MONTHLY AND QUARTERLY GDP ESTIMATES FOR INTERWAR BRITAIN

James Mitchell
National Institute of Economic and Social Research
2 Dean Trench Street, Smith Square
London SW1P 3HE
United Kingdom

Solomos Solomou
Faculty of Economics,
University of Cambridge
Cambridge, UK

Martin Weale
National Institute of Economic and Social Research
2 Dean Trench Street, Smith Square
London SW1P 3HE
United Kingdom

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Abstract

We derive monthly and quarterly series of UK GDP for the inter-war period from a set of indicators that were constructed at the time. We proceed to illustrate how the new data can contribute to our understanding of the economic history of the UK in the 1930s and have also used the series to draw comparisons between recession profiles in the 1930s and the post-war period.

Key Words: Economic History, National Accounts, Monthly GDP Data, Great Depression

JEL Reference: N34, C82

Gross domestic product is generally regarded as the most appropriate indicator of economic activity. But for the interwar period the data are only available at the annual frequency. As such, many important questions cannot be addressed in a satisfactory manner. If we are interested in the impact of historical events, such as the effect of policy changes that take place at discrete points in time, we are limited to using either annual data[1] or indicators of economic activity at a monthly or quarterly frequency that may not fully capture macroeconomic movements. But to understand the economic impact of many important events it is necessary to have data available at a higher frequency that are reliable and consistent with the annual national accounts. In this article we describe a monthly index of GDP for the United Kingdom for the period 1924-1938 and we show that it, used in conjunction with other monthly indicators, clarifies our understanding of the major economic events of the period. The index can also be aggregated to the quarterly frequency, allowing researchers to more effectively discuss the interwar economy using data at the quarterly frequency.

A considerable amount of work has been done on the development of monthly indicators of economic activity. Perhaps the best known is provided by the system of indicators developed by Burns and Mitchell (1946). Their work was anticipated by *The Economist*, which collected monthly indicators during the period 1924-1938 and published an aggregate indicator computed as the geometric mean of the indicators they collected[2]. The data set from *The Economist* forms the basis of the monthly GDP indicator that we present here, together with data for quarterly industrial production[3]. Averaging the indicator variables is not the only possible method of aggregation. Rhodes (1937) suggested instead that the first principal component of the series could be used. This amounts to identifying an aggregate which, on its own, accounts for as much as possible of the overall variation in the data set. Much more recently Stock and Watson (2002), while unaware of Rhodes work, have used the same approach to

[1] The first set of consistent historical national accounts was provided by Feinstein (1972). Improvements to the interwar national accounts were made more recently by Sefton and Weale (1995) and Solomou and Weale (1996) who allocated the discrepancies between income and expenditure in Feinstein's estimates so as to produce balanced national accounts for the period since 1920.

[2] The monthly indicators and the component series were published regularly in *The Economist* 'Trade Supplement'. The series was extended back to 1920 by the Economist, but the compilers recognised that the data were "much less reliable for the years before 1924" (Capie and Collins, 1983, p. 45).

[3] The indices covered coal consumption, electricity consumption, merchandise on railways, commercial motors in use, postal receipts, building activity, iron and steel for home consumption, raw cotton delivered to mills, imports of raw materials, exports British manufactures, shipping movements, bank clearings (metropolitan) and bank clearings (towns).

derive a monthly indicator of the US economy. While the first principal component may be a good summary of the data, it is not necessarily the aggregate that is most closely correlated with GDP. Some means is needed of selecting from the indicators a composite which is closely linked to GDP rather than one which is simply a summary of the indicator data set. In this paper we derive monthly GDP series using the latent indicator methodology outlined in the Appendix. We present the new data set and compare the high-frequency description of the British economy with other studies. We also illustrate two possible uses of the new data: first, we discuss how high frequency data improves our understanding of the end of the Great Depression in the British economy; secondly, we also use the data to compare the high frequency time-profile of the depression of the 1930s with more recent recessions[4].

1. Statistical Methodology

A statistical appendix details the econometric methodology used to construct our indicator of monthly GDP from the available annual GDP data, the quarterly industrial production data and the monthly indicator variables. When there are only a few monthly indicator variables available, regression methods could be used to construct the monthly GDP estimates. Mitchell *et al.* (2005) discuss the use of mixed-frequency variables (such as a combination of monthly and quarterly or annual variables) in regression equations and go on to show how such equations can be used to produce monthly estimates of GDP. But the fact that we have a reasonably large number of monthly indicator variables, from *The Economist*, makes it difficult to use their methods satisfactorily since the regression would run into degree-of-freedom constraints. An alternative, described in the Appendix, is to assume that the indicators, industrial production and GDP are driven, at the monthly frequency, by an underlying unobserved or latent variable. Estimates of this unobserved variable can then be used to provide a monthly indicator of GDP and the resulting monthly estimates can be

[4] Our focus in this work is on periods of economic weakness; we compare the 1930s with more recent experience. In our discussion we use the term recession to mean a period when output is falling (i.e. the economy is receding) and depression to mean a period when output is below some reference value such as the peak reached before a recession started. Thus the terms do not convey anything about the severity of the different episodes. A depression lasts longer than a recession simply because once output starts rising after a recession it inevitably takes some time to surpass its previous peak. Our emphasis, then, is on depressions thus defined.

adjusted, so that the monthly totals sum to the estimates of annual GDP, making the monthly estimates consistent with the annual national accounts. On a technical level, an additional advantage of the method set out in the Appendix is that it provides an exact solution to the problem that when modelling the logarithm of GDP, as is preferable to modelling the level of GDP, the sum of the interpolated monthly values nevertheless equals the known annual total.

In the absence of monthly economic data, which while not measures of GDP itself are believed to provide some clue about monthly movements in GDP, the best that can be done is to interpolate the annual GDP data using a univariate (dynamic) model. This is clearly not ideal, as important but offsetting intra-year movements in GDP will be missed, since the statistical model assumed to govern the determination of monthly GDP can at best be fitted to the available annual GDP data.

Fortunately, as discussed above, a range of relevant monthly indicator series, drawn from *The Economist* and used by Rhodes (1937), is available for the UK over the 1924-1938 period. Together with the quarterly industrial production series (Capie and Collins, 1983) these data provide an indication of monthly/quarterly movements in economic activity. However, they do not measure GDP itself and at best can be viewed as providing an incomplete picture. For these monthly/quarterly data to be used to draw inferences about the state of the economy as a whole it is desirable that there should be some formal statistical procedure for exploiting them and arriving at an indicator of monthly GDP. Such a procedure is likely to produce estimates of GDP which are less satisfactory than those which might have been produced by direct measurement but is preferable simply to "eye-balling" or averaging the indicator series and drawing subjective conclusions about the likely behaviour of monthly GDP in the absence of any statistical knowledge of how these series might relate to GDP. As Rhodes (1937, p. 18) notes it is necessary to "reduce this mass of data… to a more digestible form". Somewhat differently, as we explain in the statistical appendix, from Rhodes' own objective (which has also been shared by a recent econometric literature spurred by Stock and Watson, 1991) we seek to reduce the monthly/quarterly data to an estimator of monthly GDP itself. Importantly, in contrast to this literature, this means we also consider annual GDP data and therefore adopt a mixed-frequency approach to deriving monthly estimates of GDP.

Following Stone (1947) and Stock and Watson (1991) our dynamic factor-based methodology assumes that a latent variable or "factor", taken to represent the "business cycle", drives variations and co-movements in the observed monthly, quarterly and annual data. Importantly, this assumption is consistent with Burns and Mitchell's (1946) characterisation of the "business cycle" as common movements in different economic indicators. Booms and recessions are marked, respectively, not just by one but by a range of economic indicators rising and falling.

In our approach each of the observed variables (the monthly indicators, industrial production and GDP itself) is then assumed to deviate from this common factor by an idiosyncratic component, specific to each series. These idiosyncratic components are allowed to follow distinct dynamic processes. This flexibility means that the model provides a good fit to the data.

The "business cycle" is also allowed to have a differential effect on the different variables. It is found, for example, that all of the monthly indicator variables in *The Economist*, as well as industrial production and GDP, are "coincident indicators", in the sense that they rise and fall with the "business cycle". But the "business cycle" has a particularly strong effect, as we might expect, on GDP itself; although it is again important to allow for idiosyncratic dynamics to capture the noise evident in monthly GDP movements. In other words, while the "business cycle" captures the general tendency for GDP to rise and fall, it remains important, in order to achieve a good fit of the data, to model also the higher-frequency noise specific to monthly GDP movements.

2. Monthly and Quarterly GDP Series

We present data at both market prices and factor cost, but focus our attention on the market price data. In the Appendix we provide details of the data and the parameter estimates used when estimating market price data. Similar results for the estimation of GDP at factor cost are available on request.

Table 1 and Figure 1 present the new monthly GDP series for the inter-war period. The main contribution of the new data is in the macroeconomic description of the high-frequency path of the economy. A number of important features stand out: first, the return to gold in 1925 is correlated with a downturn in the months of April-July 1925; secondly, the weakness of the economy in 1928, highlighted in Solomou and Weale (1996), stands out in the high frequency data but is limited to the months of March-June.

Conventionally, the peak of the UK economy in 1929 is dated as July 1929 and the third quarter of 1929 (Burns and Mitchell, 1946). The new data show the peak as being January 1930 (with another local peak in October 1929). The dating of the recovery is also different from that reported in Burns and Mitchell (1946). On a monthly basis they date the trough as August 1932 and, on a quarterly basis, as third quarter 1932. Although our data also suggests that the trough is best dated as August 1932, the recovery tapered away in the first five months of 1933, suggesting that a clear path to recovery is not established around one local turning point – in fact a sustained recovery is not clear until well into 1933. The turning points of the 1937-8 recession are also different from those outlined in Burns and Mitchell who date the peak as September 1937. The new data suggest that GDP continued to expand until January 1938. Such differences may seem minor in that the order of magnitude is a few months but they can have substantial implications for particular questions. For example, if we wish to address the role of particular policies in generating recovery from the Great Depression, a few months can have significant implications for the analysis of the transmission mechanism by which policies may have had an impact.

The new data can also be aggregated to generate quarterly estimates of GDP. The quarterly data are presented in Table 2 and Figure 2. To help the reader evaluate our data series we also compare both our series with the quarterly estimates of interwar GDP at factor cost reported in Hayes and Turner (2007). All three sets of data are presented as indices with the average for 1924-1938 set to 100.

Figure 1: Monthly GDP at 1938 Market Prices and Factor Cost

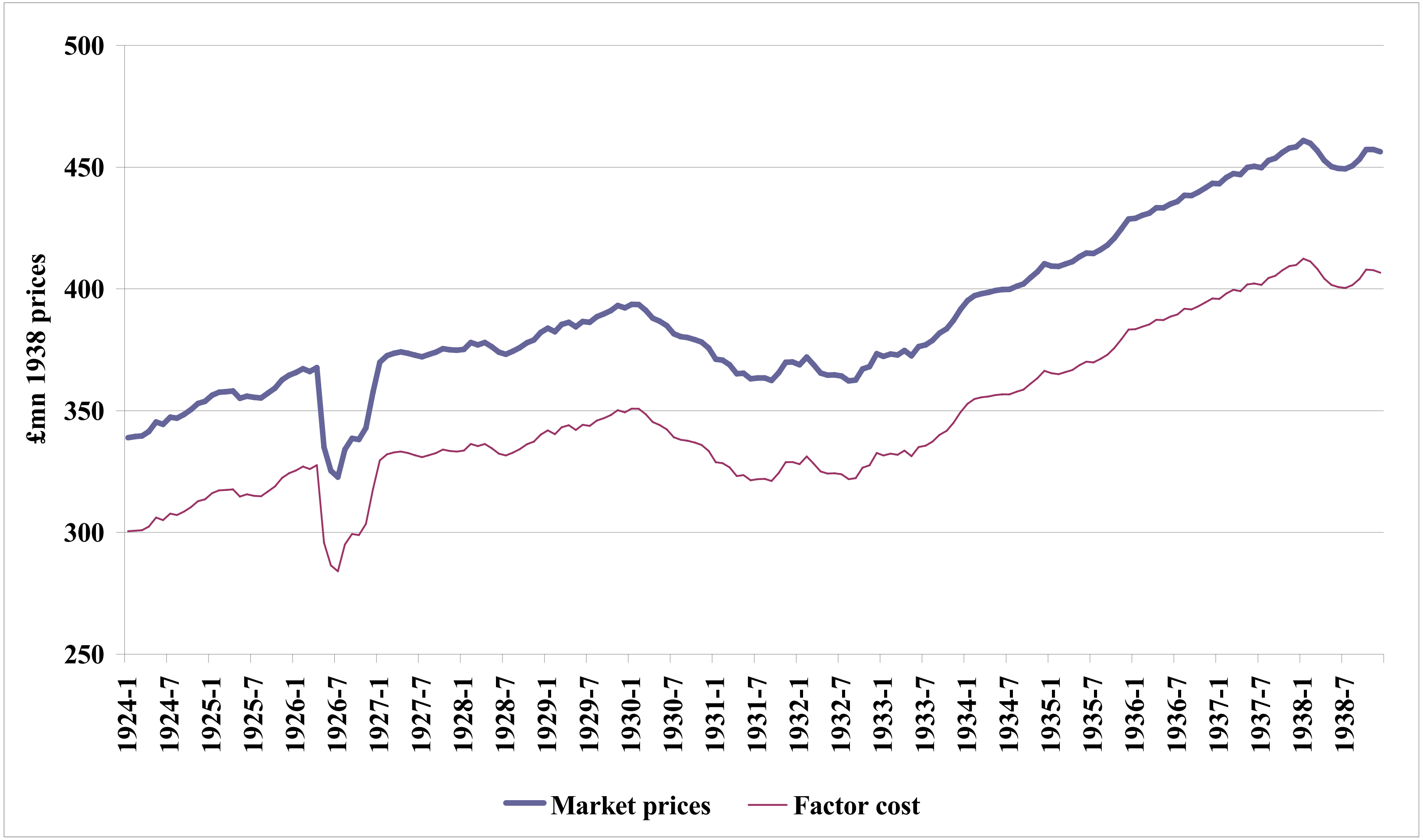


Table 1a: 1924-38 Monthly GDP at Market Prices, £mn 1938 prices

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1924	338.96	339.37	339.69	341.44	345.32	344.38	347.28	346.86	348.43	350.44	352.97	353.86
1925	356.35	357.61	357.76	358.04	355.09	355.96	355.45	355.16	357.16	359.19	362.70	364.53
1926	365.70	367.23	366.07	367.65	334.98	325.33	322.77	334.08	338.58	338.12	342.96	357.53
1927	369.92	372.60	373.57	374.10	373.60	372.76	372.11	373.04	373.99	375.50	375.00	374.82
1928	375.24	377.95	377.06	378.01	376.21	374.01	373.18	374.39	375.87	377.92	379.08	382.09
1929	383.89	382.45	385.36	386.26	384.43	386.64	386.28	388.58	389.72	391.03	393.16	392.20
1930	393.70	393.55	391.19	387.98	386.72	384.87	381.56	380.40	380.00	379.12	378.20	375.70
1931	371.12	370.76	368.88	365.15	365.39	363.06	363.41	363.41	362.35	365.59	369.93	369.95
1932	368.80	371.99	368.94	365.46	364.56	364.67	364.27	362.22	362.61	367.08	368.03	373.37
1933	372.34	373.26	372.86	374.71	372.46	376.31	377.06	378.85	381.86	383.64	387.03	391.61
1934	395.20	397.25	398.01	398.58	399.31	399.75	399.85	401.06	402.03	404.61	407.06	410.30
1935	409.40	409.25	410.23	411.17	413.25	414.73	414.53	416.11	418.01	420.93	424.67	428.74
1936	429.02	430.23	431.14	433.28	433.30	434.87	435.91	438.43	438.27	439.75	441.50	443.30
1937	443.27	445.74	447.41	446.97	449.83	450.31	449.79	452.76	453.71	456.02	457.81	458.37
1938	460.96	459.77	456.79	452.75	450.28	449.50	449.26	450.51	453.24	457.30	457.30	456.35

Table 1b: 1924-1938 Monthly GDP Data at Factor Cost, £mn 1938 prices

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1924	300.51	300.75	300.91	302.46	306.10	305.02	307.70	307.16	308.56	310.41	312.79	313.63
1925	316.08	317.30	317.42	317.66	314.76	315.59	315.09	314.82	316.82	318.86	322.37	324.24
1926	325.46	327.06	326.01	327.65	295.80	286.48	284.04	295.03	299.40	298.90	303.54	317.64
1927	329.60	332.07	332.86	333.24	332.62	331.68	330.93	331.74	332.58	333.98	333.45	333.25
1928	333.67	336.33	335.45	336.36	334.58	332.41	331.58	332.76	334.20	336.19	337.29	340.19
1929	341.88	340.40	343.18	344.00	342.12	344.20	343.74	345.91	346.93	348.15	350.21	349.29
1930	350.87	350.78	348.49	345.34	344.13	342.33	339.12	338.03	337.68	336.85	335.95	333.44
1931	328.85	328.47	326.68	323.14	323.49	321.36	321.84	321.99	321.09	324.38	328.77	328.94
1932	328.00	331.26	328.36	325.01	324.16	324.29	323.90	321.90	322.28	326.63	327.52	332.69
1933	331.58	332.40	331.92	333.66	331.36	335.03	335.65	337.28	340.10	341.72	344.94	349.36
1934	352.85	354.79	355.43	355.86	356.44	356.74	356.72	357.78	358.63	361.05	363.34	366.38
1935	365.33	365.04	365.89	366.72	368.69	370.05	369.76	371.22	372.98	375.74	379.32	383.25
1936	383.47	384.57	385.36	387.34	387.22	388.63	389.52	391.87	391.58	392.90	394.47	396.07
1937	395.85	398.11	399.63	399.09	401.82	402.22	401.63	404.49	405.36	407.59	409.32	409.87
1938	412.44	411.26	408.26	404.21	401.68	400.80	400.44	401.53	404.08	407.91	407.75	406.64

Hayes and Turner used the Chow-Lin (1971) method to interpolate GDP estimates based on Quarterly Industrial Production as an indicator variable. They used a linear model rather than one specified in logarithms. Our methodology is an improvement on the Chow-Lin method and our use of a richer set of indicator variables suggests that our data offer a more accurate depiction of the macroeconomic path of the economy. The reliance on a single volatile series, such as industrial production, to derive quarterly data for GDP explains why the Hayes-Turner Series is more volatile than our series. While we have no independent means of verification, our method could in principle produce a series very similar to theirs if that were the most appropriate interpretation of the inter-relationships in the combined set of data. The fact that it did not is a reason for preferring our more stable series to theirs. As can be seen from Figure 2, apart from the matter of volatility in the Hayes-Turner series there are important turning point differences in 1929, 1931 and 1937-8. In using a richer set of indicators we get a better description of macroeconomic turning points.

Our market price and factor cost series are scarcely distinguishable when represented in this way; this does obscure some movements which may be of interest. For example, measured relative to the fourth quarter of 1929, our estimate of GDP at factor cost shows a decline of 7.9 per cent by the third quarter of 1931, while the measure at market prices shows a decline of only 7.4 per cent. The Hayes-Turner measure shows a decline of 5.7 per cent and puts the trough of the depression in the first quarter of 1931 with output 6.4 per cent below the figure for the fourth quarter of 1931. It should be noted that these differences arise not only because of the differences in interpolation methodology, but also because we used the annual balanced GDP estimates provided by Sefton and Weale (1995) while Hayes and Turner used Feinstein's (1972) data.

Figure 2: Indicators of Quarterly GDP at 1938 prices

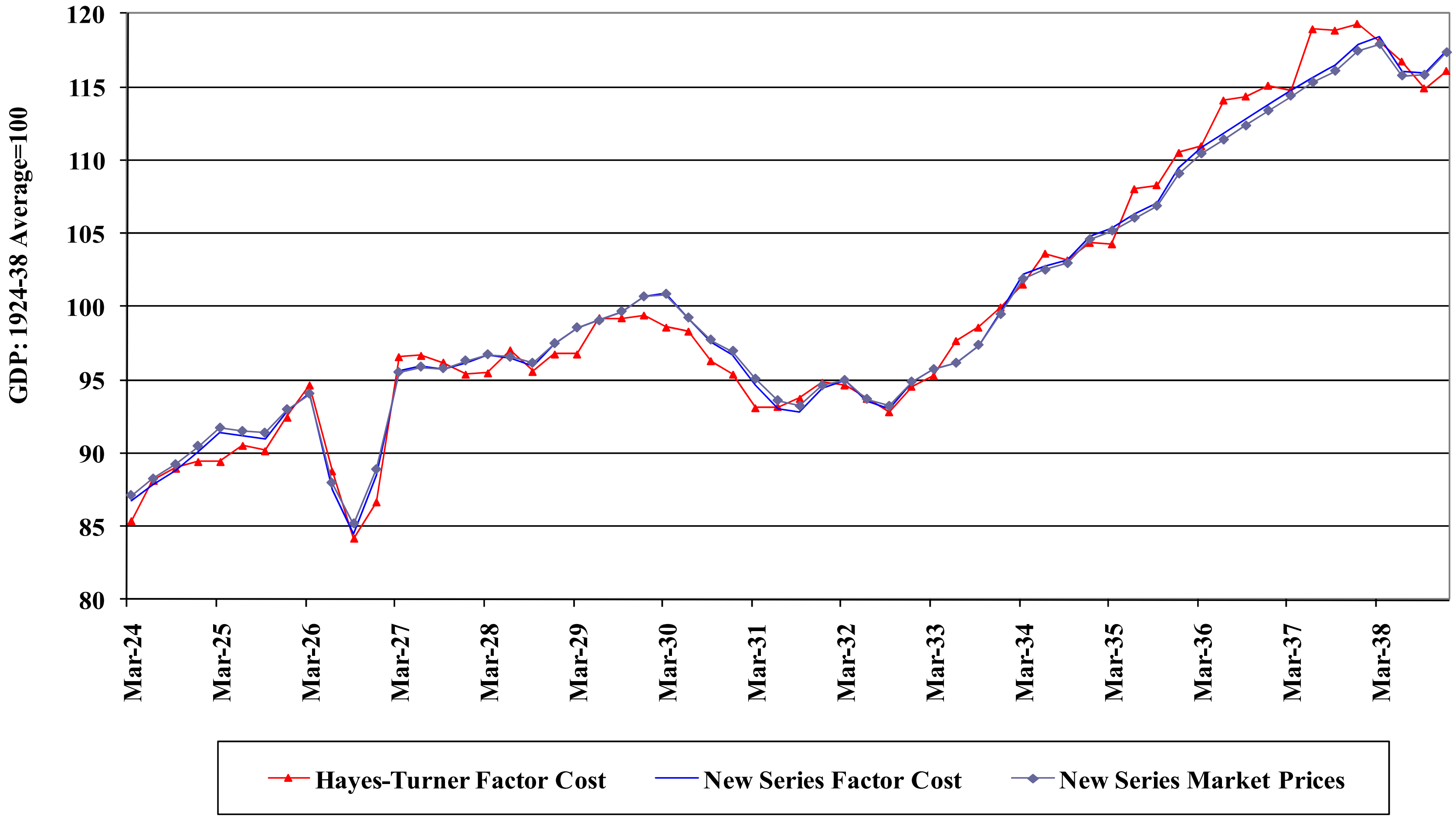


Table 2a: 1924-38 Quarterly GDP at Market Prices, £mn 1938 prices

	Q1	Q2	Q3	Q4
1924	1018.02	1031.14	1042.57	1057.27
1925	1071.72	1069.09	1067.77	1086.42
1926	1099.00	1027.96	995.43	1038.61
1927	1116.09	1120.46	1119.14	1125.32
1928	1130.25	1128.23	1123.44	1139.09
1929	1151.70	1157.33	1164.58	1176.39
1930	1178.44	1159.57	1141.96	1133.02
1931	1110.76	1093.60	1089.17	1105.47
1932	1109.73	1094.69	1089.10	1108.48
1933	1118.46	1123.48	1137.77	1162.28
1934	1190.46	1197.64	1202.94	1221.97
1935	1228.88	1239.15	1248.65	1274.34
1936	1290.39	1301.45	1312.61	1324.55
1937	1336.42	1347.11	1356.26	1372.20
1938	1377.52	1352.53	1353.01	1370.95

Table 2b: 1924-38 Quarterly GDP at Factor Cost, £mn 1938 prices

	Q1	Q2	Q3	Q4
1924	902.17	913.58	923.42	936.83
1925	950.80	948.01	946.73	965.47
1926	978.53	909.93	878.47	920.08
1927	994.53	997.54	995.25	1000.68
1928	1005.45	1003.35	998.54	1013.67
1929	1025.46	1030.32	1036.58	1047.65
1930	1050.14	1031.80	1014.83	1006.24
1931	984.00	967.99	964.92	982.09
1932	987.62	973.46	968.08	986.84
1933	995.90	1000.05	1013.03	1036.02
1934	1063.07	1069.04	1073.13	1090.77
1935	1096.26	1105.46	1113.96	1138.31
1936	1153.40	1163.19	1172.97	1183.44
1937	1193.59	1203.13	1211.48	1226.78
1938	1231.96	1206.69	1206.05	1222.30

3.1 Historical Applications of the New Data

In this section we illustrate two uses of the new data: first we apply the high frequency information on the economy to address the question of how the British economy came out of the Great Depression in the 1930s, in particular, is there evidence of expectation effects arising from the policies pursued in 1931-2; secondly, we compare the high-frequency time-profile of depression and recovery in the Great Depression of the 1930s with more recent post-war recessions.

Temin (1989) draws on Sargent (1983) to emphasise the importance of expectation changes as part of an underlying policy regime change to help economies out of the Great Depression. Temin argues that although Britain devalued in September 1931 the continuation of the policy framework of balanced budgets and restrictive monetary policy prevented an effective recovery in Britain during the 1930s. This contrasts with the experience of the USA –when Roosevelt succeeded President Hoover in March 1933 and announced the devaluation of the dollar, this was perceived as a powerful policy regime change that ended the depression in the USA. Similarly, Temin argues that Hitler’s policy announcements in early 1933 represented a change big enough to shift expectations and end the depression in Germany. Temin is aware that to evaluate how policy regime change ended the Great depression we need good quality high frequency data and provided some high frequency analysis of the recovery profiles in the USA and Germany. However, he did not provide the high-frequency data needed to analyse the British case. The new monthly GDP data allow us to evaluate the consistency of some of the ideas of the policy regime literature.

Figure 1 and Table 1 show that the devaluation in September 1931 was correlated with a significant recovery, suggesting that expectation effects may have had an impact, since it is unlikely that trade volumes responded immediately, but it is quite clear that the recovery came to an abrupt end with another downturn in early 1932, suggesting a limited policy regime change. Devaluation in September 1931 was followed by monetary easing with “cheap money” in April 1932 and the General tariff in February 1932[5]. However, neither of these policies seems to have generated immediate observable effects on the path of recovery with the economy continuing to slide between February and August 1932. Clearly, Temin's hypothesis of an absence of observable recovery in 1931-2 is consistent with the new high-frequency data. The policy moves in the British economy during 1931-2 did not generate immediate expectation effects that were powerful enough to end the depression. However, beginning in September 1932 and after a relapse in early 1933, again in June 1933 the economy moved along a path of persistent and strong recovery, suggesting that Britain was able to recover effectively during the 1930s.

Temin's evaluation of the UK experience draws on the rational expectations policy framework. However, the early rational expectations models are recognised to be based on strong and unrealistic assumptions. Bray and Savin (1986) and Evans and Honkapohja (2001) suggest that the learning path of expectations may be important. The early rational expectations models assumed perfect information on the part of economic agents together with the assumption of a unique model and knowledge of its parameters. This is of course unrealistic, and an adaptive learning approach is proposed, where agents have to take time to gather information and learn about parameters in the same way as an econometrician. This is a specific form of bounded rationality and the forecast rule of agents is adjusted over time with the emergence of new data. If adaptive learning is assumed, then expectations may converge to the fully 'rational expectations' equilibrium eventually, but may not jump to such an equilibrium immediately. The evidence from the British high frequency data may be consistent with the idea that it took time to learn that the equilibrium expectations had changed. No single event determined this but along a bumpy path between September 1931 and early 1933 the economy made a transition to a path of sustained recovery.

Such hesitant recovery paths have been observed more widely in the experience of the early 1930s. Eichengreen and Sachs (1985) report that on average there was hesitation between devaluation in the early 1930s and monetary expansion[6]. What does the British experience tell us about the role of policy regime change and the end of the great depression more generally? Clearly the British Government found it difficult to generate a favourable expectation effect on the recovery path

[5] The Import Duties Act was introduced by Neville Chamberlain in February 1932 and came into operation on 1 March 1932.
[6] Eichengreen and Sachs (1985) report that the mean lag between devaluation and monetary expansion was around 2 years in the early 1930s.

instantaneously with any single policy move – be it devaluation, tariffs or monetary expansion. However, there are a series of policy reactions that may have contributed to a persistent and strong recovery from early 1933. This suggests that it was not simple to generate a switching of an economy with one policy move. We contend that the picture of the UK can be generalised to other countries responding to the Great Depression with devaluation in 1931– an adaptive learning process may turn out to be a more general perspective for analysing policy effects on expectations[7]. To address the broader issue that arises from the British case study would require researchers to build a high frequency cross-country data set of the profile of depression and recovery in the 1930s.

3.2 Depression Profiles of the 1930s and Post-war

In this section we use the new data to compare the time-profile of depression of the 1930s with the three complete recessions of the post-war years and also with the current recession. The figures for the post-war years are calculated from the monthly GDP figures produced regularly by the National Institute of Economic and Social Research. These are computed monthly, making use of key monthly data (industrial production and retail sales) which are not available for the 1930s, and are always aligned against the latest quarterly official GDP data. While revisions to the official quarterly data can affect all the monthly estimates, obviously the data for the most recent recession are the most subject to change. All figures relate to GDP at market prices but the volume indices for the post-war years are aligned to chain-linked quarterly figures while the volume figures for the 1930s are linked to balanced Laspeyres measures.

The timing of the depressions is shown in Table 3. The start of each depression is the month in which GDP reached a peak and the last month is the month in which GDP was below this peak for the last time. It should be noted that this timing is sensitive to the end points being defined by the peak month rather than by, say, the peak of a centred three-month rolling average. Using the latter definition we would find, for example, that the current depression began in March 2008; even our choice

[7] The German case can also be incorporated into this perspective. Temin argues that the German recovery was delayed until the policy regime change of 1933. The German high frequency data suggests that recovery is built over a longer phase between 1932 and 1933 (Ritschl, 2002).

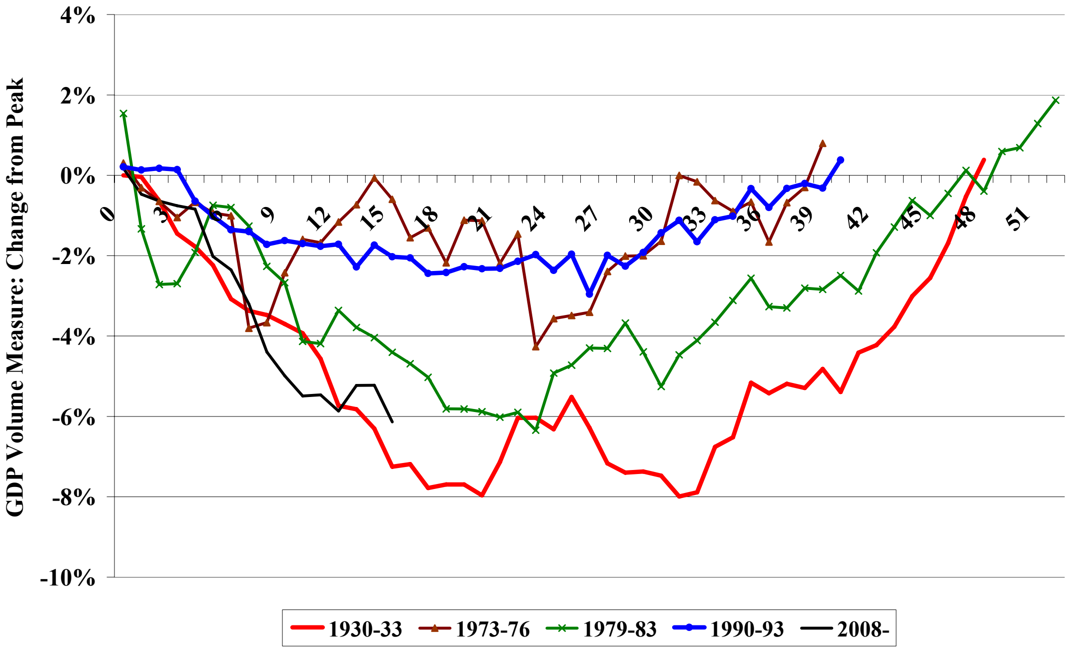
of April may seem arbitrary. Working to the two decimal places our interpolands make possible, output seems to have been very slightly lower in April than in February. But to one decimal place the output levels are the same and on these grounds we have placed the start in April. Similarly the date of emergence is sensitive to the definition; we have chosen the month after the last month in which output was depressed below the previous peak.

Table 3: The Timing of Recent Depressions

First Month	**Last Month**
January 1930	December 1933
June 1973	August 1976
June 1979	June 1983
March 1990	March 1993
April 2008	

In Figure 3, in order to suppress short-term noise we measure the change in GDP relative to the three-month average centred on the peak month. It can be seen that this has a substantial effect on the way in which the data for the 1979-1983 depression appear. GDP in June 1979 was 1½% higher than the average for the period May to July 1979 and this is shown in the positive displacement at the start of the depression. Had we instead measured the depression relative to GDP in the peak month the curve for 1979 to 1983 would have been shifted sharply down and the depression would then have appeared much more like the 1930s depression in its depth as well as its duration. The position of the other curves is not substantially affected by this treatment; as can be seen, the displacement at the start of the depression is small in the other four cases.

Figure 3: The Profiles of Five UK Depressions.



In Figure 3 we note that a number of depression-recovery profiles are observed even for this small historical selection of British depressions. A W-shaped depression-recovery profile is observed in the 1930s and the 1970s; the depression of the 1980s contains elements of V and W-shaped profiles; the depression of the 1990s is U-shaped. Explaining the determinants of these different profiles requires a more detailed discussion of each event.

In terms of profile the 1973-1976 depression appears to show the same sort of double dip to that of the 1930s. However, the factors behind this were quite different. The start of the depression is dated to May 1973. In the winter of 1973-4 oil supplies were disrupted by the OPEC embargo and there was a coal miners' strike which led to a three-day working week and widespread power cuts. While the depression started before these events, they were responsible for the sharp fall in output in the nine months of the recession. There then followed a recovery with a second dip which began late in 1974; it is worth noting that this second dip began as the stock market was close to the low point of the 1973-75 crash which is the sharpest collapse recorded on the UK stock market. The low point of the depression in the summer of 1975 followed the remarkable stock market recovery of January to March 1975 when the market, as measured by the Financial Times 30-share Index, more than doubled in the space of six weeks. But the depression as a whole was relatively short-lived with output surpassing its pre-depression level thirty-nine months after the start of the depression.

The depression which began in June 1979 also shows a steep fall followed by a sharp recovery and then a sustained downward move. The high level of demand in the second quarter of 1979 and particularly in June 1979 is generally regarded as anomalous by econometricians and there is no clear explanation of it although it may have been a result of pent-up demand after the combination of a series of strikes in the winter of 1978-79 and severe winter weather. After a fall in output in the summer of 1979 there was a recovery by the autumn. But the economy was now affected by the government's policy of high interest rates, with the Minimum Lending Rate set to 17% p.a. in November 1979 in order to bring down the inflation rate; possibly as a consequence of this policy of tight money, the exchange rate rose to a high level. This combination seems to have had a fairly sudden effect on output with the contraction continuing until April 1981 although the interest rate was reduced to 16% p.a. in July 1980 and 14% p.a. in November 1980 as the intensity of the squeeze became apparent. The exchange rate itself reached a peak[8] of 22% above its May 1979 value in February 1981 and then began to fall back, returning to its May 1979 value in January 1983 five months before output regained its 1979 peak. The expansionary influence of this more than dominated the contractionary effect of the March 1981 Budget and explains why, after the spring of 1981, the economy began to recover.

Both the 1973-1976 and the 1979-1983 depressions are described by Dow (1998) as OPEC recessions in that they both followed sharp increases in oil prices which were themselves associated with oil embargoes. In the first case the oil embargo followed the war between Israel and Egypt of November 1973.[9] In the second case it followed the revolution in Iran. But there was an important distinction

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[8] Measured by the IMF effective exchange rate index available from the Bank of England as series XUMAGBG.

[9] There had been an earlier embargo associated with Egypt's attack on Israel in 1967 but that was largely ineffective, probably because the United States was then the world's largest oil exporter.

between the two in that in the second recession policy-makers in Britain had the clear aim of using monetary policy to bring the rate of inflation down while during the first recession much greater reliance was placed on incomes policies and negotiation with trades unions.

The 1990 recession was the shortest of the complete post-war recessions; output surpassed its previous peak after thirty-seven months. Like the 1979 depression it was induced by tight monetary policy as a response to a high rate of inflation which followed on from the expansionary policies of the late 1980s. It was also, like the earlier depressions international in its spread. We date the trough of the depression to April 1992 suggesting that a very weak recovery was underway before the sterling devaluation associated with the end of ERM membership in September 1992. However, most economists would attribute an important role to this in sustaining the recovery.

The early period of the current depression suggests that what was initially a relatively mild contraction became much steeper from September 2008 onwards, with output falling by four percentage points between then and March 2009. This sharp contraction is widely linked to the financial crisis which followed the bankruptcy of Lehman Brothers on 16th September 2008. The period was associated with a steep contraction of international trade and marked de-stocking. This phase, in which output fell more steeply than in the 1930s depression, came to an end in the spring of 2009 and the current situation seems to be that output has become more stable but that there is no clear recovery underway in the Summer of 2009.

Conclusions

The strongest message from our analysis is that rather than use disparate indicators in an *ad hoc* manner to draw conclusions about the profiles of business cycles, it is preferable to use these variables to construct high-frequency estimates of GDP. There are two reasons for this. First of all, with no formal mechanism for aggregating disparate indicators it is not clear how judgement should be deployed in deciding how much importance to allocate to each; however if a formal mechanism for aggregation is used and it results in an indicator not directly related to GDP, the outcome can be only confusion. Secondly, if the indicator is not directly related to

GDP it is not clear how to relate the monthly signals it provides to that offered in standard GDP data.

Tools exist to interpolate GDP and we have shown here that, drawing on contemporaneously-collected monthly data, they can be used to produce monthly estimates of GDP for the UK for the period 1924-1938. The resulting series allows us to draw conclusions about the effects of key policy changes in the period which differ somewhat from those reached earlier without recourse to interpolated GDP figures. It also enables us to make a comparison between the depression of the 1930s and more recent depressions in the UK.

The high frequency GDP data provided here will be of use to economists and economic historians addressing a number of questions. The global financial crisis of 2008 has resulted in renewed interest in the homologies between the current events and the Great depression. This has resulted in the need for high frequency data covering both periods. To date the literature has been forced to use series for industrial production because they are available for both periods on a high frequency basis (Eichengreen and O'Rourke, 2009). However, in light of significant de-industrialisation over the post-war period, such comparisons can be very misleading when making macroeconomic comparisons. The monthly GDP series provided here allow for more relevant macroeconomic comparisons.

APPENDIX: THE TEMPORAL DISAGGREGATION METHOD AND A SUMMARY OF THE RESULTS

This appendix details the econometric methodology used to construct our indicator of monthly GDP from the available annual GDP data. The annual GDP data used (from 1924-1938) are the balanced constant price series at market values and taken from Sefton and Weale (1995, Table A.3, pp.188-189). The exercise, to ensure that the monthly GDP estimates over a calendar year sum to these annual data, is one of interpolation or, more precisely, distribution and has been considered, amongst others, by Chow and Lin (1971), Harvey and Pierse (1984) and Mitchell *et al.* (2005).

The approach taken here is to assume that a latent variable or "factor", taken to represent the "business cycle", drives variations and co-movements in the observed monthly, quarterly and annual data. A (dynamic) factor-based approach provides a parsimonious means of characterising fluctuations in a reasonably large number of variables. It avoids degrees-of-freedom constraints which a regression-based approach, that used all the indicator variables, would confront.

A1. Interpolating monthly GDP using a dynamic factor model

The particular model employed is based on Proietti and Moauro (2006). Their model has the attraction of letting us work in the log-levels of the variables, rather than their growth rates as in Stock and Watson (1991) and can handle mixed frequency data.

Consider the N-vector of monthly time-series $\mathbf{y}_{t,m}$, where the subscript t denotes the particular year, q the quarter within that year and m the month within that year, $m=1,\ldots,12$; $q=1,2,3,4$ and $t=1,\ldots,T$. It is assumed that $\mathbf{y}_{t,m}$, perhaps after a logarithmic transformation, is a linear combination of a (scalar) common factor $\mu_{t,m}$, which represents the "business cycle", and an idiosyncratic N-vector component $\boldsymbol{\mu}^{*}_{t,m}$. The business cycle's effect on each of the N time-series in $\mathbf{y}_{t,m}$ can differ and is determined by the N-vector of factor loadings, $\boldsymbol{\theta}$. The model can be represented as:

$$\left.\begin{aligned}&\mathbf{y}_{t,m} = \boldsymbol{\theta}\mu_{t,m} + \boldsymbol{\mu}^*_{t,m},\ t = 1,...,T;\ m = 1,...,12\\&\phi(L)\Delta\mu_{t,m} = \eta_{t,m},\ \eta_{t,m} \sim NID(0,\sigma^2_\eta)\\&\mathbf{D}(L)\Delta\boldsymbol{\mu}^*_{t,m} = \boldsymbol{\beta} + \boldsymbol{\eta}^*_{t,m},\ \boldsymbol{\eta}^*_{t,m} \sim NID(\mathbf{0},\boldsymbol{\Sigma}_{\boldsymbol{\eta}^*})\end{aligned}\right\} \quad (1)$$

where $\phi(L) = 1 - \phi_1 L - ... - \phi_p L^p$ is an autoregressive polynomial of order p with stationary roots and the matrix polynomial $\mathbf{D}(L)$ is diagonal with elements equal to $d_i(L) = 1 - d_{i1}L - ... - d_{ip_i}L^{p_i}$, $\boldsymbol{\Sigma}_{\boldsymbol{\eta}^*} = diag(\sigma^2_1,...,\sigma^2_N)$ and the disturbances $\eta_{t,m}$ and $\boldsymbol{\eta}^*_{t,m}$ are independently distributed.

Model (1) implies that each individual time-series $\Delta y_{it,m}$ (*i=1,…,N*), expressed as a first difference, is composed of a mean (drift) term β_i, an individual autoregressive (AR) process $d_i(L)^{-1}\eta^*_{it,m}$ as well as the business cycle (common) AR component $\phi(L)^{-1}\eta_{t,m}$. Following Stock and Watson (1991), we achieve identification by setting $\sigma^2_\eta = 1$ and assuming a zero drift in the equation for $\Delta\mu_{t,m}$. Model (1) is flexible. It can accommodate elements of $\mathbf{y}_{t,m}$ being I(1); both the common trend $\mu_{t,m}$ and the idiosyncratic components $\boldsymbol{\mu}^*_{t,m}$ are modelled as difference stationary processes. Proietti and Moauro (2006) explain how this model can be cast in state-space form, which is the precursor to estimation of the model by maximum likelihood using the Kalman filter.

However, while the model (1) governing the determination of $\mathbf{y}_{t,m}$ is considered at the monthly frequency, actual observations for some of the N variables might not be available each month. In particular, we partition $\mathbf{y}_{t,m}$ into $\mathbf{y}_{t,m} = (\mathbf{y}'_{1t,m}, y_{2t,m}, y_{3t,m})'$ where $\mathbf{y}_{1t,m}$ represents the observed monthly indicators from *The Economist* (considered further below) and $y_{2t,m}$ and $y_{3t,m}$ represent monthly industrial production and GDP, respectively, which, of course, are latent and the objects we wish to estimate.

Fortunately, we do observe annual GDP data y_{3t}, such that

$$y_{3t} = \sum_{m=1}^{12} y_{3t,m} \quad (2)$$

Similarly, we observe quarterly industrial production data y_{2q}, such thatimport

$$y_{2q} = \sum_{m=(q-1)*3+1}^{m=q*3} y_{2t,m};\ q = 1,...,4. \quad (3)$$

Harvey and Pierse (1984) first explained how a model like (1), when cast in state-space form, can be estimated subject to (flow) aggregation constraints like (2) and (3) and knowledge only of the annual GDP data, y_{3t}, and/or the quarterly industrial production data, y_{2q}. This is achieved by augmenting the state-space representation of model (1) with a so-called cumulator variable that ensures (2) or (3) is satisfied. The Kalman smoother is then used to compute the minimum mean squared error estimates for the missing observations $y_{2t,m}$ and $y_{3t,m}$.

As Mitchell *et al.* (2005) explain the state-space approach to interpolation can be seen as asymptotically equivalent to regression-based methods. First developed by Chow and Lin (1971), and generalised to a dynamic non-stationary setting by Mitchell *et al.* (2005), these methods first aggregate the latent monthly model, which relates monthly GDP to the observed monthly indicators, so as to obtain an estimable equation in the observed annual data. Estimates of the unobserved monthly interpolands may then be produced by means of the latent monthly regression equation, and estimated coefficients based on the annual model, using data on the observable monthly indicators

When $\mathbf{y}_{t,m}$ represents the logarithms of the original time-series the temporal aggregation constraint, seen previously in (2) and (3), is nonlinear: the sum of the logarithms is not the logarithm of the sum. We follow Proietti and Moauro (2006) and use their iterative algorithm to ensure the nonlinear aggregation constraint is met exactly given we model the data considered below in logarithms.

Estimation subject to the two aggregation constraints, (2) and (3), is facilitated by adopting a recursive structure whereby industrial production, as a component of GDP, affects GDP, but GDP does not affect industrial production. This means we first estimate $y_{2t,m}$ as a function of $\mathbf{y}_{1t,m}$ subject to (3), and obtain consistent estimates $\hat{y}_{2t,m}$, and then estimate $y_{3t,m}$ as a function of $\mathbf{y}_{1t,m}$ and $\hat{y}_{2t,m}$, subject to (2).

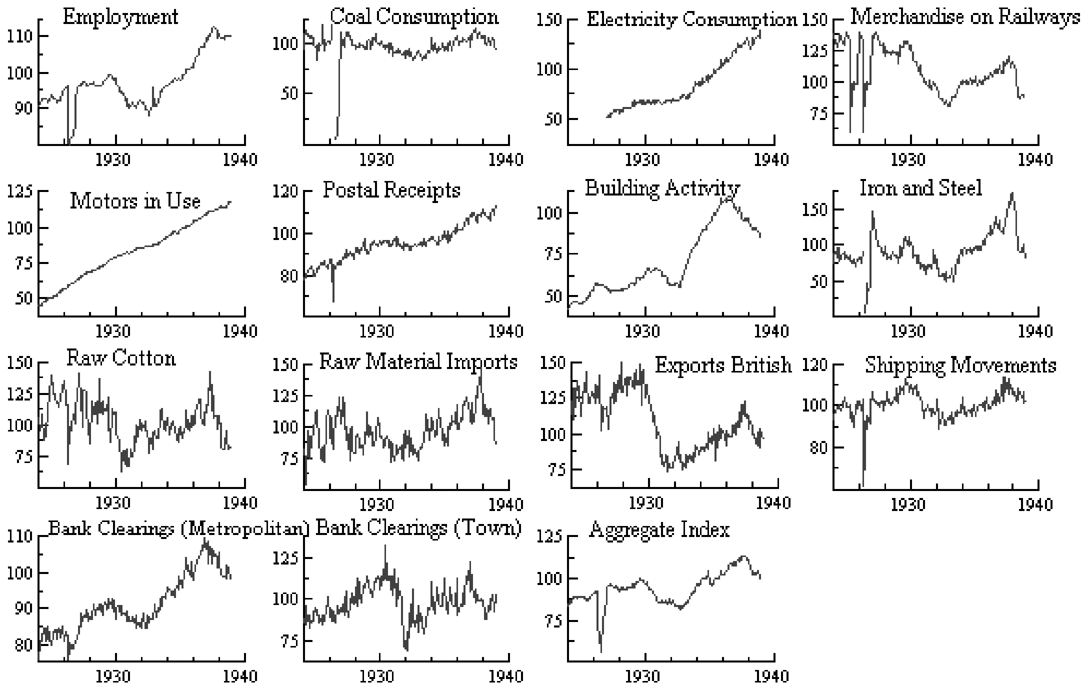
A2. The Data and Empirical Results

The Economist newspaper contains 15 index numbers from 1924m1-1938m12 pertaining to economic activity: employment, coal consumption, electricity consumption, railways, commercial motors in use, postal receipts, building activity, iron and steel for home consumption, raw cotton delivered to mills, imports: raw materials, exports of British manufactures, shipping movements, bank clearings (metropolitan), banking clearings (town) and what is called the "Aggregate Index".

The Aggregate Index, as discussed and evaluated by Rhodes (1937), in fact is itself a composite indicator designed to measure "some abstraction called Economic or Business Activity" (Rhodes, p. 18). It is a geometric average of the other 14 index numbers, with the weights chosen subjectively to reflect the relative importance of the constituent series. Rhodes (1937) set out an alternative statistical means of determining the weights and deriving an index of business activity. Our exercise, as indicated, is somewhat different from Rhodes' and later the one undertaken by Stock and Watson (1991), and others. Rather than focus on the estimated latent variable which captures the "business cycle", i.e., $\mu_{t,m}$ in model (1), we consider the estimates of monthly GDP itself. This has the attraction precisely of not being a latent variable, so that its meaning is clear to all.

Plotting the 15 series from *The Economist* in Figure A1 we see the clear effect of the General Strike in 1926. Coal production abruptly ceased in May-June 1926 and did not recover until the following year. The General Strike also had a similar effect on Iron and Steel for Home Consumption, with the whole economy clearly affected to some extent also. It is also of note that the data for Electricity were not available each month until 1927. Prior to this they are available at the quarterly frequency only. These missing observations are handled, as indicated, by the Kalman filter. What are effectively outliers, due to the General Strike in 1926, are also tackled by setting the affected observations to missing values and letting the Kalman filter and smoother fill in the observations instead. Specifically, we set coal production to a missing value from 1926m5-1926m11 and set the 1925m5 value to a missing value for several other indicator variables. We note that similar results for the post 1927 period are in fact obtained if we commence estimation of model (1) in 1928.

Figure A1: *The Economist*'s monthly data



Assuming AR(1) processes ($p=1$ and $p_i=1$) for the lag polynomials in model (1), the unknown parameters were then estimated by maximum likelihood exploiting the Kalman filter. The maximised value of the log-likelihood function, for the model explaining $\mathbf{y}_{t,m} = (\mathbf{y}'_{1t,m}, y_{2t,m}, y_{3t,m})'$, was 5343.14. The parameter estimates, and their asymptotic *t*-values, are presented in Table A1. The estimated factor loadings are all positive and are mostly significantly different from zero (at a 99% level). The sign of the estimated factor loadings is consistent with the view that all of *T*he *Economist*'s series are coincident indicators of economic activity. The *t*-values on the factor loadings are largest for employment, raw cotton delivered to mills, industrial production and GDP. This indicates that these four series are most sensitive to the "business cycle". If *The Economist*'s own preferred measure of economic activity, the Aggregate Index, were the only variable affected by the latent cyclical trend $\mu_{t,m}$ we should expect it to be the only series with a significant factor loading.

Table A1 shows that $\mu_{t,m}$ explains a statistically significant amount of the variation in the majority of *The Economist*'s 15 series, as well as, importantly, monthly GDP itself. Although our interest is with monthly GDP, rather than the "business cycle", it is perhaps of interest that $\mu_{t,m}$ does not explain a statistically significant amount of the variation in the Aggregate Index. This suggests that the best statistical characterisation of the "business cycle" is not offered, as Rhodes suspected, by *The Economist*'s preferred measure – the Aggregate Index.

Inspection of the AR coefficients in Table A1 reveals that the common factor $\mu_{t,m}$ follows an autoregressive process with a positive coefficient, with the coefficients that determine the idiosyncratic components exhibiting some heterogeneity across the different indicators. We could not accept, via a Likelihood Ratio test, the restriction that the idiosyncratic components shared a common AR coefficient. The majority of the parameters are statistically significant and the model shows good overall fit.

Table A2 presents some model diagnostics based on the Kalman filter innovations from model (1). It shows that the model appears to be reasonably well specified, with the majority of the equations (for the different series) delivering innovations free from serial correlation and non-normality. The failure of the normality test for employment, motors, the Aggregate Index and industrial production is explained by excess kurtosis (fat tails) which could not be eliminated by setting selected outlying observations to missing values. Importantly, the equation for GDP appears to be reasonably well specified.

Table A1: Parameter estimates and their asymptotic t-values

	Factor loadings (x100)		Autoregressive	
	Coeff	*t*-value	Coeff	*t*-value
Employment	1.27	12.65	-0.20	-2.62
Coal Consumption	0.96	7.40	0.79	3.96
Electricity Consumption	0.52	0.83	-0.37	-4.86
Railways	0.51	2.28	-0.50	-6.87
Motor	3.00	6.31	-0.39	-5.59
Postal Receipts	0.02	0.34	-0.22	-3.01
Building activity	0.19	1.75	-0.40	-5.83
Iron and Steel for Home consumption	0.17	1.25	0.27	3.77
Raw Cotton delivered to Mills	21.26	12.83	0.31	3.04
Imports: Raw Materials	2.37	3.99	-0.36	-5.12
Exports British	1.36	1.99	-0.35	-4.99
Shipping Movements	0.81	2.01	-0.42	-6.11
Banking clearings	1.78	8.28	-0.46	-6.66
Banking town	0.40	3.39	-0.52	-7.82
Aggregate Index	0.56	1.30	-0.39	-5.59
Monthly Industrial Production: $y_{2t,m}$	2.59	12.97	-0.10	-1.17
Monthly GDP: $y_{3t,m}$	5.62	17.01	-0.98	-77.38
ϕ (AR coefficient for the "business cycle")	-	-	0.29	3.75

Table A2: Diagnostic tests. The Box-Ljung test for no residual serial correlation with a maximum of 8 lags and the Bowman-Shenton test for normality

	Box-Ljung	Bowman-Shenton
Employment	4.61	71.08
Coal Consumption	13.07	1.41
Electricity Consumption	9.47	0.11
Railways	6.75	0.22
Motor	5.96	43.41
Postal Receipts	10.65	0.35
Building activity	12.11	1.50
Iron and Steel for Home consumption	3.45	0.08
Raw Cotton delivered to Mills	5.70	0.50
Imports: Raw Materials	10.54	2.28
Exports British	25.33	4.11
Shipping Movements	11.04	0.21
Banking clearings	12.91	1.17
Banking town	12.08	4.34
Aggregate Index	25.96	31.45
Monthly Industrial Production: $y_{2t,m}$	19.83	58.10
Monthly GDP: $y_{3t,m}$	5.24	6.75
99% critical value	17.54	7.38

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