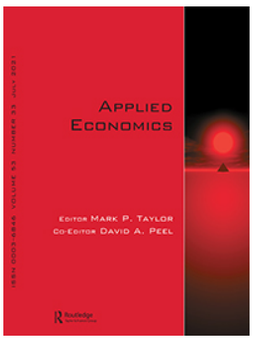

Applied Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/raec20

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To cite this article: Hakan Berument & Richard T. Froyen (2021) The Fisher effect on long-term U.K. interest rates in alternative monetary regimes: 1844-2018, Applied Economics, 53:33, 3795-3809, DOI: 10.1080/00036846.2021.1886239

To link to this article: https://doi.org/10.1080/00036846.2021.1886239

Published online: 28 Feb 2021.

APPLIED ECONOMICS
2021, VOL. 53, NO. 33, 3795–3809
https://doi.org/10.1080/00036846.2021.1886239

Routledge
Taylor & Francis Group

The Fisher effect on long-term U.K. interest rates in alternative monetary regimes: 1844-2018

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ABSTRACT

The Fisher Effect is one of the most widely studied relationships in monetary economics. Previous studies have found little evidence of a Fisher effect in pre-World War I data for the United Kingdom. An explanation for this is the near white noise property of the inflation rate under the Classical Gold Standard. There is more evidence of a Fisher effect in the post-World War II years when the inflation rate showed more persistence. This paper studies the evidence on the Fisher effect over the time period 1844-2018. This period covers several distinct monetary regimes. The monetary regime is an important factor determining the time series behavior of the inflation rate which, in turn, has been shown to be crucial to the strength of the Fisher effect. Distinctive features of the study are the focus on the long-term interest rate and coverage of the current inflation targeting regime in the United Kingdom.

KEYWORDS

Fisher effect; Inflation anchors; Inflation targeting; Long-term Interest Rate

I. Introduction

The Fisher effect, the effect on nominal interest rates from changes in the inflation rate, is among the most widely studied subjects in monetary economics. This paper investigates the way in which the existence and magnitude of the Fisher effect for long-term bonds depend on the nature of the monetary regime. The study examines the U.K. experience for a period going back to 1844–a time frame that encompasses several distinct monetary regimes.

Irving Fisher's (1896, 1930) research dates from the period of the Classical Gold Standard. Later, statistical research [(Barsky (1987) and Friedman and Schwartz (1982)], however, provided little evidence of a Fisher effect in either the United Kingdom or United States during the Classical Gold Standard period. These studies found more evidence of a Fisher effect in the post-World War II period. An explanation for this is the differing time-series properties of inflation under the Gold Standard relative to the post-World War II period. As Bordo and Schwartz (1999) observe, 'the Fisher effect … is hard to detect before 1914 because inflation was a white noise process whereas later in the 20th century, when inflation became more persistent, it becomes apparent.' According to this explanation inflation in the earlier period was in large part unforecastable and thus an inflation premium was not reflected in nominal interest rates.

Taking the chain of causation back a stage, the question arises of the explanation for the differences in the time-series properties of inflation in different periods. Here we are led to the role of the monetary regime. Hawtrey (1938) examined the Fisher effect in relation to short- and long-term rates. With respect to the long-term rate, he stated 'The effect on the long-term rate, though in some respects more obscure, is still important (p.214).' After analysing the process by which an expansion of demand leads to inflation, he turns to the end of the expansion, 'What brings the process to an end is the monetary limit. In the century up to 1914 it was the state of the gold reserve (p.216).' But 'in 1919 the monetary system had been cut loose from the gold reserve. Those who bought and sold Consols were compelled to look forward not just a few months but many years ahead (p.216).' The Bank of England, acting under the Bank Act of 1844, was required to restrict note issues in response to declines in the bullion reserve at the Bank. As inflation led to declines in the gold reserve, through both internal and external drains, the Bank of England raised its discount rate (Bank Rate) to stem the loss, thus ending

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

the inflation process relatively quickly. The end of the Classical Gold Standard in the United Kingdom in 1919 was followed by periods when there was no formal monetary regime, a return to gold, years of monetary policy by discretion and, after October 1992, an inflation targeting regime. None of these is likely to have provided long-term inflation expectations as stable as those under the Classical Gold Standard but they seem likely to have differed in the degree to which they did stabilize long-term inflation expectations.

This paper examines the relationship between the Fisher effect and the monetary regime. The regime is important, even predominant, in determining the properties of inflation. These properties in turn affect the strength of the Fisher effect. For long-term rates, the degree to which a regime results in stable long-term inflation expectations is its crucial aspect. The paper considers a sample period of 175 years. This allows for a comparison of several distinct regimes. The focus on the Fisher effect in relation to long-term rates, while not unique to this study, is a less frequent one relative to a focus on short-term rates. Our sample period, which runs to the end of 2018, enables us to consider a long period of inflation targeting. We can also examine whether events of the past decade, the financial crisis, severe recession and then the BREXIT referendum, show signs of weakening the credibility of inflation targeting in the United Kingdom.

The paper is organized as follows. Section 2 delineates the regimes that will be examined and describes the data to be used. This section also includes summary statistics, correlations between the series, and an examination of their time-series properties. Section 3 reviews previous studies of the regime shifts we examine and their implications for inflation expectations. Sections 4 details the procedures that will be used to examine evidence on the Fisher effect in each regime. Section 4 also provides a framework within which the Fisher effect for long-term bonds is interpreted. Sections 5–8 then examine evidence on the Fisher effect in each regime. Section 9 concludes.

II. Monetary regimes and preliminary data analysis

Four regimes are examined: Classical Gold Standard (1844:1–1913:12); Interwar Years (1919:1–1939:8); Policy by Discretion (1952:1–1992:9), and Inflation Targeting (1992:10–2018:12).

Data

The data are monthly, beginning in January 1844 with the passage of the Bank (or Peel) Act. The long-term interest rate is the average of daily yields over the

Table 1. Descriptive statistics[a].

	Full Sample	Gold Standard	Inter-War Years	Bretton Woods	Discretion Period	Inflation Targeting to 2008	Inflation Targeting to 2018
Long-term Interest Rate							
Mean	5.17	3.18	4.88	6.35	8.95	5.85	4.48
Maximum	16.34	4.13	6.72	9.78	16.34	8.90	8.90
Minimum	2.61	2.61	3.20	4.30	4.30	4.08	0.74
Std. Dev.	2.87	0.25	0.85	1.33	3.15	1.45	2.13
Variance	8.23	0.06	0.73	1.78	9.94	2.10	4.52
CPI Inflation							
Mean	4.58		−1.02	4.29	7.01	2.78	2.60
Maximum	26.87		22.36	12.98	26.87	5.04	5.59
Minimum	−27.70		−27.70	−0.82	−0.82	0.71	−1.56
Std. Dev.	6.83		7.48	2.55	5.31	0.91	1.37
Variance	46.66		55.99	6.48	28.16	0.82	1.88
WPI Inflation							
Mean	2.84	0.27	−2.74	3.04	6.20	1.93	1.58
Maximum	44.15	23.21	44.15	11.63	27.54	10.01	10.01
Minimum	−42.31	−22.89	−42.31	−2.12	−2.12	−1.45	−2.57
Std. Dev.	8.98	6.37	13.31	2.51	5.88	1.89	2.04
Variance	80.71	40.56	177.15	6.30	34.55	3.57	4.15

[a]Interest rates are annualized monthly interest rates (percent); CPI and WPI inflation are monthly year-over-year percentage rates of the corresponding price index. Full Sample: 1844:1–2018:12; Gold Standard: 1844:01–1913:12; Inter-War Years: 1919:01–1939:08; Bretton Woods: 1952: 01–1973:02; Discretion Period: 1952: 01–1992:09; Inflation Targeting (to 2008): 1992:10–2008:12; Inflation Targeting (to 2018): 1992:10–2018:12.

month on Consols until 1957 and the 10-year government security rate thereafter. Inflation is measured by the consumer price index (CPI) or wholesale price index (WPI). Monthly observations of the CPI are available only beginning in July 1915. Two other series are employed. These include Bank Rate or after 1972 other Bank of England policy rates and bullion holdings of the Bank of England during the Classical Gold Standard era. Data sources and definitions are provided in Appendix A.

Summary statistics

Table 1 shows means, standard deviations and variances for the main variables in the study: the long-term interest rate, as well WPI and CPI inflation rates for each of the four monetary regimes. As an additional measure of variability, the table shows the maximum and minimum values of each of these variables. Our study extends through 2018 but here the discussion pertains only to the inflation targeting (IT) regime up to the end of 2008 when the height of the financial crisis was reached. At a later point, we extend that sub-period to the post-crisis years.[1]

For the (nominal) long-term interest rate, the mean and standard deviation were highest in the regime of policy by discretion. The rate was lowest and most stable in the Classical Gold Standard era. The move to inflation targeting in 1992 reduced the mean and standard deviation, but both were still well above the levels for the Gold Standard years.

For inflation, we can make comparisons over all four regimes only for the WPI measure. By this measure average inflation in the Gold Standard era was near zero (0.27% per year) and negative in the interwar period (−2.74% per year). Inflation was highest in the period of policy by discretion (6.2% per year). Annual WPI inflation fell to 1.93% after the introduction of inflation targeting (1992–2008). The behaviour of the level of CPI inflation across the three periods for which we have monthly data followed the same pattern as WPI inflation: negative in the interwar period, highest in the period of discretionary policy, then falling with the introduction of inflation targeting.

The pattern for the variability of inflation is different. As measured by standard deviation, for both WPI and CPI inflation variability was lowest for the inflation targeting period and highest in the interwar period with variability in the period of policy by discretion falling in between. A comparison with the Gold Standard period can be made only for WPI inflation. By that measure, inflation variability under the Gold Standard was higher than in either of the post-World War II sub-periods but lower than in the interwar years.[2]

Table 2. Correlation coefficients.

-	Long Rate	WPI Inflation	CPI Inflation
		Full Sample	
Long-Term Rate	1.00	0.28***	0.46***
WPI Inflation		1.00	0.78***
CPI Inflation			1.00
		Gold Standard	
Long-Term Rate	1.00	0.03	
WPI Inflation		1.00	
		Inter War Years	
Long-Term Rate	1.00	−0.23***	−0.07
WPI Inflation		1.00	0.61***
CPI Inflation			1.00
		Bretton Woods	
Long-Term Rate	1.00	0.61***	0.44***
WPI Inflation		1.00	0.76***
CPI Inflation			1.00
		Discretion Period	
Long-Term Rate	1.00	0.76***	0.72***
WPI Inflation		1.00	0.92***
CPI Inflation			1.00
		Inflation Targeting Period to 2008	
Long-Term Rate	1.00	0.29***	−0.11
WPI Inflation		1.00	0.41***
CPI Inflation			1.00
		Inflation Targeting Period to 2018	
Long-Term Rate	1.00	0.39***	0.16***
WPI Inflation		1.00	0.61***
CPI Inflation			1.00

Note: *** indicates significance at the 1% level.

Correlation coefficients

Table 2 shows simple correlation coefficients between the long-term interest rate and monthly inflation rates. The correlation coefficient between the WPI inflation rate and the long-term interest rate is low and negative for sub-periods prior to World War II (−0.05 for the Gold Standard and −0.23 for the

[1]For the purposes of later discussion, tables include measures for the longer inflation targeting period and for a sub-period during which the Bretton Woods system was in effect (1952:1–1973:2).

[2]The focus of this paper is the relationship among the monetary regime, long-term inflation expectations, and the long-term interest rate. The monetary regime is an element of the economic structure. The behaviour of inflation and the interest rate depend on this structure as well as on the shocks that hit the economy. Thus, the price level targeting regime during the Gold Standard years may have led to higher inflation variance than inflation targeting in recent years. Greater variance of shocks hitting the economy as well as regime changes in the Interwar Years likely resulted in especially high variance in inflation and long-term interest rates in that period. A detailed consideration of these and other broader economic forces is beyond the scope of our investigation.

Interwar years), high and positive for the postwar period of policy by discretion (0.76) and positive but lower for the pre-crisis inflation targeting period (0.29). The Wald test indicates that these differences are statistically significant (10% level) when comparing the discretionary period to either of the pre-World War II regimes and when comparing the discretionary regime to the inflation targeting regime.

Because monthly CPI data are unavailable for the Classical Gold Standard regime, we cannot compare correlation coefficients between the long-term interest rates across all sub-periods for this inflation measure. For the other sub-periods, these correlation coefficients are given in the right-most column of Table 2. The correlation coefficient between the CPI rate of inflation and long-term interest rate is 0.72 for the period of policy by discretion compared to −0.07 for the interwar years and to −0.11 for the IT period (1992–2008). The differences between the correlation coefficient for the period of policy by discretion and each of the other post-World War I time periods are significant at the 10% level.

Time-series properties of the data

Table 3 shows the results of tests for unit roots in the data series using the Augmented Dicky-Fuller (ADF) procedure. The test is run in levels and first differences. For all series and samples, the tests show no evidence of unit roots in first differences, so the discussion refers to tests in levels. A 10% level of significance is used to test whether a unit root can be rejected.

For the long-term interest rate, a unit root cannot be rejected for any of the time periods considered. For inflation, data for only the WPI are available in the Classical Gold Standard years and the test rejects the presence of a unit root. For the post-World War II regimes where a unit root is not rejected in either inflation or the long-term interest rate, an Engle–Granger test for cointegration between the two series is conducted. The Engle–Granger specification estimates and implications for possible co-integration are reported in Table 4. The test indicates the presence of co-integration (significance level 5%) between the long-term rate and each of the inflation series for the period of policy by discretion (1952:1–1992:09) but not for the inflation targeting regime (1992:10–2008:12). For the Interwar years (1919:1–1939:8), as

Table 3. Dicky-fuller unit root tests.

		Full Sample		Gold Standard		Inter War Years		Discretion Period		IT Period to 2008		IT Period to 2018	
		Level	First Diff.	Level	Difference	Level	Difference	Level	Difference	Level	Difference	Level	First Diff
Long-Term Rate	Constant	−1.71	−31.39***	0.10	−11.62***	−0.94	−14.42***	−1.79	−15.32***	−2.14	−10.04***	−1.63	−8.54***
	Constant & Trend	−1.45	−31.34***	0.00	−11.73***	−2.01	−14.39***	−1.92	−15.33***	−2.62	−9.59***	−3.91**	−8.53***
CPI Inflation	Constant	−4.22***	−10.62***			−2.91	−5.50***	−2.21	−6.43***	−2.92**	−11.80***	−3.31**	−11.80***
	Constant & Trend	−4.31***	−10.63***			−2.89	−5.56***	−2.36	−6.43***	−3.47**	−11.85***	−3.33**	−11.85***
WPI Inflation	Constant	−4.91***	−14.56***	−5.24***	−11.57***	−2.98	−6.15***	−2.08	−8.89***	−0.48	−9.03***	−0.48	−9.03***
	Constant & Trend	−5.10***	−14.55***	−5.24***	−11.57***	−3.02	−6.15***	−2.21	−8.84***	−0.28	−9.23***	−0.28	−9.23***

Note: ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

Table 4. Fisher equation: Engle–Granger test[a].

	Constant	WPI Inflation	Engle-Granger Test
1919:1–1939:8	4.84	−0.02	Not Applicable
1952:1–1973:2	5.36	0.32	Co-integrated.
1952:1–1992:9	6.82	0.50	Co-integrated
1992:10–2008:12	5.95	0.25	Not Co-integrated
1992:1–2018:12	3.84	0.41	Not Co-integrated
-	Constant	CPI Inflation	-
1919 1:1939:8	4.88	0.05	Not Co-integrated
1952:1–1973:2	5.09	0.23	Not Co-integrated
1952:1–1992:9	5.70	0.47	Co-integrated
1992:10–2008:12	6.30	−0.16	Not Co-integrated
1992:10–2018:12	3.85	0.24	Not Co-integrated

[a]Engle–Granger Test: After testing for unit roots in the series for the interest rate and inflation rates with Augmented Dickey–Fuller (ADF) tests, we regress the interest rate on the WPI or CPI inflation rate and collect the residual terms. If any of the series the ADF test rejected the null of a unit root, we state 'Not Applicable'. To test for co-integration, the ADF test on the series of residual terms is performed; rejection of a unit root indicates the presence of co-integration.

noted, a unit root is not rejected for the long-term interest rate series. For the WPI and CPI inflation series, a unit root is rejected only if a trend term is excluded. The Engle–Granger test, conducted based on the assumption that inflation is in fact nonstationary, does not indicate the presence of co-integration.

III. Related literature

Our review concentrates on two issues. The first is one examined by Barsky (1987): how do the persistence and predictability of inflation affect the strength of the Fisher effect? The second concerns the role of the monetary policy regime in anchoring long-term inflation expectations.

Inflation persistence and the Fisher effect

Barsky (1987) argued that the appearance in the United States of a Fisher effect after 1960 reflected the evolution of inflation 'from essentially a white-noise process in pre-World War I years to a highly persistent, non-stationary ARIMA process in the post-1960 period (p.3).' Because market participants were unable to forecast changes in inflation in the pre-World War I era, there was no scope for an *ex ante* Fisher effect or for market mechanisms that would create an ex *post* inflation premium in nominal interest rates. Barsky documents the lack of persistence and predictability of inflation during the pre-World War I period in the United States. Barsky also finds a shift in the correlation coefficient between the short-term nominal interest rate and inflation rate in the United States from −0.17 for 1860–1939 to 0.71 for the period from 1950 to 1979. This is consistent with the pattern of correlation coefficients between the long-term interest rate and inflation in Table 2 for the United Kingdom.

Mishkin (1992) exploits an implication of the time-series properties of inflation (π) and the nominal interest rate (i) for the existence of the *long-run* Fisher effect. If we assume that the real interest rate (i-π) is stationary, then if either *i* or π is I(1), both should be I(1) and they should be co-integrated. The co-integration interpretation of the Fisher effect is one of the long-run relationship between stochastic trends in the two series. If, alternatively, the nominal interest rate is I(1) but inflation is stationary, there can be no long-run Fisher effect. Mishkin studies the relationship in the United States between short-term interest rates and inflation for 1953–90. He finds evidence of a long-run Fisher effect for some parts of the period but not for others.

A nominal anchor in alternative monetary regimes

If a monetary regime provides a nominal anchor for the rate of inflation, agents' expectations should adjust accordingly. With stable expectations of long-run inflation, the nominal interest rate on long-term bonds, if it depends on expected future short-term rates, should not react strongly to shocks in the inflation process. The statistics reported in Section 2 provide preliminary evidence on this issue. For further evidence, we examine several studies of inflation variability and uncertainty in the United Kingdom. These studies use a variety of statistical procedures to test for structural breaks and time variation in the inflation process. They do not impose break points at dates of regime shifts as we do.

Benati (2004) tests for structural breaks in three measures of U.K. inflation. He then uses band pass filtering techniques to study changes the amplitude of fluctuations in these series across sub-periods.[3] His study employs quarterly data from 1955 to 2003. Benati finds a significant breakpoint in the early 1990s that coincides with the beginning of

[3]Benati (2008) documents lower persistence of inflation in the U.K. under the Classical Gold Standard.

inflation targeting. The volatility of inflation post-1992 is lower than for other sub-periods defined at breakpoints. Another breakpoint appears to occur coinciding with the end of the Bretton Woods regime. The period which followed (1973–1992) was for the aggregates that Benati considered the most unstable in the post-World War II period.

Cogley, Sargent, and Surico (2015) study price level and inflation uncertainty and instability in the United Kingdom extending back to the late 18th century. They employ an unobserved component stochastic-volatility model to study inflation uncertainty and instability over various multi-year horizons. Comparing pre-World War I with the post-World War II years, they find that 'transient inflation volatility seems to have fallen while persistent inflation variation seems to have increased (p.1)' They find a peak in inflation volatility in the mid-1970s and a decline following the introduction of inflation targeting and granting of independence to the Bank of England in the 1990s. The increase in inflation volatility in the 1970s relative to the 1950s and 1960s suggests an effect from the Bretton Woods system that is consistent with the finding of Benati (2004).

IV. The Fisher effect in alternative monetary regimes

In Sections 5–8, we assess evidence on the Fisher effect in four monetary regimes. For each regime, we describe the policy framework of the Bank of England. We relate this framework to the time-

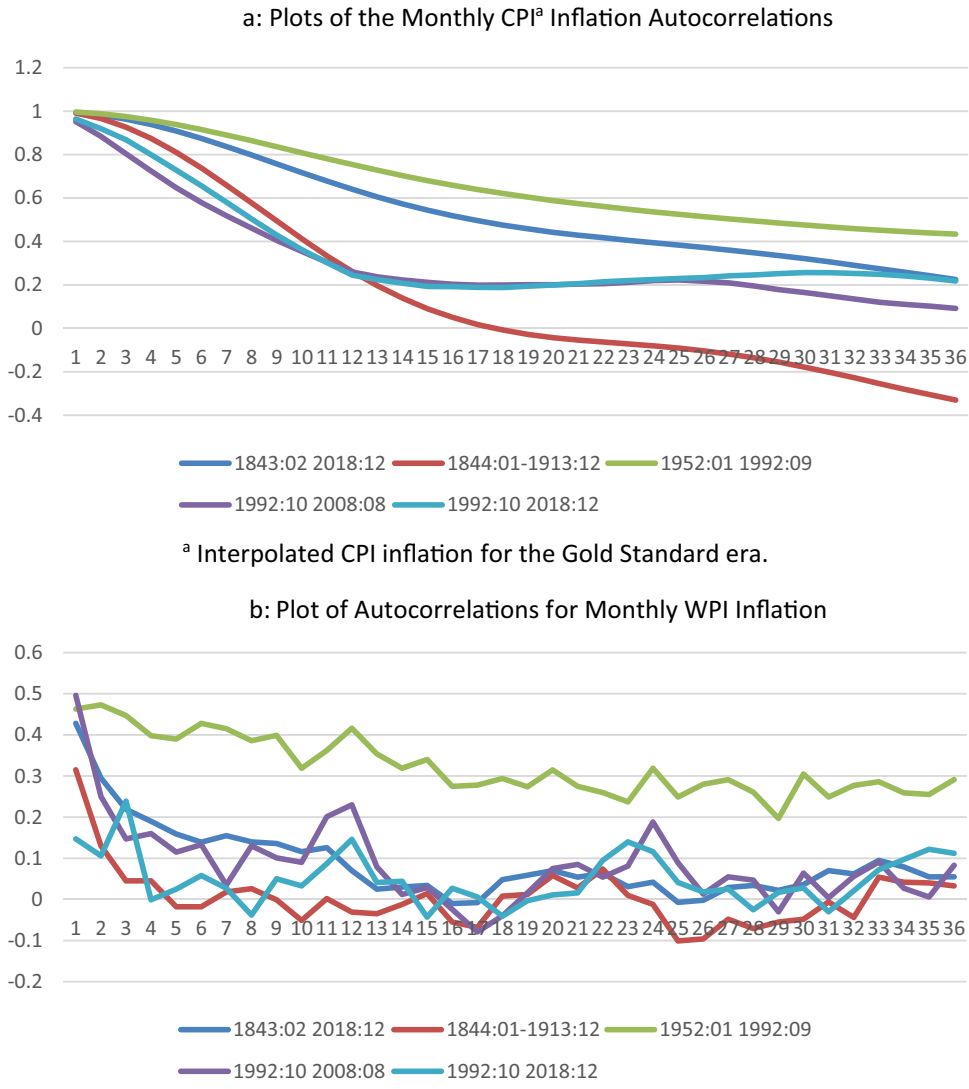

Figure 1. (a) Plots of the monthly CPI[a] inflation autocorrelations, (b) Plot of autocorrelations for monthly WPI inflation. [a] Interpolated CPI inflation for the gold standard era.

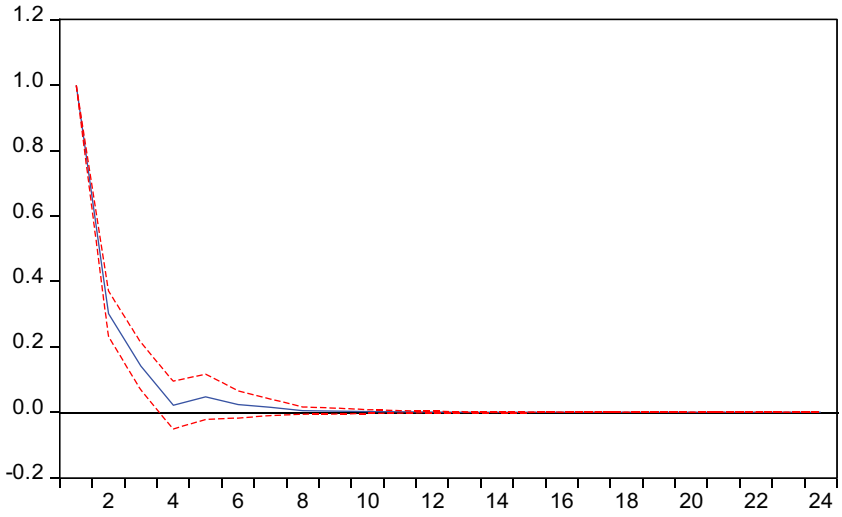

Figure 2. Response of CPI inflation: gold standard. Note. The lag order of three is chosen with the Bayesian information criteria. Eleven monthly dummies are included to account for seasonality. The middle line is for the impulse responses and the dotted red lines for the two-standard-deviation confidence bands.

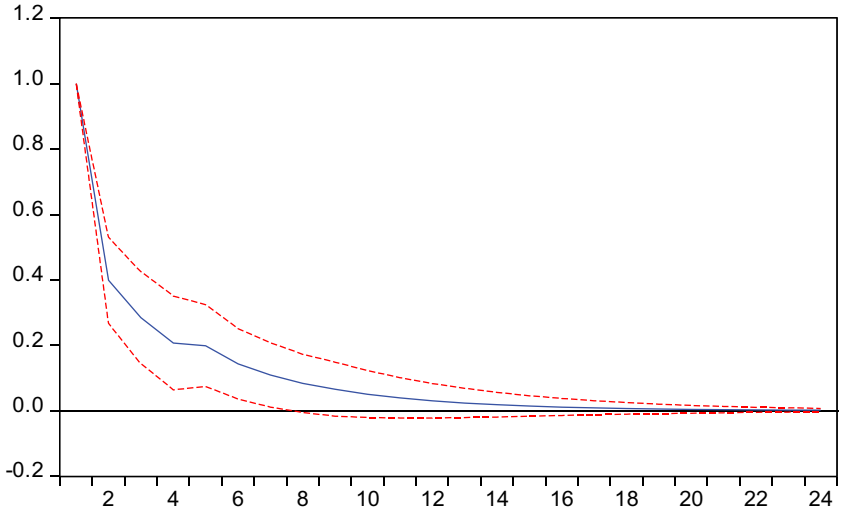

Figure 3. Response of CPI inflation: inter-war period.

series properties of the data. We also explore the autocorrelation patterns of inflation in each regime in our sample (Figure 1a and Figure 1b) and present impulse response functions to illustrate these properties (Figure 2–6). Then, we estimate regressions of the type used by Barsky (1987) for the United States to see how predictable inflation was on the basis of lagged inflation and additional variables (Table 5). Next, we consider regression estimates that measure the association between nominal long rates and leads and lags in inflation (Table 6).

Before proceeding to the examination of each regime we consider a formulation, based on Walsh (2003), of the long-term interest rate under the expectation hypothesis:

$$(1)\quad i_{n,t} = 1/n\ \Sigma_i E_t r_{t+i} + 1/n\ E_t \pi^*_{t+n} + k_{n,t}$$

where $i_{n,t}$ is the nominal interest rate on an n-period bond at time t; r_{t+i} is the one-period real interest rate at t + i; $E_t\pi^*_{t+n} = E_t p_{t+n} - p_t$, where p is the log of the price level and $k_{n,t}$ is a time varying term premium for an n-period bond.

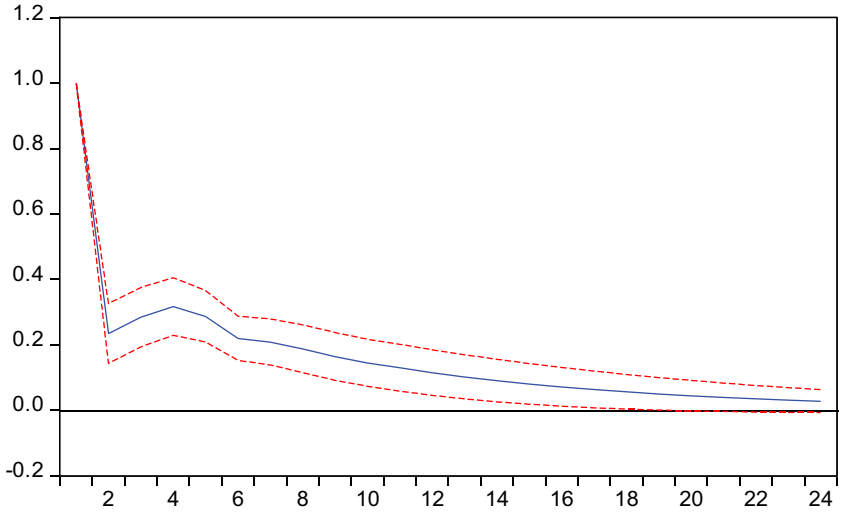

Figure 4. Response of CPI inflation: discretion period.

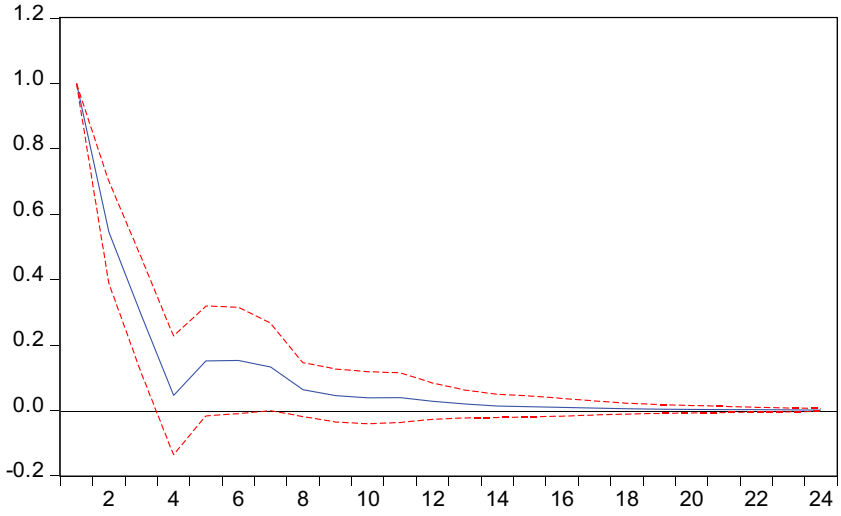

Figure 5. Response of CPI inflation: inflation targeting period to 2008.

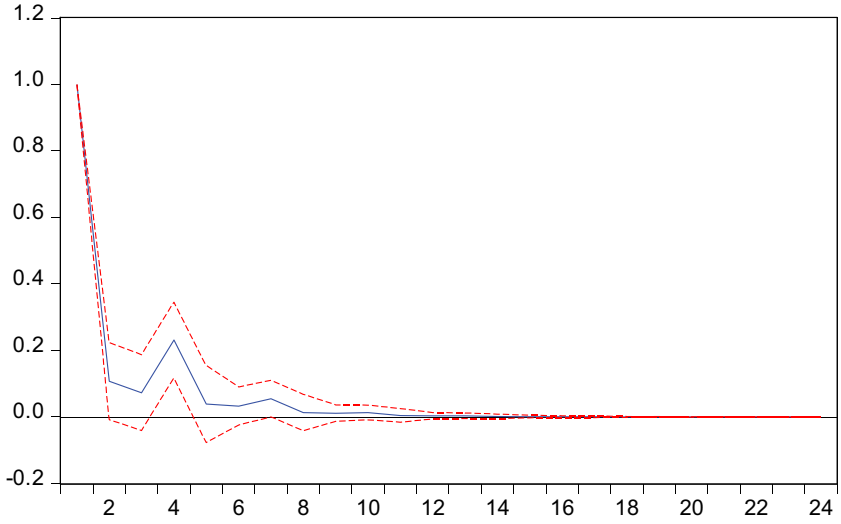

Figure 6. Response of CPI inflation: inflation targeting period to 2018.

Table 5. Predictability of monthly inflation rates.

	R^2: Seasonal Dummies Only	Lag Length[a]	$R^{2:}$ Lagged Inflation & Bank Rate	Test statistics for $Ho: \beta_1 = .. = \beta_p = \theta = 0$	Test statistics for $Ho: \beta_1 = .. = \beta_p = \theta = \delta = 0$	
			Panel A: WPI Inflation			
1844:01 1913:12	0.029	1	0.140	58.88***[b]	0.253	82.55***
1919:01 1939:08	0.030	12	0.354	8.59***		
1952:01 1992:09	0.058	7	0.441	40.11***		
1992:10 2008:08	0.157	11	0.485	8.88***		
1992:10 2018:12	0.105	3	0.172	6.11***		
			Panel B: CPI Inflation			
1919:01 1939:08	0.307	2	0.466	23.11***		
1952:01 1992:09	0.236	12	0.541	23.82***		
1992:10 2008:08	0.704	1	0.708	1.37		
1992:10 2018:12	0.577	1	0.634	23.61***		

E" [a]" The lag length is determined by the Final Prediction Error criteria. Estimation is by OLS [b] *** indicates statistical significance at 1% level.

$$\pi_t = a_0 + \sum_{j=1}^{11} a_j dj_t + \sum_{j=1}^{p} \beta_j \pi_{t-j} + \theta\, r_t + \delta\, Bullion_t + \varepsilon_t$$

Table 6. Regressions of long rates on rates of inflation.

	WPI Inflation				CPI Inflation			
	Constant	Past. Inf.[a]	Fut. Inf.[b]	R^2	Constant	Past. Inf.[a]	Fut. Inf.[b]	R^2
Full Sample	4.67	0.08	0.06	0.13	5.54	0.14	0.11	0.26
1844:1–2018:12	(31.42)[c]	(3.66)	(3.29)		(17.84)	(4.27)	(4.23)	
Gold Standard	3.18	0.00	0.00	0.01				
1844:1–1913:12	(143.73)	(0.44)	(−1.24)					
Inter War	4.79	−0.02	−0.03	0.31	4.84	−0.01	−0.05	0.19
1919:1–1939:8	(41.99)	(−2.24)	(−3.65)		(40.01)	(−0.46)	(−7.61)	
Discretion	6.18	0.31	0.14	0.61	5.62	0.30	0.18	0.57
1952:1–1992:9	(21.29)	(6.29)	(3.47)		(16.15)	(4.62)	(3.58)	
Bretton Woods	4.98	0.19	0.24	0.55	4.66	0.10	0.29	0.45
1952:1–1973:3	(33.07)	(3.82)	(4.62)		(18.82)	(1.43)	(5.40)	
IT to 2008	5.31	0.22	0.07	0.10	6.14	−0.16	0.06	0.01
1992:10–2008:12	(21.27)	(1.56)	(0.60)		(13.46)	(−0.84)	(0.14)	
IT to 2018	3.73	0.30	0.24	0.18	3.53	0.21	0.20	0.04
1992:10–2018:12	(24.67)	(2.74)	(2.23)		(5.38)	(1.30)	(1.52)	
IT 2009:1–2018:12	2.09	0.23	0.15	0.45	1.84	0.17	0.10	0.14
	(12.60)	(2.71)	(1.88)		(6.35)	(1.44)	(1.01)	

[a]Percentage changes of the current price level from its 12-month lagged value. [b] Percentage changes in the 12-period ahead price level from its current value. [c] The *t*-statistics are reported in parentheses. Estimates are by OLS (Newey–West robust standard errors).

Equation (1) breaks the nominal rate of an n-period bond into a real component equal to the average of expected one-period real interest rates over the term to maturity of the bond; a term that reflects expected inflation; and a time varying term premium. The relevant expectation of inflation is the expected average inflation rate over the term to maturity of the bond.

It is the second term in equation (1) that we expect to depend on the monetary regime. Consider three alternative monetary regimes:

(A) The Classical Gold Standard: For the 70 years of our sample, when the Classical Gold Standard was in effect, the average annual rate of inflation was 0.27%. Therefore, the second term in equation 1, the expected average inflation rate over the term to maturity of a long-term bond, should be low and subject to little variation. Movements in the nominal long-term rate would be dominated by variations in expected future real rates.

(B) Inflation Targeting: With a credible target rate for inflation, the second term in equation 1 should be approximately equal to the target rate. With a highly credible regime, it should be the case that the behaviour of the nominal long-term rate would be determined by the behaviour of expected future real rates.

(C) Policy under Discretion: Under discretion the policymaker optimizes each period without a commitment for future periods. There is no formal nominal anchor to condition long-term inflation expectations. With policy by

discretion, changes in the second term in equation 1, changes in the expected average rate of inflation, may explain much of the variation in the nominal long-term interest rate

V. The classical gold standard (1844:01-1913:12)

The Classical Gold Standard regime we consider extends from the passage of the Bank Act of 1844 to the end of 1913 shortly before the beginning of World War I. The Bank Act was the culmination of a controversy between the Currency and the Banking Schools. It reflected the victory of the Currency School adherents, who believed that control of the note issue was crucial to a smoothly functioning Gold Standard. Accordingly, the Bank Act specified that above the statutory limit, notes issued by the Bank of England had to be backed 100% by gold bullion. The Bank's policy instrument was its discount rate termed Bank Rate.

A rise in inflation would lead to a fall in the Bullion Reserve as gold was lost to the 'internal drain', meaning it went to increase the public's currency demand. An 'external drain' would also reduce the bullion reserve if the balance of trade deteriorated. The decline in the Bullion Reserve would lead the Bank of England to increase Bank Rate. This process is the 'monetary limit' referred to by Hawtrey (1938). Bank of England policy under the Classical Gold Standard resulted in substantial variations in Bank Rate. There was also substantial short-term volatility in inflation, as can be seen from Table 1. Over longer periods, however, the price level was stable. Market participants came to expect stable prices in the long run. As can be seen Table 2 and Table 4, the yield on Consols shows no indication of a correlation with the WPI inflation rate.

The estimates in Table 5 indicate low predictability of the monthly inflation rate based on past inflation or the other variables included in our regressions. In the regression of the WPI inflation rate on past inflation and the current Bank Rate, with lag lengths chosen optimally using the FPE criterion, the adjusted R^2 is 0.140.[4] Inclusion of the Gold Bullion Reserve raises R^2 to 0.253 indicating some anticipation of the effect of the 'monetary limit'. The autocorrelations (Figure 1a and Figure 1b) and the impulse response (Figure 2) for the Classical Gold Standard years indicate that the effects of shocks on inflation die out more quickly than in the other regimes we consider.[5]

The Classical Gold Standard and the associated policy framework under the Bank Act appear to have produced an environment in which long-run inflation expectations were anchored near zero. Thus, we would not expect there to be a Fisher effect on a long-term bond. When we look at the estimate in Table 6 (Row 2), the coefficient on either past or future inflation measures is near zero (−0.004 for 12-month inflation led 1 year and 0.001 for 12-month inflation lagged 1 year).[6]

VI. The interwar years (1919:1-1939:8)

The United Kingdom went off the Gold Standard in April 1919, returned to it in April 1925, then left in September 1931. From 1931 to 1939, sterling floated though it was a managed float. It was managed through an Exchange Equalization Fund (See Harrod 1969; pp.105–22). In addition to regime shifts, there were other factors that made these years ones of high economic uncertainty. The situation was not helped by erratic policy moves: After leaving the Gold Standard, Bank Rate was raised to 6% in October 1931 to prevent inflation. That commented Hawtrey (1938, 145) 'was to cry Fire, Fire in Noah's flood.' Bank Rate was then lowered to 2% by July of 1932.

The descriptive statistics in Table 1 indicate that the nominal long-term interest rate was higher on average in the interwar period relative to pre-1914 (4.88% versus 3.18%). Because average inflation was negative during the interwar years versus slightly positive in the Gold Standard years, the increase in the real rate between the two periods was greater. There was also more volatility in the long-term rate. The standard deviation of the nominal rate was more than three

[4]The regressions for the Gold Standard years and for other time periods include 11 seasonal dummies.
[5]Details for the impulse responses in Figure 2–6 are provided in Figure 2.
[6]For this estimate to be consistent requires that the long-term interest rate be stationary given the rejection of a unit root for inflation.

times greater in the interwar period than under the Gold Standard.

Looking at the inflation series, the average annual inflation over the period was −2.74% for the WPI and −1.02% for the CPI. Measured by the WPI, inflation was more variable in the interwar period relative to the Gold Standard years; the standard deviation of the monthly inflation rate was more than twice as high (13.31 compared to 6.37).

The R^2s for the inflation prediction regressions in Table 5 are higher for the interwar period than for the Classical Gold Standard years. With lagged values of inflation and Bank Rate in the WPI regression, the R^2 for the interwar period is 0.354 compared with 0.140 under the Classical Gold Standard. It is also the case that a unit root in either the CPI or WPI series can be rejected only by the Augmented Dicky-Fuller test for the case where a trend is not included. There is a clear rejection for the Classical Gold Standard period. Finally, the impulse response function for the interwar period (Figure 3) indicates more persistence for an inflation shock than for the Classical Gold Standard period.

Thus, there are indications that inflation was not just a white noise process and therefore unpredictable. Moreover, monetary arrangements during the interwar years appear unlikely to have provided stable long-run inflation expectations. Still, there is no more evidence of a Fisher effect in the interwar period than under the Classical Gold Standard. The correlation coefficients between the long-run interest rate and inflation rate are −0.07 for the CPI measure and − 0.23 for the WPI measure. The regressions in Table 6, in which the regressors have year-over-year inflation rates for the WPI and CPI (with one lead and one lag), also show negative coefficients. Finally, we do not find evidence of co-integration based on the Engle-Granger test (Table 4).

A possible reason for the absence of a Fisher effect in the interwar years is that the inflation rate was near or below zero for most of the period. Moreover, the Bank of England never lowered Bank Rate below 2%.[7] Thus, there was an effective lower bound on the nominal long-term rate of 2% plus a term premium. If the inflation rate fell when the long-term rate was at the bound it would have no effect. If the inflation rate rose, it would also have no effect until the lower bound ceased to bind.

VII. Policy by discretion (1952:1 1992:9)

In his examination of the yield on British Consols, Hicks (1967; Chapter 5) sought to explain the then historically high yield of 6.5% in 1966. This brought him to the Bank of England policy: 'One may doubt whether the authorities would be willing to risk the unemployment, and other misfortunes, which might well attend any attempt to stop inflation altogether by the really sharp application of a monetary brake.' Market participants would need to assess the 'hawkishness' of the current Bank of England regime. During the first three decades (1952–79) of this regime Keynesian principles prevailed. In his *Treatise on Money (1930, p.234)*, Keynes had written that one would not 'expect that the rules of wise behaviour by a central bank could be conveniently laid down . . . by act of Parliament.' The post-1979 years were heavily influenced by Margaret Thatcher's version of 'monetarism.' But Thatcher also leaned towards discretion.[8]

With policy under discretion, there is no nominal anchor for long-term inflation expectations. Thus, we expect that the long-term interest rates will be most sensitive to movements in the inflation rate in this regime. In terms of equation 1 in Section 4, it is in this regime that short-run changes in inflation are likely to affect the second term–the expectation of long-run average inflation. During the years when the Bretton Woods system was in effect, Balance of Payments constraints limited the scope of discretionary policy. To assess the effect of this constraint, we will examine a sub-period from 1952:1 to 1973:2.

[7]The lower bound for Bank Rate originated in the late 1840s when the Bank of England concluded that overly competitive discounting had contributed to financial instability. See Clapham (1944; p.217).

[8]In the early years of the Thatcher era, policy was guided by the Medium-Term Financial Strategy. But rules were overridden in the recession of 1980–81. As Minford (1993) characterizes it, the view of the Thatcher administration was a 'combination of enthusiasm for rules with a reluctance to abandon discretionary response (p.418).'

Evidence on the Fisher effect (1952:1-1992:9)

To begin, we examine the period 1952:1–1992:9. Table 1 shows that the average long-term nominal interest rate for this period was higher than in any of the other periods (8.95% compared, for example, to 3.18% under the Classical Gold Standard). The long-term rate was also more variable; the standard deviation (3.15%) was more than 10 times greater than under the Classical Gold Standard.

Average inflation as measured by either the CPI or WPI was higher in this sub-period than in any other in our sample (7.01% for the CPI measure and 6.2% for the WPI). The standard deviation was lower than for the Gold Standard and Interwar periods though higher than for the inflation targeting regime. The standard deviation, however, reflects monthly variations in inflation. The studies in Section 3 support the finding that such transient volatility in inflation may well have been higher during the pre-1914 years than in the post-World War II period. The same studies, however, indicate the persistent inflation volatility was lower pre-1914 as well as post-1992 compared to 1952–1992. Persistent volatility is important to the formation of long-term inflation expectations.

Looking at the regressions measuring the predictability of WPI inflation (Table 5), the R^2 is higher in this period than in the two pre-World War II sub-periods. For regressions with lagged values of inflation and the current monetary policy rate, the R^2 for the 1952–1992 sample period is 0.44 compared to 0.14 for the Classical Gold Standard regime and 0.35 for the interwar years. The auto-correlations in Figure 1 for this period show more persistence than in any other regimes. This is also true of the impulse response function in Figure 4.

Table 6 shows the regressions of the nominal long-term interest rate on a 12-month lead and a 12-month lag of inflation. The R^2 s for these equations 0.61 and 0.57 for the WPI and CPI inflation measures, respectively, are more than twice the value for any of the other regimes. The values of the coefficients in the regressions are statistically significant and large enough to indicate an economically significant Fisher effect. Further evidence of a Fisher effect comes from the test for cointegration in Table 4. A unit root is not rejected for the long-term nominal interest rate or for either inflation measure for the 1952:1–1992:9. The Engle–Granger test indicates the presence of a co-integrating relationship between the nominal interest rate and each of the measures of inflation.

The Bretton Woods years (1952:1-1973:2)

While the Bretton Woods system was in effect, U. K. macroeconomic policy was subject to a Balance of Payments constraint. This resulted in a 'stop-go' character for policy actions from the late 1950s through the early 1970s. An expansionary policy programme, for example, led to current account deficits due to higher incomes and inflation. Foreign exchange reserves would fall and runs on sterling often resulted. Policy would shift to austerity. The implication of this 'stop-go' pattern for a Fisher effect on the *long-term* bond yield is that a rise, for example, in inflation would be less likely to persist than in the flexible exchange rate era. When the Bretton Woods (1952:-1–1973:2) period is broken out in Table 1,Table 2, Table 4 and Table 6, the results are consistent with inflation being less persistent and with a weaker relationship between inflation and the long-term bond yield than for 1952–1992.

From the descriptive statistics presented in Table 1, it is apparent that the inflation rate was lower and less variable in the Bretton Woods portion of the years of policy by discretion. In Table 2, the correlation coefficients between inflation and the long-term bond yield are lower for this sub-period. The regressions of the long-term rate on 12-month leads and lags of inflation in Table 6 show weaker evidence of a Fisher Effect. The Engle–Granger test results in Table 4 indicate the presence of a co-integrating relationship between inflation and the long-term rate for the WPI inflation rate, but not for CPI inflation in the Bretton Woods years. In contrast, a co-integrating relationship is indicated for both inflation measures for 1952–1992. The Bretton Woods system appears to have provided a nominal anchor that to a degree limited the Fisher effect.

VIII. Inflation targeting (1992:9-2018:12)

The beginning of inflation targeting in the United Kingdom was announced in a speech in October 1992 by Chancellor Norman Lamont. To this

point, we have truncated this regime at the height of the financial crisis at the end of 2008. Here, we also consider an extended period (1992–2018). By extending the IT period we can examine whether post-crisis events weakened the credibility of inflation targeting.

Inflation targeting (1992:9-2008:12)

The summary statistics in Table 1 indicate that during the pre-crisis inflation targeting (IT) period the long-term interest rate was lower and less volatile than during the regime of policy by discretion. Both the CPI and WPI measures of inflation were also substantially lower and less volatile. Compared to the pre-1914 Gold Standard regime, mean WPI inflation was higher but less volatile.

Turning to measures of persistence and predictability, in Figure 1 and Figure 5, the autocorrelations and impulse response function for the IT period for WPI and CPI inflation drop off more quickly than for the period of discretionary policy. Their pattern is closer to those of the Classical Gold Standard and Interwar periods. The regressions in Table 5 to assess the predictability of inflation on the basis of lagged values of inflation and the current monetary policy rate indicate that by this measure both WPI and CPI inflation were more predictable in the IT period than in the years of policy by discretion (R^2s of 0.485 and 0.708 for WPI and CPI, respectively). For the CPI measure, which is the inflation target, it is the case, however, that most of the explanatory power of the regression stems from the included seasonal dummies. An F-test for the effect of adding lagged inflation and the policy rate does not show statistical significance. For the WPI inflation rate, the regression does indicate statistically significant predictive power for these variables.

Measures of the association between the long-term interest rate and inflation are shown in Tables 2 and Table 6. Measures using the WPI are useful because they permit direct comparison across all the regimes in our study. The IT regime is, however, one of CPI targeting. Whichever price index we consider, the IT regime shows less evidence consistent with a Fisher effect than for the discretionary period. The results for the CPI measure are quite close to the Gold Standard results – very little association between inflation and the long-term interest rate. The correlation coefficient between the long-term interest rate and CPI inflation rate for the IT period (Table 2) is −0.11 compared to 0.72 for the period of policy by discretion. For the WPI measure, the correlation coefficients are 0.29 versus 0.76. In each case, this difference is statistically significant at the 1% level. The regression of the long-term interest rate on leads and lags of CPI inflation in Table 6 has an R^2 of 0.01. For the WPI inflation rate, the R^2 is 0.10. The Chow test rejects equality of coefficients in each regression across the IT and Policy by Discretion periods decisively (p-value 0.0000). The Engle–Granger test (Table 4) does not indicate a cointegrating relationship between the long-term interest rate and either CPI or WPI inflation for the IT period.

Hawtrey (1938) cites the monetary limit as the brake on inflation under the Gold Standard. Our statistical analysis implies that inflation targeting in the United Kingdom was successful in providing an alternative anchor.

An extended IT period (1992:9-2018:12)

There are several reasons why events since 2008 might have affected the credibility of inflation targeting. The recession that accompanied the global financial crisis focused the attention of policymakers on output and employment. The BREXIT in June 2016 was clearly a cause of increased uncertainty about economic conditions including inflationary pressures.

As a first step in assessing whether events post-2008 have weakened the credibility of the IT regime, we examine whether the longer IT period is significantly different from the period of policy by discretion. Estimates for the longer IT period (1992:9–2018:12) appear in Table 1–6. We report results for both the WPI and CPI measures of inflation. As noted previously, however, because CPI inflation is the target in the United Kingdom, it is sensible to place more weight on that measure. In Table 1 it can be seen that CPI inflation is significantly lower on average and less volatile for (1992–2018) than for (1952–1992). The correlation between CPI inflation and the long-term interest rate shown in Table 2 is 0.16 for the longer IT period compared to 0.72 for (1952–92). In the regressions reported in Table 6 where the long-term interest rate is regressed on leads and lags of

inflation, the R^2 for the longer IT period is 0.04 compared to 0.57 for (1952–92). The Chow test decisively rejects the hypothesis of equality of the regression coefficients in the two periods (p-value 0.000).

The Augmented Dickey–Fuller tests reported in Table 3 reject the hypothesis of a unit root in the CPI inflation series and for the long-term interest rate when a trend is included. Thus, there is no evidence of stochastic trends in the series and therefore is no scope for a cointegration relationship between such trends. The impulse response function for this longer IT period shows a similar pattern to that for the IT period cut off in 2008. Both show the effects of an inflation shock dissipating more quickly than in the period of policy by discretion.

The summary statistics and estimates where inflation is measured by the WPI in Table 1–5 show the same pattern as those with the CPI as does the plot in Figure 1b. In Table 6, with inflation measured by the WPI, however, while the R^2 is considerably lower (0.18 compared to 0.61) for the 1992–2018 period compared to 1952–1992, the estimated coefficients indicate a significant Fisher effect of similar magnitude to the period of policy by discretion. The coefficients for the extended IT period (1992–2018) on the lead and lagged inflation rates are both significant and sum to 0.54. For the truncated IT period (1992–-2008), neither coefficient was significant. As noted previously, the IT regime was one of *CPI* targeting. Shocks to WPI inflation might not be expected to be offset by a policy response. Still, the increased response when the regime is extended may indicate less well-anchored inflation expectations.

To further evaluate the presence of a Fisher effect in the post-financial crisis period, we estimate separate regressions for the post-crisis sample period 2009:1–2018-12. These regression estimates are shown in the last row of Table 6. The estimated coefficients for each inflation measure have the same implications for the Fisher effect as those for 1992–2018: the lead and lag WPI inflation measures have a significant effect on the long-term rate; each of the coefficients in the CPI regression is insignificant.[9]

IX. Conclusion

In this study, we test for variations in the significance of the Fisher effect across four monetary regimes in the United Kingdom dating back to 1844. For the Classical Gold Standard era (1844:1–1913:12), we find no statistically significant evidence of a Fisher effect for the long-term interest rate. The Classical Gold Standard provided a very low average inflation rate. The inflation rate had low levels of persistence and predictability. Variations in the rate would be attributable to movements in expected future real interest rates. The Interwar years (1919:1–1939:8) also provide no statistical evidence of a Fisher effect. Our analysis indicated more persistence and predictability in the inflation process but that does not appear to have resulted in a closer relationship between inflation and the long-term interest rate.

It is under the regime we characterize as 'policy by discretion' (1952:1–1992:9) that we find robust evidence of a Fisher effect for the long-term interest rate. For each of the inflation measures we consider, the relationship between inflation and the nominal long-term interest rate is stronger than under any other regime we consider. The difference across regimes is statistically significant by the tests we conduct. Previous studies reviewed in Section 3, characterize this period as one with high levels of 'persistent inflation volatility' [Cogley, Sargent, and Surico (2015)]. In our interpretation, the lack of a nominal anchor in this regime led to these features of the inflation process that in turn produced a robust Fisher effect.

Previous studies (Benati (2004) and Cogley, Sargent, and Surico (2015)) identified breakpoints in the U.K. inflation process that coincide with the move to inflation targeting in the early 1990s. We evaluate inflation targeting first in a time period that ends at the height of the financial crisis in December 2008. Then, we extend the time period to the end of 2018 to see if the crisis or the BREXIT vote in 2016 appeared to have weakened the credibility of the regime. Especially for the CPI measure, which is the inflation target, the extended IT regime still

[9]The estimated constant terms in the regressions for (2009–2018) are significantly lower than for the 1992–2008 sample. This conforms to evidence from other studies (e.g. Rachel and Summers (2019)) that indicate a decline in the real rate of interest over the past several decades in industrialized countries. Such a shift complicates evaluation of a change in the Fisher effect.

appears to represent a significant regime shift from the previous regime of policy by discretion. For both the correlation coefficient and regression coefficients measuring the association between the long-term interest rate and rate of inflation, F-tests for equality with the estimates for the period of policy by discretion are decisively rejected. Other tests of the properties of the interest rate and inflation series support this conclusion.

The move to inflation targeting in the United Kingdom in 1992 appears to have been a regime shift – one that has been effective in providing an anchor to long-term inflation expectations. When considering CPI inflation, the chosen inflation target, the IT regime has precluded a Fisher effect of the magnitude evident in the period of policy by discretion. When inflation is measured by the WPI, however, for the IT regime extended to 2018, there is evidence of a statistically significant Fisher effect that may suggest weakened credibility of the regime due to events in the post-crisis years.

Disclosure statement

No potential conflict of interest was reported by the authors.

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