DISCUSSION PAPER SERIES

DP13519

THE SLOPE OF THE TERM STRUCTURE AND RECESSIONS: EVIDENCE FROM THE UK, 1822-2016

Charles A Goodhart, Terence C Mills and Forrest Capie

MONETARY ECONOMICS AND FLUCTUATIONS

ISSN 0265-8003

THE SLOPE OF THE TERM STRUCTURE AND RECESSIONS: EVIDENCE FROM THE UK, 1822-2016

Charles A Goodhart, Terence C Mills and Forrest Capie

Discussion Paper DP13519
Published 11 February 2019
Submitted 06 February 2019

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

THE SLOPE OF THE TERM STRUCTURE AND RECESSIONS: EVIDENCE FROM THE UK, 1822-2016

Abstract

This paper investigates whether the inversion of the yield spread, with short-term rates higher than the long-term rate, has been and remains an effective predictor of recessions in the U.K. using monthly data from 1822 to 2016. Indicators of recession are constructed in a variety of ways depending on the availability and properties of the data in the pre-World War 1, inter-war, and post-World War 2 periods. It is found that, using peak-to-trough recession indicators and a probit regression model, there is reasonably strong evidence to support the inverted yield spread being a predictor of recessions for lead times up to eighteen months in all three periods.

JEL Classification: E30, E32, E43, E44, N10

Keywords: yield spread, Recession, prediction, probit models

Charles A Goodhart - caegoodhart@aol.com
LSE and CEPR

Terence C Mills - t.c.mills@lboro.ac.uk
Loughborough University

Forrest Capie - f.h.capie@city.ac.uk
Cass Business School, University of London

The Slope of the Term Structure and Recessions:

Evidence from the UK, 1822 – 2016

1 Introduction

As the Fed has begun to raise the short-term official interest rate back towards 'normal' levels, there has been renewed interest whether the inversion of the yield spread has been and remains an effective predictor of recessions. But virtually all the empirical work on this has been done for the U.S.: see Gerlach and Stuart (2018) and their related references. The purpose here is to explore whether the same phenomenon appears to work equally well in the U.K. Of course, to be able to investigate this, a recession indicator must be defined; there are several ways in which this might be done. Section 2 discusses the various approaches and outlines how monthly recession indicators have been constructed for the three historical periods under consideration: the pre-World War 1 era, 1822 to 1913, inter-war years between 1920 and 1938, and post-World War 2 period beginning 1946.

In Section 3, we describe the econometric procedure for examining whether an inverted yield spread is followed by a recession, with the results presented in Section 4. Section 5 concludes.

2 Defining recessions

To carry out the analysis a recession indicator variable must be defined, and this necessitates, in turn, defining what constitutes a cycle. Clearly, the dating of the cycle matters and yet there has not always been agreement on how to do so. Earlier in British economic history fluctuations in economic activity were described, but without dating such cycles. Research was more advanced in the U.S., with NBER leading the way from the 1920s.

The NBER's approach was to collect hundreds of economic time series, then to graph and 'eyeball' them as a way of identifying the peaks and troughs in the individual series. The most important series were then grouped together and where there was the greatest coincidence of peaks and troughs, that became the basis for the reference-cycle chronology , with peaks being taken to mark the onset of recession. The dating was also partly informed by remarks in contemporary economic commentaries, with scope for disagreement.

The NBER then extended their work to the U.K. Despite fewer series available, they performed the same exercise, producing a reference-cycle chronology for the 19th and much of the 20th centuries; this became the basis for most discussions of the UK cycle , although modified slightly by Friedman and Schwartz (1982) for the late 19th century in their U.K. work, and updated by Capie and Mills (1991) . The chronology is shown in Table 1.

The subsequent conventional approach to trend/cycle analysis then became the use of *ad hoc* filters to de-trend the series, using techniques such as moving averages, examining whether the data were determined by a trend-stationary or difference-stationary process, and whether oscillations were transitory or permanent. Structural time series models assessed the trend and extent and timing of fluctuations around the trend. Kalman filters thereafter allowed such decomposition by an optimal linear filter derived by signal extraction techniques from the actual stochastic process generating the data; Mills (2003) describes these techniques.

Peaks	Troughs
1825	1826
1828	1829
1831	1832
1836	1837

1839	1842
1845	1848
1854	1855
1857	1858
1860	1862
1866	1868
1871	1879
1882	1886
1889	1893
1899	1904
1907	1908
1913	
1920	1921
1924	1928
1929	1932
1937	1938

Table 1 U.K. business cycle chronology for the 19th century and interwar period.

As interest rate data are available monthly, we need to define our recession indicator similarly. This poses some statistical problems, since we investigate three periods of British economic history: the pre-World War 1 era, 1822 to 1913; the inter-war years, 1920-1938; the post-World War 2 period beginning in 1946. But the annual business cycle chronology in Table 1 is not precise enough . So we needed to construct recession indicators based on cyclical components extracted from available GDP data. Second, pre-World-War 1 only annual GDP data are available, so that interpolation is required to generate a monthly cycle. Third, the FRED/OECD recession indicator for the post-World War 2 period, although available monthly, only begins in 1955. To include 1946 to 1954 in our analysis, then a proxy monthly series must be used to extract a cycle for these earlier years.

2.1 A recession indicator for 1822 – 1913

For the period 1822 to 1913 the logarithms of annual real GDP (denoted y_s) are found to follow the trend stationary process[1]

$$y_s = \underset{(0.832)}{-6.416} + \underset{(0.0004)}{0.0221}s + \hat{u}_s$$

$$\hat{u}_s = \underset{(0.081)}{0.732}\hat{u}_{s-1} + \hat{a}_s \qquad s = 1,2,\cdots$$

where $s = 1$ corresponds to 1822, etc., and figures in parentheses are standard errors. The appropriateness of this specification is confirmed by the accompanying unit root test statistic of $\tau_\tau = -3.64$, which rejects the difference stationary null in favour of the trend stationary alternative at significance level less than 5%.

The annual cyclical component is then defined as $\hat{u}_s = y_s + 6.416 - 0.0221s$: see Figure 1. To obtain a monthly cyclical component, $\hat{u}_s$ is converted using cubic spline interpolation, inducing a suitable degree of smoothness to interpolated values, to obtain c_t, where $t = 1$ is January 1822, $t = 2$ February 1822, etc. Two recession indicators may then be constructed. The 'negative cycle' recession indicator (CYC<0) is defined as $d_t = 1$ if $c_t < 0$ and $d_t = 0$ if $c_t \geq 0$, whereas the more conventional peak-to-trough indicator (P-T) takes the value 1 during the downswing from a local peak in c_t to a local trough and zero during the subsequent upswing, i.e., $d_t = 1$ if $\nabla c_t < 0$ and $d_t = 0$ if $\nabla c_t \geq 0$, with 'minor' upturns ignored: see Figure 2, plotting the two indicators against the monthly cycle. There are differences between the indicators, but the P-T is close to the annual pre-World War 1 chronology given in Table 1.

[1] All macroeconomic and interest rate time series used here were taken from 'A millennium of macroeconomic data for the UK. The Bank of England's collection of historical macroeconomic and financial statistics', version 3.1, available at www.bankofengland.co.uk/statistics/research-datasets . This resource provides references to original sources for the data used.

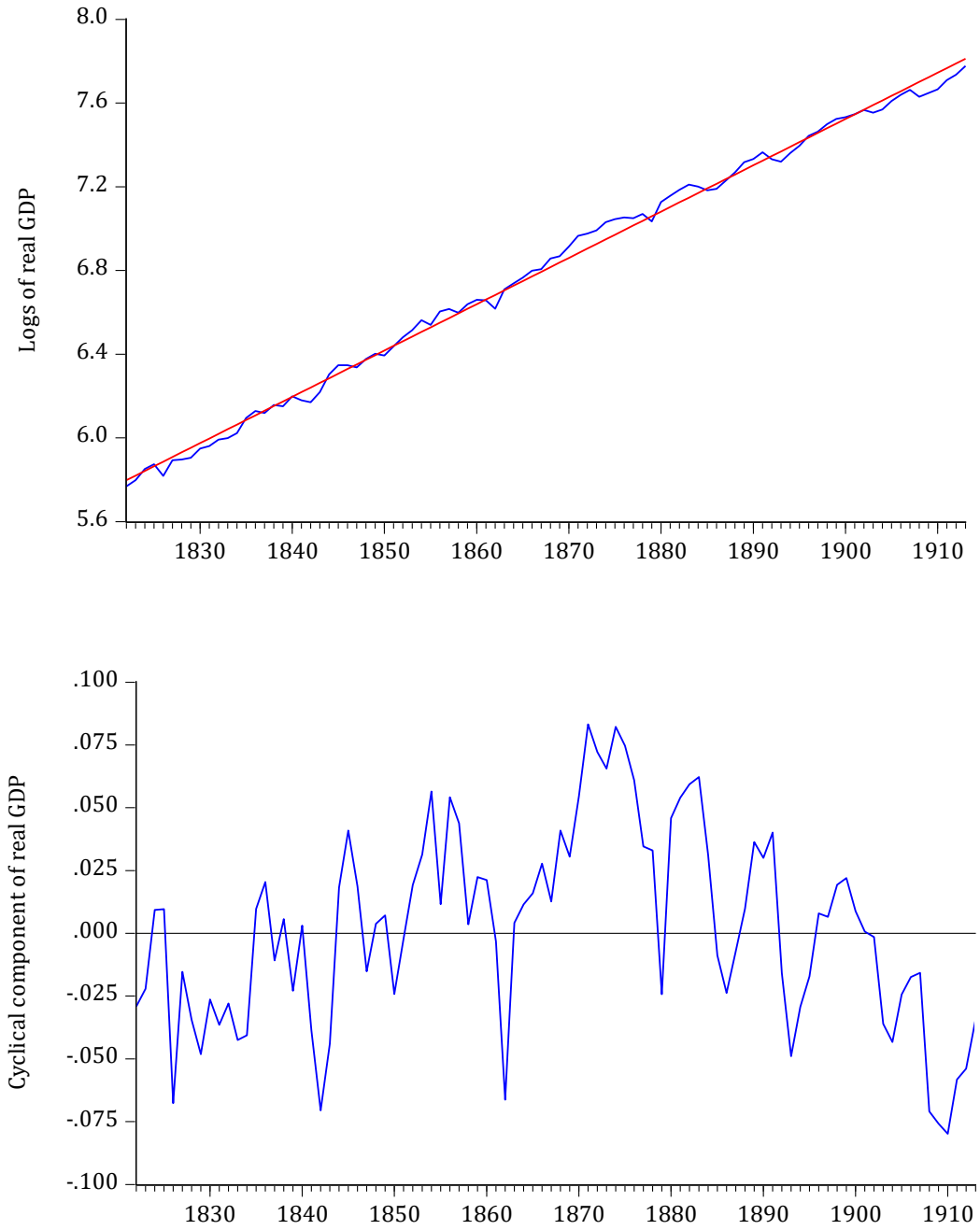

Figure 1 Top panel: logarithms of annual real GDP with linear trend superimposed; bottom panel: annual cyclical component: 1822 – 1913.

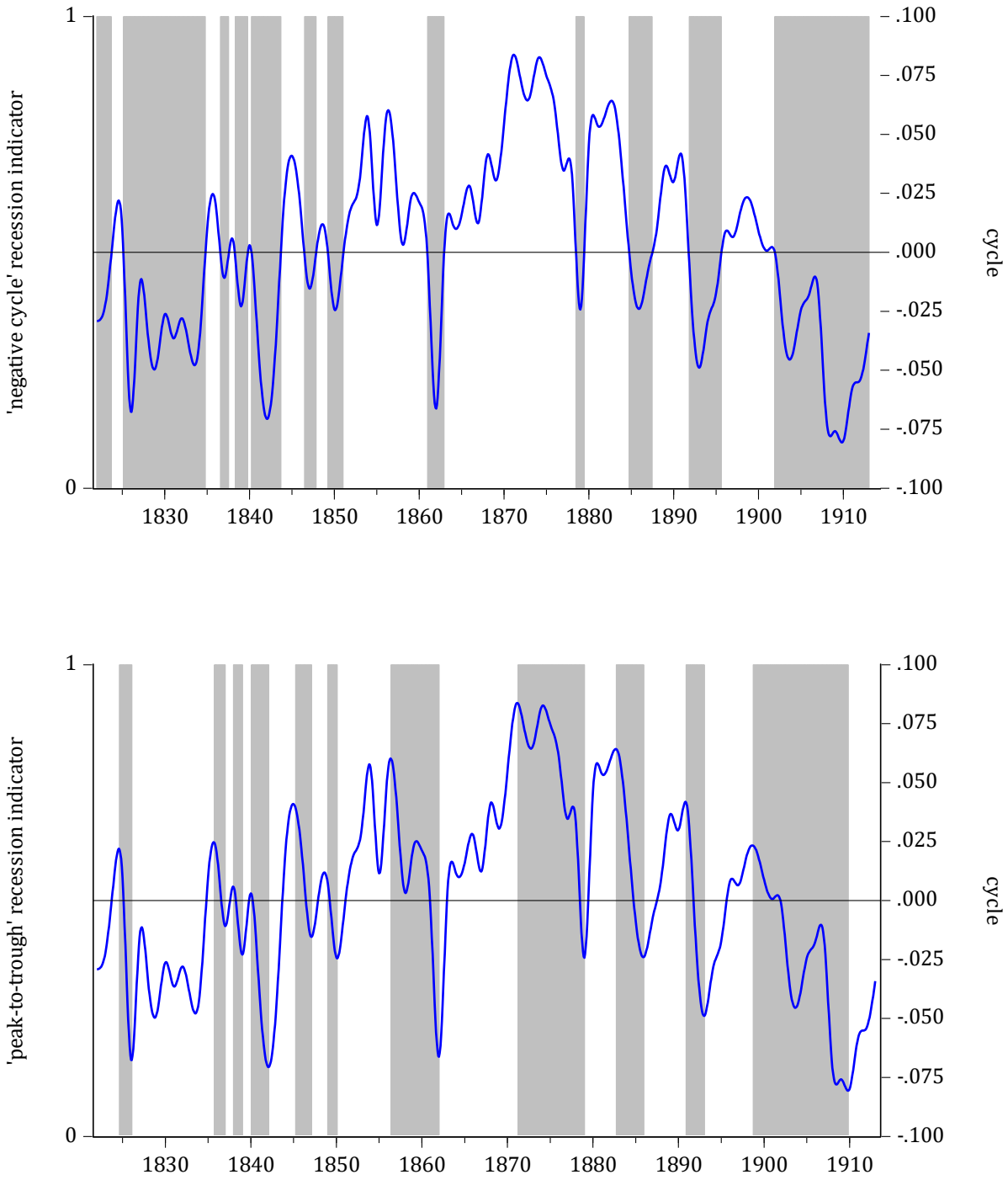

Figure 2 'Negative cycle' and 'peak-to-trough' recession indicators: 1822 – 1913.

2.2 A recession indicator for 1920 – 1938

For the inter-war years , monthly GDP data are available. The published series contains two brief, dramatic, falls followed by rebounds in GDP. Between March and May 1921 GDP fell by 16% before increasing by 21% in the subsequent two months, returning the series to its

previous level. The 1926 General Strike saw GDP fall 10% in May , remaining at that level until November, returning to its April level by December. These incidents do not reflect normal business cycles, and were removed by linear interpolation.

The following trend model was then fitted to the adjusted monthly GDP series y_t:

$$y_t = \underset{(0.029)}{5.780} + \underset{(0.00027)}{0.00138}\,t + c_t$$

$$c_t = \underset{(0.041)}{1.169}\,c_{t-1} + \underset{(0.069)}{0.166}\,c_{t-2} - \underset{(0.048)}{0.351}\,c_{t-3} + u_t$$

with the c_t series becoming the cyclical component.[2]

The CYC<0 and P-T recession indicators thus derived are shown in Figure 3; the latter providing a chronology close to that in Table 1 for the inter-war years.

2.3 A recession indicator for 1946 – 2016

The FRED/OECD peak-to-trough recession indicator is available monthly from January 1955.[3] It was extended back to January 1946 by fitting a band-pass filter to the logarithms of the monthly index of industrial production for the complete sample period from 1946 to 2016, extracting the cycle, and then defining the P-T recession indicator from this cycle for 1946-1954; this is shown in Figure 4 along with the extracted cycle, and matching well for 1955 onwards, even though the cycle is constructed solely from the index of industrial production.

[2] Autocorrelation and possible non-stationarity are allowed for by modelling the cycle as an autoregressive process. The maximum autoregressive root is estimated to be 0.96. Imposing a unit root, as suggested by the appropriate unit root test, does not alter the resulting recession indicators.
[3] Downloaded from https://fred.stlouisfed.org/series/GBRRECDM .

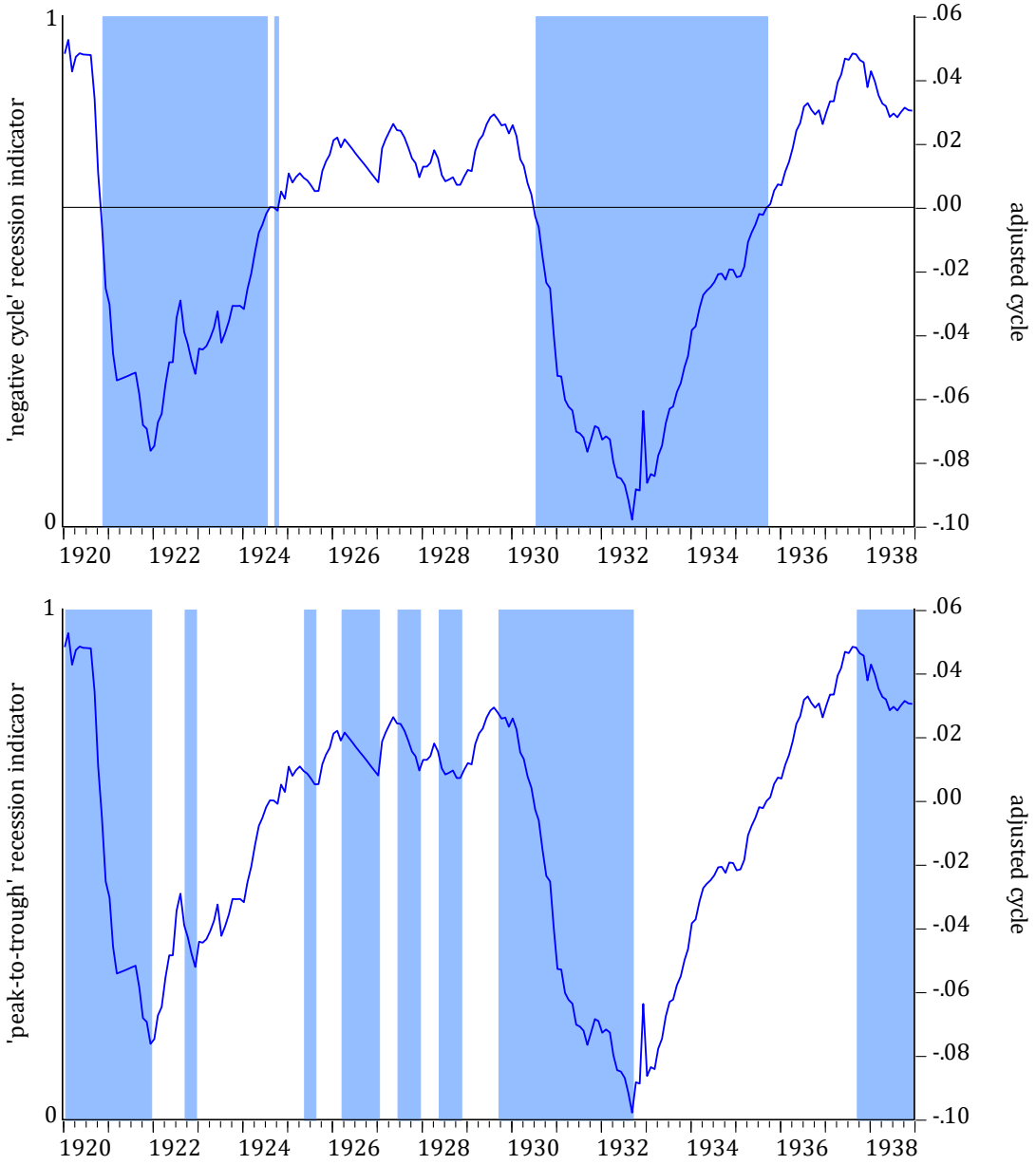

Figure 3 'Negative cycle' and 'peak-to-trough' recession indicator for 1920 – 1938.

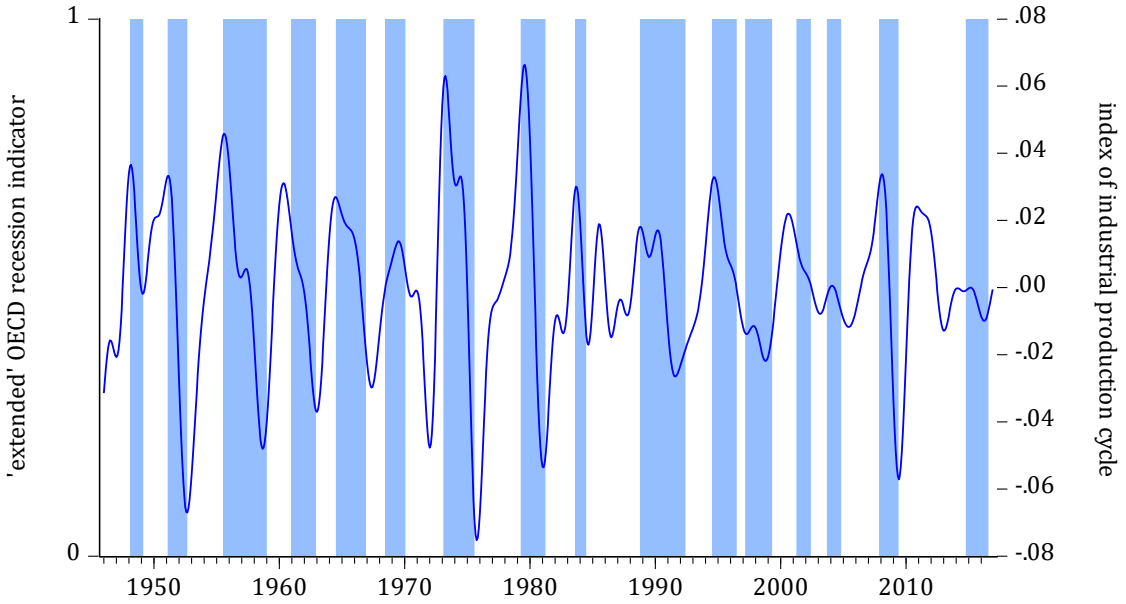

Figure 4 FRED/OECD recession indicator extended back to January 1946.

3 A model for predicting recessions

The model used to predict recessions is

$$d_{t+h} = \alpha + \beta S_t + \gamma R_t + \delta d_t + \varepsilon_{t+h} \qquad (1)$$

Here $S_t = R_t - r_t$ is the yield curve, with R_t being long interest rate and r_t short rate. For the pre-World War 1 and inter-war periods the long rate was taken to be the yield on consols and the short rate the three-month Treasury bill yield. In the post-World War 2 period the yield on 10-year gilts was used for R_t.

As the dependent variable, the recession indicator h months in the future, d_{t+h}, is binary, equation (1) is a probit model, estimated by maximum likelihood techniques: see Greene (2008). The errors, ε_{t+h}, in such predictive regressions will be autocorrelated of order $h-1$ and, consequently, estimated coefficient standard errors will be biased unless an adjustment for this is made, using autocorrelation robust standard errors computed using a fixed lag length of $h-1$.

We focus on the spread coefficient β for alternative values of h, with R_t and d_t being included as additional explanatory regressors to act as controls: if β is significantly negative then the inverted yield curve will be a predictor of recessions.

4 Results

We present results for each of the three periods for $h = 1,2,\cdots,18$, i.e., prediction horizons of up to eighteen months. With attention primarily on the spread coefficient β across these values of h. These are presented graphically with two-standard error bars attached, with the 'candlesticks' in Figures 5-7 representing approximate 95% confidence intervals.

4.1 Spread estimates for 1822 – 1913

Figure 5 shows the spread coefficient estimates for 1822 – 1913 using the P-T recession indicator. The β estimates are negative for all values of h and are significantly so for $h > 1$. Using the alternative CYC<0 recession indicator yields β estimates that are insignificantly positive for all values of h.

4.2 Spread estimates for 1920 – 1938

Figure 6 shows the spread coefficient estimates for the years 1920 – 1938 using the P-T recession indicator derived from the adjusted cycle. The β estimates are negative for all values of h, being significant at the 10% level or less for $5 \leq h \leq 10$. Once again, using the alternative CYC<0 recession indicator yields β estimates insignificantly positive for all values of h.

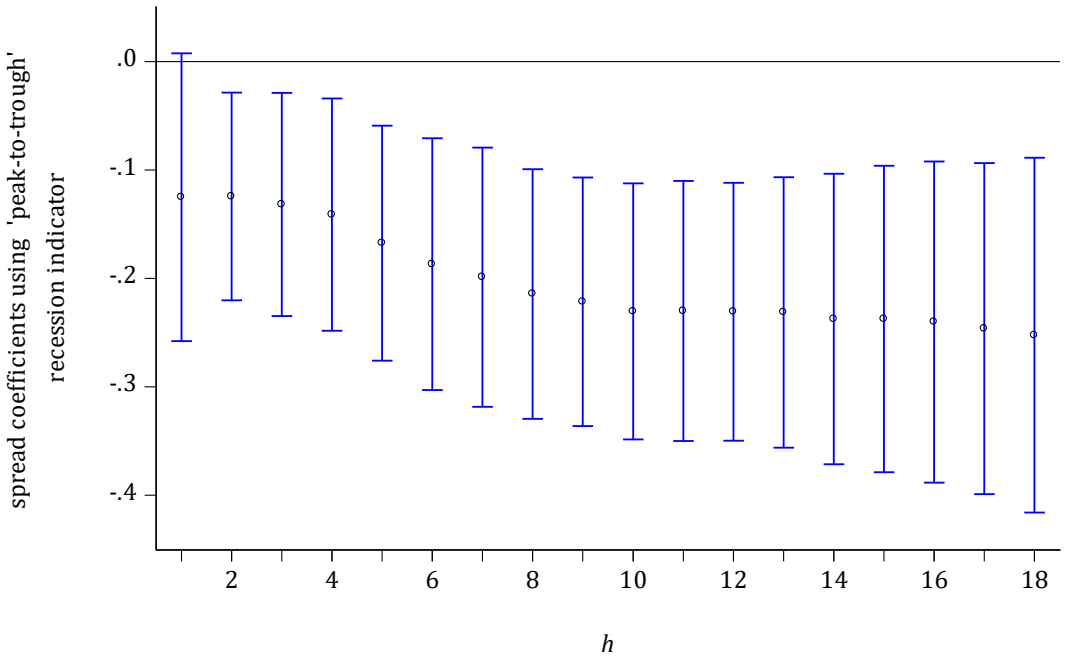

Figure 5 Spread coefficient estimates using P-T recession indicator: 1822 – 1913.

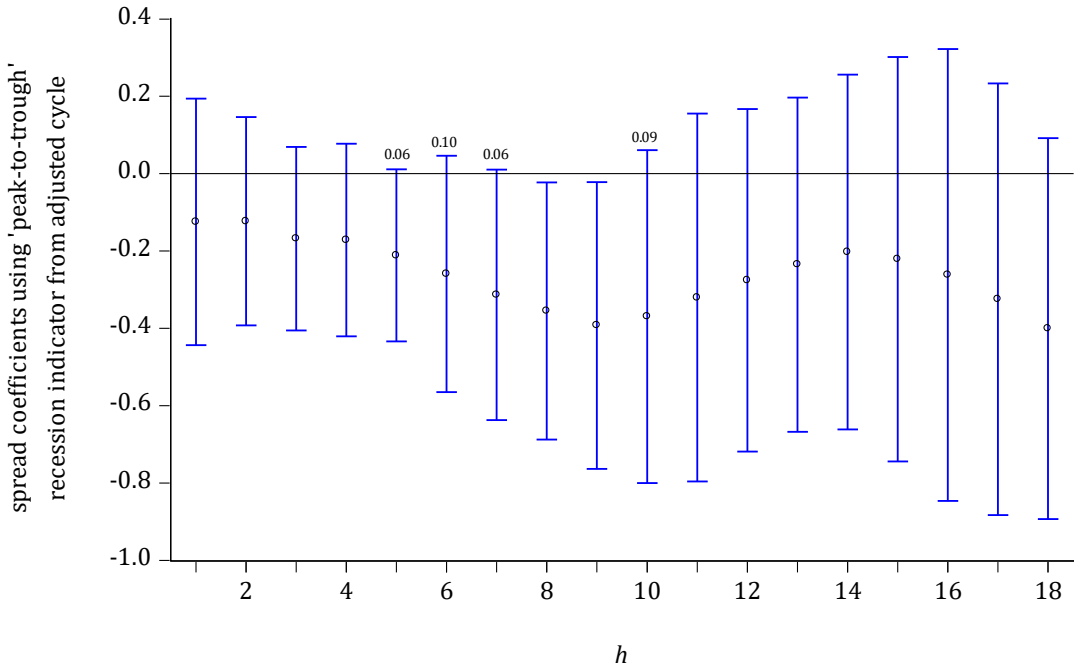

Figure 6 Spread coefficient estimates using P-T recession indicator obtained from the adjusted cycle: 1920 – 1938. Figures above candlesticks are marginal probability values.

4.3 Spread estimates for 1946 –1955

The top panel of Figure 7 shows spread coefficient estimates for the post-World War 2 period beginning in 1955 using the FRED/OECD P-T recession indicator; the bottom panel shows the estimates when the sample is extended back to 1946 using the P-T measure extracted from the index of industrial production for 1946 to 1954. For the period from 1955 all estimates of β are negative, significantly so for $h \leq 16$; when the period is extended back to 1946 the estimates remain negative and are now significant for $h \leq 17$.

5 Summary and conclusions

Using the the P-T recession indicators, reasonably strong support is found for the hypothesis that the inverted yield curve is a predictor of U.K. recessions for horizons up to 18 months for both the pre-World War 1 and post-World War 2 periods. The evidence is not quite as conclusive for the inter-war years in that, although the β coefficient estimates are negative at all horizons, the level of significance is only reasonably small for horizons between five and ten months. This finding nevertheless accords well with the evidence from the U.S.

On the other hand, using the alternative measure of recessions, i.e., CYC<0, the relationship between the spread and this measure is insignificant, or of the wrong sign, for both the pre-World War 1 and interwar periods.

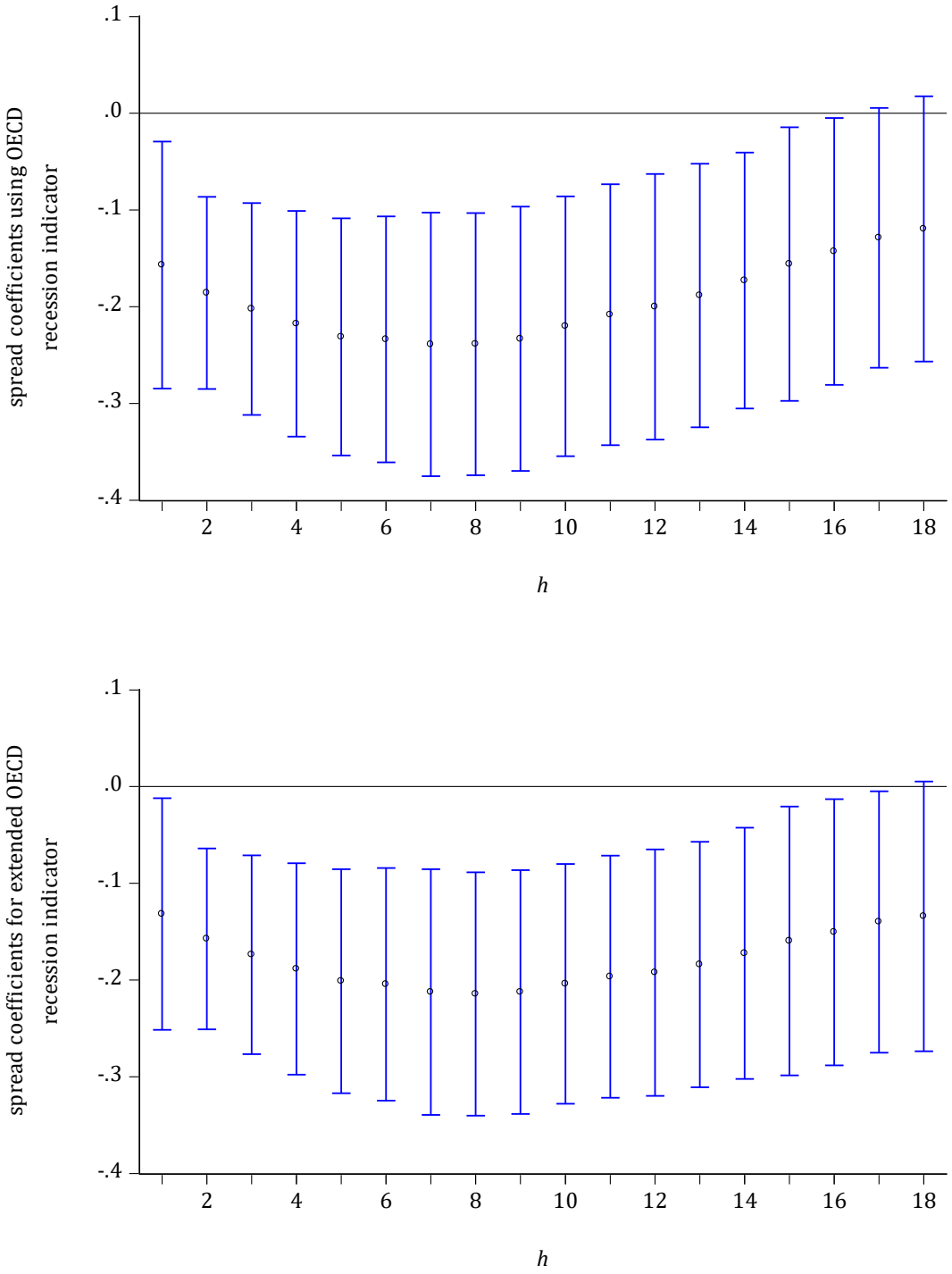

Figure 7 Spread coefficient estimates: Top panel, 1955 – 2016 using the OECD recession indicator; Bottom panel, 1946 – 2016 using the extended OECD recession indicator.

References

Capie, Forrest H. and Terence C. Mills (1991). 'Money and business cycles in the US and the UK, 1870 to 1913', *Manchester School* 59, 38-56

Friedman, Milton and Anna J. Schwartz (1982). *Monetary Trends in the United States and the United Kingdom*, Chicago: University of Chicago Press.

Gerlach, Stefan and Rebecca Stuart (2018). 'The slope of the term structure and recessions: the pre-Fed evidence, 1857-1913', CEPR Discussion Paper DP13013.

Greene, William H. (2008). *Econometric Analysis*, 6th edition, NJ: Prentice Hall.

Mills, Terence C. (2003). *Modelling Trends and Cycles in Economic Time Series*, Basingstoke: Palgrave Macmillan.