

ABSTRACT

This paper argues that non-random measurement errors in the estimates of British Gross Domestic Product makes the compromise estimate a biased indicator of medium-term economic growth. Since the compromise estimate of GDP has been widely accepted and used to describe macroeconomic trends in the British economy this has resulted in descriptions of British economic growth that are best explained as statistical artifacts. This paper questions the existence of an “Edwardian Climacteric”, argues for a rethinking of the myth of the “Great Depression” and offers new insights on inter-war economic growth.

KEY WORDS: Economic History, Economic Growth, Economic Cycles

JEL CLASSIFICATION: N13, N14, O52

BRITISH EPISODIC ECONOMIC GROWTH 1850-1938¹

Solomos Solomou²
Faculty of Economics
Austin Robinson Building
Sidgwick Avenue
Cambridge CB3 9DD
UK

Cristiano Andrea Ristuccia
Department of Applied Economics
Austin Robinson Building
Sidgwick Avenue
Cambridge CB3 9DE
UK

March, 2002

“The study of economic growth, therefore, stands closer to history than do other economic subjects ... it seems unlikely that for the foreseeable future, the economics of growth can be much more than economic history rationalised here and there to a limited degree as uniformities in the process of development are established.” (Abramovitz, 1951, pp.177-8)

Modern economic growth has not been steady (Abramovitz, 1961, 1968, 1989). Although rates of economic growth have been rapid by long-term historical standards, episodic growth phases have been the norm across time and a wide set of countries (Temple, 1999). The historical process of economic growth has been characterised by a number of episodic features. As examples, in the very long run we observe major trajectory shifts such as are captured by transitions from an agricultural to an industrial economy. Comparing the 19th and 20th century growth

¹ Research for this paper has been supported by a Research Grant from the ESRC (No. L138 25 1045). We would like to thank Charles Feinstein and the participants of the *Workshop on Productivity Growth, Trade in Foods, and Living Standards across Centuries and Countries*, December 2001, UC Davis, USA for useful comments. The usual disclaimer applies.

² Communications to: SS19@econ.cam.ac.uk

paths we observe a transition from *extensive* growth based on input accumulation, to *intensive* growth based on more rapid labour and total factor productivity growth. In the era of industrial maturity during the late 19th Century we observe episodic ‘long swings’, or low frequency fluctuations in economic growth. Events, such as policy regime changes and wars, have also had a discernable effect on the observed path of medium-term economic growth, as illustrated by the national growth patterns of the inter-war period.

The aim of this paper is to describe the specific aspects of episodic growth during the period c.1850-1938 using Britain as a case study. The research is motivated by two problems. First, British economic historians have used a very restricted set of macroeconomic data to describe the phases of British economic growth. The conventional historiography has relied on the use of the compromise estimate of GDP (the average of the output, income and expenditure estimates) and the associated productivity measures built from this index. In this paper we argue that the compromise estimate provides a biased measure of GDP, mainly because the measurement errors are not random. The case is made that we need to consider a broad set of data, with a clear understanding of the strengths and weaknesses of different series in relation to the particular issues being addressed. Secondly, the phasing of British economic growth has been based on peak-to-peak cycle growth measures. Here, we work with the Kalman filter methodology to decompose trends and cycles. This method has the flexibility of avoiding sample selection biases introduced by the researcher and allowing us to focus on the existence of low frequency cycles in a framework that allows for the existence of a number of cycles, which is essential for describing economic growth for the pre-1913 period. A methodological outline of the Kalman filter is presented in the Appendix to this paper.

The structure of the paper is as follows: section I describes some of the data problems that motivate the research; section II uses descriptive data analysis in conjunction with the Kalman filter trend-cycle decomposition method to determine the major phases of British economic growth during the period c.1850-1913. Section III considers the inter-war epoch in the light of the growth episodes of the earlier period. Section IV evaluates a number of conventional historical debates regarding the ‘Great Depression’ of the late 19th Century, the ‘Edwardian Climacteric’ and the inter-war period.

I. DATA PROBLEMS

In order to analyse historical episodic economic growth we have to make use of macroeconomic data whose reliability is much lower than comparable figures for the post-war period. As a result, we need to be aware of two important problems. There

are major discrepancies between the output, expenditure and income estimates of GDP (Feinstein, 1972; Feinstein *et al.*, 1982; Solomou and Weale, 1991). The existing literature provides an *ad hoc* solution to this problem by suggesting the use of a 'compromise' estimate of GDP³ as the most reliable index. For example, Feinstein *et al.* 1982 argue:

“While divergences between alternative indicators of GDP prevent any entirely satisfactory resolution in the timing and sectoral incidence of retardation in the British economy after 1873, the compromise-index is probably the most reliable, and it indicates that the falling-off in the rate of growth of GDP in 1873-1913 compared with 1856-1873 took place chiefly after 1899.” (Feinstein *et al.*, 1982, pp. 182-3)

The theoretical rationalization for using a compromise estimate in the face of measurement errors is that if the measurement errors are random the average provides the best unbiased estimate of GDP utilizing all the information available (Feinstein and Thomas, 2001). As is illustrated below this is clearly not the case. To use the average of the three GDP estimates to describe the macroeconomic history of the British economy is likely to generate artefact descriptions that bear little relation to historical reality. Solomou and Weale (1991) addressed the theme of reliability changes over time and constructed the 'balanced' estimate of GDP to address this. This yielded some significant differences with the compromise estimate. To date the implications of working with GDP indicators that have non-random measurement errors in the pre-1913 data has not been addressed. Economic historians and economists continue to use the compromise estimate, despite unfounded statistical assumptions.

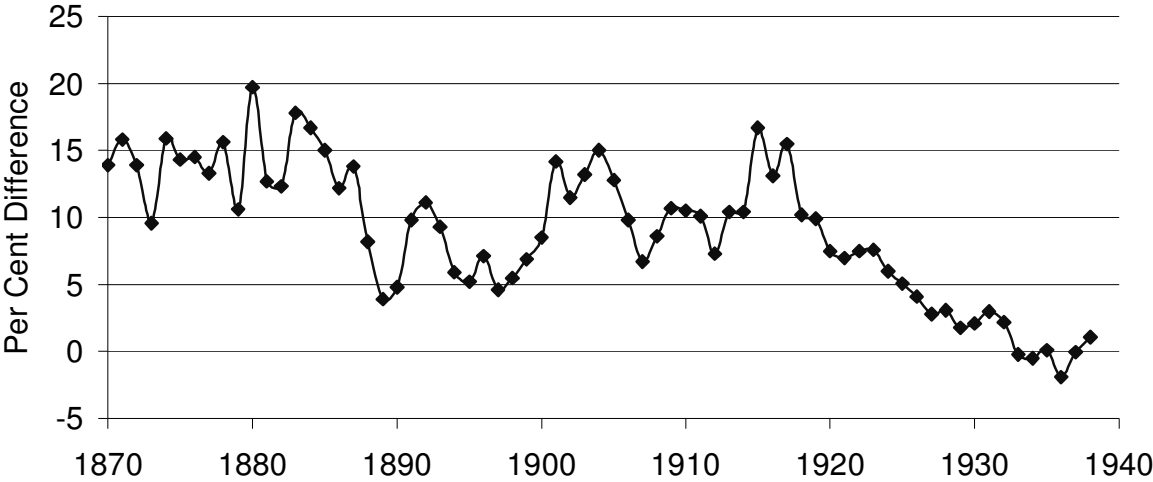
The nature of the measurement error in the data can be seen in the plot of the percentage discrepancies between the expenditure and income estimates, displayed in Figure 1⁴. It is clear that the proportional discrepancies are large, autocorrelated, and display stochastic trend movements. Given the nature of actual measurement errors in British GDP estimates, a simple average will result in a biased index of GDP. To neglect the implications of this simple point is not feasible. Instead of using a biased average, this paper uses a wide set of the available data to build a picture of medium term economic growth during the period 1850-1938. We consider a broad set of quantitative evidence that is sometimes conflicting. The focus is on macroeconomic trends but we place these trends in the context of sectoral movements. To maintain a

³ The balanced estimate of GDP (Solomou and Weale, 1991) is subject to similar criticisms. Although the averaging procedure allows for a weighting system based on data reliability and changes of data reliability over time, non-random measurement errors are neglected.

⁴ Formal statistical tests verify the existence of autocorrelation, cycles and stochastic movements in the measurement error.

focus in the light of data reliability issues we aim to use British historical data to address a very particular question: to what extent do different series agree on the description of the phases of British economic growth? Where they disagree, as a result of measurement error, we wish to highlight this as an area of future research in the reliability of the underlying data.

**Figure 1: Per Cent Residual Errors of GDP
(Expenditure-Income)/Expenditure**



II. TRENDS AND CYCLES: 1850-1913

In this section we use the Kalman filter model to estimate the trend and cycle movements during the pre-1913 period. The methodology is outlined in an Appendix to this paper⁵. Given the changes in cycles over time and the data discontinuities that arise from the world wars of the 20th Century we have dealt with this problem by employing the Kalman filter method over a time that shows evidence of a relatively stable cyclical structure. In the case of Britain, given the changes in cycles and trends over the inter-war period relative to the pre-1913 period we use the Kalman filter method to help us describe the growth path of the pre-1913 epoch and use this description to make comparisons with the inter-war period.

⁵ In the appendix we also compare the Kalman filter to other methods of trend estimation.

GROSS DOMESTIC PRODUCT

Having noted the problems in the construction of the British GDP series our aim is to utilise the three different estimates of GDP to derive a phasing of the episodes of British economic growth.

Table 1: GDP Growth Rates 1870-1913

	GROWTH PER ANNUM	STANDARD DEVIATION
Income	0.0190	0.027
Output	0.0184	0.0231
Expenditure	0.0187	0.0280
Compromise	0.0187	0.0219

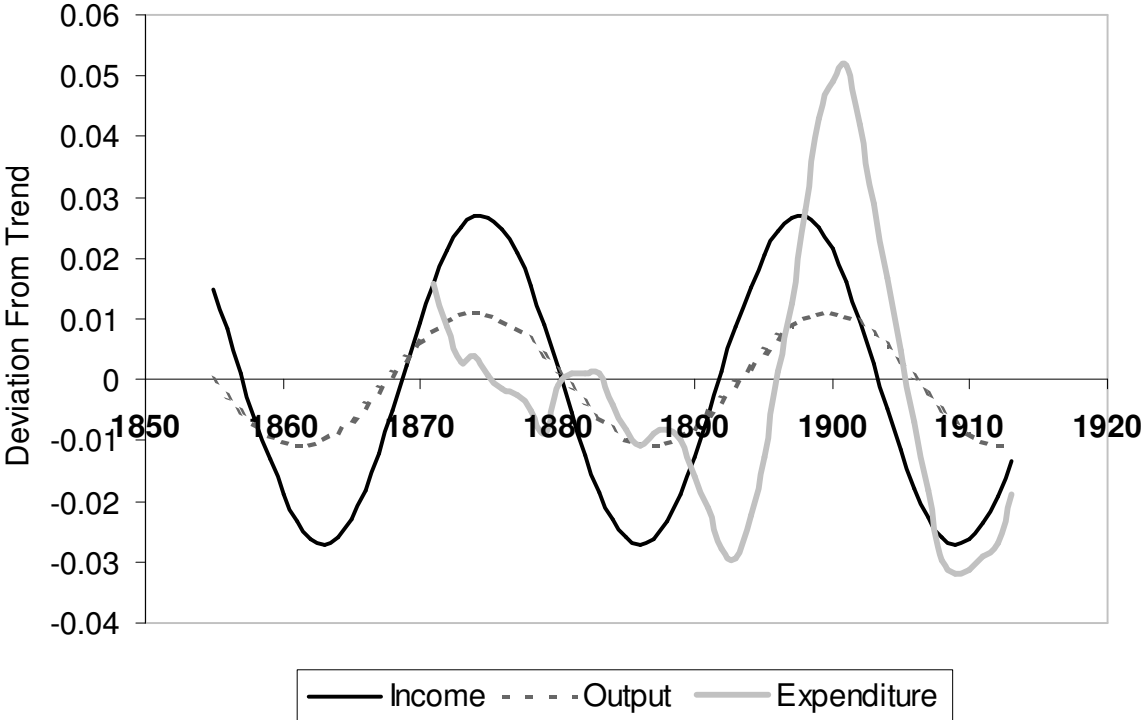
From Table 1 it is clear that all the available series are agreed on the long-term growth rate. For the period 1870-1913 we have three estimates of GDP, the income, expenditure and output series. These all yield an annual growth rate of approximately 0.019⁶. Using the Kalman filter model of trend-cycle decomposition gives us more information on the phasing of economic growth within this period. We allow for the existence of up to three cycles in the estimation. Over the sample period that we are concerned with, the Kalman filter estimate of the trend is found to be deterministic with a stable slope, reflecting a stable long-term growth rate. In the light of the stability of the long-term trend, our interest is in the existence of low frequency fluctuations of economic growth.

All three series of GDP are agreed that there is some evidence of low frequency fluctuations (see Figure 2). Although the phasing is not identical, reflecting significant non-random measurement errors in the data, all series show an upswing of growth during the 1890s and a downswing during the Edwardian period. This agreement over the period 1890-1913 reflects improved data reliability over time (Feinstein, 1972; Matthews *et al.*, 1982; Solomou and Weale, 1991). However, before the 1890s we observe significant differences that affect our phasing of medium term economic growth. The income and output series show a downswing in

⁶ As a result, the compromise and balanced averages also average a growth rate of 0.019 over this period.

the 1870s and early 1880s, followed by an upswing from the mid-1880s, whilst the expenditure series shows a ‘downswing’ beginning in the 1870s and lasting until 1893⁷.

Figure 2: Long Swings in Income, Expenditure and Output Estimates of GDP



In the light of the fact that in the long run all series are agreed on the estimate of economic growth, we seek to consider the level of agreement in terms of a phasing of the major episodes of growth, as captured by the low frequency fluctuations and trend movements of the available series. Since the income and output estimates of GDP (and their average as a compromise estimate) are available over a longer period (1855-1913) we have also estimated Kalman filter models over this period. The main advantage of this is that we can get a better sense of the swings of the 1860s and 1870s. Although there is a difference in the way the long term trend is depicted by the two series, with the output series best described as trend-stationary whilst the income series shows a moderate growth retardation from the 1890s, both series give a similar phasing of the long swings (see Figure 2).

⁷ Since the expenditure estimate of GDP only exists for the period 1870-1913 it would be more appropriate to argue that the rate of economic growth is low during 1870-1890, compared to the 1890s.

The expenditure series has been reconstructed only for the period 1870-1913 and is recognized to be significantly more reliable after c.1890. The expenditure side of GDP displays low frequency fluctuations with a downswing in the 1870s and early 1880s, an upswing in the 1890s and a downswing in the Edwardian period. The main difference to the other series is to be found in the period of the 1880s and early 1890s, which is depicted as a low growth episode in the expenditure series. Analysing the cyclical structure of the expenditure series suggests that most of the cyclical variation has been placed in the low frequency fluctuations. The high frequency fluctuations are not significant (reflecting the extensive use of linear interpolation). Overall the series does not capture the cyclical history of the period. As a result, the fluctuation observed has been depicted as part of a long swing, with a downswing over the period 1870-93. Such a pattern of growth can be attributed to the data generation methods (in particular the extensive use of interpolation/extrapolation), suggesting that some discretion needs to be exercised in employing the expenditure estimate to phase the episodes of growth over the period before the 1890s.

Summarising, an analysis of the individual GDP series suggests that because the income and output series offer a similar phasing of the low frequency fluctuations, the compromise estimate of GDP captures the general pattern of low frequency fluctuations in the British economy⁸. However, the compromise estimate also creates significant distortions in the description of the amplitude and timing of the observed low frequency fluctuations. As a result, the long swing fluctuations are of very low amplitude during the pre-1890 period. The only significant growth variation that remains in this series is the retardation that has become labeled as the 'Edwardian Climacteric', representing a growth break during 1899-1913 relative to the period 1850-1899 (McCloskey, 1970; Matthews *et al.*, 1982; Feinstein *et al.* 1982). This interpretation has distorted historical reality. Placing the evidence in the context of a debate on data reliability, the significant growth episodes that need to be explained have been neglected; instead, attention has been focused on explaining growth episodes that are merely statistical artifacts.

To get a sense of the magnitude of growth variations, Tables 2 and 3 present growth rates over the long swing phases of the income and output estimates of GDP. The swings found showed marked fluctuation (see inter-period growth measures reported in Table 2). Tables 4 and 5 show similar calculations based on the specific phases derived from the compromise estimate of GDP. Clearly the observed inter-period growth rate changes were large enough to yield a shift in the growth trajectory of the economy. In terms of the historical significance of these growth variations,

⁸ The two series are used to construct the compromise estimate over 1855-1870 and have a two-thirds weight over the period 1870-1913.

since the British economy was influenced by a number of cycles at the same time, the growth episodes capture the sum of cyclical growth variations observed by contemporaries.

Table 2: Long Swings of GDP Based on Kalman Filter Phasing of Output Estimate of GDP

	GROWTH RATE PER ANNUM	INTER-PERIOD GROWTH CHANGE
1855-1861	0.0215	-
1861-1874	0.0214	-0.0001
1874-1887	0.0131	-0.0083
1887-1899	0.0235	+0.0104
1899-1913	0.0168	-0.0067

Table 3: Long Swings of GDP Based on Kalman Filter Phasing of Income Estimate of GDP

	GROWTH RATE PER ANNUM	INTER-PERIOD GROWTH CHANGE
1855-1863	0.0193	-
1863-1874	0.0247	+0.0054
1874-1886	0.0149	-0.0098
1887-1899	0.0292	+0.0143
1899-1913	0.0101	-0.0191

Table 4: Long Swings of GDP Based on Kalman Filter Phasing of Compromise Estimate of GDP

	GROWTH RATE PER ANNUM	INTER-PERIOD GROWTH CHANGE
1864-1876	0.0220	-
1876-1887	0.0157	-0.0063
1887-1899	0.0263	-0.0106
1899-1910	0.0097	-0.0166

Table 5: Long Swings of GDP Based on Kalman Filter Peak-to-peak Phasing of Compromise Estimate of GDP

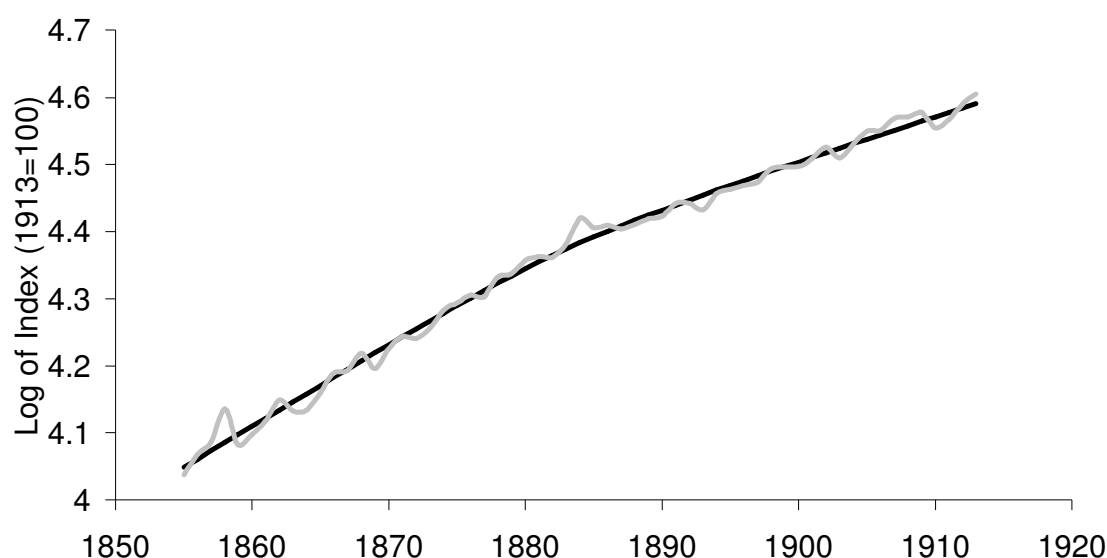
	GROWTH PER ANNUM	INTER-PERIOD CHANGE
Income Estimate		
1864-1876	0.0243	-
1876-1887	0.0162	-0.0081
1887-1899	0.0300	+0.0138
1899-1910	0.0072	-0.0228
Output Estimate		
1864-1876	0.0200	-
1876-1887	0.0136	-0.0064
1887-1899	0.0235	+0.0099
1899-1910	0.0121	-0.0114
Expenditure Estimate		
1864-1876	-	-
1876-1887	0.0176	-
1887-1899	0.0253	+0.0077
1899-1910	0.0099	-0.0154

The evidence considered so far suggests that long swings in GDP are a feature of British economic growth during the period c.1855-1913. Despite the problems of data reliability, for the purpose of identifying growth episodes in the long swing frequency, the income and output estimates yield a similar phasing of the swings of British economic growth. The low amplitude of the observed swings in the output estimate is an outcome of data construction that is now well recognised. The income series, which is better suited to the study of fluctuations (Feinstein *et al.*, 1982) suggests that the true amplitude is high.

LABOUR PRODUCTIVITY

The discussion so far has pinpointed some significant problems with phasing the historical growth path of the British economy. Although the income and output estimates of GDP suggest a similar long swing phasing for British economic growth, there are significant differences to note. Whilst the output estimate is depicted as a trend-stationary path, the income estimate shows moderate retardation at the end of the 19th Century. Although these measurement errors did not affect the phasing of long swings in GDP we need to be careful as we broaden the discussion to other variables, such as productivity.

Figure 3: Labour Productivity and Kalman Filter Trend (1855-1913). Output estimate of GDP



We begin with an analysis the path of aggregate productivity by considering the two longest series before 1913. Labour productivity measured using the output estimate of GDP is presented in Figure 3. The Kalman filter decomposition of trend and cycle movements suggests that the trend of labour productivity is stochastic with a significant step retardation during the period c.1870-1890 and more stable growth during the periods c.1855-1870 and c.1890-1913 (see Figure 4). Although long swings in labour productivity can be identified, the variance of the swings is low and statistically insignificant⁹.

⁹ As noted above the use of linear interpolation in the construction of the output series means that the series is not well suited for analysing the cyclical path of the economy. When looking at

Figure 4: Kalman Filter Estimate of Slope of Labour Productivity 1855-1913: Output estimate of GDP

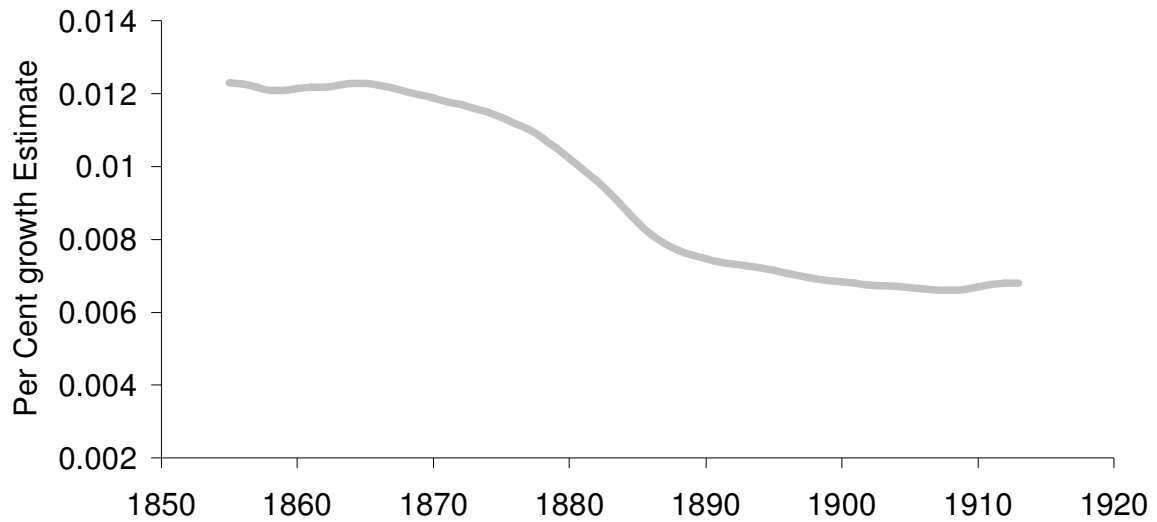
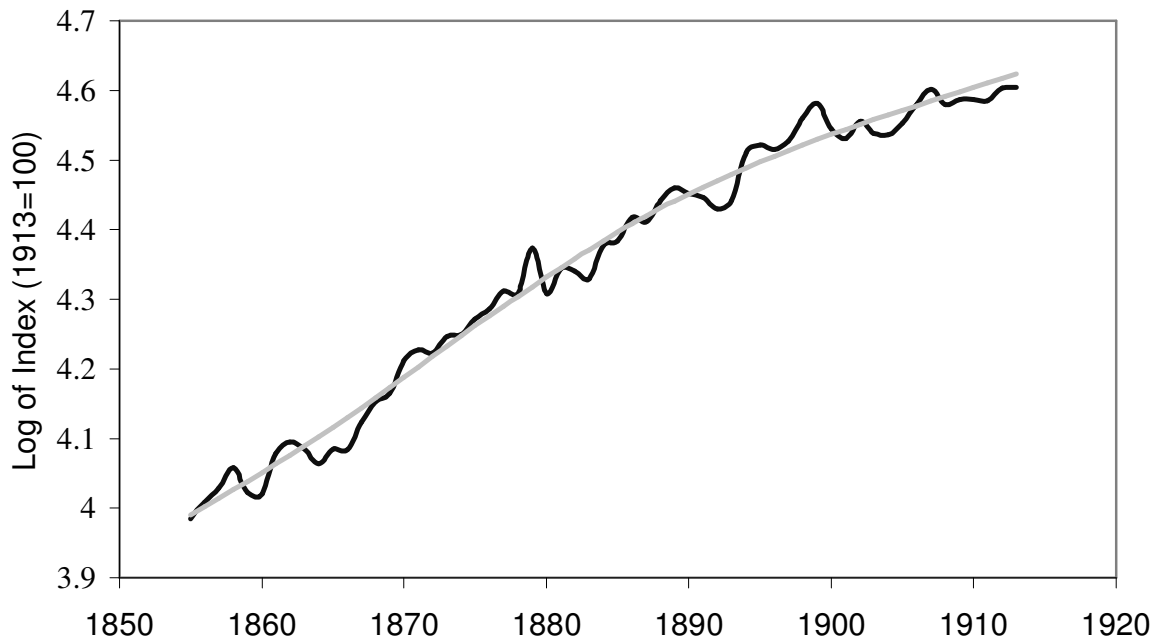


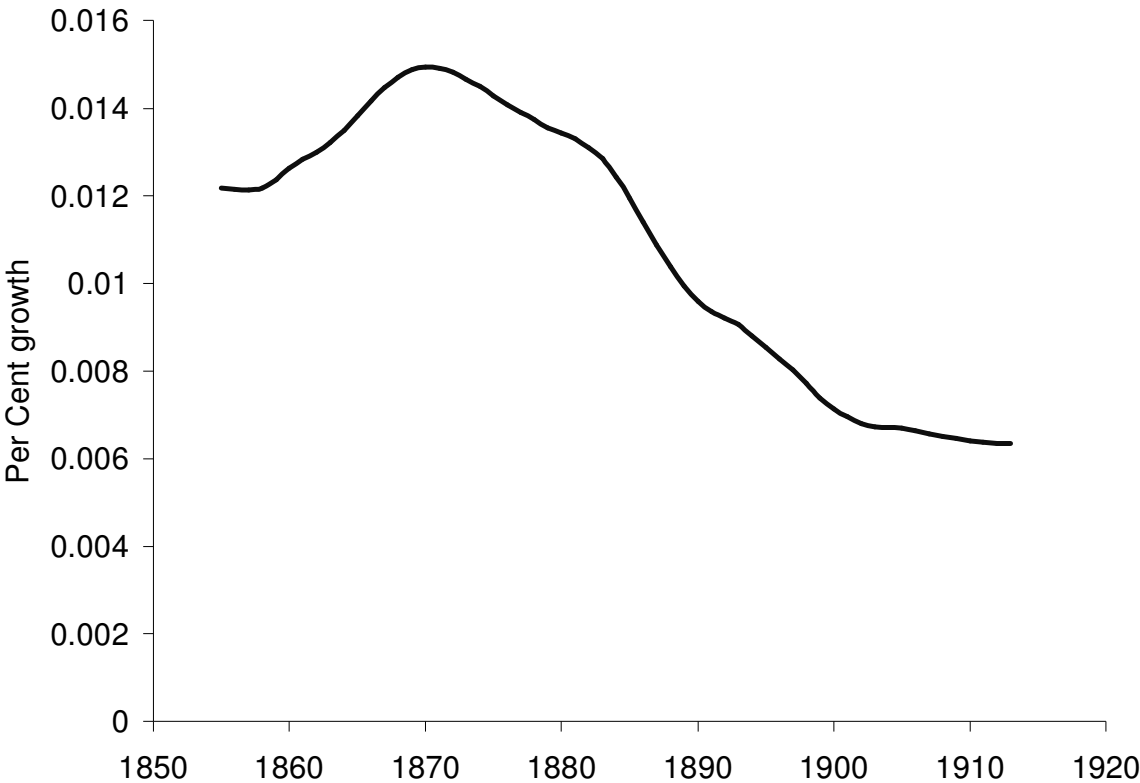
Figure 5: Labour Productivity and Kalman Filter Trend 1855-1913: Income estimate of GDP



labour productivity this is further complicated by the existence of long term fluctuations in labour input that are not synchronised with the movements of output.

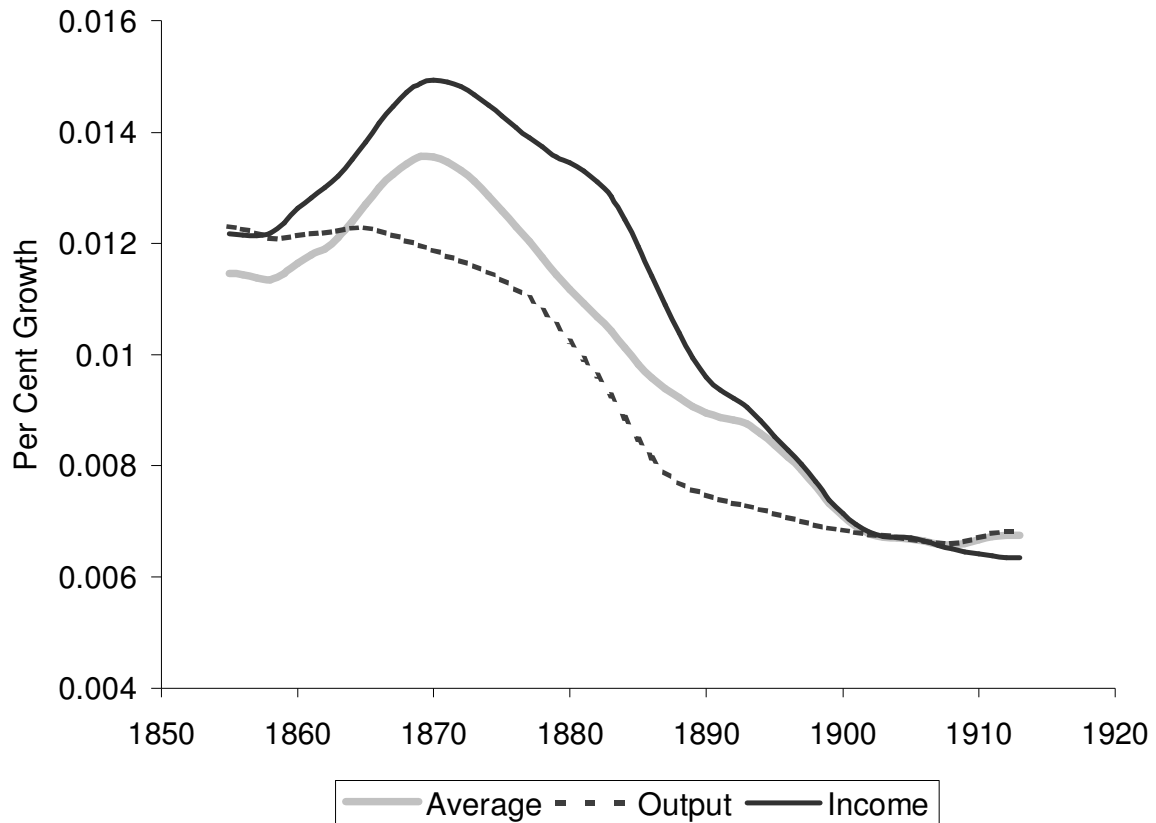
The movement of labour productivity derived from using the income estimate of GDP is plotted in Figure 5. A stochastic trend is observed, with labour productivity showing significant step retardation during the 1880s and 1890s and more stable productivity growth during c.1855-80 and the early 20th Century (see Figure 6). On top of this we observe a series of episodic swings, similar in phasing to the GDP swings outlined above (although the productivity swings have a lower amplitude than the output swings).

Figure 6: Kalman Filter Estimate of Slope of Labour Productivity 1855-1913: Income GDP



In order to consider the inferences derived from using the compromise estimate of GDP we construct an aggregate labour productivity series utilising the average of the income and output estimates of GDP over the period 1855-1913. This gives us a long run series that is depicted in Figure 6. A Kalman filter decomposition of trends and cycles suggests that labour productivity growth is stochastic, trended upwards during the period c. 1855-1870, falls significantly during c.1870-1900 and settles on a relatively stable rate during the early 20th Century.

Figure 7: Kalman Filter Output and Income Estimates of Slope of Labour Productivity



A number of features stand out when analysing this measure of labour productivity. First, the long swings observed in GDP are not observed in aggregate labour productivity. Secondly, a trend of growth retardation is observed throughout the period c.1870-1900, reflecting the fact that the output estimate shows retardation in the period 1870-90 and the income estimate shows retardation in the 1880s and 1890s. The average of the two series encompasses the period 1870-1900. Thus, non-random measurement errors are affecting the phasing of British labour productivity growth and averaging confounds the historical issues. A valid conclusion is that there is evidence of retardation in productivity growth sometime during the period c.1870-1900 but we cannot be exact about the specific phase. It would be misleading to infer from the average that retardation is observed during this period and to proceed to explanations. A similar conclusion holds for our understanding of long swings in productivity. So far we have found robust evidence for long swings in GDP. Utilising the compromise estimate of labour productivity suggests long swings

are not observed in aggregate labour productivity. However, given the structure of measurement errors the only inference we can make is that long swings are not observed in the output estimate but they are observed in the income estimate. Since the income estimate is better suited for analysing the cyclical path of the economy we cannot dismiss the evidence for long swings in productivity by simply focusing on the results arising from the compromise estimate¹⁰. The timing of the observed swings in labour productivity is similar in phasing to growth swings in GDP¹¹.

Summarising, the analysis of labour productivity shows that the late 19th Century was a period of significant long-term change. Both the income and output estimates show a stochastic trend retardation observed sometime during the period c.1870-1900. The Edwardian period stands out as a period of low labour productivity growth but is not a period of change. In addition to this long-term trajectory change in aggregate labour productivity growth we cannot rule out the existence of long swings in labour productivity growth, as reflected in our analysis of labour productivity using the income estimate of GDP.

SECTORAL GROWTH

The extent of structural change over the period 1850-1913 suggests that to understand macroeconomic trends we need to consider the patterns of sectoral growth. Here we consider the sectoral movements in agricultural and industrial production. In the British case agricultural production over the period for which we have reliable annual data (1867-1913) is trend stationary around a mildly negative sectoral output growth rate¹². The best fitting Kalman filter model is a three-cycle decomposition, with average periods of 2.7, 8.0 and 20.0 years. The resulting decomposition is plotted in Figure 8. For much of the time the cycle with the dominant amplitude is the long cycle¹³. The observed swings clearly have a similar timing to macroeconomic swings before c.1890 and follow an inverse path to macroeconomic swings after c.1890.

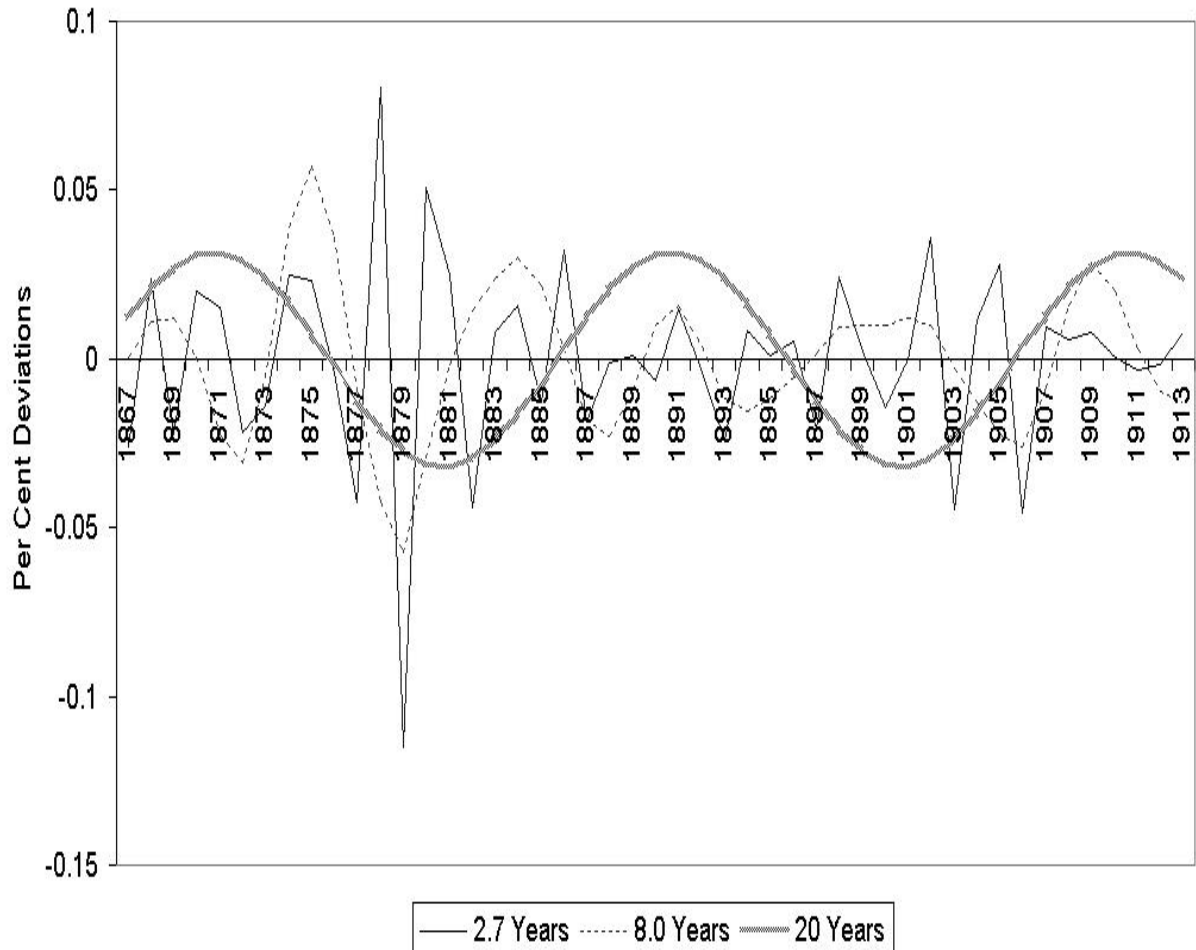
¹⁰ The output estimate of GDP has been constructed with extensive use of linear interpolation and the imposition of artefact 9-year cycles. As a result it is of limited use for the study of episodic fluctuations.

¹¹ Analysing labour productivity trends from the expenditure side of GDP over the period 1870-1913 suggests marked swings but there is no trend break. The Edwardian period is one of a downswing in a long swing growth process.

¹² Feinstein (1972) gives annual agricultural production series since 1855. However the data during 1855-1866 have been produced from assumptions that are likely to reduce annual variations. The trend-stationarity of agricultural output over this period is a robust result using a number of tests (Khatri, Solomou and Wu, 1998).

¹³ The amplitude of each of the short cycles is about one third that of the long cycle.

Figure 8: Cycles in British Agricultural Output, 1867-1913



Industrial Production shows a stable long-term growth rate over the period with a cyclical structure that is focused on the trade cycle frequency, although we should bear in mind that the significance of this cyclical frequency may result from the data generation methods. This cyclical structure in Lewis's industrial production index has been noted by Crafts *et al.* (1989). However, for a large proportion of the aggregate index, Lewis has imposed such a periodic cycle (or the equivalent cycle of marriages) on *a priori* grounds (Lewis, 1978). This Juglar cycle was imposed on iron and steel products, commercial building, clothing, printing and chemicals. Overall, these sectors account for 28.2 per cent of the total industrial production index and 35 per cent of the manufacturing and construction index. Further cyclical processes are imposed on components of the construction index (Lewis, 1978, p.254). In the same context it should also be borne in mind that the series

for electricity, food and gas are constructed by assuming trend lines without annual fluctuations. These industries account for a further 6 per cent of the total index; hence, the cycle imposed by Lewis is further reinforced by the *a priori* assumption of simple linear trend lines in a number of other series. The implication of Lewis's data is that we cannot use the existing industrial production index to analyse business cycles. Similarly, the extensive use of linear interpolation means that the series is also of limited use in the study of low frequency fluctuations.

Labour productivity trends in these two sectors also reveal major sectoral differences that help us understand the observed aggregate trends. The path of labour productivity in agriculture shows a long-term trend of decelerating growth over the period from the 1860s to the early 20th Century. In addition to this long-term trend of deceleration we observe swings of low and high productivity growth. The swings of agricultural sector productivity are correlated with swings in agricultural output, with downswings in the 1870s and 1890s and upswings in the 1880s and 1900s.

The trend in manufacturing sector labour productivity is stable during 1869-1913 (with a growth rate of 0.011). The only episodic growth variations that stand out are swings in labour productivity growth of approximately 20 years with upswings in the 1870s and 1890s and downswings in the 1880s and the 1900s (see Table 6).

Table 6: Labour Productivity Growth in British Manufacturing
(Per cent growth per annum)

	GROWTH RATE	INTER-PERIOD GROWTH CHANGE
1871-1881	0.0139	-
1891-1891	0.0093	-0.0046
1891-1900	0.0126	+0.0033
1900-1910	0.0080	-0.0046

Comparing these sectoral swings over time reveals an inverse pattern during the period 1870-1913. The observed macroeconomic trends need to be understood in terms of these sectoral swings. During c.1865-1890 the aggregate swings mainly reflect the swings in the agricultural sector (partly because the amplitude of agricultural swings was relatively high and the sector still had a large share in GDP). During the period c.1890-1913 the aggregate swings were mainly driven by the swings in the manufacturing sector as the relative decline of the agricultural sector

reduced the impact of agriculture on the macroeconomy. Similarly, the long-term trend of decelerating growth of labour productivity has to be partly accounted for by a significant contribution from the agricultural sector and should not be seen as a macro trend that needs separate explanation. The manufacturing sector showed stable long-run output and labour productivity growth during the pre-1913 period.

III. INTER-WAR ECONOMIC GROWTH

As noted above the path of British GDP over the period 1850-1913 averaged a rate of growth of approximately 2 per cent per annum. There is also evidence of long swings in economic growth with the periods c.1874-86 and c.1899-1910 being episodes of low growth. In the light of this evidence a pertinent question to ask is, how successful was the interwar British economy in returning to the pre-1913 growth path? We can glimpse at the changes taking place from the results reported in Table 7. While GDP growth had averaged approximately 2 per cent per annum during 1870-1913, the long-run average growth rate for the period 1913-29 was below 1 per cent per annum. For most of the interwar period (1925-37) long-run output growth averaged 2 per cent per annum, a rate that is comparable to the pre-1913 epoch. Adverse shocks accounting for the poor long-run performance during the period 1913-37 are to be found in the trans-war period of 1913-25 (Broadberry, 1988; Solomou, 1996). This description of the growth process suggests that the shocks observed in the immediate postwar reconstruction period (1918-21) had *persistent* adverse effects on long-run macroeconomic performance. The post-1913 economy failed to return to the pre-war growth path; instead, following the trans-war shocks, aggregate output settled on a low-level equilibrium that persisted.

Table 7: Peak-to-peak Growth Rates of GDP 1913-37
(Growth per annum)

GDP	1913-29	1925-29	1929-37
Income	0.007	0.024	0.019
Expenditure	0.005	0.015	0.017
Output	0.009	0.021	0.022
Compromise	0.007	0.020	0.020

As noted above, labour productivity growth showed a descending trend growth rate during the pre-1913 period. Both the income and output estimates depict a comparable path in the long run, but with a slightly different phasing. We concluded that most of the labour productivity retardation had taken place within the period 1870-1900, although we could not be more exact given the nature of the measurement errors in the data. Over time, as data reliability improves, the output, income and expenditure estimates of GDP show very similar low labour productivity growth during c.1900-1913.

Comparing inter-war and pre-1913 trends suggests that the descending trend growth rate of the pre-1913 period was being reversed. Trend growth rates in labour productivity began to pick up during the period 1913-29 and were sustained at comparable rates during the 1930s. The income estimate of GDP shows a labour productivity growth rate that averaged approximately 1% per annum over the period 1913-29, comparable to the rates of growth observed in the late 19th Century (see Tables 8 and 9). In the light of a decelerating labour productivity growth rate before 1913 this marks a significant trend break. The output estimate of GDP similarly shows that growth rates began to rise during 1913-29 and the 1930s. During 1925-37 labour productivity growth rates settled at 1.1 % per annum, comparable to the growth rates observed before the 1870s. The trend in labour productivity growth in the period 1913-29 is more striking in the light of the trend in GDP. We noted that the shocks of 1918-21 left aggregate output at a low-level equilibrium throughout the 1920s. This is in marked contrast to the positive segmentation in labour productivity growth.

Table 8: Growth Rates Labour Productivity (Income Estimate of GDP)

	GROWTH RATE	INTER PERIOD GROWTH CHANGE
1855-1864	0.0087	-
1864-1875	0.0190	+0.0103
1875-1886	0.0132	-0.0058
1886-1897	0.0099	-0.0033
1897-1909	0.0051	-0.0048
1909-1929	0.0087	+0.0036
1929-1937	0.0077	-0.0010

Table 9: Long Term Growth Rates Labour Productivity
(Income Estimate of GDP)

1855-1913	0.0107
1875-1913	0.0088
1913-1929	0.0098
1929-1938	0.0086

A discontinuity also began to emerge in the trends of manufacturing sector labour productivity relative to the pre-1913 period. During c.1870-1913 we observe a stable trend growth rate with long swings in labour productivity. Over the period 1920-38 we observe a discontinuity from the mean path that is observed for the pre-1913 period. Instead of settling on the mean growth rate of the pre-1913 period (1.3 % per annum) the growth rate more than doubled to 2.9% per annum. Manufacturing labour productivity growth began to accelerate in the inter-war period relative to the past (see Table 10). Rates of growth began to display trend acceleration in the late 1920s and this process continued at an accelerated pace during the 1930s. During the peak to peak cycle phases of 1924-29 and 1929-37 growth of manufacturing sector labour productivity averaged 0.0167 and 0.0254 respectively. Comparing these high growth rates to the upswings of the pre-1913 period also suggests a break in path (inter-war growth rates were well above the boom episodes of the pre-1913 period (labour productivity growth averaged 1.34% per annum in the 1870s and 1.26% in the 1890s).

Table 10: Labour Productivity Growth in British Manufacturing 1870-1937
(Per cent growth per annum)

	GROWTH RATE	INTER-PERIOD GROWTH CHANGE
1870-1913	0.0133	-
1913-1929	0.0149	+0.0016
1929-1937	0.0254	+0.0105

The nature of the change in the trend in manufacturing sector labour productivity can be better understood in the context of the performance of manufacturing output. Our

discussion of the pre-1913 period suggests that output growth grew on a stable long-term trend (over the periods 1855-1913 or 1870-1913). The rate of growth averaged 2.3% per annum. During the inter-war years of 1920-1938 the output growth rate averaged 2.8 % per annum. However given the low long-term trend level of the manufacturing sector after WWI we need to consider the path inclusive of the war period. In fact, during 1913-29 manufacturing sector output growth averaged 1.4 % per annum. Although manufacturing output grew rapidly during the late 1920s this was not sufficient to allow the economy to return to its pre-1913 growth rate. In contrast, the trends in labour productivity over the whole period 1913-29 took an upward step relative to the pre-1913 period. Given that this was a period of slow output growth, the upward step in labour productivity growth is even more remarkable. In the circumstances of the 1930s when output growth increased significantly relative to 1913-29 the upward trend in manufacturing sector labour productivity saw more of a marked upward discontinuity.

The trends in agricultural output and productivity also underwent significant change in the inter-war years relative to the past. In the pre-1913 period we noted that the long-term trend in agricultural output showed a negative rate of change. During the inter-war period this was significantly reversed with agricultural output growth averaging 1% per annum. The sector's output growth rate continued in episodic swings with an average growth rate of 2% per annum in the 1920s and stagnant growth in the 1930s.

The change in labour productivity was even more dramatic. During 1855-1913 agricultural labour productivity grew at descending rates over time. The Kalman filter trend estimates suggest a slope change from 1.2% per annum in the 1850s and 1860s to 0.3% per annum in the Edwardian period. In the 1920s a major discontinuity is observed, with labour productivity growth averaging 7.5 % per annum during the 1920-29. Although this was followed by stagnation in the 1930s, over the whole inter-war period labour productivity growth averaged 3.6% per annum. Such movements in the productivity level of the sector suggest significant changes in the sector's innovation path.

The interwar period saw a number of major changes to the nature of episodic growth, relative to the pre-1913 period. The low economic growth of the period 1899-1913 was not reversed as might be expected from a mechanical long swing process. Instead, low economic growth was reinforced by new adverse shocks during 1919-21. At the same time we observe an acceleration in labour productivity growth that suggests that despite the adverse effects to aggregate output, the supply-side potential of the economy was expanding and manifesting a favourable labour productivity path both in the aggregate trends and across the major sectors of the economy. A number of historical growth questions arise from such observations. Did the higher growth rate of the manufacturing sector's labour productivity result

from the rapid diffusion of new technology, such as electricity? Such a hypothesis has been put forward by a number of recent papers on America and Holland (David, 1990; David and Wright 1999; Smits *et al.* 1999). British growth trends are consistent with this hypothesis.

IV. DISCUSSION: PHASES OF ECONOMIC GROWTH

The long-term performance and phasing of economic growth in the British economy since 1850 has attracted much attention from British and American economists with an historical interest in the process of economic growth (Cairncross, 1953; Feinstein *et al.* 1982; Matthews *et al.* 1982; Rostow, 1948). Over the years the area has developed with the impulse of new and more reliable data sets. For example, revisions to Hoffmann's figures for industrial production have eliminated the Great Depression of 1873-96 from the literature. The national income figures of Prest (1948), Jeffrey and Walters (1955) and Feinstein (1972) have reinforced this view and have also given rise to a large literature on the Edwardian Climacteric of 1899-1913. We have shown how conclusions about the historic growth path are dependent on the specific features of the data used. This descriptive survey suggests that we need to rethink many of the existing interpretations of medium term British economic growth. This has arisen because the literature has accepted the use of the compromise estimate of GDP in phasing British economic growth. Using this series suggests that the dominant growth variation over the period 1855-1913 is observed during 1899-1913, reinforcing the idea of an Edwardian Climacteric and the myth of the Great Depression. We argue that the compromise estimate has generated a number of statistical artifacts that have been mistaken for genuine trend changes.

Is the 'Great Depression' a myth? The evidence considered so far suggests that there is certainly no foundation to a unified low growth phase stretching over the period 1873-96. Such phases were used by Kondratieff (1925) Schumpeter (1939) and other long wave economists to describe historical economic growth drawing mainly on price data. However, if the Great depression is to be interpreted as an epoch of growth as perceived by contemporaries then we need to be more careful in dismissing the idea. The phrase "Great Depression" was first used by contemporaries in reports to the Royal Commission on the Depression of Trade and Industry (1886) set up to explain the slow growth of the British economy during the period of the 1870s and early 1880s. The quantitative evidence considered here suggests that over this phase we observe a clear cyclical retardation in macroeconomic trends in GDP and aggregate labour productivity. To contemporaries these macroeconomic trends were reinforced by significant economic problems in key sectors of the economy. For example, agricultural

output was significantly depressed in the decade of the 1870s, export growth collapsed from the high growth rates of 1865-73 and domestic investment levels fell over the period 1876-86. These changes were not ordinary trade cycle fluctuations; they are best characterised as a long swing depression. At the macroeconomic level many of these changes were reversed during the mid-1880s and 1890s. The economic problems of the 1870s and early 1880s represent long-term cyclical and structural adjustments that need to be explained. Defined as a contemporary evaluation of the changes taking place in the 1870s and early 1880s the Great Depression is a reality that historians need to explain rather than dismiss.

The use of the compromise estimate in describing British macroeconomic trends has resulted in the idea of an 'Edwardian climacteric', representing a significant downward step of economic growth during 1899-1913 relative to the pre-1899 period. Studies that have looked at the peak-to-peak growth rates of compromise GDP are all agreed that the dominant variation in GDP growth is observed over the inter-period comparison of 1856-99 and 1899-1913. The inter-cycle growth variations within 1856-99 are small and statistically insignificant (McCloskey, 1970; Feinstein, 1982; Solomou, 1987). Whilst this is a robust feature of the compromise estimate, this paper has shown that inappropriate data averaging has resulted in a kink in economic growth c.1899. As a result, the slow growth episode of 1899-1913 stands out as a *unique* episode of slow economic growth. This paper has argued that there is no solid foundation to the idea of a structural break in British economic growth during this period. A low growth phase during 1899-1913, which belongs to the observed pattern of episodic swings in economic growth before 1913, has been mistaken for a climacteric. The comparative evidence suggests that the period of slow *cyclical* growth during the Edwardian period was common to Britain and a number of other major industrial countries, including Germany (during 1899-1913) and France (during 1899-1907). Explanations for this episode of growth have to be sought in an international context, not in ideas of individual national failure.

Our analysis of labour productivity trends reinforces the emphasis away from the Edwardian period. As illustrated above, we observe labour productivity retardation sometime during the period c.1870-1900. Although the Edwardian period is the end point of this low growth transition it is not a period of further change. The emphasis on an Edwardian climacteric has failed to recognise important long run changes in the British economy during the late 19th Century.

Comparing interwar economic growth with pre-1913 trends has highlighted a number of interesting changes. The most striking growth change is the dichotomy of output and labour productivity trends during the 1920s. Whilst the shocks of the trans-war period, in particular 1919-21, prevented output from returning to the pre-1913 growth path during the 1920s, aggregate labour productivity trends began to

pick up in the 1920s, relative to the long period of descending growth rates from the late 19th Century. This productivity revival is even more striking at a sectoral level, with manufacturing and agriculture making significant labour productivity gains in the 1920s. This suggests that the conventional interpretation of British interwar growth as being the outcome of policy regimes needs to be balanced by also considering changes in the supply-side potential of the economy. The rapid productivity gains of manufacturing and agriculture in the 1920s, relative to the past, suggest that this was a period when innovation was bearing fruit. Had the macroeconomic environment been more appropriate, the effect of these changes would have been more dramatic. As it turned out, change is observable but relatively small in magnitude. Once the macroeconomic environment became more expansionary in the 1930s, labour productivity growth in manufacturing accelerated further. Whether this supply-side potential was expanding as a result of the rapid diffusion of electricity, electricity using machinery and machine tools warrants further consideration.

CONCLUSIONS

The quantitative economic history of British economic growth has been written using the compromise estimate of GDP as the representative macroeconomic index. Although in theory this may seem a reasonable and simple measure to use, in practice this has resulted in significant misinterpretations of historical reality. The measurement errors in the component series are not random, resulting in a number of statistical artifacts. For example, the literature has observed a major retardation of GDP and productivity in the Edwardian period. We find that the downturn of the Edwardian period is best explained as a cyclical feature of economic growth. As for labour productivity the evidence suggests that the most marked retardation is observed in the late 19th Century. Although the data is not reliable enough to pinpoint the exact dates of retardation we conclude that there is a long-term retardation in aggregate labour productivity *within* the period 1870-1900. Moreover, the emphasis of our analysis is that the observed trends can only be understood in terms of the massive structural change we observe over the sixty years before 1913. Much of the aggregate productivity retardation in the late 19th Century reflects the problems of the agricultural sector and the rapid structural change associated with agricultural decline. The manufacturing sector sustained a stable productivity path during the period.

As noted above the conclusions drawn in this paper are based on a judgement utilising a broad set of data. The aim has been to emphasise that economic historians discussing medium-term economic growth need to reject the use of the compromise estimate of GDP and the associated measures of productivity that go with this.

Ideally, revisions to the national income data over time will eliminate the non-random measurement errors. In the meantime, utilising existing information is robust enough to reject much of the conventional description of British economic growth and offer descriptions that are more robust in capturing the historical time-profile of growth.

This paper has argued for a more appropriate use of British historical data when discussing a phasing of British economic growth. The use of inappropriate mechanical averaging of GDP series has distorted historical reality. As it turns out, when analysing episodic growth phases most of the British data provides a consistent macro picture. Moreover, this picture differs significantly from the descriptions of conventional historiography. No doubt as many of the underlying data problems are addressed we will be able to improve on the description being proposed here. The forthcoming revisions to British Industrial production and GDP over the 19th Century by Feinstein address many of the existing data problems. However, at this stage it is important to distinguish between myth and reality in descriptions of British economic growth.

APPENDIX: KALMAN FILTER STRUCTURAL MODEL OF TIME SERIES DECOMPOSITION

In order to shed some light on the empirical features of trend movements and low frequency fluctuations in economic growth during this period we use the following Kalman filter structural model of time series decomposition (Harvey, 1985, 1989):

$$y_t = \mu_t + \psi_t + \varepsilon_t \quad (1)$$

Where

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \xi_{t-1} \quad (2)$$

$$\beta_t = \beta_{t-1} + v_t \quad (3)$$

$$\psi_t = (1 - \rho \cos \lambda L)\omega_t + (\rho \sin \lambda L)\omega_t^* / (1 - 2\rho \cos \lambda L + \rho^2 L^2)$$

where μ_t stands for the trend component of y_t ; ξ_t allows the trend to shift up and down; v_t accounts for shocks to the slope, β_t ; ψ_t captures the cyclical regularities in y_t ; L represents the lag operator; ω_t represents the shocks to the cyclical component; ε_t accounts for short-term erratic movements and possible measurement errors in y_t . ε_t , ξ_t , v_t and ω_t are assumed to be mutually independent white noise processes, with ω_t^* arising by construction under the constraint that $\sigma(\omega) = \sigma(\omega^*)$; λ is the frequency of the cycle and ρ is the damping factor. The existence of short (high frequency) and long (low frequency) cycles makes it necessary to model a number of cycles simultaneously.

Maximum likelihood estimates of the unknown parameters $\sigma(\xi)$, $\sigma(v)$, $\sigma(\varepsilon)$, $\sigma(\omega)$ and ρ can be obtained by the Kalman filter algorithm. The latter implements a set of recursive equations from given initial values of the parameters, which are successively updated in the light of every new observation (Harvey, 1989).

Although such a time-series structural model has the limitation of imposing a *specific* structure upon the data, it has a number of important advantages. First, the model nests two extreme specifications for the trend; the deterministic or trend-stationary model and the stochastic trend or 'difference stationary' model. Moreover, since the model allows ξ and v to vary over time, this allows for the possibility that the trend may be deterministic over sub-periods, while possessing a significant stochastic component over the entire period. The model ultimately lets the data determine the shape of the trend and thus makes it possible to extract the cyclical component under a wide variety of possible trend specifications. The main advantage of this framework is that we can focus both on the nature of trend variations and the patterns of low frequency fluctuations *jointly* and independent of sample selection biases.

In choosing to use the Kalman filter methodology we have also considered other filters. The Hodrick-Prescott filter has been employed widely in the recent business

cycle literature but is not considered appropriate for our purpose given a focus on low frequency cyclical fluctuations. The low frequency long swings of the pre-1913 period would simply be transferred to the trend component in the H-P filter. The wavelet methodology was also considered. This trend-cycle decomposition has the advantage of being able to capture changes in the amplitude *and* period of cycles over time. However, in practice, the method is of limited use in historical research given that it is data intensive.

REFERENCES

- Abramovitz, M., (1951), 'Economics of Growth', in Haley, B.F. (ed.), *A Survey of contemporary Economics*, pp. 132-78, Homewood, Illinois: Richard D. Irwin for the American Economic Association.
- Abramovitz, M., (1959), 'Historical and Comparative Rates of Production, Productivity and Prices', Statement in US Congress, Joint Economic Committee, *Employment, Growth and Price Levels, Hearings*, 86th Congress, Pt.II, Washington D.C.: US GPO, pp. 411-66.
- Abramovitz, M., (1961), 'The Nature and Significance of Kuznets Cycles', *Economic Development and Cultural Change*, V. 9, No. 3, pp. 225-249.
- Abramovitz, M., (1968), 'The Passing of the Kuznets Cycle', *Economica*, V. 35, pp. 349-367.
- Broadberry, S.N., (1986), *The British Economy Between The Wars: A Macroeconomic Survey*, Oxford: Basil Blackwell.
- Cairncross, A.K., (1953), *Home and Foreign Investment, 1870-1913: Studies in Capital Accumulation*, Cambridge: Cambridge University Press.
- Crafts, N.F.R., Leybourne, S.J. and Mills, T.C., (1989), 'Trends and Cycles in British Industrial Production, 1700-1913', *Journal of the Royal Statistical Society*, A. 152, pp. 43-60.
- David, P.A., (1991), 'Computer and Dynamo: The Modern Productivity Paradox in a Not-too-distant Mirror, in *Technology and Productivity: The Challenge for Economic Policy*, Paris: OECD.
- David, P.A., and G. Wright, (1999), 'Early Twentieth Century Growth Dynamics: An Inquiry into the Economic History of Our Ignorance', Stanford: SIEPR Discussion Paper No. 98-3.
- Feinstein, C.H., (1972), *National Income, Expenditure and Output of the United Kingdom, 1856-1965*, Cambridge: Cambridge University Press.
- Feinstein, C.H., Matthews, R.C.O. and Odling-Smee, J., (1982), 'The Timing Of The Climacteric And Its Sectoral Incidence In The UK 1873-1913', In Kindleberger and Di Tella (eds.), *Economics In The Long View: Essays In Honour Of W.W. Rostow*, Vol. 3, London and Basingstoke: Macmillan.

- Feinstein, C.H., and Thomas, M., (2001), 'A Plea For Errors', University of Oxford Discussion Papers in Economic and Social History, Number 41.
- Kondratieff, N.D., (1925), 'The Major Economic Cycles', *Voprosy kon'iunktury*, V. I, pp. 28-79. An abridged English translation appears as 'The Long Waves in Economic Life', *Review of Economic Statistics*, (1935), V. 17, No. 6, pp. 105-115.
- Friedman, M. and Schwartz, A.J., (1982), *Monetary trends in the United States and the United Kingdom: their relation to income, prices, and interest rates, 1867-1975*, Chicago and London: University of Chicago Press.
- Harvey, A.C., (1985), 'Trends and Cycles in Macroeconomic Time Series', *Journal of Business & Economic Statistics*, V. 3, No. 3, pp. 216-227.
- Harvey, A.C., (1989), *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge: Cambridge University Press.
- Jefferys, J.B. and Walters, D., (1955), 'National Income and Expenditure of the United Kingdom, 1870-1952' in Kuznets, S.S. (ed.) *Income and Wealth*, Series V, London.
- Lewis, W.A., (1978), *Growth and Fluctuations 1870-1913*, London: Allen & Unwin.
- Lewis, W.A. and O'Leary, P.J., (1955), 'Secular Swings in Production and Trade, 1870-1913', *Manchester School*, V. 13, No. 2, pp. 113-152.
- Matthews, R.C.O., Feinstein, C. and Odling-Smee, J., (1982), *British Economic Growth 1856-1973*, Oxford: Clarendon Press.
- Prest, A.R., (1948), 'National Income in the United Kingdom 1870-1946', *Economic Journal*, V. 58, pp. 31-62.
- Rostow, W.W., (1948), *British Economy of the 19th Century*, Oxford: Clarendon Press.
- Schumpeter, J.A., (1939), *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, New York and London: McGraw-Hill.
- Smits, J.P., de Jong, H. and van Ark B., (1999), 'Three Phases of Dutch Economic Growth and Technological Change, 1815-1997', Research Memorandum GD-42, Groningen Growth and Development Centre.
- Solomou, S.N., (1987), *Phases of Economic Growth, 1850-1973: Kondratieff Waves and Kuznets Swings*, Cambridge: Cambridge University Press.
- Solomou, S.N. and Weale, M.R., (1991), 'Balanced Estimates of U.K. GDP, 1870-1913', *Explorations in Economic History*, V. 28, No. 1, pp. 54-63.
- Solomou, S.N. and Weale, M.R., (1993), 'Balanced Estimates of National Accounts when Measurement Errors are Autocorrelated: The UK 1920-38', *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, Vol. 156, No. 1, pp. 89-105.

Solomou, S.N., (1996), *Themes In Macroeconomic History: The UK Economy 1919-1939*, Cambridge: Cambridge University Press.