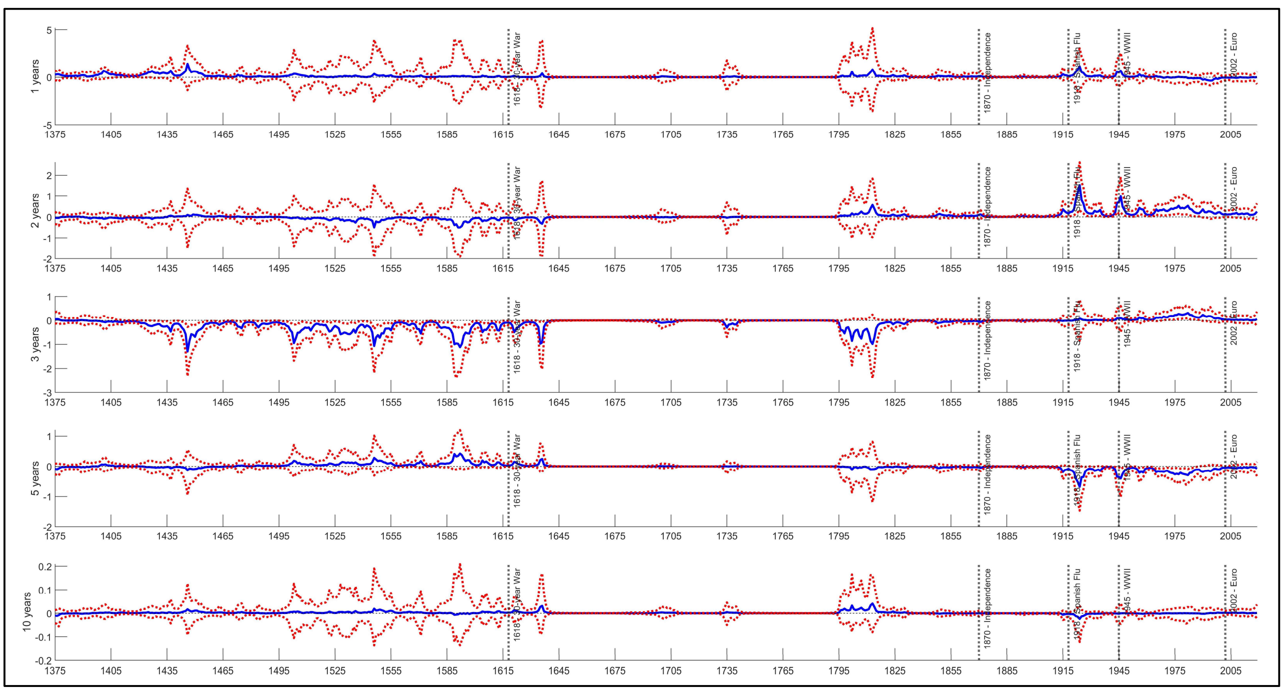


Figure 1. Data plots for the eight advanced economies

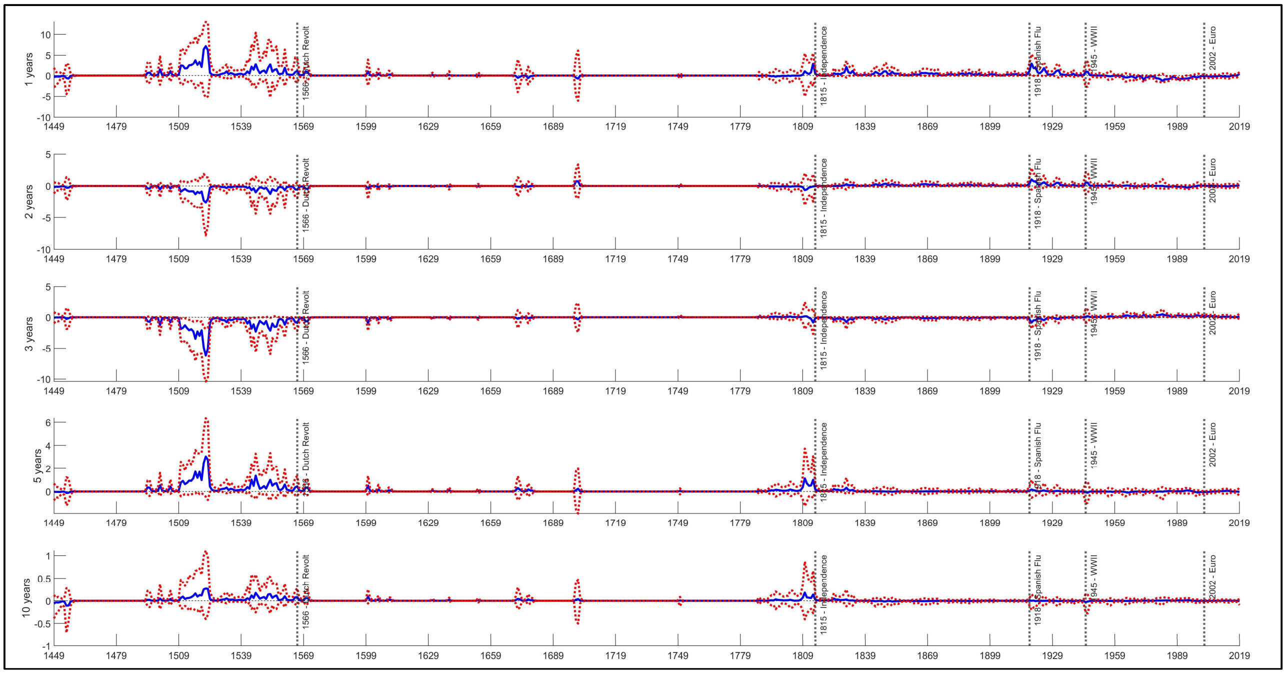
2(a). Impulse responses of France



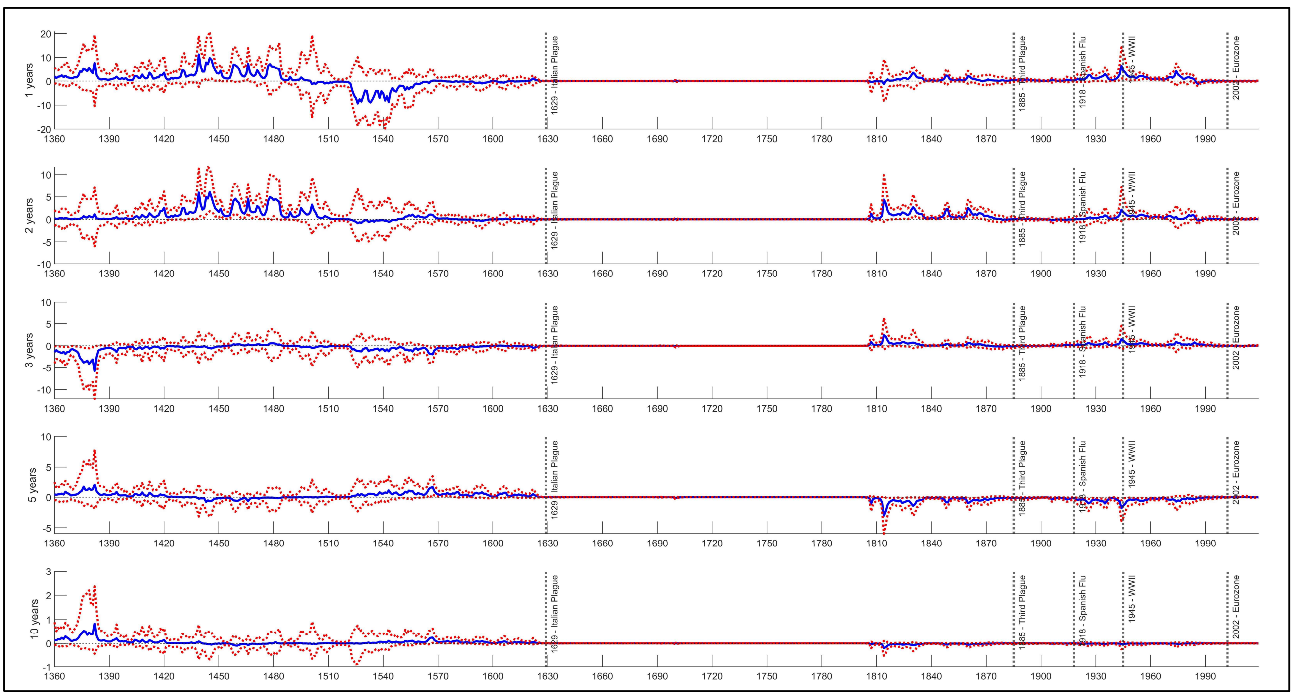
2(b). Impulse responses of Germany



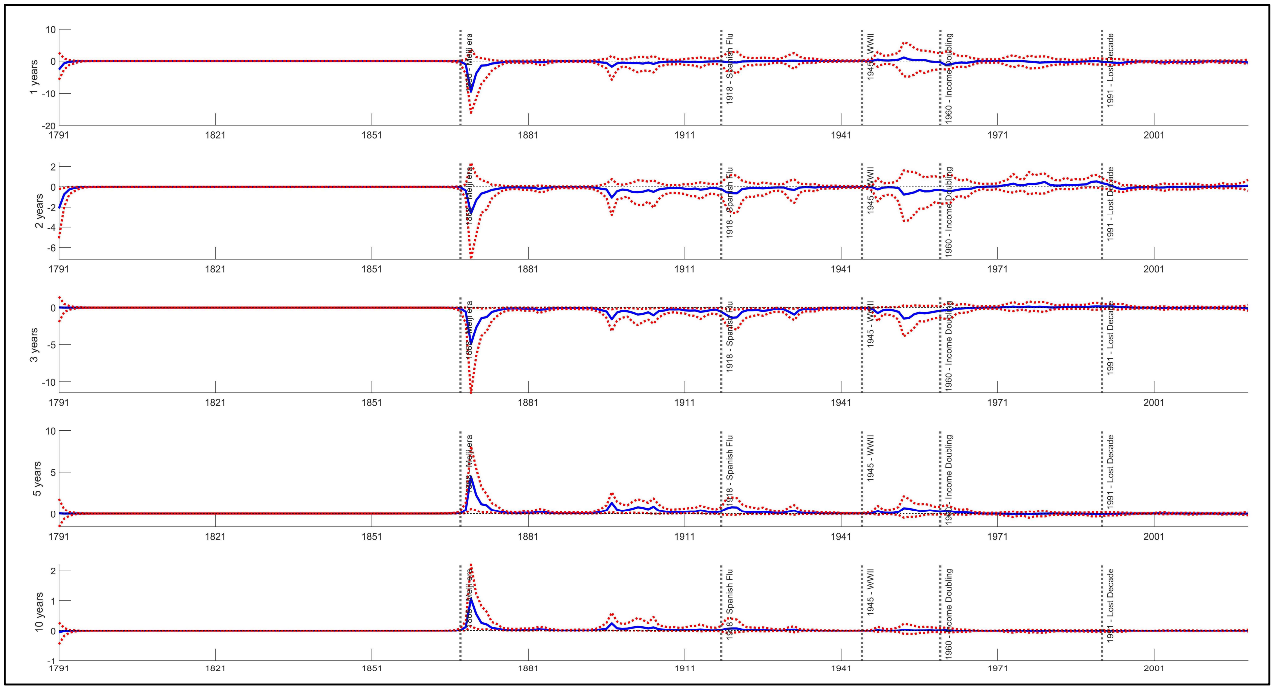
2(c). *Impulse responses of Holland / the Netherlands*



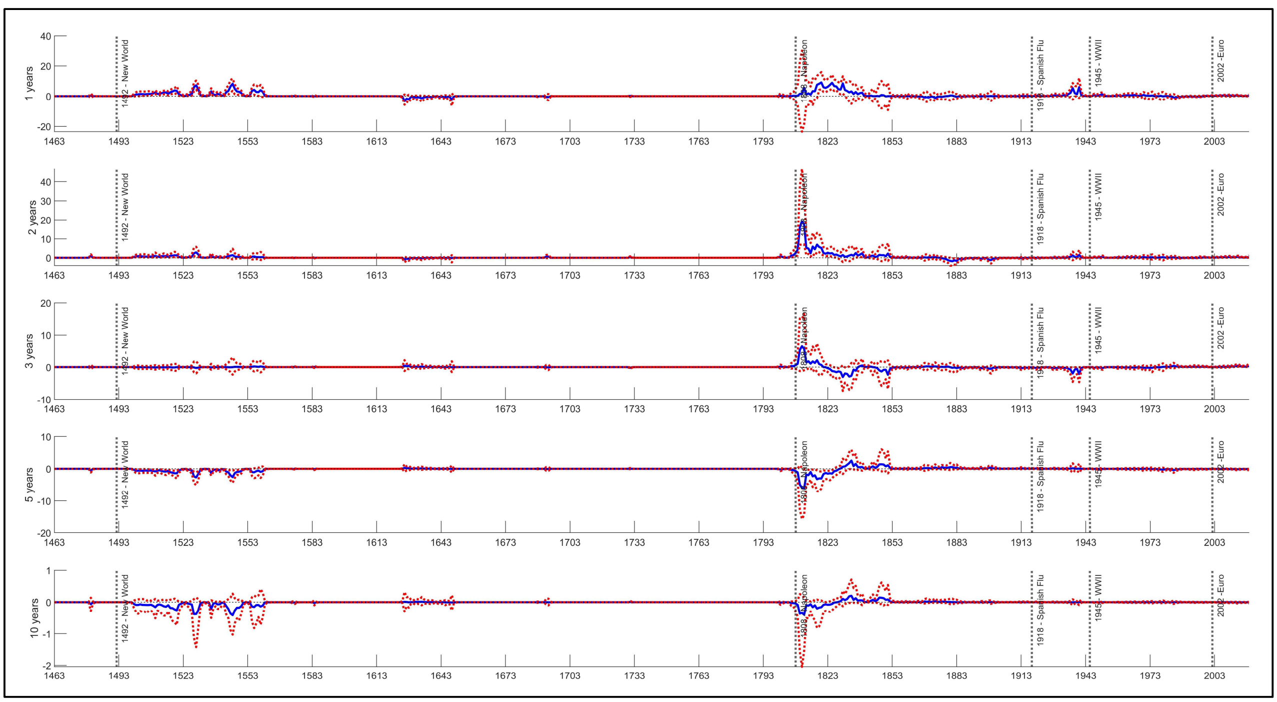
2(d). *Impulse responses of Italy*



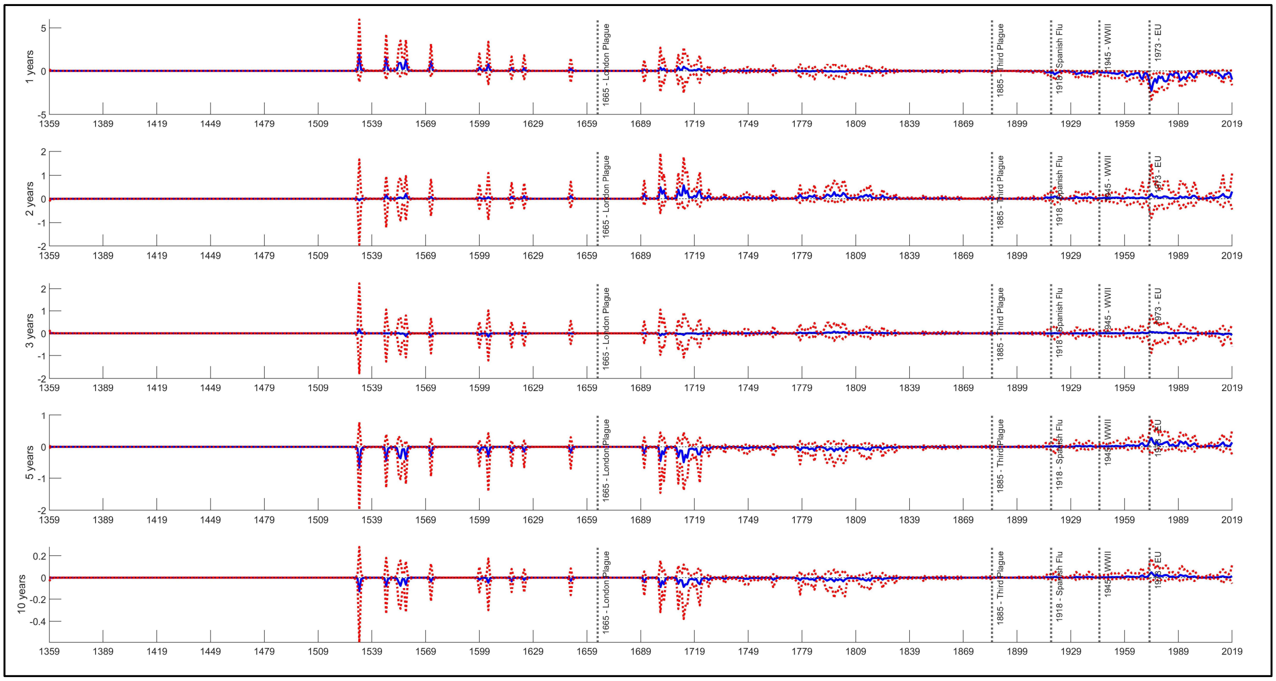
2(e). *Impulse responses of Japan*



2(f). *Impulse responses of Spain*



2(g). Impulse responses of the United Kingdom (UK)



2(h). Impulse responses of the United States (US)

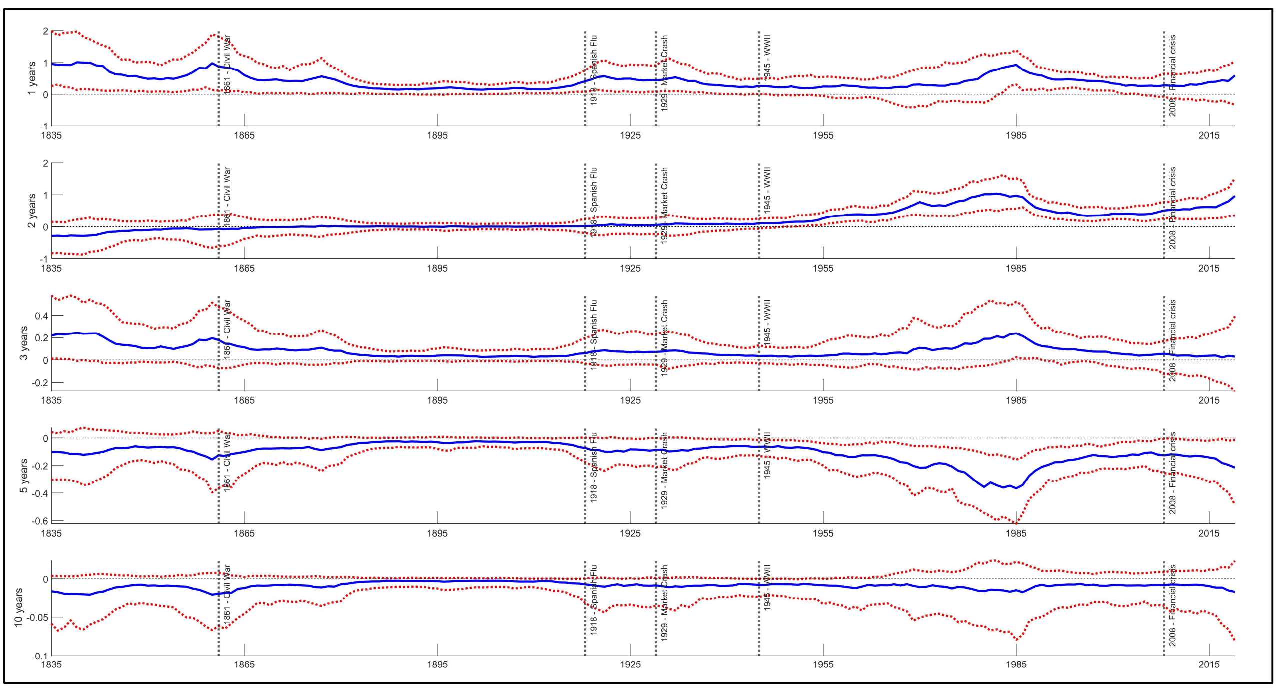


Figure 2. Time-varying real Interest rates response to an inflation shock for the eight advanced economies