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BRITISH ECONOMIC GROWTH AND DEVELOPMENT

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Abstract: British per capita GDP grew at an average annual rate of 0.13 per cent between 1086 and 1700. Although the annual growth rate increased to 0.48 per cent between 1700 and 1870, the period covering the Industrial Revolution, this was still not particularly fast. What mattered for Britain's catching-up and forging ahead of other economies was its resilience, with few episodes of negative growth. By the late nineteenth century, other countries had begun to emulate Britain's Industrial Revolution and by the beginning of the twentieth century, the United States had emerged as the new per capita income leader. However, the process by which the United States and Germany overtook Britain owed more to a later structural shift out of agriculture and developments within services than to any change in the comparative productivity position within manufacturing. After 1870, other countries were bound to grow faster than Britain while catching-up, and once Britain had fallen behind, it too could benefit from borrowing technology and institutions from abroad. TFP growth has been an important proximate source of Britain's rise to GDP per capita leadership and also of Britain's relative economic decline since 1870. However, the ultimate source of these developments in technology lies in the institutional framework. Britain's rise to GDP per capita leadership occurred as innovators responded to the factor price combination that they faced within an environment shaped by the Enlightenment. After 1870, British relative decline occurred as barriers to competition arose and slowed the response to technological change.

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1. INTRODUCTION

The British economy plays an important role in the discipline of economic history because it was the location of the first Industrial Revolution, arguably the most important development in world history, ushering in a new era of continuously rising living standards that soon began to spread to other parts of the world. As Mokyr (1993: 131) put it: "Although the center of the stage has long been taken over by others, Britain's place of honor in the history books is assured: It will remain the Holy Land of industrialism." However, recent work has shown that the process of economic growth and development began much earlier than the eighteenth century. This paper begins the story in 1086, the date of the Domesday Survey undertaken by William I two decades after the Norman Conquest of 1066. This remarkable document provides sufficient information to estimate national income, and can be linked to the continuous annual series that can be reconstructed from the much larger array of documentary evidence that exists on the economy from around 1270. As well as providing a quantitative overview of the growth and development of the British economy from the eleventh century to the Industrial Revolution of the eighteenth and nineteenth centuries, this chapter also explores the performance of the British economy as other economies caught up and forged ahead during the period after 1870.

An important issue that needs to be settled from the outset is the territory to which this study refers, as the political geography of the British Isles has varied over time. For the period 1086-1700, the data refer to England, while for the period 1700-1870 they refer to Great Britain, consisting of England, Wales and Scotland. For the period since 1870, the main series are for the territory of the United Kingdom of Great Britain and Northern Ireland. This means that southern Ireland, which was part of the United Kingdom from 1801 to 1920 is effectively excluded for the whole of this period. It should be noted that this is not an insignificant exclusion, since the population of Ireland, which was substantially poorer than the rest of the UK, was over 30 per cent of the UK total before the Great Famine of 1846, but had fallen to less than 10 per cent by 1920 (Mitchell 1988: 11-13). Fig. 1 plots the path of GDP per capita for this evolving definition of Britain over almost a millennium of history from 1086 to 2018.

A number of findings can be highlighted covering the period 1086-1870, the period of Britain's rise to world economic leadership (Broadberry et al. 2015). First, between 1086 and 1700, episodes of positive per capita GDP growth in England were interspersed with periods of stagnation rather than trend negative growth. This meant that the British economy was significantly richer on the eve of the Industrial Revolution than it had been at the time of the

Domesday Survey, having already developed the ability to maintain living standards during periods of positive population growth. In this way, the British economy was already breaking free from Malthusian constraints long before the Industrial Revolution. Second, British per capita GDP growth increased only to 0.48 per cent per annum between 1700 and 1870, the period that included the Industrial Revolution (Crafts and Harley 1992). What mattered for Britain's catching-up and forging ahead of other economies was its resilience. Compared with other countries, there were few episodes of negative growth in Britain, and when they did occur, they were relatively mild (Broadberry and Wallis 2017).

Turning to the period since 1870, further important findings have been derived from historical national accounting. First, by the late nineteenth century, other economies in Western Europe and North America had begun to emulate Britain's Industrial Revolution and, as a result, Britain's industrial leadership was being seriously challenged (Broadberry 1997). By the beginning of the twentieth century, the United States had emerged as the new per capita income leader. Second, the process by which the United States and Germany overtook Britain during the twentieth century has often been misunderstood. This owed more to a later structural shift out of agriculture and developments within services than to any change in the comparative productivity position within manufacturing during the Second Industrial Revolution (Broadberry 1998). Third, although British relative economic decline undoubtedly occurred during the twentieth century, its extent should not be overstated. After the 1970s, when Britain was overtaken by much of western Europe, this created catching-up possibilities for Britain, which began to be realized during the 1980s and lasted until the financial crisis of 2008 (Crafts 2018). At the time of writing, however, a new British "productivity puzzle" has emerged (Crafts and Mills 2020).

2. FROM THE DOMESDAY SURVEY TO THE LATE-THIRTEENTH CENTURY

Roughly two decades after the Norman conquest of England in 1066, William the Conqueror conducted a Great Survey of the country, recording the annual value (valet) of every piece of landed property to its lord, also noting a number of key economic resources on the land, including people, livestock, ploughs and property. It later became known as the Domesday Book, and provides enough information for a number of scholars to have attempted to estimate English GDP for 1086. The most recent estimate by Walker (2015) follows an output-based approach broadly consistent with the system of national accounts (SNA) adopted by

Broadberry et al (2015) for the period 1270-1870, and is therefore preferred to earlier estimates by Snooks (1995) and Mayhew (1995).

Tab. 1 provides the key magnitudes in summary form. Part A covers the seigniorial sector, the recorded income (valet) of which was £75,065. There has been some controversy over whether this reflects the income generated only by arable agriculture or includes the income generated by other resources. However, there are good reasons to believe that the valet covered only income from arable agriculture, including the fact that (1) the value of mills, where recorded, frequently exceeded the valet, and (2) when livestock recorded in satellite texts were omitted from the Domesday Book, the scribe did not adjust the valets (Walker 2015: 29-30). To obtain the total seigniorial income it is therefore necessary to add income from livestock agriculture (non-working animals) and also from other resources, including mills, fisheries, salthouses and property. The income from livestock agriculture was obtained from data on animal numbers, which are restricted to the counties covered in the Little Domesday Book (Essex, Norfolk and Suffolk) and Circuit II (Wiltshire, Dorset, Somerset, Devon and Cornwall) and are projected to other locations using the relationship between animal stocking densities in those counties and the whole country in 1300 (Walker 2015: 39). For seigniorial income from other resources, Walker (2015: 40) uses the average valuation of resources where both numbers and valuations were recorded to compute the value of resources where only numbers were provided.

Part B covers the non-seigniorial sector, again distinguishing between income from arable agriculture, livestock agriculture and other resources. The non-seigniorial income from arable agriculture consists of two items, derived using ploughs belonging to the peasants. The first item, ploughs (partial demesne),was obtained by multiplying the seigniorial arable income by the proportion of time that ploughs belonging to the peasants were employed off the demesne (91.7 per cent of the time), weighted by the number of peasant ploughs relative to those operated on behalf of the lords (Walker 2015: 39). However, in ploughs (non-demesne), an additional allowance was made for a discrepancy between two measures of the number of ploughs, one referring to plough-lands (seigniorial land for so many ploughs) and the other a direct measure of the "number of ploughs" owned by both peasants and lords, which indicates a surplus of 12,592 ploughs, assumed to be used exclusively on peasant lands (Walker 2015: 39). The non-seigniorial livestock income was obtained from estimates of the ratio between stocking densities on peasant lands compared with densities on seigniorial lands in the late

medieval period (Walker 2015: 37-38). For non-seigniorial income from other resources, Walker (2015: 31) assumes that the average of the recorded valuations can be used for manors where resources were included but without valuations.

Part C adds a number of excluded items, including income from unrecorded property and excluded territories. Although it is possible to obtain estimates for urban property incomes in Domesday Book, they are under-recorded. A rough estimate of total property income is derived from an assumption that 10 per cent of the population was living in towns. Walker (2015: 41-42) subtracts recorded property income from this to obtain unrecorded property income of £31,320. In addition, no data are recorded for the four northern counties of Cumberland, Westmorland, Northumberland and Durham, most likely due to the harrying of the north. The number of households in these counties is based on the population density of Cheshire, Lancashire and Yorkshire, and mean incomes are assumed to be as in the rest of the country, resulting in a tentative estimate of £15,167 for the income of the excluded counties.

Combining the separate estimates for the seigniorial and non-seigniorial sectors plus the excluded items results in a GDP estimate for Domesday England of £430,362. Note that this is lower than Walker's (2015) final GDP value of £500,000, which includes a number of counterfactual elements, such as unutilized ploughs and climate change, that go beyond United Nations SNA principles. The pastoral sector made up just 17.1 per cent of the income of the agricultural sector, a figure which is much lower than the 39.9 per cent suggested by Broadberry et al. (2015) for the 1270s. However, this is likely to be an understatement of the size of the pastoral sector, reflecting the restricted reporting of animal numbers in the Domesday Book. Note also that Walker's estimates suggest that agriculture accounted for 85.6 per cent of GDP, a very high figure compared with Broadberry et al.'s (2015) figure of 45.2 per cent in 1381. This suggests that much of the agricultural activity recorded in Domesday Book includes industrial activities such as construction, textiles, iron working and food processing, as well as service sector activities such as transport, distribution and finance.

The estimate of GDP for England in 1270 in Tab. 2 is based on a detailed study of agriculture, industry and services, described in Broadberry et al. (2015), which will be discussed in the next section. The figures of nominal GDP in the two years 1086 and 1270 are shown in the first row of Tab. 2, and suggest a growth of nominal income by a factor of 8.2. However, since population and the price level both increased substantially, any increase in real

GDP per capita was minimal. The population data are also taken from Broadberry et al. (2015) and suggest an increase in the number of inhabitants by a factor of 2.55. The path of the price level between the two years is the most difficult variable to establish. Here, we take the unweighted average of Clark's (2004; 2006) series for arable, pastoral and manufactured products for the period 1221-1270, extended back to 1166 using Farmer's (1988) data for arable and pastoral prices. Assuming no inflation between 1086 and 1166, the price level increased by a factor of 3.21 between 1086 and 1270. As a result, there was little change in real GDP per capita between the two periods. In 1270 prices, GDP per capita increased from £940,000 in 1086 to £1,025,000 in 1270 before falling back to £902,000 by 1279.

3. BRITISH ECONOMIC DEVELOPMENT, 1270-1870

3.1 Data sources, 1270-1870

The richness of British sources from the late thirteenth century makes it possible to reconstruct GDP and population on an annual basis. As a result, Broadberry et al. (2015) are able to estimate GDP per capita for England over the period 1270-1700 and for Great Britain covering 1700-1870. Output is estimated separately for the agricultural, industrial and service sectors.

For agriculture, three main data sources are available, covering the medieval, early modern and modern periods, respectively. First, the Medieval Accounts Database of Campbell (2000; 2007) is based mainly on a large sample of manorial accounts drawn up using a common template by the reeve who managed the demesne under close supervision of the lord's bailiff or steward. These accounts provide detailed information on land use, crops, animals and livestock products for the period 1270-1492. Second, the Early Modern Probate Inventories Database assembled by Overton (1991; 2000) and Overton et al. (2004), pulls together similar information for the period between 1553 and 1720, extracted from inventories drawn up by the Church Commissioners for the estates of farmers. Third, the Modern Farm Accounts Database of Turner et al. (2001), which runs from 1720 until 1913, is based on a large sample of accounts produced by farmers and kept in local record offices. For all three datasets, arable agricultural outputs were calculated by multiplying the acreage for each crop by the yield per acre. The trends in yields were estimated for each of the three main time periods, based on microdata obtained from the three databases, and applied to the total acreage for the country as a whole. For output of the livestock sector, a similar procedure was undertaken, multiplying the number of animals by the shares producing and their yields. Prices for individual arable and livestock products are used to convert the output into current prices and create weights for the agricultural

real output index. For the period between 1492 and 1553, there is a gap as the manorial records come to an end before the probate inventories become available. This gap has been filled at the level of total agricultural output using the demand function approach of Crafts (1985) and Allen (2000). Agricultural consumption per head is assumed to be a function of its own price, the price of non-agricultural goods and income. Income, own-price and cross-price elasticities are estimated from the data for output (adjusted for net imports), prices and real wages over the period 1301-1492 and 1553-1700, and used to predict the missing values of output between 1492 and 1553, based upon the known values of prices and real wages for this period.

Production estimates exist for the key English industries up to 1700, based on careful reconstruction from archival records by generations of scholars. Crucial sources include Carus-Wilson and Coleman (1963) for wool and woolen cloth, drawing on detailed records of exports of wool and woolen cloth; King (2005) for iron, based on a reconstruction of all blast furnaces, their capacity and knowledge of when they were in blast; and Hatcher (1973) for tin, based on receipts of coinage dues. Outputs related to leather and food processing are estimated by Broadberry et al. (2015) on the basis of key inputs obtained from the reconstruction of the agricultural sector. Construction combines detailed information on cathedral building with an index of housebuilding based on population and urbanization, while the growth of book production is based on titles listed by the British Library. These series are combined to generate an index of industrial production from 1264 to 1700. Crafts and Harley (1992) offer an index from 1700 until 1870, to which Broadberry et al. (2015) add some new series.

The service sector follows the approach developed by Deane and Cole (1962), with some adjustments. The sector is broken down into commerce, housing, domestic services and government. The commerce indicator is based on combining estimates of domestic trade (the volume of agricultural and industrial output adjusted for the growing share that was marketed) and international trade (derived from the detailed records of trade that were kept for taxation purposes), freight transport (based on merchant shipping tonnage, distances travelled on the main trade routes and volumes shipped) and financial services (using the velocity of money, derived by comparing estimates of the stock of money with existing estimates of nominal national income). Housing and domestic services are assumed to grow at the same rate as population. Government activity is based on its revenue, which exists in detailed annual exchequer accounts back to the early twelfth century (O'Brien and Hunt 1999).

The three real output series for the agricultural, industrial and service sectors are combined using a set of sectoral weights which capture the changing structure of the economy. The starting point is an input-output table for 1841 from Horrell, Humphries and Weale (1994). The nominal value added shares for 1841 are projected back using the sectoral real output series reflated to convert them into nominal series. The principal sources for the price series used include Clark (2004; 2005; 2006), Beveridge (1939) and Thorold Rogers (1866-1902). Value-added shares for each sector are derived in this way at roughly 50-year intervals, and used to create a chained index of GDP, following Feinstein (1972). To estimate GDP per capita, this aggregate GDP series is divided by population, taken from Wrigley and Schofield (1989) and Wrigley et al. (1997) for the period since 1541, and derived from information on the number of tenants in a regionally representative sample of manors using the method of Hallam (1988) for the pre-1541 period.

A number of the most important time series are available in printed form in Appendix 5.3 of Broadberry et al. (2015), but a wider range of series can now be downloaded from the Bank of England website by accessing the database "A Millennium of Macroeconomic Data", version 3.1. The same series can also be accessed from the CAGE Research Centre website at the University of Warwick.

3.2 British economic growth, 1270-1870

Fig. 2 shows the long run evolution of real GDP, population and real GDP per capita over the long period 1270-1870. The data are plotted on a decadal average basis to highlight trends rather than short run fluctuations. GDP per capita stagnated during 1270-1348, before increasing sharply between 1348 and 1400, as population declined more sharply than GDP following the shock of the Black Death. GDP per capita then remained on a plateau between c.1400 and 1650 as population at first continued to fall and then began to recover from the late fifteenth century. A new GDP per capita growth phase started around 1650, as population stagnated and then declined slightly. Although GDP per capita growth slowed down after 1700 as population growth resumed, it remained positive and became increasingly stable, with fewer and milder years of negative GDP per capita growth. It seems, then, that the Industrial Revolution was less about growing faster and more about avoiding periods of negative growth, or shrinking, than has previously been realized (Broadberry and Wallis 2017).

Tab. 3 presents the average annual growth rates for the same three series: GDP, population and GDP per capita. Notice how the growth rate of GDP per capita during the first half of the nineteenth century(1800s-1850s) was actually slightly slower than after the Black Death (1350s-1400s) and after the Civil War (1650s-1700), despite the fact that GDP growth was much faster. The reason for this was the very different paths of population in these three periods. Whereas population declined very sharply after the Black Death, and still declined slightly after the Civil War, it grew very rapidly during the first two-thirds of the nineteenth century. This points to a major difference between modern economic growth and pre-industrial growth, as highlighted by Kuznets (1966). Pre-industrial growth was associated with falling population, and this led to an increase in land per capita and capital per capita, which in turn led to higher output per capita. However, this was clearly not a route to sustained growth. For Kuznets, sustained or modern economic growth required a growing population together with rising output per capita.

3.3 Britain in international comparative perspective, 1000-1870

Tab. 3 provides one yardstick for assessing Britain's economic performance: how did the growth rate of GDP per capita in a particular period compare with the growth rate in other periods? However, it is also useful to know how Britain was performing relative to other countries in terms of levels of productivity and living standards. Estimates of GDP per capita have also been produced for a number of neighboring European economies over the period 1000-1870, and Fig. 3 sets out the data for Britain compared with the Netherlands, Italy and Spain.

The data are displayed in 1990 international dollars for comparability with each other, following the framework of Maddison (2010). GDP per capita in national currencies cannot simply be compared at the nominal exchange rates which may move to clear international asset markets rather than reflect the price of goods and services that people living in the different countries purchase. The purchasing power parity (PPP) between two currencies is obtained by comparing the prices of individual products and services, weighted by their importance in the expenditure of households. In a two-country comparison, say between Britain and Italy, a different PPP would be obtained using British weights rather than Italian weights, so a compromise estimate can be obtained by taking the geometric mean of British and Italian weighted PPPs. However, a series of bilateral comparisons made this way may not be transitive, so in multi-country comparisons, it is necessary to choose a set of international weights. Using

PPPs for 1990, GDP per capita for all countries can be converted to 1990 international dollars, which provides a convenient standard for comparing per capita incomes over space and time. The World Bank poverty standard in 1990 suggested "bare bones subsistence" income was $1 per day, or $365 per year. Since any society has a rich elite living well above this level, Maddison adopted $400 as a guide to the minimum level of GDP per capita that should be expected. This is a useful figure to bear in mind when assessing the plausibility of the GDP per capita estimates.

The estimates of GDP per capita in Fig. 3 are graphed at decadal frequency, as in Figure 2, to focus on growth trends. They show that before the arrival of the Black Death in the mid-fourteenth century, Britain was a relatively poor northwest European economy, at about the same level of GDP per capita as the Netherlands, and substantially poorer than the Mediterranean economies of Italy and Spain. Nevertheless, at around $800 in 1990 prices, average living standards in Britain were substantially above bare bones subsistence of $400. By the mid-nineteenth century, by contrast, Britain and the Netherlands were substantially richer than Italy and Spain, with GDP per capita around $3,000, or nearly 8 times bare bones subsistence. This requires careful interpretation, however, since a consideration of the distribution of income suggests that nevertheless around 40 per cent of the English population were indeed living at bare bones subsistence on the eve of the Black Death, and still around 20 per cent in the nineteenth century (Broadberry et al. 2015: 329).

The reversal of fortunes between northwest Europe and Mediterranean Europe occurred in two phases. The first turning point came with the Black Death in 1348. Before then, per capita incomes were substantially higher in Italy and Spain than in Britain and the Netherlands. Although Italy, Britain and the Netherlands all received a positive boost to per capita incomes following the collapse of population beginning in the mid-fourteenth century, only Britain and the Netherlands remained permanently richer as population recovered. A second turning point occurred around 1500, as new trade opportunities opened up between Europe and Asia via trade routes around the south of Africa, and between Europe and the Americas via the Atlantic Ocean. The Netherlands first caught up with Italy then forged ahead during the Dutch Golden Age, while Britain experienced a further growth episode from the mid-seventeenth century. Notice that a key element in the British rise to per capita income leadership in Europe was the much lower incidence of negative per capita growth. Whereas periods of per capita growth in Italy and Spain were followed by periods of negative growth, Britain (and also the Netherlands)

tended to remain on a higher plateau after a growth episode, so that the next growth phase started from a higher level.

3.4 Structural change, 1270-1870

An important aspect of modern economic growth is structural change (Kuznets 1966; 1974). It has long been noted that economic development is associated with a shift in the structure of the economy away from dependence on agriculture. This has traditionally been seen as a process of industrialization, although recent research suggests that this understates the role of services. Broadberry et al. (2015) note that the British economy diversified away from agriculture over a longer time span than was once believed by economic historians. Agriculture was less important and services more important earlier than widely perceived, with important consequences for sectoral productivity performance. Labor productivity growth was faster in industry than in agriculture during the Industrial Revolution rather than the reverse, as early quantification of the Industrial Revolution had appeared to suggest.

The quantitative dimensions of the structural shift away from agriculture in the British economy are set out in Tab. 4. The first point to note is that agriculture's share of output and employment declined in importance over time, while the shares of industry and services increased, as would be expected for a developing nation. Second, however, note that even as early as 1381, agriculture accounted for less than 60 per cent of employment and less than 50 per cent of nominal GDP, so that even in the fourteenth century, industry and services accounted for a substantial share of economic activity. Third, although agriculture accounted for a smaller share of output than employment for most of the period under consideration here, thus making agriculture a low productivity sector, this had ceased to be the case by 1801, a point first highlighted by Crafts (1985). Fourth, although industry increased its share of nominal GDP more rapidly than services until 1700, this ceased to be the case during the Industrial Revolution period. This may at first sight seem surprising, but can be explained by a decline in the relative price of industrial goods, as technological progress increased productivity and drove down prices. By contrast, the more modest productivity improvement in services led to an increase in their relative price, so that the share of services in nominal GDP increased more rapidly than the share of industry after 1700.

A fifth striking feature of Tab. 4 is that much of the shift of labor from agriculture to industry occurred before 1759, which has important implications for the pattern of labor

productivity growth before and during the Industrial Revolution. If, as was once believed, the shift of labor from agriculture to industry had taken place at the same time as the Industrial Revolution, then much of the growth of industrial output could be explained by increased labor input rather than by productivity growth. This counter-intuitive result was implicit in the work of Deane and Cole (1962), but confronted more explicitly by Crafts and Harley (1992). With much of the shift of labor from agriculture to industry occurring between 1522 and 1759, there was a period of labor-intensive industrialization (or proto-industrialization) without any dramatic growth of industrial labor productivity, which can be tracked in Tab. 5. This was then followed by an Industrial Revolution, where capital deepening and technological progress raised industrial labor productivity rapidly after 1759.

3.5 Accounting for British economic growth, 1270-1870: proximate causes

Armed with the estimates of British economic growth before 1870 from Tab. 3 and Fig. 2, we now turn to explanation. The framework adopted here is based on Maddison's (1988) distinction between proximate and ultimate sources of economic growth, also adopted in Broadberry and Fukao (2021). To assess the contribution of proximate causes, growth accounting begins with a production function to determine whether economic growth came from the use of more factor inputs or from the more effective use of existing inputs (Solow, 1957). In the simplest formulation, aggregate output (Y) is produced using inputs of capital (K) and labor (L) and A is a measure of efficiency or total factor productivity (TFP):

$$Y = AF(K, L) \tag{4}$$

The growth rate of output (ΔY/Y) can be related to the growth rates of the inputs of capital (ΔK/K) and labor (ΔL/L) and the growth rate of TFP (ΔA/A).

$$\Delta Y/Y = \alpha\, \Delta K/K + \beta \Delta L/L + \Delta A/A \tag{5}$$

The weights α and β reflect the relative importance of inputs in the production process, measured by their shares in the costs of production. For labor this is the share of wages in the value of output, while for capital it is the share of profits. The growth accounting equation can also be written in intensive rather than extensive form, to show how the growth of per capita output can be explained by the growth of capital per capita (capital deepening) or total factor productivity growth:

$$\Delta y/y = \alpha\, \Delta k/k + \Delta A/A \tag{6}$$

where the growth of output per capita (Δy/y) is equal to the growth of output minus the growth of labor, and capital deepening (Δk/k) is the growth of capital minus the growth of labor.

The framework can be adapted to include human capital (H) and land (R) as additional factor inputs. This results in the extensive form growth accounting equation:

$$\Delta Y/Y = \alpha\, \Delta K/K + \beta \Delta L/L + \gamma \Delta H/H + \theta \Delta R/R + \Delta A/A \quad (7)$$

where the weights γ and θ reflect the relative importance of human capital and land in the production process. The intensive form growth accounting equation then becomes:

$$\Delta y/y = \alpha\, \Delta k/k + \gamma \Delta h/h + \theta \Delta r/r + \Delta A/A \quad (8)$$

where human capital deepening (Δh/h) is equal to the growth of human capital minus the growth of labor, and the change in the land-labor ratio (Δr/r) is the growth of farmland minus the growth of labor.

The labor input is measured not just by the number of workers (usually assumed to grow in line with population), but must also take into account the number of days worked per person per year and the quality of the labor force. In economic history, these aspects are usually discussed under the headings "industrious revolution" and "human capital" (de Vries, 1994; Baten and van Zanden, 2008). The capital input is gross fixed capital excluding dwellings. With independent measures of output, labor, capital and land, total factor productivity is derived as a residual, famously described by Abramovitz (1956: 11) as "some sort of measure of our ignorance", but often used as an indicator of technological change.

Part A of Tab. 6 presents the results of the growth accounting exercise in extensive form using equation (7) to account for the growth of GDP in Britain. The labor force is assumed to move in line with population from Broadberry et al. (2015) and allowance is also made for changes in the average number of days worked per person per year from Humphries and Weisdorf (2019). The stock of human capital is measured by the average years of education per person from de Pleijt (2018) multiplied by the population. The capital stock from Broadberry and de Pleijt (2021) is measured by fixed capital excluding dwellings. The land variable is the cultivated acreage from Broadberry et al. (2015). For most of the period, the factor input weights are 40 per cent for labor (population and annual days worked), 20 per cent for human capital, 20 per cent for fixed capital and 20 per cent for land, but from the 1830s onwards the split between fixed capital and land is adjusted to 30 per cent for capital and 10 per cent for land. This reflects the roughly equal shares of fixed capital and land in national wealth at current prices until the nineteenth century in Broadberry and de Pleijt (2021) and the changing factor shares during the modern period in Crafts (2021a: 312).

Note that the last two columns of Tab. 6A (TFI growth and TFP growth) add up to the first column (GDP growth). The main result is that output growth was driven predominantly by the growth of inputs, with TFP growth playing a relatively minor role. Input growth was in turn driven primarily by population growth, which declined after the arrival of the Black Death then recovered from the 1450s. The population decline caused by the Black Death wiped out one-third of the population within three years and more than half the population within a century of its arrival in 1348, affecting not only the supply of labor and the stock of human capital, but also the amount of land that could be cultivated by the smaller workforce and the incentives to accumulate capital. Annual days worked per capita declined during the dramatic population collapse between the 1340s and the 1400s, but then increased in line with the industrious revolution, so that the more modest episodes of population decline in the first half of the fifteenth century and the second half of the seventeenth century were offset by an increase in days worked per capita. As population recovered from the 1450s, inputs of land, fixed capital and human capital all grew and days worked per capita increased. Capital growth became noticeably more important from the 1830s, while relatively little growth of farmland was possible beyond recovery from the post-Black Death decline.

Part B of Tab. 6 presents the results of growth accounting in intensive form for Britain, using equation (8) to show how the growth of GDP per capita can be explained by work intensity, human and physical capital deepening, changes in the land-labor ratio and growing efficiency. Again, the last two columns (TFI per capita growth and TFP growth) add up to the first column (GDP per capita growth). The main result from Tab. 6B is that TFP growth was as important a driver of growth in GDP per capita as the contribution of per capita total factor input growth, accounting for around half of the positive GDP per capita growth in most periods, and for the vast bulk of GDP per capita growth between the 1690s and the 1830s. Nevertheless, the contribution of factor inputs was not unimportant, and developments can again be split into two periods, covering the Black Death years and the subsequent period of population recovery. TFI per capita growth after the Black Death was driven by the effects of population decline, when survivors had extra land, capital and education opportunities and also more leisure as days worked per person declined. With the recovery of population from the 1450s, human capital per capita continued to grow, albeit at a declining rate as most of the population became literate. Note that the capital-labor ratio grew relatively little until after the 1830s, while the land-labor ratio drifted downwards as population increased. Increasing the quantity and quality

of labor thus played an important role, together with innovation, in driving the British transition to modern economic growth.

3.6 Accounting for British economic growth, 1270-1870: fundamental causes

Growth accounting is useful in identifying the proximate source of growth, but cannot really explain why the Industrial Revolution occurred in Britain rather than elsewhere. If an industrious revolution and capital accumulation were the proximate sources, why did they happen in Britain rather than in France or the Netherlands? And to the extent that technological progress was responsible, why again did the key innovations occur in Britain? This section therefore turns to the more fundamental causes of economic growth, which are often divided by economists into two categories, geography and institutions.

Economic geographers make an important distinction between first-nature and second-nature geography. First-nature geography covers natural endowments such as mineral deposits or climate, while second-nature geography covers man-made factors such as access to markets and agglomeration economies. Allen (2009) emphasizes both aspects of economic geography in his explanation of Britain's primacy during the Industrial Revolution, with urban growth and international trade playing crucial roles. The dramatic growth of London from the seventeenth century affected agricultural productivity in the counties surrounding London by encouraging specialization and division of labor to supply a growing market. Success in international trade, first within Europe during the seventeenth century via the new draperies and later encompassing the Americas, Africa and Asia during the eighteenth and nineteenth centuries as Britain acquired a global empire, boosted the demand for labor and maintained real wages even in the face of substantial population growth (Allen, 2009: 109-111, 113-114, 118).

Allen also notes the links between the growth of London and the development of Britain's unique factor price combination of cheap coal and high wages. The coal was always in the ground, but the industry only developed as the growth of London put upward pressure on the price of firewood as the demand for fuel increased. Coal is seen by Allen (2009: 88-89) as a backstop technology, initially more expensive than wood in London because of the high cost of transporting it from Newcastle. As the price of wood rose, coal from the northeast became competitive with wood in London, and was available on a large scale at constant cost, so that its price at source remained low. The coal mining industry then spread from the northeast to western England, Scotland and Wales as the coal-burning home spread more

widely across Britain. These were the regions where industry was able to benefit from coal that was cheaper than in the rest of Europe (Allen 2009: 93-96). The high wages resulted from agglomeration economies associated with urban growth, as well as from the higher agricultural productivity in the counties surrounding the growing urban market.

Allen (2009: 138-144) sees the key innovations of the Industrial Revolution as a response to high wages and low coal prices in Britain, with the new technology characterized as labor-saving and coal-using. This framework is also useful in understanding why the key innovations of steam-driven machinery in industries such as cotton textiles, iron and engineering were not immediately adopted elsewhere, since they were designed to be profitable in the circumstances of Britain's unique factor-price combination. But Britain's advantage did not last forever, as further technological change adapted the new technologies to other factor price combinations, and eventually made them dominate the old technologies over a much wider range of factor prices.

Although Allen (2009: 4-5, 14-15, 125-126) explicitly seeks to distance himself from the idea of institutions playing an important role, it seems but a small step from the characterization of entrepreneurs as responding to factor price incentives to a consideration of how individuals respond to the incentives provided by the "rules of the game" embodied in the wider institutional framework (North 1990). North defined institutions as the rules of the game, both formal and informal, which define and limit the set of choices that individuals make. He saw institutions as affecting economic performance by providing incentives for individuals to engage in socially productive activities such as exchange and production, invention and innovation, saving and investment. Although North and Weingast (1989) sought to explain the Industrial Revolution as a response to the institutional changes introduced by the Glorious Revolution of 1688, the lag of around a century between the two developments makes it hard to draw a firm link between the "credible commitment" supposedly secured by the constitutional settlement and the later economic development. To be convincing, a clearer link is needed between the institutional change and the innovations of the Industrial Revolution.

Like Allen, Mokyr (2009) places the explanation of a sustained acceleration in the rate of technological progress at the heart of understanding the Industrial Revolution. This is consistent with the dominant role of TFP growth in the intensive growth accounting exercise between the 1690s and the 1830s noted in the previous section. Unlike Allen, however, Mokyr

(2009: 40) embeds his explanation firmly within the wider institutional framework, drawing on his idea of a European Industrial Enlightenment, with scientists, engineers and inventors engaged on a Baconian program of research based on experimentation and scientific method, directed at solving practical problems to produce "useful knowledge". In the British case, however, Mokyr (2009: 120) sees it as important that these scientists, engineers and inventors were able to engage with a supply of skilled craftsmen, which existed partly as a result of historical contingency from past industrial developments, and partly as a result of a flexible institution in the form of the apprenticeship system. The engagement between theoretically-minded scientists and more practical skilled craftsmen was institutionalized in the British setting through organizations such as the Royal Society, the Lunar Society, and a host of other scientific bodies that held regular meetings across the whole country. Mokyr (2009: 63-78) also emphasizes the effects of the Enlightenment on the wider institutional structure of society, although this part of the argument, with its emphasis on ideology increasingly coming to dominate vested interests, is necessarily more speculative.

As Crafts (2011: 166) notes, although Allen (2009) and Mokyr (2009) see themselves as offering competing explanations of the Industrial Revolution, their arguments are not mutually exclusive and could indeed be characterized as complementary. It would not be unreasonable to see British innovators as responding to the factor price combination that they faced within an environment shaped by the Enlightenment.

Most work on institutions focuses on the link with growing by considering incentives for investment and innovation. However, as noted earlier, the key to improved long run performance during the period 1270-1870 lies in reduced shrinking rather than increased growing (Broadberry and Wallis 2017). Hence it is also necessary to consider the link between institutions and shrinking, which has received much less attention. The first shift of attention in this direction can be seen in North et al. (2009), where it is linked to the development of an "open access" society. This is a society where access to economic rents is not limited to a small elite, but rather open to all. In such a society, more individuals have the possibility of looking after their own economic interests, which is especially important when an economy is hit by negative shocks. Open access societies allow more people agency, making the economy more resilient.

3.7 An alternative Malthusian view

There have also been attempts to estimate British national income from the income side. This involves the estimation of labor income from data on employment and real wages, which can then be combined with income from capital and rental income from land. In the absence of readily available data on the returns to capital and land, the real wage has been the most popular alternative to GDP per capita since the pioneering work of Phelps Brown and Hopkins (1955; 1956), who provided an annual series for England back to the mid-thirteenth century. However, this approach requires care because the nominal wage data are most readily available as daily wage rates, which do not come with information on the number of days worked per year. As Angeles (2008) points out, there can be substantial divergence between the trends in real wages and GDP per capita as a result of a change in the number of days worked per year, a shift in labor's share of income or a change in the relative price of consumption goods. He shows that there was considerable divergence in English GDP per capita and real wages between 1700 and 1820 due primarily to an "industrious revolution" (or increase in days worked per year), with a distributional shift against labor and an increase in the relative price of food also having significant effects. Broadberry et al. (2015) use the same framework to explain the divergence between the daily real wage rate and GDP per capita between 1270 and 1870. The key factor explaining the divergence between the trend growth of GDP per capita and the stationarity of the real wage was the long drawn-out increase in days worked per year between the post-Black Death period and the Industrial Revolution. Subsequent research by Humphries and Weisdorf (2019) has confirmed this, with their estimates of days worked per year derived from a comparison of daily wages with annual wages from long-term contracts. Clark's (2007; 2010) British GDP per capita series, which adds income from capital and land rents to wage income derived on the assumption of constant days worked per year, follows a very similar path to daily real wages, and is therefore not a reliable guide to long-term growth between 1250 and 1850.

4. THE UK ECONOMY SINCE 1870: CONVERGENCE AND DIVERGENCE

This section covering the period since 1870 will focus on the territory of the United Kingdom within its current borders. By the mid-nineteenth century, the United Kingdom had reached the zenith of its global economic leadership and other economies were seeking to emulate its Industrial Revolution. The story of the next 150 years was one of relative economic decline, as other countries caught up with and in some cases overtook the United Kingdom. Nevertheless, it is important to keep this decline in perspective, as the United Kingdom has remained a relatively rich country, and at the time of writing still boasts the fifth largest economy in the world.

4.1 Data sources since 1870

For the period between 1870 and 1950, the main source for UK data is Feinstein (1972), who consolidated a major historical project under the leadership of Richard Stone, the architect of the official national accounts. Feinstein's historical series started in 1855 and linked up to the official series which began after World War II. There have been some minor modifications to these series, by both Feinstein and other researchers, and these can now be downloaded from the Bank of England website by accessing the database "A Millennium of Macroeconomic Data version 3.1". For the period since 1950, the official estimates published at the time have been used, rather than a recent revision, which raised the growth rate of GDP by around 0.3 percentage points between 1950 and 1990. This has a substantial effect on UK economic performance relative to other countries, which raises questions about the appropriateness of the new series for use in international comparisons. The issue concerns the use of a new consumer price index (CPI) rather than the retail price index (RPI) used at the time to deflate nominal expenditure. Whilst there may be good theoretical reasons for deflating nominal expenditure using the CPI index, it must be borne in mind that over this period independent estimates of GDP were made from the output and income sides as well as from the expenditure side. Before changing the expenditure estimates by such a large amount, it would be important to investigate the implications for reconciling the new series with the output estimates, which were based largely on volume indicators or nominal values deflated by producer prices, and are thus unaffected by the use of a CPI rather than an RPI. This is particularly important given the large number of independent benchmark studies of comparative productivity performance between the United Kingdom and other leading economies, including the United States and Germany, that have been built up from the output side and can thus act as a series of benchmark cross-checks on time series projections covering the whole of the twentieth century (Broadberry, 1998).

For international comparisons at the aggregate level, use can be made of the historical national accounts of three rich economies that were seen as Britain's major competitors during the long twentieth century: the United States, Germany and Japan. For Germany and the United States, the data can be downloaded from the Maddison Project Database, version 2013 and updated to 2018 using the Maddison Project Database version 2020. The 2013 version is preferred here because the 2020 version works in terms of 2011 prices rather than 1990 prices, despite using a 1990 benchmark to anchor the comparative GDP per capita levels for the pre-1990 period. In addition,

the US GDP per capita series has been altered significantly in the 2020 version to be consistent with a US/UK benchmark for 1913, and is therefore inconsistent with the widely accepted US series. For Japan, Fukao et al. (2015) have revised downwards GDP per capita growth in constant prices during the period 1940-1955, by using volume data rather than deflated value data at a time of rationing, hyperinflation and black markets. In addition, growth during the period 1874-1940 has been adjusted downwards by improving the estimates of value added relative to gross output and providing a new benchmark for 1874. Projecting back from 1990 to 1874 with a significantly lower growth rate results in a level of GDP per capita in 1874 that is 34 per cent higher than suggested by Maddison (2010).

4.2 UK economic growth since 1870

Fig. 4 charts the evolution of real GDP, population and GDP per capita in the UK over the period 1870-2018, continuing the story of growth and development begun in Fig. 2 for the period 1270-1870. Tab. 7 presents the average annual growth rates for the same three series. Between 1870 and 2018, GDP per capita increased by a factor of almost 7 or an average annual growth rate of 1.3 per cent over a period of nearly a century-and-a-half. The two major deviations from steady growth that stand out in Fig. 4 are the increase of GDP per capita during the two world wars, followed by postwar slumps. By contrast the Great Depression beginning in 1929 was a relatively mild affair in the United Kingdom, barely visible in the graph. Notice, however, that the financial crisis of 2008 had a significant impact on prosperity, with GDP per capita surpassing its 2007 peak only in 2015. This sustained period of slow GDP per capita growth has been labelled the "UK productivity puzzle".

Another noticeable trend in Fig. 4 and Tab. 7 is the slowing down of population growth from the late nineteenth century as the United Kingdom went through a demographic transition from a society where slow population growth is a result of high rates of both fertility and mortality to one where slow population growth is a result of low rates of both fertility and mortality. During the Industrial Revolution, there was an interlude where population growth increased substantially as mortality declined with rising living standards, as can be seen in Tab. 3. From around 1870, however, population growth fell back as fertility also began to decline sharply. Guinnane (2011) points to a number of economic factors that can be seen as contributing to this fertility transition: (1) a lagged response to the decline in infant and child mortality, meaning that less births were needed to achieve a given family size; (2) innovations in contraceptive methods; (3) increasing direct costs of child-bearing, such as restrictions on

child labor; (4) changes in the opportunity cost of child-bearing, such as female employment opportunities; (5) changes in the returns to child quality as technological progress increased the demand for educated workers; (6) the rise of state social insurance and private savings which reduced the need for a large family to support parents in later life.

4.3 The United Kingdom since 1870 in international comparative perspective

From the eighteenth century beginnings of the Industrial Revolution to 1870, UK GDP per capita grew faster than anywhere else as British industry led the world in terms of technology, industrial production and manufactured exports. From around 1870, however, other countries began to grow faster as they emulated British industrial developments. Between 1870 and 1913, the United Kingdom had the slowest GDP per capita growth rate of the 4 economies considered in Fig. 5. Although this is often viewed as a period of British relative decline, it is important not to get too carried away with the notion of failure, and take account of the level as well as the growth rate of GDP per capita. As Abramovitz (1986) and Baumol (1986) pointed out, it is easier for relatively poor countries to grow rapidly from a low level of productivity, since they can benefit from the transfer of better technology or institutions developed abroad. The flip side of this catching-up or convergence perspective is that countries starting out with high productivity should be expected to grow more slowly. Before 1913, Germany and Japan were clearly still catching-up on the United Kingdom and the United States was only barely edging ahead.

World War I provided a massive economic shock to the United Kingdom, as noted in the discussion of Fig. 4 above, with an initial wartime boom followed by a catastrophic postwar slump. This allowed the United States to open a substantial lead during the 1920s, but Germany remained behind the United Kingdom as a result of wartime disruption and postwar hyperinflation, while Japan continued to catch up. The Great Depression of the 1930s hit the United States and Germany much harder than the United Kingdom, and the US GDP per capita lead evaporated in the middle of the decade, while the Germany/UK gap increased again.

World War II saw the US/UK GDP per capita lead rise to a peak before settling at around 30 per cent ahead of the other rich economies. Although Germany and Japan experienced “super-growth” during the 1950s and 1960s, this is best seen as recovery from the catastrophic collapse of their economies during the war. Once they had recovered, both Germany and Japan settled down to the rich country average annual GDP per capita growth

rate of 1.5 to 2.0 per cent. Since the financial crisis of 2008, GDP per capita growth has been slower in most economies, although the productivity slowdown has been more pronounced in the United Kingdom than in the other three countries.

4.4 Structural change since 1870

Broadberry (1998) conducted a sectoral analysis of comparative labor productivity levels between 1870 and 1990 to suggest that the United States and Germany caught up with and forged ahead of the United Kingdom largely by shifting resources out of agriculture and improving their relative productivity position in services rather than by improving their position in manufacturing, as had been commonly assumed. Although the original analysis was conducted at the level of nine sectors, the essentials of the argument can be demonstrated using the three main sectors of agriculture, industry and services. The analysis was also extended to 2007 by Broadberry et al. (2013).

Tab. 8 sets out the changing structure of employment on a headcount basis in the three economies of the United Kingdom, the United States and Germany. The classic pattern of development noted by Kuznets (1974), with the economy dominated by agriculture at low levels of development, followed by a phase of industrial-led development and leading ultimately to a dominance of services, is clearly visible in the data for these three economies. However, there have also been some substantial differences between countries in the timing of the major sectoral shifts, with the structural transformation away from agriculture occurring much later in the United States and Germany than in the United Kingdom. In 1871, agriculture accounted for just 22.2 per cent of employment, compared with around 50 per cent in both the United States and Germany. Since value added per employee is much lower in agriculture than in industry or services, this gave the United Kingdom a substantial boost to overall labor productivity. This explains why the United Kingdom could have an overall labor productivity lead in the late nineteenth century despite not having particularly high labor productivity in industry.

But if the United Kingdom enjoyed an advantage from having a small share of the labor force in low-productivity agriculture in the nineteenth century, this turned into a disadvantage in the twentieth century. Whereas the United States and Germany had a large supply of rural labor that could be redeployed in higher value added activities, the United Kingdom lacked such a resource, a condition which Kaldor (1962) described as “premature maturity”. It is worth

noting that agriculture still accounted for just under a quarter of German employment in 1950, so that Germany remained in a position to benefit from the release of surplus agricultural labor during its "super-growth" phase after World War II.

To see how the changing structure of the economy affected overall economic performance, it is helpful to examine the sectoral shares of employment in Tab. 8 together with the comparative labor productivity levels by sector for the US/UK and Germany/UK cases in Tab. 9. Labor productivity is measured here in terms of output per employee, without any allowance for differences in hours worked per year by full-time employees, part-time working, or labor force participation rates. This means that although they are closely related, comparative levels of labor productivity are not identical to comparative levels of GDP per capita. In about 1870, the United Kingdom had a labor productivity lead in services over both the United States and Germany, and this was an important factor in explaining the United Kingdom's overall labor productivity leadership at this time. However, Tab. 9A shows how the United States overtook the United Kingdom in both services and the whole economy before World War I and continued to forge ahead until after World War II, since when the United Kingdom has been narrowing the gap slowly. The comparative productivity performance in the economy as a whole thus mirrored the situation in services, which was also the sector that was coming to dominate the economy. In industry, the United States already had a productivity lead by 1870, and although this lead increased to a peak in 1950, it was back to the pre-World War I level by 1990, while at the whole economy level the United States had gone from being more than 10 per cent behind to nearly 30 per cent ahead. In agriculture, comparative US/UK labor productivity increased continuously between 1870 and 2007, but the major development in this sector was the dramatic decline in agriculture's share of economic activity, with employment accounting for just one or two per cent in both countries by 2007.

Tab. 9B tells a similar story for the Germany/UK labor productivity comparison, but with German overtaking occurring later than in the US case. Once again, comparative productivity performance in the whole economy mirrored the situation in services, with Germany overtaking the United Kingdom between 1950 and 1973. Although Germany continued to forge ahead until the 1980s, the productivity lead was never as large as that of the United States. Again, the level of comparative productivity in industry was similar before World War I and in the early twenty-first century, although industrial productivity in the United States was substantially higher than in both European countries. Although Germany increased

its productivity performance in agriculture, it remained behind the United Kingdom. The main development in agriculture was again the decline in its share of economic activity, with the release of surplus labor from agriculture playing a major role in German catching-up.

4.5 Accounting for UK economic growth since 1870: proximate causes

Tab. 10 provides growth accounting results for the United Kingdom since 1870 from Crafts (2021b). The methodology differs slightly from that underpinning the growth accounting exercise reported in Tab. 6 due to the availability of more data for the post-1870 period. The first difference is that the labor input can be measured in terms of hours worked rather than population and average days worked per year. Second, rather than treating the average years of education data as a measure of the stock of human capital, they are translated into a labor quality index, following the approach of Matthews et al. (1982), who assumed a 6 per cent increase in labor quality per year of schooling. Both the hours worked and labor quality indices are then weighted by the share of labor in national income. Third, for the period since 1950, estimates of capital inputs are based on capital services rather than the capital stock, following the approach of Oulton and Wallis (2016). Fourth, given the relatively minor role of agriculture in the economy by the late nineteenth century, no allowance has been made for the input of land.

Tab. 10A sets out the growth accounting results in extensive form. As in Tab. 6A, the last two columns of Tab. 10A add up to the first column and thus indicate the relative importance of the growth of inputs (TFI growth) and the more efficient use of inputs (TFP growth). Three main periods can be identified. First, before World War I and during the interwar period, output growth was driven mainly by the growth of inputs, with the quantity and quality of labor playing an important role, as well as capital growth. Second, between 1950 and 2007, TFP growth became more important relative to input growth, and within TFI growth capital became more important than labor inputs as population growth slowed and hours worked per person per year declined. Third, since 2007, there has been a dramatic decline in the growth of output driven by a strongly negative TFP growth rate.

Part B of Tab. 10 analyses the results in intensive form, explaining the growth of GDP per hour worked, or labor productivity. As in part A, the final two columns add up to the first column, and it is helpful to consider the results in terms of three periods. First, before World War I, labor productivity growth was driven mainly by increasing labor quality and capital

deepening, with TFP growth playing only a minor role. Second, between 1924 and 2007, TFP growth accounted for around half of labor productivity growth. Third, since 2007 labor productivity growth has collapsed to almost nothing as a result of strongly negative TFP growth combined with a sharp decline in capital deepening.

4.6 Accounting for UK economic growth since 1870: fundamental causes

When considering the fundamental causes of British economic growth before 1870, the main problem was to explain why Britain was the first economy to have an Industrial Revolution and make the transition to modern economic growth. For the period after 1870, the problem is to explain the loss of economic leadership and a century-and-a-half of economic decline relative to the United States, Germany and other developed economies. Broadberry and Crafts (1992; 1996) focused on competition and the institutional framework.

Much of the extensive "declinist" literature has focused almost exclusively on manufacturing (Aldcroft and Richardson 1969; Wiener 1981; Elbaum and Lazonick 1986). As we have seen, however, the loss of UK productivity leadership in the economy as a whole owes more to developments within services and a later structural shift out of agriculture than to any long run change in the comparative productivity position of industry. However, this does not necessarily mean that industry can be absolved of all blame for relative decline. To see why, it is necessary to consider the institutional framework and the workings of competition. National industries which fail to keep up in the international productivity race are ultimately replaced by imports, so in the long run do not show up in the productivity figures. Whereas in the mid-nineteenth century British industry was the "workshop of the world", by the late twentieth century Britain no longer possessed an outsized manufacturing sector as uncompetitive industries and low-productivity firms in surviving industries had been eliminated by international competition. Although some services, such as shipping, have always been internationally tradable and can be replaced by imports, in much of the service sector international competition has been relatively weak, so that services falling behind in the productivity race have not been removed. Hence the important role played by services in changing comparative productivity performance over the long run. The barriers to competition in services have sometimes been natural, as for example on the railways or in the distribution sector where services can only be provided locally, but at other times they have stemmed primarily from regulation, as in financial services. However, it should also be borne in mind

that even when barriers are natural, foreign ownership can still have an impact on productivity performance (Broadberry 2006: 129.)

The importance of a competitive institutional framework in eliminating inefficient manufacturers was made by McCloskey and Sandberg (1971) in the context of British manufacturing between 1870 and 1914. Although labor productivity was already significantly higher in US manufacturing during the nineteenth century, this was a result of different factor endowments and relative factor prices. Habakkuk (1962) argued that US manufacturers developed capital intensive technology because of land abundance, making labor scarce, and that these techniques were not profitable in Britain or Germany, where land was scarce and labor abundant. In fact, the story is more complicated than this due to a complementarity between natural resources and machinery, so that machinery developed in America was resource intensive and could not be used in Europe where resources were relatively scarce. In addition, US firms developed mass production techniques, suitable only for producing long runs of identical products and these techniques were less suited to Europe where markets were smaller and consumers more resistant to standardization (Broadberry 1997). The major British industries at this time consisted of large numbers of small firms clustered in Marshallian districts achieving external economies of scale, and wide open to international competition without significant barriers to trade. Since Britain was the world's largest exporter of manufactures at this time, McCloskey and Sandberg (1971) drew the reasonable conclusion that the labor productivity gap with the United States was not a sign of inefficiency. Rather, British industry was adjusting efficiently to the rise of competition from abroad.

During the interwar period, however, competitive forces became much weaker, limiting the pressures on inefficient firms and industries to exit. Substantial tariff barriers were erected as Britain abandoned its prewar free trade stance in favor of imperial preference and there was growing industrial concentration in domestic markets with collusion among large firms (Broadberry and Crafts 1992). Whereas Abramovitz (1986) stresses the opportunities for growth provided by economic backwardness, Olson (1982) emphasizes institutional constraints on catching-up. Olson sees interest groups as a barrier to growth, and Britain as a society with a long period of stability accumulating more special interest groups, thus experiencing slower growth. These factors can be seen as playing a role in the significant widening of the US/UK productivity gap between 1914 and 1950.

Britain emerged from World War II highly dependent on Commonwealth markets, a legacy of Imperial Preference as the liberal world order disintegrated between the wars. This left an unfortunate legacy for the postwar period, when Europe became a major growth market and Commonwealth countries grew relatively slowly. Clearly a major reorientation of export markets was needed, but this was hampered by the anti-competitive culture of much of British industry after decades of market-sharing through international cartels and collusion in domestic markets (Broadberry and Crafts 1996). State intervention often worked actively against competition, with governments keen to promote national champions in a number of industries. This led to the creation of a host of unsuccessful large companies, including British Leyland in motor vehicles, British Shipbuilders in shipbuilding, Alfred Herbert in machine tools, ICL in computers and GEC in electrical engineering (Broadberry 1997).

The UK institutional framework began to move in a more competitive direction on both the international and domestic fronts during the 1970s and 1980s, initially as a result of Britain's entry into the European Economic Community (EEC) and binding government budget constraints setting limits to costly state subsidies to national champions. Over time, particularly under the Conservative governments of Margaret Thatcher, British firms were forced to become competitive by their own efforts or go to the wall (Crafts 2012). The British manufacturing sector became much smaller, but narrowed the labor productivity gap with Germany and other OECD countries. Relative decline in terms of GDP per capita was stemmed as Britain shook off the label of the "sick man of Europe", at least for several decades.

5. CONCLUSION

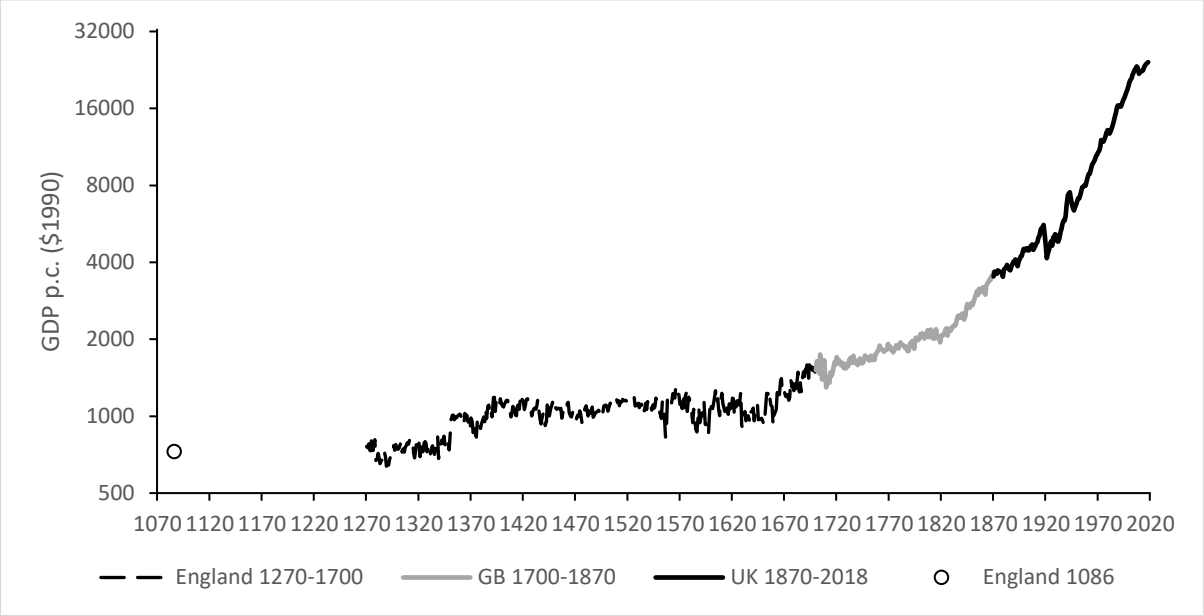
Britain holds an important place in the discipline of economic history as the location of the first Industrial Revolution and the survival of rich sources of data stretching back to the Domesday Survey of 1086. British per capita GDP grew between 1086 and 1700 at an average annual rate of 0.13per cent. Although the annual growth rate increased to 0.48 per cent between 1700 and 1870, the period that included the Industrial Revolution, this was still not particularly fast. What mattered for Britain's catching-up and forging ahead of other economies was its resilience. Compared with other countries, there were few episodes of negative growth in Britain, and when they did occur, they were relatively mild.

By the late nineteenth century, other economies in Western Europe and North America had begun to emulate Britain's Industrial Revolution and by the beginning of the twentieth

century, the United States had emerged as the new per capita income leader. However, the process by which the United States and Germany overtook Britain during the twentieth century has often been misunderstood. This owed more to a later structural shift out of agriculture and developments within services than to any change in the comparative productivity position within manufacturing. Although British relative economic decline undoubtedly occurred during the twentieth century, a catching-up or convergence framework is essential to keep it in perspective. Other countries were bound to grow faster than Britain while catching-up, and once Britain had fallen behind, it too could benefit from borrowing technology and institutions from abroad. Britain remains a rich country and still has the fifth largest economy in the world.

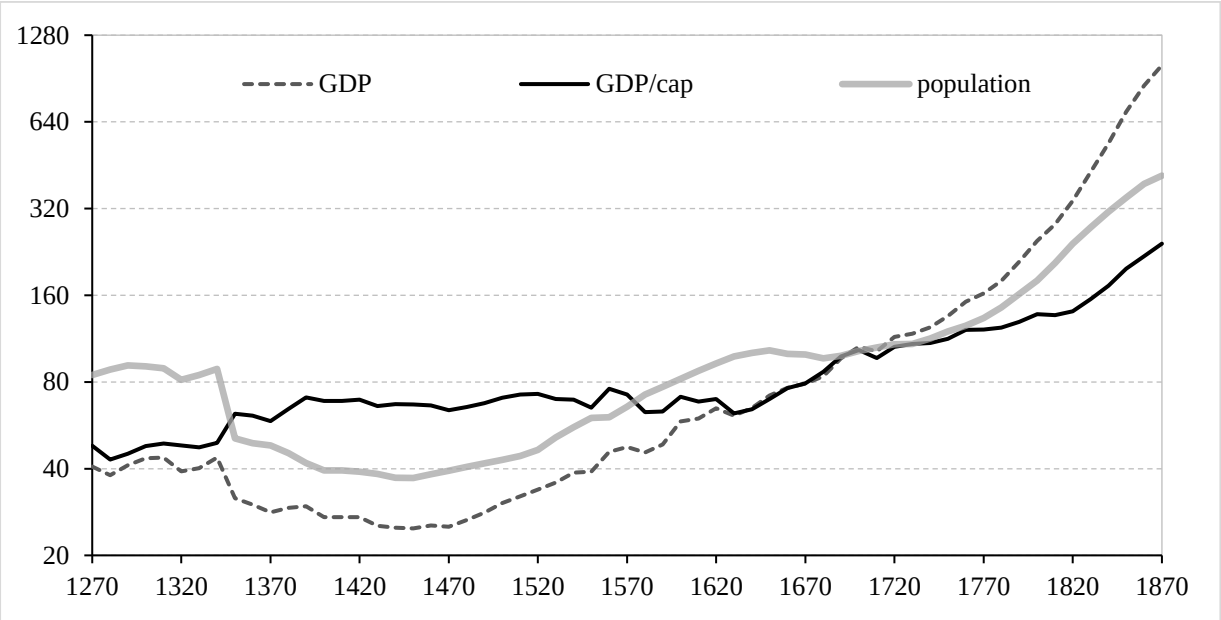
TFP growth has been an important proximate source of Britain's rise to GDP per capita leadership and also of Britain's relative economic decline since 1870. However, the ultimate source of these developments in technology lies in the institutional framework. Britain's rise to GDP per capita leadership occurred as innovators responded to the factor price combination that they faced within an environment shaped by the Enlightenment. After 1870, British relative decline occurred as barriers to competition arose and slowed the response to technological change.

Fig. 1: GDP per capita in England 1086-1700, Great Britain 1700-1870 and the United Kingdom 1870-2018 (log scale, $1990)



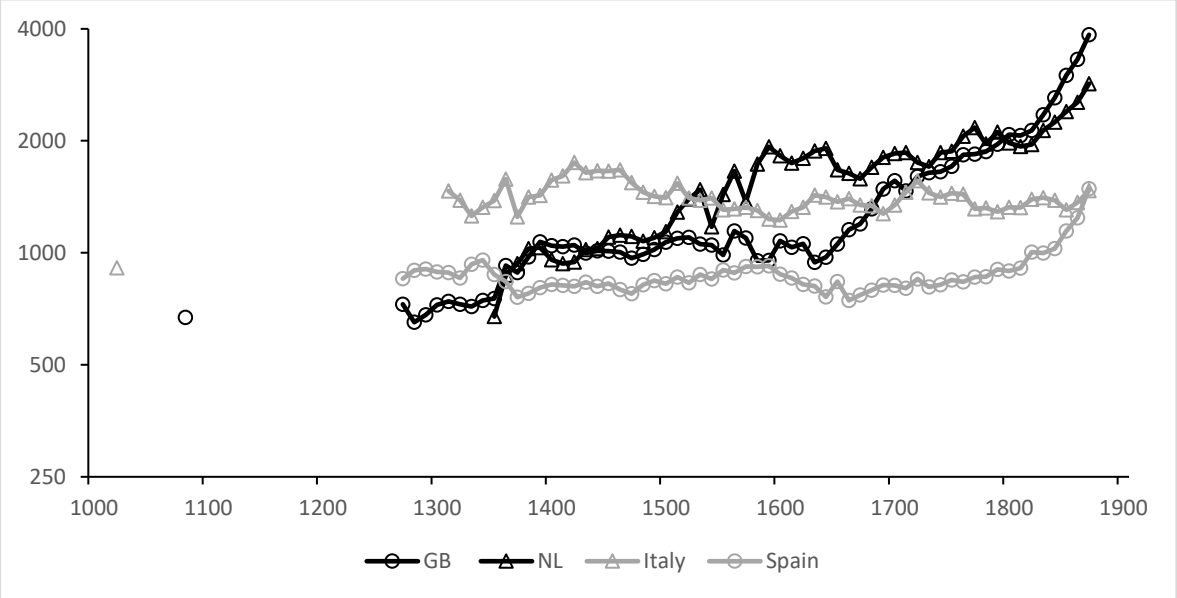
Sources: Walker (2014), Broadberry et al. (2015), Bank of England's Millennium of Macroeconomic Data version 3.1, Central Statistical Office (1996).

Fig. 2: Real GDP, population and real GDP per capita, England 1270-1700 and Great Britain 1700-1870 (averages per decade, log scale, 1700 = 100)



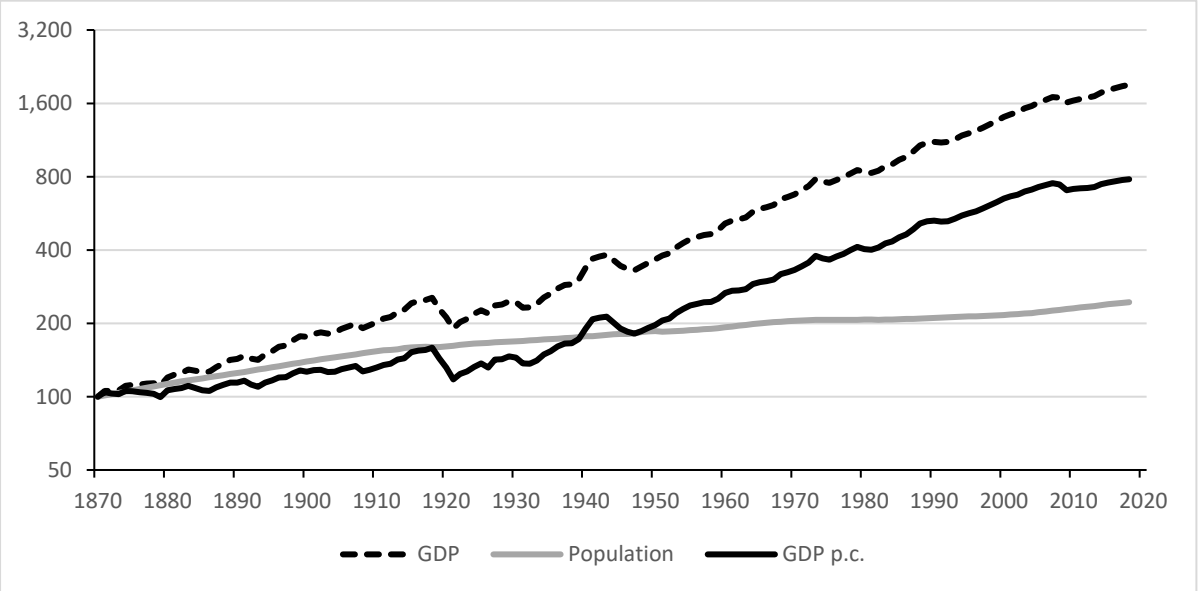
Source: Broadberry et al. (2015: 204).

Fig. 3: GDP per capita in Britain and other European economies, 1000-1870 (averages per decade, log scale, 1990 international dollars)



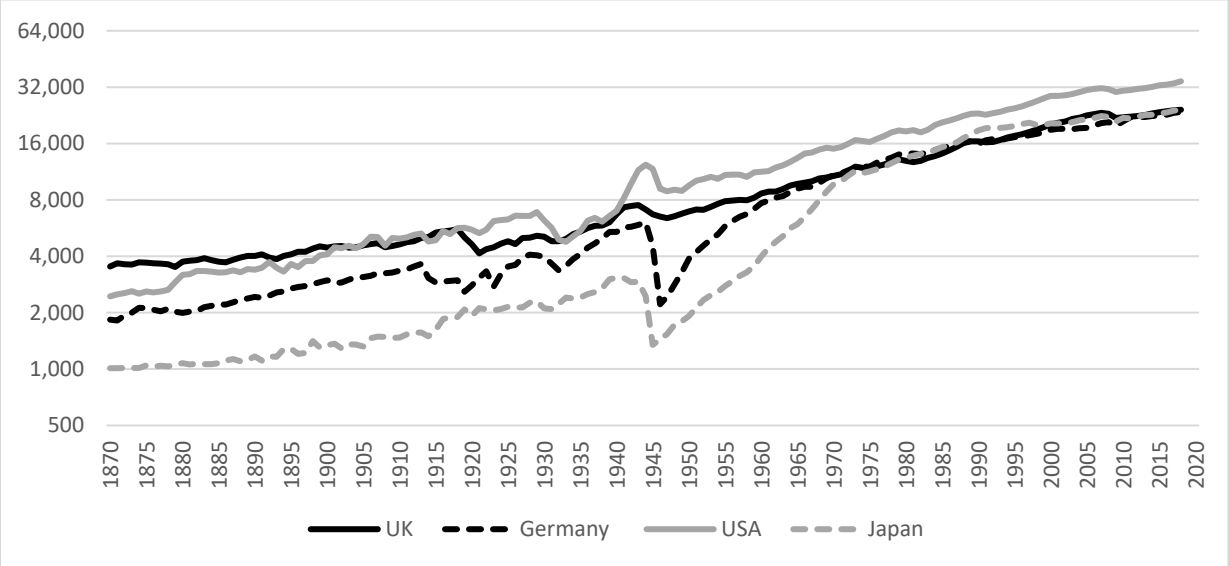
Sources: GB: Broadberry et al. (2015), Walker (2015); NL: van Zanden and van Leeuwen (2012); Italy: Malanima (2002; 2011); Spain: Álvarez-Nogal and Prados de la Escosura (2013).

Fig. 4: Real GDP, population and real GDP per capita, United Kingdom 1870-2018 (log scale, 1870=100)



Sources: Bank of England's Millennium of Macroeconomic Data, version 3.1, apart from GDP 1950-1990 from Central Statistical Office (1996).

Fig. 5: GDP per capita in the United Kingdom and competitor countries, 1870-2018 (log scale, 1990 international dollars)



Sources: UK: Bank of England's Millennium of Macroeconomic Data, version 3.1, apart from GDP 1950-1990 from Central Statistical Office (1996); Germany and USA: Maddison Project Database, version 2013; Japan: Fukao et al. (2015).

Tab. 1: English national income in 1086

	£ in current prices
Seigniorial	
Recorded income	75,065
Non-working animals	12,639
Mills, fisheries, salthouses, property, etc.	6,887
A. Total seigniorial income	94,591
Non-seigniorial	
Ploughs (partial demesne)	169,005
Ploughs (non-demesne)	61,665
Non-working animals	50,223
Mills, fisheries, salthouses, property, etc.	8,391
B. Total non-seigniorial income	289,284
Excluded items	
Unrecorded property	31,320
Other counties	15,167
C. Total income from excluded items	46,487
Total national income (=A + B + C)	430,362

Source: Walker (2015: 30).

Tab. 2: English GDP per head in 1086 and 1270

	1086 in current prices	1086 in prices of 1270	1270 in current prices
GDP (£m)	0.430		4.47
Population (m)	1.71		4.36
Price level (1086=100)	100		374
GDP per capita (£)	0.251	0.940	1.025

Sources: GDP in 1086 from Walker (2015); Population in 1086 and GDP and population in 1270 from Broadberry et al. (2015); Price index to convert GDP per capita in current 1086 prices to GDP per capita in 1270 prices from Farmer (1988) for the period to 1221, then Clark (2004; 2006) for 1221-1270.

Tab. 3: Growth rates of real GDP, population and real GDP per capita, England 1270-1700 and Great Britain 1700-1870 (% per annum)

	Real GDP	Population	Real GDP per capita
A. England			
1270s-1300s	-0.02	0.27	-0.29
1300s-1350s	-0.64	-0.52	-0.12
1350s-1400s	-0.30	-1.06	0.76
1400s-1450s	-0.06	-0.21	0.15
1450s-1500s	0.40	0.25	0.15
1500s-1550s	0.51	0.65	-0.14
1550s-1600s	0.81	0.62	0.19
1600s-1650s	0.41	0.51	-0.10
1650s-1700	0.78	-0.04	0.82
1270s-1700	0.22	0.04	0.18
B. Great Britain			
1700-1750s	0.49	0.30	0.19
1750s-1800s	1.21	0.77	0.44
1800s-1850s	2.08	1.34	0.74
1850s-1870	0.12	1.54	0.58
1700-1870	1.31	0.84	0.48

Source: Broadberry et al. (2015: 208).

Tab. 4: Sectoral shares in nominal GDP and the labor force, England 1381-1700 and Great Britain 1700-1870 (%)

A. Nominal GDP shares

Year	Region	Agriculture	Industry	Services	Total
1381	England	45.5	28.8	25.7	100.0
1522	England	39.7	38.7	21.6	100.0
1700	England and Britain	26.7	41.3	32.0	100.0
1759	Britain	29.7	35.2	35.1	100.0
1801	Britain	31.3	32.7	36.0	100.0
1841	Britain	22.1	36.4	41.5	100.0

B. Labor force shares

Year	Region	Agriculture	Industry	Services	Total
1381	England	57.2	19.2	23.6	100.0
1522	England	58.1	22.7	19.2	100.0
1700	England and Britain	38.9	34.0	27.2	100.0
1759	Britain	36.8	33.9	29.3	100.0
1801	Britain	31.7	36.4	31.9	100.0
1841	Britain	23.5	45.6	30.9	100.0

Source: Broadberry et al. (2015: 344).

Tab. 5: Sectoral annual growth rates of output, labor-force and labor productivity, England 1381-1700 and Great Britain 1700-1851

Period	Annual % growth:					
	Agriculture			Industry		
	Output	Labor-force	Labor productivity	Output	Labor-force	Labor productivity
1381-1522	0.01	-0.01	0.02	0.27	0.10	0.17
1522-1700	0.38	0.25	0.13	0.73	0.66	0.07
1700-1759	0.79	0.22	0.57	0.63	0.31	0.32
1759-1801	0.85	0.44	0.41	1.54	0.97	0.57
1801-1851	0.74	0.64	0.10	3.00	1.74	1.23
	Services			GDP		
	Output	Labor-force	Labor productivity	Output	Labor-force	Labor productivity
1381-1522	0.06	-0.16	0.23	0.11	-0.02	0.14
1522-1700	0.74	0.60	0.14	0.60	0.45	0.16
1700-1759	0.70	0.44	0.26	0.69	0.32	0.38
1759-1801	1.36	1.00	0.36	1.23	0.79	0.44
1801-1851	2.16	1.45	0.71	2.10	1.35	0.74

Source: Broadberry et al. (2015: 367).

Tab. 6: Accounting for British growth, 1340s to 1860s (% per annum)

A. Accounting for growth of GDP

	GDP	Popu-lation	Work days p.c.	Human capital	Capital	Land	TFI	TFP
1340s - 1400s	-0.73	-0.51	-0.17	-0.10	-0.08	-0.11	-0.98	0.25
1400s - 1450s	-0.21	-0.05	0.11	0.19	-0.09	-0.02	0.14	-0.35
1450s - 1640s	0.50	0.21	0.10	0.26	0.10	0.01	0.69	-0.19
1640s - 1690s	0.84	-0.02	0.17	0.09	0.10	0.00	0.34	0.49
1690s - 1830s	1.08	0.30	0.08	0.17	0.19	0.05	0.78	0.31
1830s - 1860s	2.28	0.47	0.06	0.53	0.57	0.00	1.92	0.36

B. Accounting for growth of British GDP per capita

	GDP p.c.	Work days p.c.	Human capital p.c.	Capital p.c.	Land p.c.	TFI p.c.	TFP
1340s - 1400s	0.54	-0.17	0.15	0.17	0.14	0.30	0.25
1400s - 1450s	-0.08	0.11	0.22	-0.06	0.01	0.28	-0.35
1450s - 1640s	-0.03	0.10	0.16	0.00	-0.09	0.16	-0.19
1640s - 1690s	0.88	0.17	0.10	0.11	0.01	0.39	0.49
1690s - 1830s	0.34	0.08	0.02	0.04	-0.10	0.03	0.31
1830s - 1860s	1.11	0.06	0.30	0.34	-0.23	0.75	0.36

Sources and notes: Broadberry and de Pleijt (2021). Weights for 1340s-1830s: 0.4 for labor and work effort, 0.2 for human capital, 0.2 for capital and 0.2 for land. Weights for 1830s-1860s: 0.4 for labor and work effort, 0.2 for human capital, 0.3 for capital and 0.1 for land.

Tab. 7: Annual growth rates of real GDP, population and real GDP per capita, United Kingdom, 1870-2018 (%)

	Real GDP	Population	Real GDP per capita
1870-1913	1.9	1.0	0.8
1913-1929	0.6	0.4	0.2
1929-1938	1.8	0.4	1.4
1938-1950	2.0	0.5	1.4
1950-1973	2.9	0.5	2.4
1973-1995	1.9	0.1	1.7
1995-2007	2.8	0.5	2.4
2007-2018	1.1	0.7	0.3

Source: Bank of England's Millennium of Macroeconomic Data version 3.1, apart from GDP 1950-1990 from Central Statistical Office (1996).

Tab. 8: Sectoral shares of employment, 1870-2007 (%)

A. United Kingdom

	Agriculture	Industry	Services	Total
1871	22.2	42.4	35.4	100.0
1911	11.8	44.1	44.1	100.0
1924	8.6	46.5	44.9	100.0
1930	7.6	43.7	48.7	100.0
1937	6.2	44.5	49.3	100.0
1950	5.1	46.5	48.4	100.0
1973	2.9	41.8	55.3	100.0
1990	2.0	28.5	69.5	100.0
2005	1.4	18.4	80.2	100.0

B. United States

	Agriculture	Industry	Services	Total
1870	50.0	24.8	25.2	100.0
1910	32.0	31.8	36.2	100.0
1920	26.2	33.2	40.6	100.0
1930	20.9	30.2	48.9	100.0
1940	17.9	31.6	50.5	100.0
1950	11.0	32.9	56.1	100.0
1973	3.7	28.9	67.4	100.0
1990	2.5	21.8	75.7	100.0
2005	1.5	16.7	81.8	100.0

C. Germany

	Agriculture	Industry	Services	Total
1871	49.5	29.1	21.4	100.0
1913	34.5	37.9	27.6	100.0
1925	31.5	40.1	28.4	100.0
1930	30.5	37.4	32.1	100.0
1935	29.9	38.2	31.9	100.0
1950	24.3	42.1	33.6	100.0
1973	7.2	47.3	45.5	100.0
1990	3.4	39.7	56.9	100.0
2005	2.1	25.5	72.4	100.0

Sources: Headcount measure of employment from Broadberry (1998), updated using the EUKLEMS database (O'Mahony and Timmer, 2009).

Tab. 9: Comparative labor productivity levels by sector, 1869/71 to 2007

A. US/UK

	Agriculture	Industry	Services	Aggregate economy
1869/71	86.9	153.6	85.9	89.8
1889/91	102.1	164.1	84.2	94.1
1909/11	103.2	193.2	107.4	117.7
1919/20	128.0	198.0	118.9	133.3
1929	109.7	222.7	121.2	139.4
1937	103.3	190.6	120.0	132.6
1950	126.0	243.5	140.8	166.9
1973	131.2	214.8	137.4	152.3
1990	151.1	163.0	129.6	133.0
2007	196.4	166.2	125.1	127.7

B. Germany/UK

	Agriculture	Industry	Services	Aggregate economy
1871	55.7	91.7	62.8	59.5
1891	53.7	99.3	64.4	60.5
1911	67.3	127.7	73.4	75.5
1925	53.8	92.3	76.5	69.0
1929	56.9	97.1	82.3	74.1
1935	57.2	99.1	85.7	75.7
1950	41.2	91.8	83.2	74.4
1973	50.8	121.1	120.1	114.0
1990	75.4	111.0	134.9	125.4
2007	92.4	105.2	117.5	114.6

Sources and notes: Broadberry (1998), updated using the EUKLEMS database (O'Mahony and Timmer, 2009).

Tab. 10: Accounting for UK growth, 1873-2016 (% per annum)

A. Accounting for growth of GDP

	GDP	Hours worked	Labor quality	Capital	TFI	TFP
1873-1913	1.86	0.80	0.90	1.90	1.76	0.10
1924-1937	2.13	1.43	0.65	0.63	1.72	0.41
1950-1973	2.85	-0.38	0.77	4.36	1.48	1.37
1973-1995	1.87	-0.20	0.74	3.43	1.26	0.61
1995-2007	2.88	0.80	0.40	4.27	1.97	0.91
2007-2016	0.95	0.88	0.64	2.34	1.72	-0.77

B. Accounting for growth of British GDP per hour

	GDP per hour	Labor quality	Capital deepening	TFI deepening	TFP
1873-1913	1.06	0.90	1.10	0.96	0.10
1924-1937	0.70	0.65	-0.80	0.29	0.41
1950-1973	3.23	0.77	4.74	1.86	1.37
1973-1995	2.07	0.74	3.63	1.46	0.61
1995-2007	2.08	0.40	3.47	1.17	0.91
2007-2016	0.07	0.64	1.46	0.84	-0.77

Sources and notes: Crafts (2021b: 703). Capital has a weight of 0.25 apart from 0.35 for 1873-1913 and 0.275 for 1950-1973. The weight of labor (both quantity and quality) is one minus the weight of capital. The TFP growth rate is slightly different for the period 1950-1995 due to the use of a different GDP series as discussed in the text.

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