Sooner Than You Think:
the Pre-1914 UK Productivity Slowdown was Victorian not Edwardian

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Abstract

This paper re-examines UK productivity growth in the decades before World War I using a new dataset compiled by Thomas and Dimsdale (2017). We find that the productivity slowdown of the early 20th century was quite modest and does not deserve to be called a climacteric. A more serious slowdown in labour productivity growth occurred in the 1870s. Neither of these episodes should be regarded as a precedent for the current severe deterioration in UK productivity performance. Nor should a late-Victorian productivity slowdown be attributed to the end of the steam age despite the popularity of this belief.

Keywords: climacteric; growth accounting; time series modelling; productivity slowdown

JEL Classification: N13; O47

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1. Introduction

The weakness of UK productivity growth since the start of the global financial crisis has been remarkable and is still not fully understood. The so-called 'productivity puzzle' is captured by the observation that in 2018 quarter 4, real GDP per hour worked was actually only 2.0 per cent above the pre-crisis peak level seen in 2007 quarter 4 and was 18.3 per cent lower than if pre-crisis trend growth had been sustained (ONS, 2019).

This productivity slowdown has prompted renewed interest in an earlier slowdown, namely, that in Edwardian Britain. Goodridge et al. (2014) suggest that 1900 to World War I may be the only previous period when total factor productivity (TFP) growth was equally dismal and comment that this makes these years highly unusual. TFP growth averaged zero per cent per year between 1899 and 1913 according to Feinstein et al. (1982), who used the term 'climacteric' to describe these years. The Deputy Governor of the Bank of England, in an interview with the Daily Telegraph in 2018 which attracted great deal of attention, compared the current state of the economy with the 'climacteric', 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. In doing so, he repeated the argument famously made by Phelps-Brown and Handfield-Jones (1952).

It is fair to say that more recent papers by quantitative economic historians have been sceptical of these claims. Crafts et al. (1989), using a time series approach, found that the decrease in trend growth after 1899 was only about 0.15 percentage points per year, while Crafts and Mills (2004) pointed out that, on a growth accounting basis, the contribution of steam power to industrial productivity growth actually strengthened in the late 19th century. Interestingly, before the very influential paper by Feinstein et al. (1982) many economic historians, notably including Coppock (1956), thought that the Victorian climacteric occurred in the 1870s rather than at the turn of the century.

This paper re-examines UK productivity growth in the decades prior to World War I using a new dataset compiled by Thomas and Dimsdale (2017). This has two key differences compared with the vintage of data used by Feinstein et al. (1982). First, the series for real GDP is based on the 'balanced estimates' made by Solomou and Weale (1991) rather than the 'compromise estimate' of GDP favoured by Feinstein (1972). Second, the data include an annual series for hours worked per year, which means labour productivity growth can be analysed per hour rather than per worker. We provide descriptive averages for relevant periods and analyse trend productivity growth using a Hodrick-Prescott (1997) filter methodology.

Our main results are as follows. First, the slowdown in average annual productivity growth after 1899 was about half as bad as Feinstein et al. (1982) thought. Comparing 1873-99 with 1899-1913, we find that labour productivity growth fell from 1.18 per cent per year to 0.84 per cent while TFP growth fell from 0.81 to 0.42 per cent. Second, the decline in trend labour productivity growth after 1899 was only slight, falling from 0.91% in the late 1890s to a minimum of 0.75% in 1913. Third, the productivity slowdown in the 1870s was more impressive and more worthy of the climacteric label. There was a sustained fall in trend labour productivity growth from 2.15 per cent per year in 1869 to 0.84 per cent in 1890. This is reflected in a substantial fall in the period average from 2.06 per cent per year in 1856-73 to 1.18 in 1873-99. Fourth, the Edwardian climacteric is not really a good precedent for the current

productivity slowdown. Both labour productivity growth and TFP growth at 0.07 and -0.29 per cent per year, respectively, are much weaker now than then. Moreover, the gap between the actual level of labour productivity and that which would have been expected on the basis of the trend prior to the downturn is now much bigger: we estimate that ten years after 2008 this gap was 19.7 per cent whereas ten years on from 1899 it was 5.5 per cent (Crafts and Mills, 2019).

1. Data

Our data are taken from Thomas and Dimsdale (2017). This source is superior to earlier datasets in two ways which matter for our analysis. First, it embodies several important revisions that have recently been made to historical estimates of real GDP. For the period prior to 1855, these are based on the study by Broadberry et al. (2015), which provides annual estimates where previously only benchmark years were available. For the period from 1870 to 1913, the 'balanced estimates' made by Solomou and Weale (1991) are used rather than the 'compromise estimate' of GDP favoured by Feinstein (1972).[1]

Second, the Thomas and Dimsdale (2017) dataset contains estimates for total hours worked on an annual basis from 1856 onwards which we use for our analysis.[2] This is an important improvement which permits time-series analysis of labour productivity growth in terms of output per hour worked rather than per worker during the pre-World War I period. Given the considerable changes to hours worked after the mid-19th century this is much preferred and, in particular, it makes a notable difference at the end of the mid-Victorian boom. Prior to 1856 the estimates of hours worked, which provide the basis for an interpolated series, are available only for a few benchmark years at wide intervals between which there are substantial differences. We do analyse the pre-1856 data, which has the advantage that the years around 1870 are not near the beginning of the sample period but note that they have to be treated with caution. Fortunately, for the years after 1870 the estimated trend rate of labour productivity growth is essentially the same whether estimation starts in 1761 or 1856. Our analysis is based on Table A56 column O of Thomas and Dimsdale (2017).

2. A Growth Accounting Perspective

Before turning to time-series analysis it is helpful to set out the implications of the new data in a growth accounting format. This was the method used by Feinstein et al. (1982) to validate their view that the climacteric occurred after 1899, so repeating the analysis with the new data gives a clear insight into the difference that they make as well as a check on whether the claim of an Edwardian climacteric is convincing.

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[1] As is well-known, there is a significant discrepancy between the expenditure, income and output series for GDP, notably in the post-1899 period. Compromise and balanced estimates are alternative ways to make a weighted average of the three series. The former is derived by taking the geometric average whereas the latter uses weights based on their relative reliability, which in this instance is based on Feinstein's own assessment.

[2] The Thomas and Dimsdale series for annual hours worked is constructed using the method developed by Matthews et al. (1982) but only implemented by them for benchmark years. The starting point is estimates of average full-time 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.

Feinstein 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

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

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

$$\Delta Y/Y = \alpha\,\Delta K/K + (1-\alpha)\,\Delta L/L + \Delta A/A \tag{2}$$

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

$$\Delta log(Y/L) = \alpha \Delta log(K/L) + \Delta logA \tag{3}$$

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.

In this formulation the contribution to growth of labour quality is not quantified but will accrue as part of A, a residual which can be thought of as 'crude TFP'. Feinstein et al. (1982) followed a periodization based on estimating growth rates of output and inputs between end dates which were selected for having relatively low unemployment rates and were regarded by them as years of high economic activity. This precluded taking explicit account of labour quality, which they only attempted to measure for a few benchmark years.

In Table 1 we report growth-accounting estimates using data from Thomas and Dimsdale (2017) for the periodization chosen by Feinstein et al. (1982) and juxtapose them with the original. 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 together with 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 1 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 percentage points 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).[3] This is almost entirely because they examined the climacteric in terms of output per worker rather than output per hour worked.[4]

[3] Boyer and Hatton (2002) developed improved estimates of unemployment rates which would imply a slightly different periodization, with the years of high economic activity demarcating the sub-periods following the sequence 1872, 1883, 1890, 1899. This makes only a trivial difference. For 1856-72, 1872-1899 and 1899-1913, labour productivity growth rates are 2.05, 1.23 and 0.84 per cent per year, respectively, while TFP growth rates are 1.33, 0.82 and 0.42 per cent per year, respectively.

[4] This was apparently because they only had available estimates for hours worked for the benchmark years of 1856, 1873 and 1913, so their discussion of sub-periods within 1873-1913 had to be conducted in terms of employment. A reader of the parent study by Matthews et al. (1982), whose estimates used output per hour worked, would have seen that productivity growth fell sharply after 1873.

The implication of employing the new data is that using the label 'climacteric' to describe the slowdown in UK productivity growth in the early 20th century seems inappropriate. This was a modest decline compared with nowadays. It also serves to detract from the more serious fall in productivity growth in the 1870s. Indeed, if anything, it would seem to vindicate the basic position taken by Coppock (1956) before Feinstein et al. (1982) became conventional wisdom, namely, that the term climacteric was better used to describe the 1870s rather than the 1900s.[5]

3. Time Series Analysis of Trend Growth in UK Productivity

The underlying model for obtaining trend growth rates is that of an additive decomposition of the series x_t, the logarithm of the variable under consideration and which is observed over the years $t = 1,2,\ldots,T$, into a trend, μ_t, and a cycle, ψ_t, typically assumed to be independent of each other, i.e.,

$$x_t = \mu_t + \psi_t \qquad E(\mu_t \psi_s) = 0 \text{ for all } t \text{ and } s \tag{4}$$

The actual model used here is one in which the trend follows a random walk

$$\mu_t = \mu_{t-1} + \beta_{t-1} + a_t \tag{5}$$

in which the drift, which is the trend growth rate here, also follows a, albeit driftless, random walk

$$\beta_t = \beta_{t-1} + b_t \tag{6}$$

The errors a_t and b_t are assumed to be independent zero mean white noises with variances σ_a^2 and σ_b^2. The cycle ψ_t is also assumed to be white noise with variance σ_ψ^2 and, from the assumption made in (4), will be independent of both a_t and b_t. Equations (4)-(6) are together known as a structural model and their specifications have been chosen to ensure that the trend component could be both smooth and slowly evolving. Furthermore, as we discuss below, it also has the additional benefit of having a ready interpretation as a popularly used trend filter.

The model may be fitted by casting equations (4)-(6) into state space form and estimating the parameters by employing maximum likelihood via the predictive error decomposition of the Kalman filter, with the trend component then being estimated using the Kalman smoother (Mills, 2019, chapter 17 provides an introductory discussion of such models). When the model was fitted to the labour productivity series discussed in section 2, it was found that the variance of the error to the trend equation (5), σ_a^2, was estimated to be both very small and insignificantly different from zero. Setting this variance to zero produces what is known as a 'smooth trend' structural model and is equivalent to obtaining the trend using a Hodrick-Prescott (HP) filter with the smoothing parameter, say λ, set to a very large value (see, for example, Mills, 2019, chapter 8). The labour productivity trend and trend growth rate shown superimposed on the actual (log) level and growth rate in Figures 1 and

[5] Coppock's justification for a climacteric in the 1870s was based on output growth calculated from the old Hoffmann index of industrial production to derive industrial productivity growth. This is not an appropriate methodology.

2, respectively, for 1856 to 1913 were, for convenience, computed using the HP filter with $\lambda = 1{,}000$.[6] This setting does indeed produce a satisfactorily smooth, albeit slowly evolving, trend component and readily interpretable trend growth rates, defined as $100\Delta\mu_t$, which gives the growth rate in percentages per annum.[7]

Figures 3 and 4 show the results of repeating the analysis for the longer sample period of 1760 to 1913. Trend labour productivity growth peaks in 1869 at 2.15% for the sample beginning in 1856, and in 1870 at 2.11% for the longer sample beginning in 1760. Trend growth then declines to 0.84% (0.85%) in 1890 before recovering slightly to 0.91% by 1897. There is then a slow and small decline to 0.75% by 1913. It is thus clear that extending the sample period back to 1760 makes little difference to the behaviour of trend labour productivity growth during the period of interest.[8]

Other models may, of course, be used to specify the trend component: for example, a popular choice is to specify μ_t as a deterministic segmented trend, typically linear in t, although Mills and Crafts (1996) have used a cubic polynomial. Fitting a segmented linear trend, with unknown but empirically selected break points, found that there was a single break at 1875 where trend growth dropped from 2.6% to 0.9%, which is consistent with the estimates from the structural model. A non-linear trend, such as a smooth transition function, may also be used, but attempts to do so here were unsuccessful due to an inability to obtain convergence of the parameter estimates.[9]

Of course, the data that we have analysed are imperfect and may yet be subject to further revisions. In particular, further research may yet resolve the discrepancy between the expenditure, income and output series for GDP and, if so, the dimensions of the post-1899 slowdown could look somewhat different.[10]

4. Discussion

The context in which discussion of a productivity slowdown or climacteric might well be placed is the debate about the alleged failure of the UK economy during at least part of the 1873 to 1913 period. Many (not mutually exclusive) explanations for underwhelming growth performance have been put forward by various proponents of failure, including entrepreneurial failure leading to sluggish

[6] This means that the critique of the use of HP filters in Hamilton (2018) is not applicable here, see the appendix.
[7] The use of a higher value for λ than is often employed in much macroeconomic modelling (for example, setting the smoothing parameter to 100 is common practice when using annual data) may also be justified from the theoretical and simulation analyses of Harvey and Trimbur (2008) and Flaig (2015).
[8] If the exercise is repeated using data from 1760 into the 21st century then during the 1856-1913 period trend labour productivity growth peaks at 1.67% in 1868 before declining to 0.93% in 1903 before slightly increasing to 1.03% by 1913.
[9] Mills (2009, 2016, 2019) provides detailed historical and technical development of these various approaches.
[10] Solomou and Thomas are currently engaged on a project to improve the GDP estimates. They have already made improved income estimates and used them to make a provisional re-calculation of Feinstein's compromise estimate (Solomou and Thomas, 2019). Repeating our analysis using this series to estimate labour productivity gives results which are essentially unchanged from those that we obtained for the post-1856 sample as reported in the main text.

development and adoption of new technology (Aldcroft, 1964), capital market failure with excessive foreign investment but too little finance of domestic industry (Kennedy, 1987), an inadequate national innovation system with sub-optimal investment in human capital and R & D (Pollard, 1989), overcommitment to old industries (Richardson, 1965), a slowdown in export demand growth (Meyer, 1955), and a hiatus between general-purpose technologies as the age of steam came to an end (Phelps-Brown and Handfield-Jones, 1952). The first four of these hypotheses highlight a failure to exploit the opportunities of the second industrial revolution as well as rival economies such as Germany and the United States, and as such are better suited to explaining disappointing growth in the early 20th century than in the 1870s.

The suggestion that there was a failure was vigorously disputed by McCloskey (1970), who claimed that in the pre-First World War period the British economy was 'growing as rapidly as permitted by the growth of its resources and the effective exploitation of the available technology' (p. 451) and argued that there was no dip in productivity performance till the Edwardian period and even then it was probably only a blip. To a considerable extent, McCloskey's position has been vindicated by quantitative economic historians who have looked at testable implications of the failure claims, as is made clear by recent reviews of the literature. In particular, choices of technique were nearly always correct (Magee, 2004), foreign investment was profitable and new industries were not unduly neglected by the capital market (Chabot and Kurz, 2010) while the specialized British banking system worked well (Chambers, 2014). Much more questionable, however, is the UK's technological performance as, for example, the data on patenting confirm (Nicholas, 2014). More speculatively, an endogenous-growth perspective might suggest that a stronger commitment by government to fostering a 'knowledge economy' could have raised the growth rate and relaxed the supply-side constraint invoked by McCloskey.

The revised productivity growth estimates presented in this paper have some impact on the failure debate. It should, however, be recognised that the issue of whether and when there was a productivity slowdown is of limited relevance. Our estimates indicate that it is inappropriate to use the term climacteric to describe the 1899 to 1913 period: the decline in trend productivity growth was quite modest and productivity growth fell by less than Feinstein et al. (1982) thought. However, a critic of UK performance might look at Table 1 and stress the failure of productivity growth to accelerate in the early 20th century and to match the much faster TFP growth achieved by the United States (1.7 per cent per year in 1899-1929 and 2.3 per cent per year in 1929-41) as the second industrial revolution took hold.[11] Similarly, while our estimates do suggest that some may want to describe the productivity slowdown in the 1870s and 1880s as a climacteric (as was believed by earlier economic historians), this may have been largely unavoidable if it was not feasible to sustain productivity growth at mid-19th century rates in the staple industries of the first industrial revolution (Crafts and Mills, 2004).

Even so, there are some implications of the new estimates that are worth noting, including that they undermine McCloskey's argument that any productivity slowdown was inconsequential and so failure was implausible. It is also clear, despite McCloskey's claim to the contrary, that labour productivity growth did not match that of the United States. Labour productivity growth in the UK fell from 2.06

[11] These estimates are for crude TFP growth (i.e., subsuming labour quality in TFP) in the private domestic economy based on Kendrick (1961).

per cent per year in 1856-73 to 1.18 per cent in 1873-99 and 0.84 per cent in 1899-1913, whereas the United States recorded 2.11 per cent per year in 1874-99 and 1.72 per cent in 1899-1913 (Kendrick, 1961).[12]

Re-positioning the date of the significant productivity slowdown to the 1870s rather than the 1900s does make a difference to some of the detailed arguments. As far as the export demand hypothesis is concerned, it makes the timing look better. Export growth fell from 3.5 per cent per year in 1857-1873 to 2.1 per cent per year in 1873-1899, but then increased to 3.6 per cent per year in 1899-1913 (Feinstein, 1996). However, the big doubts about this hypothesis, which are about establishing a link from exogenous changes in export demand to productivity performance and the direction of causality between export and productivity growth, remain.

As far as the general-purpose technology explanation is concerned, the timing looks worse. Evaluated by growth accounting, the contribution of steam power to labour productivity growth in industry rose from 0.41 per cent per year in 1850-1870 to 0.51 per cent per year in 1870-1910 (Crafts and Mills, 2004). Indeed, as Musson pointed out a long time ago, 'steam-powered mechanization … [was] still proceeding at a tremendous pace … the 1870s did not witness the end of the 'massive application' of steam power' (1963, p. 530). Since steam's contribution to labour productivity across the whole economy was felt over a long period and was never very intense (Crafts, 2004), any waning of its impact could not have made a big difference to overall growth performance in the late 19th or early 20th centuries.

Even though there was a significant slowdown in trend labour productivity growth from around 1870, in historical perspective this should not be seen as too disappointing. Notably, growth performance still exceeded that of the classic industrial revolution period at the end of the 18th and beginning of the 19th centuries: as is clear from Figure 4, trend labour productivity growth did not reach 0.75 per cent per year until 1825. There are, in fact, good reasons to think that while the national innovation system was inferior to that of the United States in the late 19th and early 20th centuries, it was considerably improved compared with late 18th and early 19th century Britain (Crafts, 2018). The capital market was much better developed, intellectual property rights were stronger, and there were many more apprenticeships together with an increased emphasis on scientific and technical education.

Finally, it is quite misleading to claim that the productivity slowdown just prior to World War I is a precedent for today's productivity puzzle. One way to establish that is to compare the extent to which real GDP per hour worked is below the previous trend growth path ten years after the start of the downturn. Ten years on from 2008 we estimate the shortfall was 19.7 per cent whereas ten years on from 1899 it was 5.5 per cent (Crafts and Mills, 2019). A second way to make the point is by comparing growth accounting estimates for the current slowdown with those reported in Table 1 relating to 1899-1913. The estimates reported in Table 2 show a fall of about 2 percentage points per year in labour productivity growth and about 1.5 percentage points in TFP growth compared with the 40-plus years prior to the financial crisis. In the period 2007-2016, labour productivity growth was only 0.07% per year and TFP growth was -0.29% per year compared with 0.84% and 0.42% per year, respectively, in 1899-1913

[12] These estimates are for output per man year in the private domestic economy (Kendrick 1961, pp. 333-334).

5. Conclusions

Our reappraisal of UK productivity performance in the decades leading up to World War I indicates that the analysis put forward by Feinstein et al. (1982) should be revised in view of more recent data. In particular, the availability in Thomas and Dimsdale (2017) of an annual series for labour productivity based on hours worked rather than headcount permits a new view of both the timing and the extent of productivity slowdown.

We find that the use of the term 'climacteric' to describe slower productivity growth from 1899 to 1913 is inappropriate. There was a slowdown but it was quite modest. Contrary to some recent suggestions, this period is not a precedent for the much larger deterioration in productivity growth experienced by the UK in recent years. Neither is the productivity slowdown that characterized the 1870s and 1880s although this was both more pronounced and of a longer duration than that of the early 20th century. Nevertheless, we believe that if the label 'climacteric' is to be used in the context of 19th century productivity growth it should be used for the 1870s.

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Table 1. Growth Accounting Estimates for the Early 20th Century Productivity Slowdown (% per year)

a) Based on Early 1980s' Data

	Real GDP Growth ΔY/Y	***Capital Stock Growth ΔK/K***	***Labour Inputs Growth ΔL/L***	***Labour Productivity Growth Δ(Y/L)/(Y/L)***	***Contribution from Capital Deepening αΔlog(K/L)***	***TFP Growth ΔlogA***
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 and *L* is employment and the periodization is based on intervals between years of high economic activity, see text.

Source: Feinstein et al. (1982).

b) Based on Modern Data

	Real GDP Growth ΔY/Y	***Capital Stock Growth ΔK/K***	***Labour Inputs Growth ΔL/L***	***Labour Productivity Growth Δ(Y/L)/(Y/L)***	***Contribution from Capital Deepening αΔlog(K/L)***	***TFP Growth ΔlogA***
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 and *L* is hours worked.

Source: All estimates are based on Thomas and Dimsdale (2017). Real GDP is Table A8, column B, capital stock is Table A55, column X, labour inputs are derived by multiplying employment in Table A50, column B by hours worked per year in Table A54, column AW. The contribution from capital

deepening is 0.35 x (capital stock growth – labour inputs growth) and TFP growth is obtained as a residual.

Table 2. Growth Accounting Estimates for the Early 21st Century Productivity Slowdown (% per year)

	Real GDP Growth ΔY/Y	***Capital Services Growth ΔK/K***	***Labour Inputs Growth ΔL/L***	***Labour Productivity Growth Δ(Y/L)/(Y/L)***	***Contribution from Capital Deepening αΔlog(K/L)***	***TFP Growth ΔlogA***
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: K is net capital, L is hours worked.

Source: All estimates are based on Thomas and Dimsdale (2017). Real GDP is Table A8, column B, capital services is Table A55, column AM, labour inputs are derived by multiplying employment in Table A50 column B by hours worked per year in Table A54 column AW. The contribution from capital deepening is 0.25 x (capital stock growth – labour inputs growth) and TFP growth is obtained as a residual.

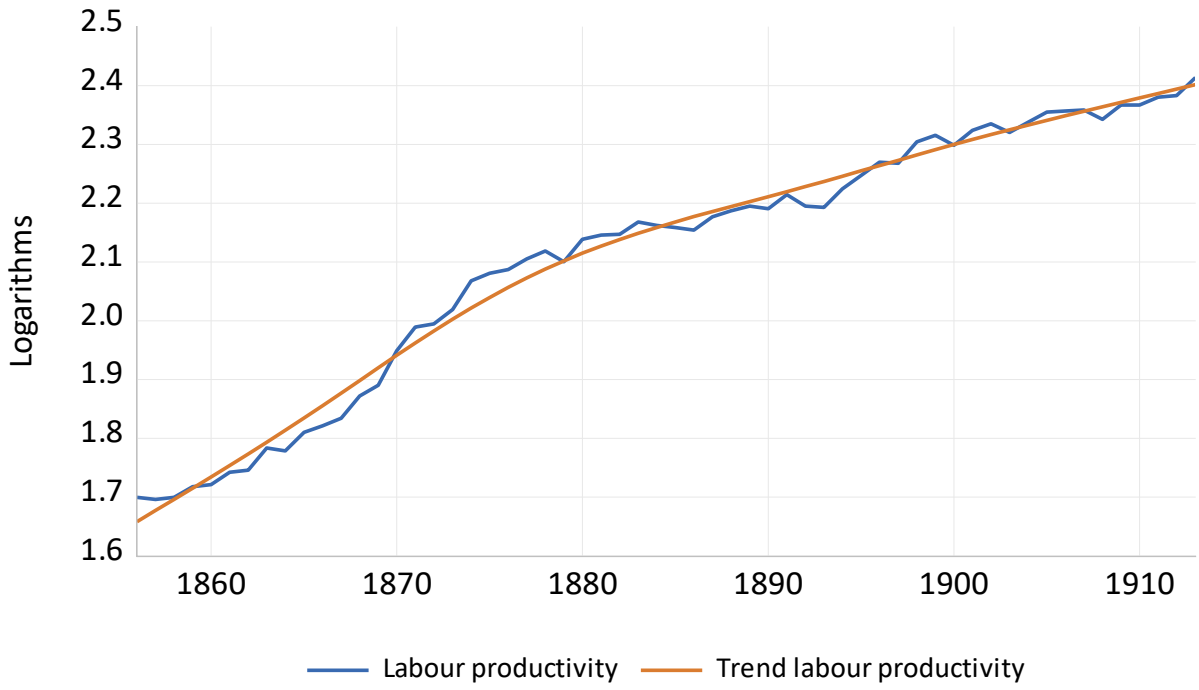

Figure 1 Labour productivity and trend labour productivity, 1856 – 1913.

Figure 2 Labour productivity growth and trend labour productivity growth rates: 1857 – 1913.

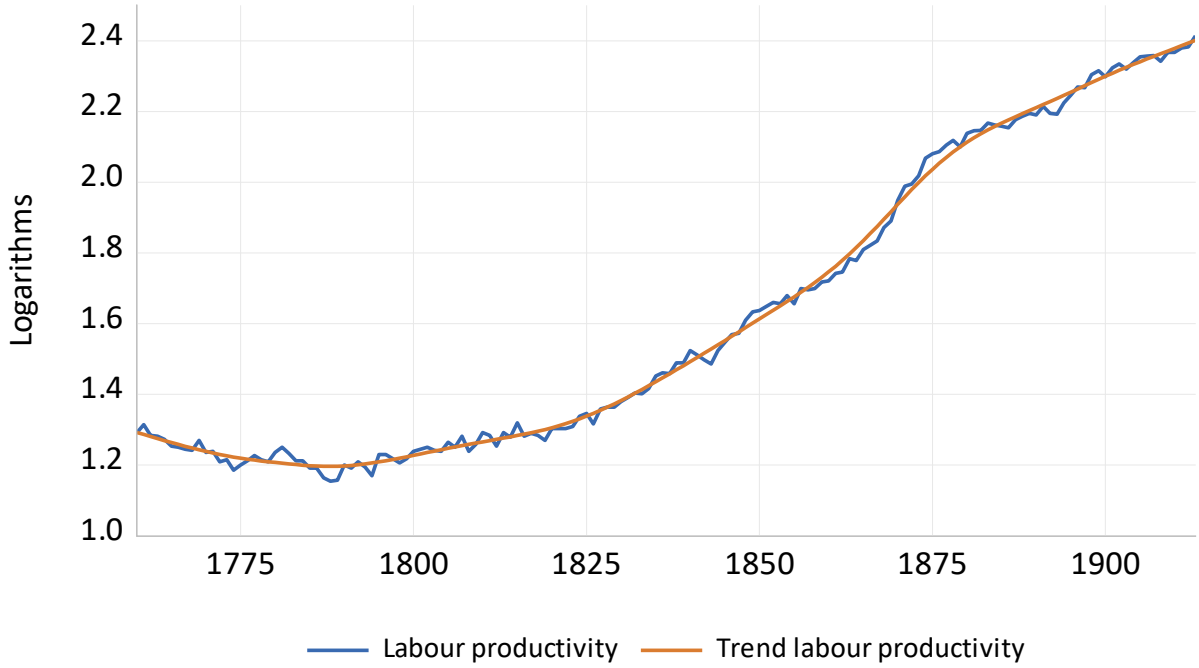

Figure 3 Labour productivity and trend labour productivity, 1760 – 1913.

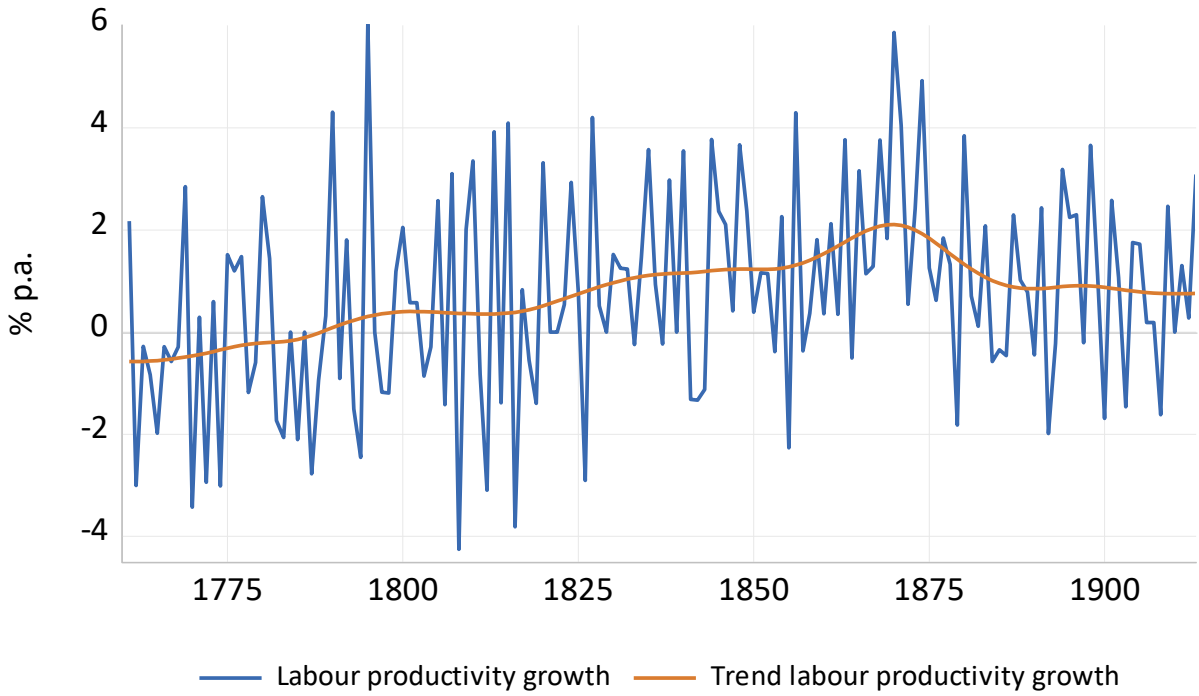

Figure 4 Labour productivity growth and trend labour productivity growth rates: 1761 – 1913.

Appendix

Hamilton (2018) has recently criticised the use of the HP filter, arguing against the widespread use of the filter to extract a business cycle component from monthly and quarterly macroeconomic time series. This criticism is, however, not applicable to our estimates. As we have emphasised, our purpose here is to extract a smooth and evolving trend component from annual data. The structural model (4)-(6), with the error variance of the trend component set to zero in accordance with the data, achieves this aim. Given the results obtained with this estimation, it is then helpful to note the correspondence to the HP filter with a large setting of the smoothing parameter as an aid to the interpretation of the trend component model.

Hamilton (2018) also proposes an alternative, 'robust', method of estimating the trend component. This is to use the predicted values, $\hat{x}_t(h)$, from the regression of x_t on a constant and the lagged values $x_{t-h}, x_{t-h-1}, x_{t-h-2}, x_{t-h-3}$ to estimate the trend component, so that the trend growth rate is estimated as $100\Delta\hat{x}_t(h)$. For all values of h between 1 and 5 the estimated trend growth rates from this regression follow essentially the same pattern as the observed growth rates. This can be seen, for example, in Figure 5, which plots observed growth, $100\Delta x_t$, along with $100\Delta\hat{x}_t(1)$, so that, at least in this case, the Hamilton approach provides little useful information on the evolution of trend growth.

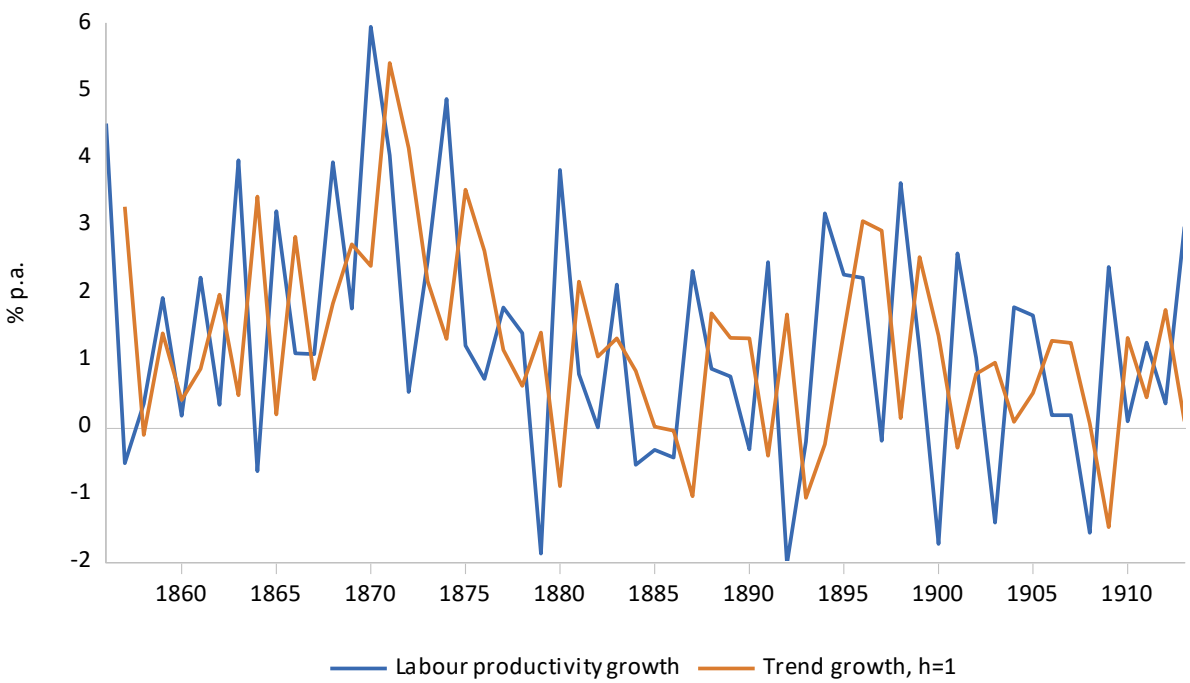

Figure 5 Labour productivity growth and trend productivity growth rates calculated using Hamilton's approach with $h = 1$, 1856-1913.