The Sources of British Economic Growth since the Industrial Revolution: Not the Same Old Story

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Abstract

This paper updates the classic growth accounting research of the early 1980s taking account of improved data that has subsequently become available. The picture of long-run growth which results from incorporating many revisions is considerably different. The long-run path of productivity growth is now that of a roller-coaster with twin peaks in the third quarters of the 19th and 20th centuries rather than a U-shape. Productivity growth appears to have been very slow to accelerate in the Industrial Revolution, the notion of an Edwardian climacteric is not persuasive and the current productivity slowdown stands out as unprecedented.

Keywords: Climacteric; Golden Age; Growth Accounting; Industrial Revolution; Productivity Growth; Productivity Puzzle

JEL Classification: N13; N14: O47: O52

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1. Introduction

The publication of Matthews et al. (1982) was a major landmark in the study of long-run British economic growth. It was the first serious attempt to utilize growth accounting techniques as an integral part of the description of growth performance over the long run and provided estimates of the sources of growth covering the years 1856 to 1973. It was accompanied by Feinstein (1981) which developed a similar analysis for 1760 to 1860, encompassing the era of 'take-off', and by Feinstein et al. (1982) which contained a detailed review of the so-called climacteric by looking at sub-periods within 1873-1913. The overview which emerged was that productivity growth had followed a U-shape from the industrial revolution to the golden age with the bottom of the U in the early 20th century and the fastest total factor productivity growth in the early 19th century and in the golden age after World War II.

Growth accounting was used by Matthews et al. (1982) as a framework to organize the facts of economic growth and to benchmark performance. In this regard, they saw total factor productivity (TFP) growth as a useful diagnostic of 'success' and 'failure' but recognised that it is susceptible to errors of measurement and that, because it is derived as a residual, high-quality estimates of TFP growth require careful and accurate measurements both of factor inputs and real GDP. Subsequent research has made progress on both fronts which now permits growth accounting using the same neoclassical methodology to be implemented better. As we shall see, to some extent this stems from improved measurement techniques, but it is also a result of imaginative and diligent use of historical sources.

Accordingly, over subsequent years the data available for the construction of growth accounts has improved and expanded considerably although even now the foundations laid by Charles Feinstein's remarkable scholarship underpin a good deal of what can be done. Also, of course, we now know what followed the golden age and that adds a new perspective with the advantage of hindsight. Major changes to the data include better estimates of GDP growth notably but not only for the industrial revolution period, improved estimates of capital inputs, and the opportunity to measure labour inputs entirely in terms of hours worked rather than headcount. These and other refinements to the data have been compiled and quality assured in a new dataset produced at the Bank of England (Thomas and Dimsdale, 2017).

This paper considers the picture of the sources of British economic growth that is embodied in the revised data and compares it with that derived from the earlier vintage. It turns out that in total the data revisions make quite a big difference. The main new results are as follows.

First, both labour productivity growth and TFP growth were much lower during the industrial revolution than it appeared 40 years ago. Slower productivity growth results from significant downward revisions to estimated real GDP growth and also from the development of estimates of hours worked which were not available to Feinstein.

Second, the idea of an Edwardian 'climacteric' (major productivity slowdown) identified by Feinstein et al. (1982) as characterizing the years 1899-1913 is much less persuasive than they believed. Partly this is because the growth slowdown is less marked according to the new estimates. But also it appears overshadowed by a bigger slowdown at the end of the 'mid-Victorian boom' in the 1870s, it

pales into insignificance compared with recent experience since the financial crisis, and TFP growth in these years far exceeded anything seen during the classic industrial revolution period.

Third, it is still possible to see a U-shaped pattern to TFP growth with the lowest point just before World War I but the starting point would be in the mid-19th century. Overall, however, the shape over the long run now looks more like a rollercoaster in the light of the new view of the industrial revolution and the slowdown after the golden age. Even so, the years between 1973 and 2007 emerge as a period of relatively strong labour productivity growth by historical standards well ahead of almost all periods before World War II.

Fourth, real GDP growth, and to a slightly lesser extent productivity growth, are appreciably stronger in the years after World War II than previously thought. This is mainly due to recent revisions to GDP estimates. Although it modifies the detail, taking an internationally comparative perspective this leaves intact the idea of a British failure in these years of rapid catch-up growth since being overtaken by other European countries prior to 1973 is still apparent.

Fifth, the decrease in productivity growth after 2007 is unprecedented in British economic history. This adds weight to the notion of the 'productivity puzzle', namely that in 2018 quarter 4, real GDP per hour worked was only 2.0 per cent above the pre-crisis peak level seen in 2007 quarter 4. It would have been 22.3 per cent higher if pre-crisis trend growth had been sustained (ONS, 2019). The pre-crisis peak level of labour productivity was only surpassed in 2016 quarter 2.

2. New Estimates for Growth Accounts

As was noted above, over the past 40 years or so research has led to significant revisions in the data with which to construct growth accounting estimates both with regard to output and inputs. These data have been assembled in Thomas and Dimsdale (2017). In many ways they are still imperfect but the items reviewed here are improvements on what was previously available. This section briefly reviews the main developments and notes their original sources.

Several important revisions have been made to estimates of real GDP. For the period prior to 1855, Broadberry et al. (2015) provide estimates built up from the output side. This entails construction of new indices of real output for the agricultural, industrial and services sectors which extend the coverage and improve the weighting of earlier estimates. Sectoral value-added weights are then used to obtain annual estimates of real GDP which had not previously been available. Broadberry et al. (2015) confirm the findings of Crafts (1985) and of Crafts and Harley (1992) that the earlier study by Deane and Cole (1962), which deflated estimates of nominal income for benchmark years by an inappropriate price index and on which Feinstein (1981) relied, significantly overestimated output growth during the early 19th century. In fact, the new estimates by Broadberry et al. (2015) suggest that growth was even a bit slower than estimated by Crafts and Harley (1992) in the first three decades of the century.

For the period from 1870 to 1948, the 'balanced estimates' made by Sefton and Weale (1995) and Solomou and Weale (1991) can now be used rather than the 'compromise' estimate of GDP favoured by Feinstein (1972). Whereas the compromise approach is based on the geometric average of the expenditure, income and output estimates, the balanced approach weights the

average according to the reliability of the different estimates.[1] This may give different results when the three series differ, as is notably the case for the decades before World War I. The implication is that the growth slowdown of the early 20th century is less severe than Feinstein et al. (1982) believed.

For the period since 1948, current ONS estimates are the preferred choice of Thomas and Dimsdale (2017). For the period up to 1973, these show rather stronger growth than the series used by Matthews et al. (1982). This is an outcome of recent revisions, notably a switch to using CPI rather than RPI to deflate nominal expenditures, as explained in Bank of England (2011). This adds about 0.3 percentage points per year to GDP growth throughout 1948 to 1973. In addition, a change in national accounting conventions means that R & D is now treated as final investment expenditure which adds about 0.15 percentage points to GDP growth in these years.

Turning to inputs, new estimates are available for capital and estimates of labour inputs based on hours worked rather than headcount are feasible. Feinstein (1988) updated his earlier estimates of capital stocks for the period 1760 to 1920 which amongst other things put his earlier work for the industrial revolution period and his estimates for the later 19th century on a consistent basis and provided a reliable series for the net capital stock. For the period since 1950, estimates of capital inputs based on capital services are now available (Oulton and Wallis, 2016) which supersede the earlier estimates made on a capital stocks basis.[2] The difference between these methods is that capital services weight the growth of capital assets by their respective rental prices, whereas capital stocks weight assets by their asset price.

For hours worked during the industrial-revolution period the best option appears to be the series derived from the work of Humphries and Weisdorf (2019) in Thomas and Dimsdale (2017, Table A54, column F). This is based on a massive compilation of wage rates from historical sources with days worked inferred by assuming that annual earnings of day-wage workers and those on annual contracts were the same. It is probably fair to say that pre-1856 estimates of hours worked should be regarded as not very reliable (Feinstein, 1998).[3] For 1856-1913, Thomas and Dimsdale (2017, Table A54, column AW) include a series for hours worked per year throughout the period covered by this paper which uses various additional sources to implement on an annual basis the basic methodology of Matthews et al. (1982) used by them to make estimates for a few benchmark years; this permits a new view of labour productivity during the so-called climacteric.[4] This series is continued for later years using the standard official sources of the *Ministry of Labour Gazette* and then the *Labour Force Survey*.

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[1] The latter approach is preferable because it takes fuller account of the available information; see Stone et al. (1942).

[2] Capital inputs grow faster when measured in terms of capital services rather than capital stocks, especially in the ICT era. The respective growth rates are 4.24 versus 4.02 in 1950-79, 3.85 versus 3.11 in 1979-2000, and 3.40 versus 3.13 in 2000-13 (Oulton and Wallis, 2016).

[3] Alternative estimates for benchmark years in Voth (2001) show a considerable rise in hours worked between 1760 and 1800 and would imply negative labour productivity growth in that period.

[4] The starting point is estimates of average fulltime weekly hours worked with allowances then made for overtime, short-time and part-time working. Adjustments are then made to allow for holidays, sickness and strikes. The method is explained in more detail by Matthews et al. (1982) in their Appendix D with sources listed in Table D1.

A significant weakness of the Thomas and Dimsdale (2017) dataset with regard to its use for growth accounting is that is does not contain estimates of labour quality which can be used to augment hours worked in arriving at labour input. Using crude estimates of relative earnings to weight different types of labour, Matthews et al. (1982) made estimates for benchmark years which were dominated by changes in educational attainment, but they regarded their results with some caution. Nevertheless, their estimates are still the best available for the years 1856 to 1973.[5] Prior to that date, recent research by de Pleijt (2018) has provided estimates of years of schooling using evidence on literacy rates and on the number of secondary schools to calculate primary- and secondary-school years, respectively. These can be used as the basis for an (incomplete) index of labour quality using the same assumption as Matthews et al. (1982) about the return to educational attainment.[6] For the years since 1975, better estimates are available using a modern methodology where labour quality growth is the difference between the rate of growth of compensation-weighted labour inputs, where the labour force is classified by age, gender and educational attainment based on the *Labour Force Survey*, and that of hours worked (Bell et al., 2005; ONS, 2017).[7]

Matthews et al. (1982) used a conventional (neoclassical) growth accounting methodology which is based on treating the economy as if it can be characterized by a Cobb-Douglas production function with constant returns to scale

$$Y = AK^{\alpha}L^{1-\alpha} \qquad (1)$$

where Y is output, K is capital, L is labour and A is total factor productivity (TFP) while α and $(1 - \alpha)$ are the elasticities of output with respect to capital and labour, respectively. The basic growth accounting formula is

$$\Delta Y/Y = \alpha\Delta K/K + (1 - \alpha)\Delta L/L + \Delta A/A \qquad (2)$$

This can be re-written in terms of the rate of growth of labour productivity as

$$\Delta\ln(Y/L) = \alpha\Delta\ln(K/L) + \Delta\ln A \qquad (3)$$

where the first term represents the contribution of capital deepening. The output elasticity, α, is assumed to equal the share of profits in national income.

Adapting this equation to take account of labour quality as a component of labour input gives the expression

$$\Delta\ln(Y/L) = \alpha\Delta\ln(K/L) + (I - \alpha)\Delta\ln(LQ/L) + \Delta A/A \qquad (4)$$

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[5] Matthews et al. (1982) took account of changes in the intensity of work arguing that shorter hours might be compensated by improved productivity of the remaining work time. This assumption mainly affects the estimates for 1856 to 1873 which saw a notable fall in weekly hours. The allowance that they made is 'arbitrary', as they admit, and is perhaps not what is usually understood by 'labour quality'. Most growth accounting studies prefer to leave any such effects in the residual.

[6] This entails assuming a 6 per cent increase in labour quality per year of schooling. Years of schooling were 1.36 in 1700 and 1.43 in 1830 before rising to 2.05 in 1856. Alternative estimates for 'skills per worker' growth can be found in Williamson (1985). These give quite similar results to the labour quality growth reported in Table 3.

[7] Education accounts for a large share of labour quality growth throughout the 20th century on these estimates: 77% in 1924-37, 65% in 1950-73, 95% in 1980-1990 and 89% in 1990-2002.

This approach is also applied to the modern data in what follows. Equations (2) and (3) are used to produce Tables 1 and 2 while equation (4) is the basis for Table 3. Part a) of Table 1 summarizes the early vintage of growth accounting estimates using the periodization favoured by the authors but excluding the episodes of the World Wars. This table reports 'crude' TFP growth which treats labour input in terms of quantity while disregarding quality. Part b) maintains this design but extends the coverage back to 1700 and forward to 2016. Table 2 focuses on the treatment of the 'climacteric' in Feinstein et al. (1982) which considered growth accounts for business-cycle peak to business-cycle peak and again reports both the original estimates and estimates using modern data. Estimates of labour quality growth are not available for this periodization so the discussion of the climacteric is based on crude TFP growth. Table 3 takes account of labour quality by including it in labour input which results in lower TFP growth other than in the late 18th century. This was the preferred approach in Matthews et al. (1982) but estimates of labour quality growth were not made by Feinstein (1981) for the period before 1856 or by Feinstein et al. (1982) for sub-periods within 1873 to 1913.

3. Two Vintages of Estimates Compared

This section considers how far growth accounting estimates change if the modern data discussed in section 2 are used. The exposition seeks simply to itemize the main differences that emerge in Tables 1, 2 and 3 leaving discussion of the implications for the understanding of British growth performance to the following section.

The comparisons are organized chronologically by reviewing four periods where the modern data make a difference. These comprise the industrial revolution where a big change has come from improved estimates of real output growth, the climacteric of the pre-World War I period where additional data on hours worked and balanced estimates of GDP produce a revised picture, the interwar period where the use of net capital stock estimates has a noticeable impact, and the post-World War II golden age where a new GDP deflator raises the growth rate appreciably.

The industrial revolution is the episode where the new estimates are most different from those of 40 years ago. As is reported in Table 1, labour productivity growth is now estimated to have been much lower throughout the classic industrial-revolution years (1760-1830) – by about 0.1 percent per year during 1760 to 1800 and 1 per cent per year between 1801 and 1830. In the new estimates, TFP growth is much lower during 1801-1830 (0.19 per cent per year compared with 1.3 per cent). The main reason for this is that output growth is now seen as much slower than was supposed by Deane and Cole (1962) on whose estimates Feinstein (1981) relied. Taking account of labour quality based on years of schooling makes virtually no difference, as Table 3 shows.

The central features of the Edwardian climacteric according to Feinstein et al. (1982) were a fall in real GDP growth from 2.1 per cent per year in 1873-1899 to 1.4 per cent per year in 1899-1913 accompanied by a decline in labour productivity growth from 1.2 to 0.5 per cent per year and in TFP growth from 0.7 to 0.0 per cent per year. The new estimates based on hours worked rather than employment and on balanced rather than compromise GDP reported in Table 2 alter this picture quite considerably. The slowdown is relatively mild with GDP growth, labour productivity growth, and TFP growth falling by 0.33, 0.34 and 0.39 per cent per year, respectively. A key point to note is that the major fall in labour productivity growth occurs after 1873 (rather than after 1899) in the

new estimates, from 2.06 per cent in 1856-1873 to 1.18 per cent per year in 1873-1899 which compares with 1.3 to 1.2 per cent per year in Feinstein et al. (1982). This is almost entirely because they examined the climacteric in terms of output per worker rather than output per hour worked.[8]

Matthews et al. (1982) saw the interwar period as the point at which British productivity performance started to bounce back from the low point of the early 20th century. This view was predicated on their comparison of 1899 to 1913 with 1924 to 1937. Table 2 shows a recovery of crude TFP growth and labour productivity growth from 0.0 to 0.6 per cent per year and 0.5 to 0.7 per cent per year, respectively. The new estimates in Table 2 show a mixed picture with labour productivity growth slightly lower in 1924 to 1937 than 1899 to 1913 (0.70 versus 0.84 per cent per year) and a smaller improvement in TFP growth from 0.42 to 0.90 per cent per year. On the other hand, TFP growth is higher in the new estimates in 1924 to 1937 (0.90 versus 0.6 per cent per year) since net (but not gross) capital deepening made a negative contribution to labour productivity growth. Interestingly, however, the new, but not the old, estimates show faster TFP growth in the interwar period than in the first half of the 19th century.

The 'golden age' after World War II was highlighted by Matthews et al. (1982) as the period when productivity growth was at an all-time high. This is still the case in the new estimates; growth during the period was stronger with real GDP growth at 3.36 per cent per year in 1950-1973. This pushes up TFP growth to 2.44 per cent per year compared with 2.1 per cent in the old estimates, TFP* growth from 1.7 to 1.88 per cent, and labour productivity growth from 3.3 per cent to 3.74 per cent per year, as reported in Tables 1 and 3. The new estimates endorse the notion of an all-time high by confirming that productivity growth slowed down subsequent to the golden age.

The U-shape in productivity growth highlighted by Matthews et al (1982) can still be seen but only by truncating the view at both ends. Instead, the picture that captures the long run is that of a roller coaster with quite a long climb to the first peak in the mid-19th century with a spell in the doldrums before a second peak about a hundred years later followed by descent to the nadir (we hope!) of the last ten years.

4. Implications

This section considers what difference adopting the new growth accounting estimates set out above would make to the historiography of long-run British economic growth. No doubt, further improvements to the dataset may be made and, quite possibly, different methods of growth accounting may be preferred in future but it seems useful to take stock of the implications of this new vintage of estimates.

With regard to growth during the industrial revolution, the new output growth estimates of Broadberry et al. (2015) broadly confirm the macroeconomic picture outlined by Crafts and Harley (1992). They show slightly faster labour productivity growth through the period but nevertheless

[8] This was apparently because they only made estimates for hours worked for the benchmark years of 1856, 1873 and 1913 and could only discuss sub-periods within 1873-1913 in terms of employment. A glance at Table 1 or Table 3 shows that a reader of Matthews et al. (1982), whose estimates used output per hour worked, would have thought that productivity growth fell sharply after 1873.

the story is still a slow acceleration of growth and no Rostovian take off.[9] This may seem surprising if we see the industrial revolution as a period of dramatic technological progress but this only affected a relatively small part of the economy. It took a long time before steam power, the general purpose technology of the time, was developed to the point at which it had a significant impact; from 1760 to 1830, Crafts (2004) estimated that steam raised labour productivity growth and TFP growth by 0.003 and 0.014 percentage points per year, respectively. So, there is already a reasonable explanation for 'slow' productivity growth during the industrial revolution and the historiography has adjusted.

The Edwardian climacteric was first proposed by Phelps-Brown and Handfield-Jones (1952) who saw it has a hiatus when the productivity impact of the steam-powered technologies of the first industrial revolution waned and that of the new technologies of the second industrial revolution, based on electricity, the internal combustion engine and chemicals, had yet to have much effect. This has remained a popular view among non-specialist economists, for example Lipsey et al. (1998) and the Deputy Governor of the Bank of England.[10] However, it did not stand up well to quantitative scrutiny even on the basis of old vintage data; Crafts et al. (1989) estimated a time-varying trend model using a Kalman Filter methodology and found that the maximum decrease in trend GDP growth was from 2.03 per cent per year in 1899 to 1.88 per cent in 1908.[11] Crafts and Mills (2004) showed that a reduced impact of steam was not a plausible explanation of slowing growth in the late 19th century.

The idea of the climacteric as promulgated by Feinstein et al. (1982) has been seen as connoting failure of the British economy at a time when it was being overtaken by the United States (Thomas, 1988). For those who take this view, the difference between crude TFP growth of 0.0 per cent per year between 1899 and 1913 in the old vintage estimates and 0.42 per cent per year in the new changes the detail but not the substance of the comparison.[12] In any case, the salient feature is that Britain did not match the acceleration of American TFP growth from 0.4 per cent between 1855 to 1890 to 1.3 per cent in 1890-1905 and 1.5 per cent in 1905-1927 (Abramovitz and David, 2001). Where the new estimates make most difference is in highlighting an earlier productivity slowdown in the 1870s which many years ago was alleged by Coppock (1956) and which now deserves more attention.

Matthews et al. (1982) was notable for a more favourable view of economic performance during the interwar period than had been typical of traditional accounts. The new estimates reinforce that tendency to some extent in terms of stronger TFP growth; if labour quality is included in labour inputs, TFP growth is now estimated to have been 0.41 per cent per year rather than 0.2 per cent. This represents faster TFP growth than at any time prior to 1850, which was not the case in the old estimates, and probably reflects a more modern economy whose growth capabilities were stronger and spread across more sectors of the economy than those of the early industrial-revolution days (Crafts, 2018a). It should also be noted that TFP growth was 0.36 per cent per year and labour

[9] Broadberry et al. (2015) do present a revised picture of relative sectoral productivity growth rates based on new estimates of the sectoral allocation of employment. The implications of this are reviewed in Crafts (2014).
[10] Ben Broadbent in a notorious interview with the Daily Telegraph in 2018 compared the current state of the economy with the sharp fall in productivity growth during the pause between the age of steam and the age of electricity at the end of the Victorian era.
[11] Feinstein et al. (1982) argued that the climacteric in TFP growth came entirely from slower GDP growth rather than slower growth of total factor inputs so they were hypothesizing a fall in trend GDP growth.
[12] The idea of 'failure' has been hotly disputed in particular by McCloskey (1970).

productivity growth was 0.66 per cent per year during the period 1929 to 1937 which was a much better outcome for the interwar crisis than the -0.77 per cent and 0.07 per cent, respectively, recorded during 2007 to 2016.

On the basis of inter-temporal comparisons, then, productivity growth in the interwar economy now looks better than has hitherto been recognised. It is also true that a comparison with the United States in the interwar period also looks a bit better partly because new research has revised downwards American TFP growth by taking fuller account of labour quality than was done by Kendrick (1961). Whereas comparing Matthews et al. for 1924 to 1937 with Kendrick for 1919 to 1941 showed UK TFP growth at 0.2 per cent versus US TFP growth at 2.16 per cent per year, the new estimates are 0.41 per cent for the UK compared with 1.76 per cent per year for the United States according to Bakker et al. (2019). That said, UK productivity growth is still a long way below the American level and this remains a big caveat on optimistic interpretations of interwar British performance.

The standard narrative for the European golden age after World War II is that UK economic growth was the fastest in its economic history but that the UK did not take advantage of the opportunity for rapid catch-up growth as well as its European peer group so its productivity grew more slowly. Policy errors and the institutional legacy undermined economic growth in this period (Crafts, 2018a). While there was greater scope for catch-up in other countries on account of larger initial productivity gaps with the United States and their growth was augmented by reconstruction and a structural shift out of agriculture (Temin, 2002), nevertheless UK failure was evidenced by being overtaken, i.e., falling behind other European countries in terms of productivity levels during the golden age.

The new estimates which show faster TFP and labour productivity growth between 1950 and 1973 (2.44 versus 2.1 per cent per year and 3.74 versus 3.3 per cent per year, respectively) change the details of this comparison but not the main conclusion. As is reported in Table 4, there is still a substantial shortfall of productivity growth compared with France and West Germany and those countries are still estimated to have higher labour productivity levels in 1973, by 12.6 and 11.9 per cent, respectively.

The estimates reported in this paper provide an interesting historical perspective on recent productivity performance. The years after 2007 have the lowest TFP growth of any period reported in Table 3 and the worst labour productivity growth since the 18th century. On top of this, what is truly remarkable is the fall in productivity growth since the pre-crisis years when it was very respectable by historical standards. Comparing 1995 to 2007, we see that TFP growth fell by 1.68 and labour productivity by 2.01 percentage points per year.[13] This is completely unprecedented; the Edwardian climacteric is not in the same league.

5. Conclusions

The first significant historical growth accounting studies for the UK appeared in the early 1980s. Work by Feinstein (1981) on the industrial revolution period was quickly superseded but the much

[13] It is possible that measurement issues play some part in the recent dramatic productivity slowdown. This is an issue on which further research is desirable but at the moment it appears that the slowdown is for the most part not a statistical artefact (Crafts, 2018b).

more ambitious study by Matthews et al. (1982) covering 1856 to 1973 remains a standard reference point in the literature. Since then, however, there have been many improvements to the available data which cumulatively lead to a picture of long run growth performance that is significantly different in a number of ways.

Matthews et al. (1982) described U-shaped productivity growth over the long run with the low point in the early 20th century. Now the picture seems to be one of twin peaks in productivity growth about a hundred years apart, in the third quarters of the 19th and 20th centuries. The bottom of the U was seen in the sister publication by Feinstein et al. (1982) as an Edwardian climacteric which has sometimes been seen as a precursor to the current productivity puzzle. Using more recent data, the Edwardian productivity decline seems a good deal less severe and the post-2007 slowdown seems quite unprecedented.

Inter-temporal comparisons have now changed somewhat and in some respects give very different results from what someone unfamiliar with the data might believe. Notably, labour productivity growth in the alleged Victorian failure of the late-19th century far exceeded that in the classic Industrial Revolution years of the late-18th and early-19th century while labour productivity growth in the late-20th century matched the best performance of the 'workshop of the world' in the mid-Victorian boom.

In two key episodes of British economic growth we now have distinctly different estimates for productivity growth compared with those made a generation ago – much slower during the Industrial Revolution but appreciably faster during the Golden Age. That said, current mainstream interpretations will only need to be revised in terms of detail. The Industrial Revolution can still be seen as a gradual transition to modern economic growth and the Golden Age is still a period when UK productivity performance compared unfavourably with the European peer group.

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Table 1. Growth Accounting Estimates, 1700-2016 (% per year)

a) From the Early 1980s

	ΔY/Y	*ΔK/K*	*ΔL/L*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*TFP*
1761-1800	1.1	1.0	0.8	0.3	0.1	0.2
1801-1830	2.7	1.4	1.4	1.3	0.0	1.3
1831-1860	2.5	2.0	1.4	1.1	0.3	0.8
1856-1873	2.2	1.9	0.0	2.2	0.8	1.4
1873-1913	1.8	1.9	0.9	0.9	0.4	0.5
1924-1937	2.2	1.8	1.5	0.7	0.1	0.6
1951-1973	2.8	3.9	-0.5	3.3	1.2	2.1

Notes: α = 0.5 in 1761-1860, 0.41 in 1856-73, 0.43 in 1873-1913, 0.3 in 1924-37 and 0.27 in 1951-73; K is gross capital pre-1951 and net capital thereafter, L is employment pre-1856 and hours worked thereafter, TFP is 'crude TFP' which includes labour quality.

Sources: Feinstein (1981), Matthews et al. (1982).

b) Based on the Millennium Spreadsheet

	ΔY/Y	*ΔK/K*	*ΔL/L*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*TFP*
1700-1760	0.67	0.67	0.42	0.25	0.10	0.15
1760-1780	0.85	0.70	0.86	-0.01	-0.06	0.05
1780-1800	1.48	1.50	1.02	0.46	0.19	0.27
1800-1830	1.62	1.59	1.33	0.29	0.10	0.19
1830-1856	2.36	3.00	1.15	1.11	0.65	0.46
1856-1873	2.38	2.38	0.32	2.06	0.72	1.34
1873-1913	1.86	1.90	0.80	1.06	0.38	0.68
1924-1937	2.13	0.63	1.43	0.70	-0.20	0.90
1950-1973	3.36	4.36	-0.38	3.74	1.30	2.44
1973-1995	1.98	3.43	-0.20	2.18	0.91	1.27
1995-2007	2.88	4.27	0.80	2.08	0.87	1.21
2007-2016	0.95	2.34	0.88	0.07	0.36	-0.29

Notes: α = 0.40 in 1700-1830, 0.35 in 1830-1913, 0.25 in 1924-37, 0.275 in 1950-73, 0.25 in 1973-2016; K is net capital, L is hours worked, TFP is 'crude TFP' which includes labour quality.

Source: derived from Thomas and Dimsdale (2017) using Table A55 Cols W, X and AM for capital inputs, Tables A50 Col B and A54 Cols F and AW for labour inputs, Table A8 Col B for real GDP, and Table A56 Col B for factor shares.

Table 2. Growth Accounting Estimates for the Early 20th Century Slowdown (% per year)

a) From the Early 1980s

	ΔY/Y	*ΔK/K*	*ΔL/L*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*TFP*
1856-73	2.2	2.0	0.9	1.3	0.5	0.8
1873-82	1.9	2.4	0.6	1.3	0.7	0.6
1882-89	2.2	1.6	1.1	1.2	0.3	0.9
1889-99	2.2	1.8	1.1	1.1	0.3	0.8
1899-1907	1.2	2.4	0.7	0.5	0.8	-0.3
1907-13	1.6	1.4	1.1	0.4	0.1	0.3
1873-99	2.1	2.0	0.9	1.2	0.5	0.7
1899-1913	1.4	2.0	0.9	0.5	0.5	0.0
1924-37	2.2	1.8	1.5	0.7	0.1	0.6

Notes: K is gross capital, L is employment and TFP is 'crude TFP' which includes labour quality.

Source: Feinstein et al. (1982).

b) Based on the Millennium Spreadsheet

	ΔY/Y	*ΔK/K*	*ΔL/L*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*TFP*
1856-73	2.38	2.38	0.32	2.06	0.72	1.34
1873-82	1.85	2.28	0.35	1.50	0.68	0.82
1882-89	1.76	1.24	1.11	0.65	0.04	0.61
1889-99	2.27	1.89	0.98	1.29	0.32	0.97
1899-1907	1.50	2.81	0.82	0.68	0.69	-0.01
1907-13	1.85	0.94	0.81	1.04	0.05	0.99
1873-99	1.98	1.85	0.80	1.18	0.37	0.81
1899-1913	1.65	2.00	0.81	0.84	0.42	0.42
1924-37	2.13	0.63	1.43	0.70	-0.20	0.90

Notes: K is net capital, L is hours worked and TFP is 'crude TFP' which includes labour quality.

Source: Thomas and Dimsdale (2017).

Table 3. Growth Accounting Estimates with Millennium Spreadsheet allowing for Labour Quality, 1700-2016 (% per year)

a) From the early 1980s

	ΔY/Y	*ΔK/K*	*ΔL/L*	*ΔLQ/ LQ*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*Human Capital Deepening*	*TFP**
1856-1873	2.2	1.9	0.0	1.4	2.2	0.8	0.8	0.6
1873-1913	1.8	1.9	0.9	0.8	0.9	0.4	0.5	0.0
1924-1937	2.2	1.8	1.5	0.6	0.7	0.1	0.4	0.2
1951-1973	2.8	3.9	-0.5	0.6	3.3	1.2	0.4	1.7

Notes: estimates from Table 1 adjusted to include labour quality growth in labour input. Labour quality includes impact of changes in intensity of work but not occupational shifts. TFP* does not include the labour quality component.

Source: Matthews et al. (1982).

b) Based on Modern Data

	ΔY/Y	*ΔK/K*	*ΔL/L*	*ΔLQ/ LQ*	*Δ(Y/L)/ (Y/L)*	*Capital Deepening*	*Human Capital Deepening*	*TFP**
1700-1760	0.67	0.67	0.42	0.01	0.25	0.10	0.01	0.14
1760-1780	0.85	0.70	0.86	-0.01	-0.01	-0.06	-0.01	0.06
1780-1800	1.48	1.50	1.02	-0.02	0.46	0.19	-0.01	0.28
1800-1830	1.62	1.59	1.33	0.01	0.29	0.10	0.01	0.18
1830-1856	2.36	3.00	1.15	0.13	1.11	0.65	0.08	0.38
1856-1873	2.38	2.38	0.32	0.50	2.06	0.72	0.32	1.02
1873-1913	1.86	1.90	0.80	0.90	1.06	0.38	0.58	0.10
1924-1937	2.13	0.63	1.43	0.65	0.70	-0.20	0.49	0.41
1950-1973	3.36	4.36	-0.38	0.77	3.74	1.30	0.56	1.88
1973-1995	1.98	3.43	-0.20	0.74	2.18	0.91	0.42	0.75
1995-2007	2.88	4.27	0.80	0.40	2.08	0.87	0.30	0.91
2007-2016	0.95	2.34	0.88	0.64	0.07	0.36	0.48	-0.77

Notes: estimates from Table 1 adjusted to include labour quality growth in labour input. Labour quality through 1856 is based only on years of schooling (de Pleijt, 2018) assuming a 6 per cent increase in labour quality per additional year, and for 1856 to 1973 is from Matthews et al. (1982) including the additional component for occupational shifts (p.261, 266) but excluding the impact of changes in intensity of work. TFP* does not include the labour quality component which is accounted in human-capital deepening.

Sources: derived from Bell et al. (2005), de Pleijt (2018), Matthews et al. (1982), ONS (2017), and Thomas and Dimsdale (2017).

Table 4. Comparative Productivity Performance in the Golden Age, 1950-1973

a) Productivity Growth, 1950-73 (% per year)

	Y/L	*TFP*
France	4.83	4.02
UK	3.74	2.44
West Germany	5.83	4.06

Note: TFP is 'crude TFP'.

Sources: Table 1 and the long-term productivity database for Bergeaud et al. (2016).

b) Real GDP/Hour Worked (UK =100 in each year)

	France	*West Germany*
1950	80.3	70.0
1973	112.6	111.9

Note: GDP is measured in terms of 1990 Geary-Khamis dollars.

Sources: derived from Thomas and Dimsdale (2017) and The Conference Board (2016)