CAGE

Working Paper

771/2025
September 2025

Innovation and the Great Divergence

Stephen Broadberry
Runzhuo Zhai

UNIVERSITY OF WARWICK

UKRI Economic and Social Research Council

INNOVATION AND THE GREAT DIVERGENCE

Stephen Broadberry, Nuffield College Oxford, stephen.broadberry@nuffield.ox.ac.uk

Runzhuo Zhai, Renmin University, runzhuo.zhai@ruc.edu.cn

2 September 2025
File: Innovation and the Great Divergence v10.doc

Abstract: Recent developments in historical national accounting suggest that the timing of the Great Divergence hinges on the different trends in northwest Europe and the Yangzi Delta region of China. The positive trend of GDP per capita in northwest Europe after 1700 was a continuation of a process that began in the fourteenth century, while the negative trend in the Yangzi Delta continued a pattern of alternating periods of growing and shrinking, but reaching a new lower level. These GDP per capita trends were driven by different paths of innovation. TFP growth was strongly positive in Britain after the Black Death, in the Netherlands during the sixteenth century and again in Britain from the mid-seventeenth century. Although TFP growth was positive in China during the Northern Song dynasty, it was predominantly negative during the Ming and Qing dynasties, in the Yangzi Delta as well as in China as a whole.

JEL classification: N10, N30, N35, O10, O57
Key words: Great Divergence; technology; growth accounting

Acknowledgements: We thank Joel Mokyr and Zhiwu Chen for insightful comments and suggestions. We are also grateful to participants in the 2022 World Economic History Congress, Paris, the Chinese Economic History Conference at the University of Manchester, the 2024 Quantitative History Conference at Shanghai Jao Tong University, the 2024 Asian Historical Economics Conference at Hong Kong University, the 2025 Economic History Society Conference at Strathclyde University and seminars at the Universities of Newcastle, York, Yale, Tsinghua, Bocconi, Lund and NHH Bergen for helpful feedback.

I. INTRODUCTION

When Kenneth Pomeranz (2000) coined the term "Great Divergence" to describe the emerging gap in productivity and living standards between Europe and Asia, there was very little agreement about either the timing or the causes of the divergence. For much of the twentieth century, many economic historians treated the Industrial Revolution as just the culmination of a process of gradual improvement, beginning in the late middle ages and continuing throughout the early modern period (Weber, 1930; Landes 1969; North and Thomas,1971). On this view, as Europe transformed its institutions and accumulated capital, Asia stagnated and began to fall behind. Innovations during the Industrial Revolution, particularly in technology, were seen as accelerating this process of divergence, rather than initiating it. Pomeranz (2000) questioned what he saw as the Eurocentric bias of this account, claiming that as late as 1800, the Yangzi Delta region of China was as developed as Britain and the Netherlands, the richest parts of Europe. Other parts of Asia were also characterised as equally developed at the end of the eighteenth century (Hanley, 1983; Parthasarathi, 1998; 2011). This chimed with the work of Frank (1998) and other economic historians working in California, and became known as the California School.

However, despite the fundamentally quantitative nature of the revisionist claims being made, this work was not generally based on systematic analysis of data. Whilst this was understandable given the past focus of quantitative economic history on the modern period, and particularly the period since the mid-nineteenth century, the new century has seen much progress in the extension of the quantitative approach both back in time and across space to cover Asia as well as Europe. This paper draws on the new sources of data that have been uncovered to provide a quantitative assessment of both the timing of the Great Divergence and its causes. In particular, we use historical national accounting to establish the path of GDP per capita in regions of Europe and Asia, and growth accounting to assess the role of innovation in explaining GDP per capita growth.

This paper argues that the revisionist authors of the California School were right to point to regional variation in economic performance in both Europe and Asia. We find that the Yangzi Delta, the richest region of China during the Ming and Qing dynasties, remained broadly on a par with Britain and the Netherlands in the richest northwest region of Europe until the start of the eighteenth century. However, the California School went too far in claiming parity of economic performance between the two continents until the nineteenth century. The historical national accounting data presented here suggest that the Great Divergence dates from the eighteenth rather than the nineteenth century, a view that has recently been endorsed by Pomeranz (2011; 2017). However, this is obviously a lot later than suggested in the traditional view, where Europe was seen as forging ahead since at least 1500, if not as early as 1300.

In addition, growth accounting is used to assess the contributions of factor inputs and the efficiency with which those inputs were used. Those inputs include the growth of the labour force, increased labour effort, investment in both human capital and fixed capital and the growth of total factor productivity (TFP). Obtained as a residual, TFP growth is a measure of changes in the efficiency with which inputs are utilised. It has often been equated with technological innovation, but this is not the only kind of innovation. Indeed, Schumpeter (1934) characterised innovation as encompassing a wide range of "new combinations". This includes the introduction of a new good or new quality of a good and the introduction of a new method of production, all of which are consistent with the narrow definition of innovation as technological progress. However, Schumpeter (1934: 66) also included the opening of a new market, the conquest of a new source of supply of raw materials or semi-manufactured goods and the carrying out of the new organisation of any industry. This broader definition covers some of the most important developments in the history of the rise of the West, such as the opening of new trade routes from Europe to Asia and the Americas from the sixteenth century, which permitted an expansion of markets as well as securing new sources of supply. It also includes organisational changes such as breaking free from guild restrictions, moving from the putting-out system to factory production, the development of the modern corporation and financial innovations such as banking, insurance and stock markets. We should also add structural change from low value added to higher value added activities, which is another way of allowing for more efficient combinations of factor inputs, particularly as the share of agriculture in economic activity gave way to the rising shares of industry and services.

We show how recent progress in quantification of the main factor inputs allows us to carry out a growth accounting exercise for the leading parts of both Europe and Asia. TFP growth was positive in China during the Northern Song dynasty, when China was the world's richest nation, but predominantly negative during the Ming and Qing dynasties in the Yangzi Delta as well as in China as a whole. In northwest Europe, by contrast, TFP growth was strongly positive in Britain after the Back Death, in the Netherlands during the sixteenth and early seventeenth centuries, and in Britain continuously from the mid-seventeenth century. These different paths of innovation were critical for the Great Divergence. We show how technological innovation had a role to play by analysing data on famous scientists and apprenticeships, but also note the importance of the wider "new combinations" during periods of rapid TFP growth, including structural change away from agriculture and the opening of new markets indicated by the expansion of European merchant fleets.

2. PATTERNS OF ECONOMIC GROWTH IN EUROPE AND ASIA, 1000-1870

Until recently, most accounts of economic growth before 1870 were largely qualitative. That changed with Maddison's (2001), *The World Economy: A Millennial Perspective*, published shortly after Pomeranz's (2000) *The Great Divergence*. Although Maddison's (2001) dataset was a major breakthrough for quantification of long run economic growth, it contained a large amount of "guesstimation" or "controlled conjectures", with a number of observations set at or close to $400 in 1990 international prices. This is equivalent to most people living at "bare bones subsistence", or the World Bank poverty level of $1 per day, with a small rich elite on top. Furthermore, Maddison provided his conjectural estimates only for a small number of benchmark years.

Stimulated by Maddison's work, economic historians began to extend estimates of per capita income back further in time using data based on archival records. As a result, a firmer picture has emerged of the contours of long run growth and development in both Europe and Asia. This is possible because medieval and early modern Europe and Asia were much more literate and numerate than is often thought, and left behind a wealth of data in documents such as government accounts, customs accounts, poll tax returns, parish registers, city records, trading company records, hospital and educational establishment records, manorial accounts, probate inventories, farm accounts, tithe files and other records of religious institutions. With a national accounting framework and careful cross-checking, it is possible to reconstruct population and GDP back to the medieval period, sometimes at decadal or even annual frequency.

2.1 Europe's Little Divergence

For some European countries, abundant quantitative information has survived, so that historical national accounts can be constructed directly on a sectoral basis in great detail. Britain and Holland have very rich data, with historical national accountants able to build on decades of detailed data processing by generations of scholars as well as well-stocked archives (Broadberry, Campbell, Klein et al., 2015; van Zanden and van Leeuwen, 2012). For other countries, where information is more limited, or where there has been less processing of existing data, Malanima (2011), Álvarez-Nogal and Prados de la Escosura (2013) and others have developed a short-cut method for reconstructing GDP, building on pioneering work by Crafts (1985) and Wrigley (1985). In the short-cut method, the economy is first divided between agriculture and non-agriculture. In the agricultural sector, output is estimated via a demand function, making use of data on population, real wages and the relative price of food, together with elasticities derived from later periods and the more recent experience of other less developed economies. In Allen's (2000: 13-14) notation:

$$Q^A = rcN \qquad (1)$$

where Q^A is real agricultural output, r is the ratio of production to consumption, c is consumption per head and N is population. Real agricultural consumption per head is assumed to be a function of its own price in real terms (P^A/P), the price of non-agricultural goods and services in real terms (P^{NA}/P), and real income per head (y). Assuming a log-linear specification, we have:

$$\ln c = \alpha_0 + \alpha_1 \ln(P^A / P) + \alpha_2 \ln(P^{NA} / P) + \beta \ln y \qquad (2)$$

where α_1 and α_2 are the own-price and cross-price elasticities of demand, β is the income elasticity of demand and α_0 is a constant. Consumer theory requires that the own-price, cross-price and income elasticities should sum to zero, which sets tight constraints on the plausible values, particularly given the accumulated evidence on elasticities in developing countries (Deaton and Muellbauer, 1980: 15-16, 60-82).

For the non-agricultural sector, output is assumed to have moved in line with the urban population, but with some allowance made for rural industry and the phenomenon of agro-towns. This approach began with Wrigley (1985), and has recently been combined with the demand approach to agriculture to provide indirect estimates of GDP in a number of European countries during the early modern period (Malanima, 2011; Álvarez-Nogal and Prados de la Escosura, 2013; Schön and Krantz, 2012). With the path of agricultural output (Q^A) derived using equations (1) and (2), overall output (Q) is derived as:

$$Q = \frac{Q^A}{1-\left(Q^{NA}/Q\right)} \qquad (3)$$

where the share of non-agricultural output in total output (Q^{NA}/Q) is proxied by the urbanisation rate. The approach can be made less crude by making an allowance for higher productivity in the non-agricultural sector, so that (Q^{NA}/Q) increases more than proportionally with the urbanisation rate.

The new estimates of GDP per capita based on historical national accounting data for four key economies in northwest and Mediterranean Europe are presented in Figure 1 for the period 1000-1870. Although these data were constructed on an annual basis, they are provided here at decadal frequency from 1270 onwards. In Mediterranean Europe, Italy and Spain experienced long-term stagnation between 1300 and 1800, as bursts of episodic growth alternated with period of negative growth, or shrinking. In northwest Europe, by contrast, Britain and the Netherlands experienced trend long run growth from the mid-fourteenth century, as short bursts of episodic growth were interspersed with longer periods of stagnation, avoiding periods of substantial shrinking (Broadberry and Wallis, 2025).

The reversal of fortunes between northwest and Mediterranean Europe occurred in two phases. The first turning point came with the arrival of the Black Death in the mid-fourteenth century. 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 1348, 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 between the 1540s and 1620s, while Britain experienced a further growth episode from the mid-seventeenth century.

Second-generation estimates of GDP per capita are now also available for other European countries, including France, Sweden, Poland, Portugal and Germany (Ridolfi and Nuvolari, 2022; Schön and Kranz, 2012; Krantz, 2017; Malinowski and van Zanden, 2017; Palma and Reis, 2019; Pfister, 2022). These estimates are shown in Figure 2 and confirm the picture of no trend growth between 1300 and 1800 outside northwest Europe, which forged ahead of the rest of the European continent from around 1500, led initially by the Netherlands, then by Britain.

2.2 Asia's Little Divergence

Data are available for some Asian economies for some time periods, but there has been relatively little work so far processing this material. Much work remains to be done on the Chinese data, but it is now possible to produce decadal estimates of GDP from the output side for China as a whole reaching back to the Northern Song dynasty apart from gaps during dynastic changes and for the Yangzi Delta back to the beginning of the Ming dynasty (Broadberry, Guan and Li, 2018; 2021; Zhai, 2023). Indian data are less abundant, and it has so far only been possible to produce decadal estimates back to 1800 and benchmarks every half century between 1600 and 1800 (Broadberry, Custodis and Gupta, 2015). Apart from Abū ’l-Fazl’s [1595] remarkable document, *The Ā’ īn–i-Akbarī*, most of the information about India comes from the records of the European East India Companies and the British Raj. Japan also has a wealth of data, but at this stage the estimates are available only for a handful of benchmark years before the Meiji restoration of 1868 (Takashima, 2017; Bassino, Broadberry, Fukao et al., 2019).

The second generation GDP per capita estimates for Asia are set out in Figure 3. They suggest that China was the leading Asian economy during the Song dynasty, but was overtaken by Japan during the eighteenth century, while India declined through the seventeenth and eighteenth centuries. This has led to the suggestion of an Asian Little Divergence occurring at about the same time as the European Little Divergence. However, care must be taken here about the timing of the Asian Little Divergence because of differences in the size of the countries being compared. The population of Japan in 1600 was 17 million, at a time when the Chinese population was 160 million (Bassino, Broadberry, Fukao et al., 2019; Maddison, 2010). A more appropriate comparator for Japan would be the Yangzi Delta, widely regarded as China’s richest region. Measured against the Yangzi Delta, the reversal of fortunes between China and Japan was delayed until after the Meiji restoration rather than during the eighteenth century.

Figure 4 compares Zhai’s (2023) estimates of GDP per capita for the Yangzi Delta with alternative estimates from Broadberry, Guan and Li (2021) and Broadberry and Guan (2022).

Broadberry Guan and Li (2018) made the first attempt to provide estimates of GDP per capita in the leading region of China over a substantial period of time, derived by assuming that the ratio between the Yangzi Delta and China as a whole in the 1820s remained constant over time. The ratio for the 1820s was obtained from a comparative study by Li and van Zanden (2012), who found per capita incomes in the Yangzi Delta to be around half of the level in the Netherlands in the 1820s. This suggests a per capita GDP figure of around $1,050 for the Yangzi Delta, in 1990 international dollars, or about 75 per cent higher than in China as a whole. Applying the ratio between the Yangzi Delta and China as a whole in the 1820s to Chinese GDP per capita from Broadberry, Guan and Li (2021) for earlier years produces a quantification of the leading Chinese region in the same units as the other countries in Figure 3. This does not have to mean that the Yangzi Delta was always the leading region, but rather that there was always a region that was proportionally as far above the Chinese average as the Yangzi region in the 1820s.

Broadberry and Guan (2022) provide estimates of Chinese GDP per capita for four benchmark years, broken down into seven macro regions during the Ming and Qing dynasties, establishing that East Central China was the richest macro region. However, this region still contained around a third of China's population, so data are also provided for the Yangzi Delta, the core of East Central China, widely seen as the richest part of China since the Ming. With a population of around 20 million in 1600, about the same as France, the Yangzi Delta is more comparable in size to a European nation state. For the Northern Song dynasty, although it is not possible to derive a full regional breakdown, data are provided for Kaifeng Fu, the region containing the capital city. Broadberry and Guan's (2022) benchmark estimates are broadly consistent with the time series projections of Broadberry Guan and Li (2021), which hold constant the ratio between GDP per capita in China's leading region and the empire as a whole.

Zhai's (2023) reconstruction of GDP per capita from the output side uses a similar methodology to Broadberry, Guan and Li (2018) but applied at the regional level using local sources such as gazetteers. Zhai's (2023) results are broadly consistent with the Broadberry, Guan and Li (2021) and Broadberry and Guan (2022) estimates over the period 1400-1870. For the rest of the paper we will focus on Zhai's (2023) estimates for the Yangzi Delta during the Ming and Qing dynasties, combined with Broadberry and Guan's (2022) benchmark estimate for Kaifeng Fu during the Northern Song dynasty.

2.3 The Great Divergence

Figure 5 plots the new GDP per capita estimates for the leading regions of Europe from Figure 1 together with the series for the leading regions of China from Figure 4, to provide a focus on the Great Divergence. Kaifeng Fu was substantially richer than Italy and Britain in the eleventh century. When it is next possible to make a comparison between the leading regions of China and Europe at the beginning of the Ming dynasty, the Yangzi Delta was on a par with Italy, which was then the richest European region. Although the Netherlands forged ahead during the sixteenth century, the Yangzi delta closed the gap by the mid-seventeenth century, and also remained ahead of Britain, the larger northwest European economy. From the end of the seventeenth century, however, GDP per capita in the Yangzi Delta began a long decline coinciding with the transition to modern economic growth in northwest Europe. The Great Divergence can thus be seen as beginning around 1700. These trends can be seen more clearly comparing the leading regions of China with the leading regions of Europe one at a time in Figure 6.

Figure 6A shows the comparative positions of Britain and the leading regions of China. During the Northern Song dynasty, Britain was a backwater of Europe, with GDP per capita less than half the level of Kaifeng Fu, the region around the capital city, Kaifeng. Britain improved its position during the second half of the fourteenth century following the Black Death, which reduced population by around half. This left many of those who survived with more land and capital, with even the landless benefitting from higher wages as factor proportions changed in favour of labour. Although the gap between the two economies narrowed during the sixteenth and early seventeenth centuries as GDP per capita declined in the Yangzi delta and remained on a plateau in Britain, overtaking was delayed until the very end of the seventeenth century, as the Yangzi Delta experienced a sharp increase in GDP per capita during the Ming-Qing transition. This occurred as a result of the sharp population decline resulting from the dynastic struggle. The critical juncture thus occurred around 1700 as Britain made the transition to modern economic growth, with population and GDP per capita both growing at the same time, while GDP resumed its secular decline in the Yangzi Delta as the cultivated land area failed to keep up with the resumption of population growth.

Turning to the comparison between the Netherlands and the leading regions of China in Figure 6B, we see that although the Netherlands did forge ahead of the Yangzi Delta briefly during the early seventeenth century, the Yangzi Delta very nearly caught up again during the Ming-Qing transition, so that the critical juncture is again seen to be delayed until the end of the seventeenth century. In Figure 6C, we can see the relationship between Italy and the leading regions of China. Since Italy was the leading region of Europe in the eleventh century, the substantial gap between Kaifeng Fu and Italy confirms that Kaifeng Fu was the richest region in Eurasia, and most likely in the world. Although the Yangzi Delta fell behind Italy during the eighteenth century, it should be borne in mind that by this time, Italy had long since lost its position as the European leader, and was now part of the poorer European periphery. This again reinforces the dating of the Great Divergence to 1700 rather than any earlier period, as it is from this date that the leading region of China not only failed to keep up with the leading region of Europe, but also began to fall behind the European periphery.

It is reassuring that the historical national accounting evidence suggests the eighteenth century as the beginning of the Great Divergence, since this seems to be the new consensus that is emerging from both California School authors such as Pomeranz (2011; 2017) and from economic historians using other quantitative indicators such as real wages and urbanization rates (Broadberry and Gupta, 2006; Allen, Bassino, Ma et al., 2011). It seems that the California School authors were right to point to the importance of regional variation within both Asia and Europe, but a bit too optimistic about the performance of the richest parts of Asia during the eighteenth century.

2.4 Dynamics of the Great Divergence

Settling the timing of the Great Divergence does not mean that what happened earlier can be disregarded in seeking to understand its origins. It is important to also examine the dynamics of the income process. Using annual estimates of GDP per capita reaching back to the thirteenth or fourteenth century for a number of countries, a radically new picture of the Industrial Revolution has appeared. Northwestern Europe forged ahead of the rest of Europe and also diverged from Asia not by growing faster during periods of positive growth, but rather by reducing the frequency and rate of shrinking during periods of negative growth (Broadberry and Wallis, 2025). Indeed, the period of improved long-run economic performance actually took place at a time when the average rate of growing during periods of positive growth was slowing down. This process of avoiding growth reversals in northwestern Europe can be traced back to the growth episode following the Black Death of the mid-fourteenth century. In this sense, the origins of the Great Divergence are still to be found in the late medieval period, as earlier generations of economic historians argued, even though at this stage northwestern Europe had not forged ahead of the rest of Europe or Asia.

Explaining the Industrial Revolution has more in common with solving the problem of development today than is usually acknowledged. Getting growth going in the first place, the traditional focus of analysis, is only part of the story. Just as important is ensuring that periods of positive growth are not followed by periods of negative growth, or shrinking (Broadberry and Wallis, 2025). This has been highlighted in the case of developing economies today by Easterly, Kremer, Pritchett et al. (1993) and Pritchett (2000). For the transition to modern economic growth in northwest Europe, it means paying as much attention to the absence of negative trend growth after the Black Death as to the innovations that started episodes of positive growth during the eighteenth century. For the decline of China and India, it requires paying more attention to the increasing frequency and rate of shrinking from the eighteenth century.

3. GROWTH ACCOUNTING AND THE GREAT DIVERGENCE

3.1 Growth accounting

Armed with the estimates of economic growth before 1870 from the previous section, this paper now turns to explanation. Growth accounting begins with a production function to assess 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 labour *(L)* and *A* is a measure of efficiency or total factor productivity *(TFP):*

$$Y = AF(K, L) \qquad (4)$$

The growth rate of output *($\Delta Y/Y$)* can be related to the growth rates of the inputs of capital *($\Delta K/K$)* and labour *($\Delta L/L$)* and the growth rate of *TFP ($\Delta A/A$)*.

$$\Delta Y/Y = \alpha\, \Delta K/K + \beta \Delta L/L + \Delta A/A \qquad (5)$$

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 labour 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:

$$\Delta y/y = \alpha\, \Delta k/k + \Delta A/A \qquad (6)$$

where the growth of output per capita *($\Delta y/y$)* is equal to the growth of output minus the growth of labour, and the growth of capital per capita *($\Delta k/k$)* is the growth of capital minus the growth of labour.

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:

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

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:

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

where the growth of labour quality *($\Delta h/h$)* is equal to the growth of human capital minus the growth of labour, and the growth of land per capita *($\Delta r/r$)* is the growth of farmland minus the growth of labour.

The labour input is measured not just by the number of workers (usually assumed to grow in line with population), but ideally takes into account the number of days worked per person per year and the quality of the labour 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 ideally measured by fixed capital excluding dwellings, although this is one of the most difficult series to obtain from historical sources (Feinstein, 1978; 1988). Measures of farmland are usually restricted to the arable acreage, as it is much harder to obtain reliable estimates of the amount of land used for grazing livestock. With independent measures of the growth of output, labour, capital and land, total factor productivity growth is derived as a residual. As noted earlier, although this is often used as an indicator of technological change, here it is taken to be a broader measure of innovation, including organisational change.

3.2 Accounting for British growth

Part A of Table 1 presents the results of the growth accounting exercise in extensive form using equation (7) to account for the growth of GDP in Britain. The labour force is assumed to move in line with population from Broadberry, Campbell, Klein 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, Campbell, Klein et al. (2015). For most of the period, the factor input weights are 40 per cent for labour (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 (2021: 312).

Note that the last two columns of Table 1A (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 before recovering 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 labour and the stock of human capital, but also the incentives to accumulate capital and the amount of land that could be cultivated by the smaller workforce. 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 Table 1 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-labour 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 Table 1B is that TFP growth was as important a driver of growth in GDP per capita as the contribution of per capita total factor inputs, accounting for around half of the positive GDP per capita growth. 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, as 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-labour ratio grew relatively little until after the 1830s, while the land-labour ratio drifted downwards as population increased. Increasing the quantity and quality of labour thus played an important role, together with innovation, in driving the British transition to modern economic growth.

3.3 Accounting for Dutch growth

For the case of Holland, van Zanden and van Leeuwen (2012) report the results of a growth accounting exercise in extensive form using population, human capital, fixed capital and land as the factor inputs to explain the growth of GDP. Since they provide the growth rates for all series and also the factor shares, it is possible to reproduce their results in extensive form and extend the exercise to the intensive form to account for the growth of GDP per capita. The results are reported in Table 2 using their factor shares. These are also the factor shares used in the British case for the nineteenth century, with a smaller share of non-labour incomes accruing as a return to land (10 per cent) and a larger share to fixed capital (30 per cent). This seems reasonable given the earlier structural shift of the Dutch economy away from agriculture and towards a growing reliance on grain imports (de Vries and van der Woude, 1997: 198-210).

Beginning with the extensive growth accounts in Table 2A, total factor input growth was the main driver of GDP growth over the period 1540s-1800s, as in the British case. Again, as in the British case, population growth was the main driver of TFI growth. Turning to the intensive growth accounts in Table 2B, however, we see a much stronger role for TFP growth in explaining GDP per capita growth, particularly during 1540s-1620s. Nevertheless, as in the British case, factor inputs also had a significant role to play. Human capital deepening was the most important driver of TFI per capita from the 1620s onwards, while fixed capital deepening was more important during the 1540s-1620s. The land-labour ratio made a mainly negative contribution to GDP per capita growth.

3.4 Accounting for Chinese growth

So far, growth accounting has been used to explain the path of GDP per capita in northwest Europe, but for an understanding of the Great Divergence it is also necessary to explain the path of GDP per capita in China. We begin with China as a whole, before also presenting growth accounts for the Yangzi Delta. Data on China's GDP and the inputs of land (the cultivated area) and labour (population) are available from Broadberry, Guan and Li (2018; 2021). Human capital has been proxied by the number of book titles available at decadal frequency from McDermott (2005) for the period 1131-1566 and van Leeuwen and Xu (2022) for the period after 1550.

Due to the limited availability of reliable historical data on both investment flows and stocks of fixed capital in China, we utilise three different methods for estimating capital. The first approach makes use of the perpetual inventory method (PIM), as in the British and Dutch cases. This approach was pioneered in the case of China by Fu (2014), who made use of an early version of Broadberry, Guan and Li's GDP estimates together with some strong assumptions about the evolution of consumption to derive estimates of investment, which were then cumulated to arrive at estimates of the capital stock. The second approach, based on the work of Perkins (1969), establishes upper and lower bounds to the growth of the capital stock. The third approach, which provides our preferred series, makes use of Kaldor's (1963) "stylised facts" about economic growth, established on the basis of data for the nineteenth and twentieth centuries. Fortunately, the first two methods are broadly consistent, with Kaldor's stylised fact of a constant capital-output ratio over the long run, which lies between the other two methods in all three dynasties, thereby providing the best compromise estimate. The details of all three methods are discussed in Appendix 1, together with Table A1 comparing the different capital stock series and Figure A1 showing the associated capital-output ratios.

The results of growth accounting for China using these variables and covering the period 980s-1840s are reported in Table 3. The extensive growth accounts in Table 3A show that GDP growth was driven mainly by total factor input growth, particularly population growth. This is very much in line with the results for Britain and Holland. However, in the case of China, TFP growth was always small in magnitude and predominantly negative. As a result, when we turn to the intensive growth accounts in Table 3B, TFP growth also rarely boosted GDP per capita growth and then only by a small amount. The only period when there was positive growth of both GDP per capita and TFP occurred during the Ming-Qing transition, but this was followed by a period of more substantial and sustained negative growth of both variables. The only other period of positive TFP growth was during the Northern Song dynasty, but this was offset by negative growth of TFI per capita as rapid population growth counteracted the accumulation of fixed capital and human capital. Since land per capita was declining and other inputs were barely keeping up with population growth, apart from a period of strong human capital deepening during the Ming dynasty, GDP per capita also trended down over the period as a whole. The Qing period 1690s-1840s was particularly disastrous for China, with sharply declining factor inputs per capita amplified by negative TFP growth.

3.5 Accounting for Yangzi Delta growth

We have shown earlier that the Yangzi Delta was the leading region of China during the Ming and Qing dynasties. For this period, we can also conduct growth accounting for the Yangzi Delta using data from Zhai (2023). The extensive growth accounts in Table 4A show that GDP growth was driven primarily by the growth of total factor input in the Yangzi Delta as well as in China as a whole. Trends in the labour force played an important role as population first increased during the Ming dynasty, then declined sharply during the Ming-Qing transition before increasing again during the Qing dynasty. However, these developments in the quantity of labour were reinforced by similar trends in the quality of labour, as the growth of human capital was strongly positive apart from during the Ming-Qing transition. The growth of cultivated land was only weakly positive. As in China as a whole, TFP growth was negative over the 1400s-1850s period as a whole, with positive TFP growth restricted to a short period during the Ming-Qing transition.

The intensive growth accounts in Table 4B show that GDP per capita growth was negative over the 1400s-1850s period as a whole, driven largely by the predominantly negative TFP growth. Again, as in China as a whole, the trend in land per capita was predominantly negative as the cultivated area could not be expanded sufficiently to keep up with demographic trends apart from during the catastrophic population collapse of the Ming-Qing transition.

3.6 Accounting for the Great Divergence

McCloskey (1981: 108) wrote "ingenuity rather than abstention governed the industrial revolution". Although growth accounts in extensive form over the very long run show that output growth in northwest Europe was driven largely by total factor input growth rather than by TFP growth, this does not mean that investment/savings (or abstention) was more important than innovation (or ingenuity) in the Great Divergence. Rather, McCloskey's vision is confirmed using the growth accounts in intensive form. GDP per capita growth in northwest Europe, which underpinned the rise in living standards, was driven as much by TFP growth as by physical and human capital deepening. Just as northwest Europe made the transition to modern economic growth from around 1700, in China, and in particular in the Yangzi Delta, GDP per capita trended down as the land-labour ratio fell, human and fixed capital deepening slowed down and even turned negative while TFP growth was also slightly negative.

4. INNOVATION IN NORTHWEST EUROPE AND CHINA

The Great Divergence occurred in the eighteenth century as northwest Europe made the transition to modern economic growth at the same time as Qing dynasty China and the Yangzi Delta entered a period of negative per capita income growth. However, northwest Europe and China, including the Yangzi Delta, had been on different paths of innovation since at least the Ming Dynasty. This shows up in the different paths of total factor productivity, with positive TFP growth in Britain during the second half of the fourteenth century, a strong burst of TFP growth in the Netherlands from the 1540s followed by a dynamic transformation of Britain from the 1640s to the Industrial Revolution, combined with mildly negative TFP growth in China and the Yangzi Delta during the Ming Dynasty and strongly negative TFP growth during the Qing. Here we consider the key innovations that underpinned these patterns in the four regions. Important roles were played not only by technological innovations but also by the wider range of innovations suggested by Schumpeter (1934) in his use of the term "new combinations", which we take to include the opening of new markets, organisational change and structural change.

4.1 Innovation in Britain

We will be most interested in the strong burst of TFP growth in Britain from the mid-seventeenth century onwards. However, there was also a period of positive TFP growth during the period of increasing GDP per capita between the 1340s and the 1400s. Much of the increase in GDP per capita during this period can be explained by the growth of per capita inputs, as population collapsed with the arrival of the Black Death, leaving survivors with more land and capital, and better educational opportunities (Broadberry, 2021; Broadberry and de Pleijt, 2021). However, there was also substantial positive TFP growth, which we would see as arising from innovation as the collapse of population after the arrival of the Black Death led to an increase in the relative price of labour, which provided an incentive to adopt capital-intensive technology such as the water-powered fulling mill (Carus-Wilson, 1952: 409-410; Munro, 2003a: 204-209). The use of more capital-intensive technology has frequently been associated with faster TFP growth through learning by doing (Arrow, 1962; David, 1975; Broadberry and Gupta, 2009). Additional benefits arose from the move of the industry away from its traditional centres in lowland eastern towns to rural locations in the west of England to take advantage of faster-flowing upland rivers, which allowed producers to break free from the restrictions imposed by urban guilds, an important organisational innovation (Carus-Wilson, 1952: 410-412). As a result of these productivity improvements, England was transformed from an exporter of high-quality raw wool to an exporter of woollen cloth during the second half of the fourteenth century, as can be seen in Figure 7. A further element in the shift of exports away from wool towards cloth was the fiscal regime, which Edward III used to increase the tax on exports of wool, resulting in export duties as a percentage of wool prices above 40 per cent for much of the fourteenth and fifteenth centuries. Since other measures included a ban on all foreign cloth imports and an invitation to foreign artisans to settle and practise their craft in England, Edward III has sometimes been portrayed as following a proto-mercantilist policy to boost the domestic cloth industry. However, Edward's motives seem to have been primarily fiscal, to help finance the Hundred Years War (Munro, 2003b: 279, 299-301). The combination of all these factors can be seen as opening up new markets for English woollen cloth producers previously focused on the home market and giving a boost to structural change away from agriculture and towards higher value-added manufacturing (Broadberry, Campbell, Klein et al., 2015: 144-146).

Britain did not exhibit significant TFP growth during the period 1400s-1640s. This should not be seen as surprising, since Britain was widely viewed as a backwater of Europe at this time. From the 1640s to the 1860s, however, Britain recorded substantial growth of GDP per capita, driven largely by TFP growth. Indeed, from the 1690s to the 1830s, TFP growth accounted for almost all the GDP per capita growth as accelerating population growth slowed down the growth of per capita human capital and fixed capital (Table 1B). Britain became the workshop of the world between about 1750 and 1830, as TFP growth grew rapidly in the modernising sectors that contained the great technological innovations of the Industrial Revolution, such as the steam engine, the spinning jenny, the water frame and coke-smelted iron (Crafts, 1985: 70-88; Allen, 2009: 135-237). Madsen and Murtin (2017) provide a time series on the number of famous scientists in Britain derived from data collected by Gascoigne (1984), shown here in Figure 8 in index number form, based on 1600=100. The number of famous scientists in Britain began to increase significantly from the early seventeenth century, although Mokyr (2009: 40-62, 107-123) emphasises that it was the interaction between scientists and skilled craftsmen that produced the "useful knowledge" that underpinned the

Industrial Revolution. Wallis (2019: 256-257) concludes from data on the number of annual entries to apprenticeship shown in Table 5 that there was a remarkably high incidence of apprenticeship in England, with 9 to 12 per cent of all teenage males or 15 to 22 per cent of teenage males outside agriculture starting fee-paying apprenticeships in the eighteenth century.

Moving beyond technological change, other developments that may be expected to have boosted TFP growth during the period 1640-1870 include structural change away from agriculture, the opening up of new markets in the expanding British Empire and the related securing of new sources of supply. The importance of structural change is illustrated in Table 6 by the dramatic decline in the share of agriculture in the English labour force from just under 60 per cent in 1500 to under 40 per cent by 1700 and just over 30 per cent by 1800, resulting in England having the most productive agricultural labour force in Europe (Broadberry, Campbell, Klein et al., 2015: 195; Allen, 2000: 8-9). Although Spain and Portugal had been the early pioneers in the voyages of discovery that established new trade routes to China and the existence of new continents, it was ultimately the British who won out in the struggle between European powers to rule the waves. This was an important development for Britain in terms of opening new markets for exports and securing new sources of supply for material inputs. Although it clearly involved important technological innovations in the design of ships and navigational devices, as emphasised by Maddison (2001), there were also innovations in organisation, including trading corporations such as the East India Company, reforms to improve incentives in the Royal Navy and the emergence of London as the world's most innovative financial and commercial centre (Chaudhuri, 1978; Allen, 2002; Carlos and Neal, 2011).

4.2 Innovation in the Netherlands

The Netherlands experienced an episode of rapid growth of GDP per capita between 1540 and 1620, driven by total factor productivity growth (Table 2B). This reflected significant improvements of Dutch technology and organisation in a number of areas, including fishing, shipbuilding, land reclamation, water control, agriculture and finance (Maddison, 2001; de Vries and van der Woude, 1997). In fishing, during the fifteenth century the Dutch developed a new type of factory ship, the herring buss, which permitted crews to gut, clean, salt and barrel herring while at sea (de Vries and van der Woude, 1997: 243-254). The Dutch merchant shipbuilding industry developed into the largest and most technically advanced in Europe between the 1460s and 1600s, culminating in the development of the fluitschip, which created a tube-like hull that maximised loading space within the constraints imposed on depth by the shallow waters off the Dutch and Baltic coasts, and on other dimensions by tolls based on length and breadth (de Vries and van der Woude, 1997: 355-357).

Innovation in the control of water played a major role in the development of Dutch agriculture (Maddison, 2001: 78). Settlers in the middle ages occupied mounds and turned them into polders by building dykes to keep off flood waters and as their skills in hydraulic management improved, large areas of new land were reclaimed. By the beginning of the sixteenth century, water management and engineering were entrusted to professionals, with farming communities raising taxes to provide funds for water boards. Windmills were used as a power source for pumps which were used to control canal waters (de Vries and van der Woude: 27-32). Within this context, Dutch agriculture developed a high degree of specialisation, concentrating on the production of high value added meat and dairy produce, while grain was imported using the profits from the export of livestock products. The structural shift from low value added arable to high value added livestock farming was another source of TFP growth. By 1600, the release of labour from agriculture had proceeded further in the

Netherlands than in the rest of Europe, as can be seen in Table 6. By 1700, however, the share of the labour force engaged in agriculture was even smaller in England, where a highly commercialised agriculture produced enough grain to feed the population without recourse to substantial imports until well into the nineteenth century (Deane and Cole, 1962; Crafts, 1985).

Further specialisation and structural change resulted from Dutch success in international trade, beginning with dominance of the Baltic region and later spreading to longer distance trade despite the pioneering of these routes by the Spanish and Portuguese (de Vries and van der Woude, 1997: 350-408). An important factor here was the more adequate funding of the Dutch traders, particularly after the formation of the *Verenigde Oostindische Compagnie* (United East India Company or VOC) in 1602 (de Zwart and van Zanden, 2018: 31). From the mid-seventeenth century, however, the Dutch found themselves squeezed by British and French mercantilism, so that by 1780, the carrying capacity of the Dutch merchant fleet had fallen behind both the French and British fleets (Table 7). A series of disruptions to the financial ties between London and Amsterdam resulted from the Anglo-Dutch Wars, the foundation of the Batavian Republic under French Revolutionary pressure and the incorporation of the Kingdom of Holland into the French Empire by Napoleon, leaving London as the supreme financial centre (Carlos and Neal, 2011).

4.3 Innovation in China

In China, TFP growth was positive between the 980s and 1120s during the Northern Song dynasty. This is consistent with Chinese technological advances across a wide range of industries at this time (von Glahn, 2016: 245-249; Lin, 1995: 270). Indeed, a number of innovations that are often seen as crucial to the emergence of modern economic growth in Industrial Revolution Britain can be seen to have already appeared in Song dynasty China. In iron, coke smelting was widespread in the eleventh century, while in textiles, the spinning wheel had been introduced by the thirteenth century and central power sources subsequently applied to the spinning of yarns (Hartwell, 1962; Mokyr 1990: 212). The Chinese shipbuilding industry was producing ocean-going junks that were much larger and more seaworthy than the best European ships well before 1400 (Mokyr, 1990: 215). While genuine porcelain had first appeared during the Tang Dynasty, improvements led to it being exported in large quantities during the Song Dynasty (Mokyr, 1990: 218; Elvin, 1973: 285; von Glahn, 2016: 247-248).

There were also innovations in Chinese agriculture at this time, including seed drills, weeding rakes and the deep-tooth harrow (Mokyr, 1990: 209). Improvements in water control allowed the draining and irrigation of lands, permitting the expansion of rice cultivation in the south, while the introduction of new varieties of quick-ripening Champa rice permitted rapid population growth. This resulted in population growth outstripping the growth of other factor inputs, leading to negative per capita total factor input growth offsetting the positive TFP growth. The net outcome was negative growth of GDP per capita between the 980s and 1120s (Table 3B).

China did not experience significant TFP growth between the 1120s and 1620s during the Mongol interlude and the Ming dynasty. This is consistent with the Needham puzzle, named after the historian of Chinese science and technology who highlighted the achievements of the Song dynasty and wondered why China did not go on to achieve a full-fledged scientific and industrial revolution (Needham, 1981; Lin, 1995). Lin (1995: 276) argues that China was predominant in technological invention based on experience during pre-modern times, but did not shift from the experience-based process of invention to the experiment-cum-science-based innovation that came to dominate the modern world. He sees this as a result of China's bureaucratic system combined with its imperial and ideological unification, which effectively blocked the growth of modern science (Lin, 1995: 281-285). Li and Zha (2002) provide data on 850 famous Chinese scientists between 980 and 1840 CE, which we use to construct an index of the number of famous scientists for comparison with Britain in Figure 8. Since the data for Britain and China have been constructed by different authors, we do not compare the absolute number of scientists in the two countries. In index number form, however, they can reasonably be taken as indicative of the growth trends in Britain and China, with the growth of the British index outstripping the growth of the Chinese index from the seventeenth century onwards.

China experienced a burst of positive GDP per capita growth and TFP growth between 1620 and 1690 during the Ming-Qing transition. This can be explained partly by the substantial territorial expansion at this time, leading to the acquisition of new markets (Table 3) and also to relief from pressure on the land-labour ratio (Wang, Liu, Guo et al, 1991: 308-424). However, a bigger boost to the land-labour ratio came from the loss of around a quarter of the population during the civil war at the time of the regime change. The positive effect of this on Chinese TFP growth can be likened to the effects of the population collapse in Britain after the Black Death, increasing pressures to adopt more capital-intensive methods, resulting in positive TFP growth through learning by doing. Government policies from 1644 also helped, with the Qing state providing loans for livestock, seeds and farm tools as well as tax exemptions for a limited period to people reclaiming abandoned land (Wang, Liu, Guo et al., 1991: 228-276; Chen, 2013: 18-47).

As population recovered, however, this positive TFP growth was not sustained from the 1690s, after which Qing China experienced substantial negative growth of both GDP per capita and TFP. The return to rapid population growth during the Qing Dynasty led to a decline in cultivated land per capita, which could not be offset completely by rising grain yields, putting downward pressure on agricultural output per capita. This is broadly consistent with the emphasis on the land-labour ratio by Chao (1986) and Huang (2002). Work by Bernhofen, Eberhardt and Morgan (2016) shows that internal grain markets were becoming less integrated during the Qing Dynasty, consistent with a less efficient use of resources, or negative TFP growth. In addition, Yang (2022) finds that the share of China's male labour force in agriculture remained broadly constant between 1734 and 1898, giving no boost to TFP from a structural shift away from agriculture. Under these circumstances, GDP per capita was bound to fall, with negative TFP growth playing a significant role.

4.4 Innovation in the Yangzi Delta

TFP data for the Yangzi Delta are only available between the 1400s and 1840s. For this period, TFP trends in the Yangzi Delta are very similar to those in China as a whole, as can be seen in Tables 4 and 3 respectively. For both the main Ming (1400-1620) and Qing (1690-1840) periods, TFP growth was negative, with a short interlude of positive TFP growth during the transition between the two dynasties (1620s-1690s). This suggests that innovations that were available to China as a whole were also available to its leading region, the Yangzi Delta. We also know from the work of Yang (2022) that the Yangzi Delta experienced the same stability in agriculture's share of the labour force as in China as a whole.

Although we do not have an independent measure of TFP growth for the Yangzi Delta between the 980s and 1400s, this was the period of the rise to economic leadership of that region during the reversal of fortunes between the North and the South of China. We have already noted the importance of Champa rice in China during the Northern Song dynasty. In fact, this innovation is usually seen as a crucial part of the shift in the centre of economic gravity from the North to the South of China and the emergence of the Yangzi Delta as China's per capita income leader (Broadberry and Guan, 2022). Other writers have also stressed the improvement of waterways, mass migration triggered by war, and the growth of domestic commerce as additional contributing factors to this reversal of fortunes (Elvin, 1973; Chen and Kung, 2022; Liu, 2015). More recently, Chen, Lin and Peng (2025) have argued strongly for the role of Arab-led maritime trade as the key trigger for this important development. Arab and Persian traders who arrived on the South Coast of China found porcelain and ceramics in abundance. Since Islamic culture banned the use of gold and silver in vessels used for drinking and eating, while art and architecture were required to avoid the depiction of human and animal figures due to rules against idolatry, the non-figurative Chinese ceramics made them ideal for trade with the Islamic world. The resulting export boom in porcelain and ceramics is seen as stimulating growth of the industry, which can be traced through the increase in the number of porcelain kilns in the South, typically located close to maritime customs offices. This Smithian growth, facilitated by an open-door policy to the outside world and long-distance trade, is consistent with Schumpeter's characterisation of innovation as new combinations rather than technological progress narrowly defined.

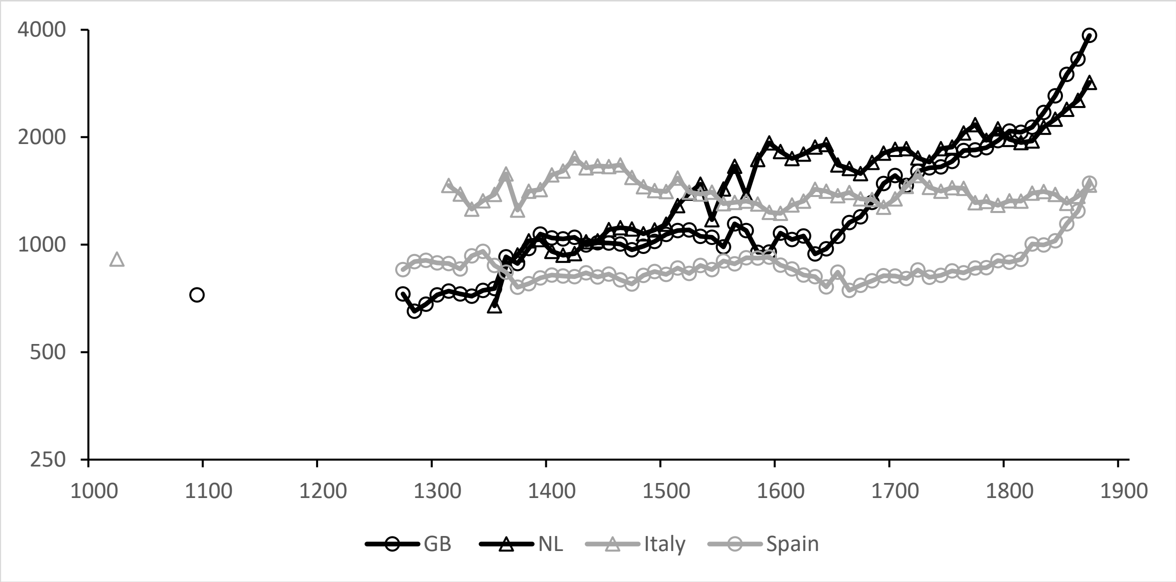
5. CONCLUSIONS

This paper seeks to establish the role of innovation in the Great Divergence of GDP per capita between Europe and Asia. The first step involves establishing the quantitative dimensions of the Great Divergence by tracking the paths of GDP per capita over the period 1000-1870 in the two continents, taking account of regional variation. The Great Divergence of GDP per capita between the leading regions of Europe and China occurred around 1700 as a period of positive growth in Britain and the Netherlands coincided with a period of negative growth in China and the Yangzi Delta. However, it is also instructive to note the trends in the two continents in the centuries preceding the divergence. The positive trend in northwest Europe was a continuation of a process that began after the arrival of the Black Death in the mid-fourteenth century. In most parts of Europe, as population declined by 50 per cent or more, Malthusian gains in living standards were followed by a reversal of per capita growth, or shrinking, as population growth returned. By contrast, the gains were consolidated in Britain and the Netherlands and provided a permanently higher level of per capita income from which the next growth phase occurred. As a result, there was a reversal of fortunes between northwest Europe and the Mediterranean region. Adding other European economies to the picture confirms the finding that between 1300 and 1800, positive trend growth of per capita incomes was restricted to northwest Europe.

The negative trend in GDP per capita in China as a whole and also in the Yangzi Delta from around 1700 was a return to a long run pattern of decline from the period of China's global per capita income leadership during the Northern Song dynasty. After a brief interruption during the positive growth of the Ming-Qing transition, the strongly negative trend in the Yangzi Delta from the beginning of the eighteenth century represents not just a falling behind Britain and the Netherlands, the leading European economies, but also a decline relative to the poorer regions of Europe, where GDP per capita remained on a plateau before picking up in the nineteenth century.

The second step in the paper seeks to establish the role of innovation in the Great Divergence by using growth accounting to assess the contribution of TFP growth to GDP per capita growth in the leading regions of Europe and Asia. Although the growth of GDP in northwest Europe over the very long run was driven primarily by the growth of the factors of production (population, days worked per person, human capital, physical capital and land), the growth of GDP per capita was driven as much by TFP growth. TFP growth was strongly positive in Britain after the Back Death, in the Netherlands during the sixteenth century and again in Britain from the mid-seventeenth century. TFP growth was positive in China during the Northern Song dynasty, when China was the world's leading economy, but was predominantly negative during the Ming and Qing dynasties, in the Yangzi Delta as well as in China as a whole.

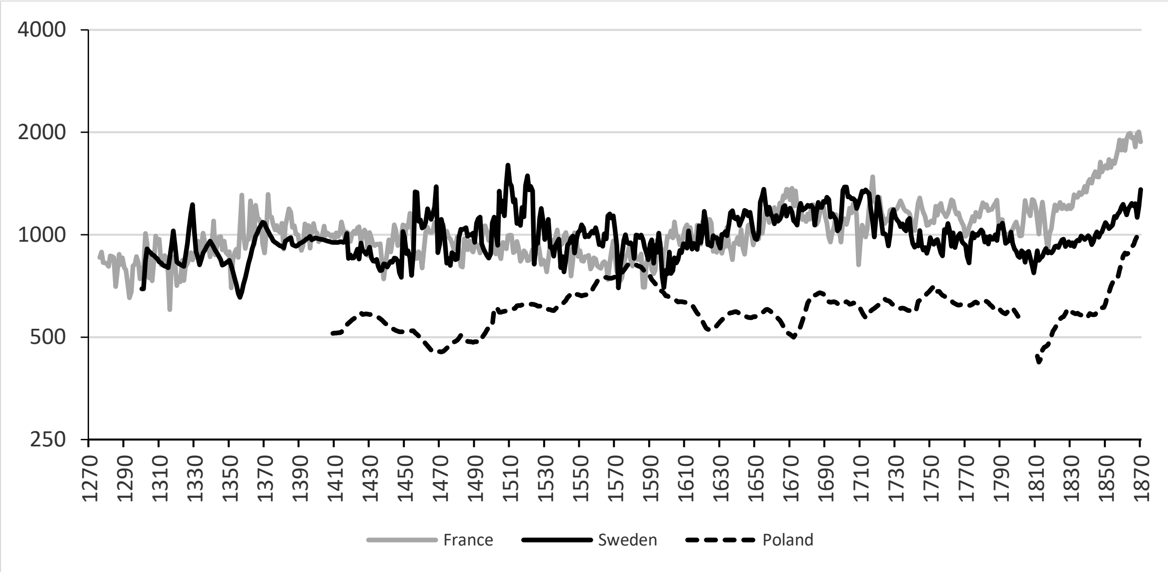
FIGURE 1: GDP per capita in northwestern and Mediterranean Europe, 1270-1870 (1990 international dollars)



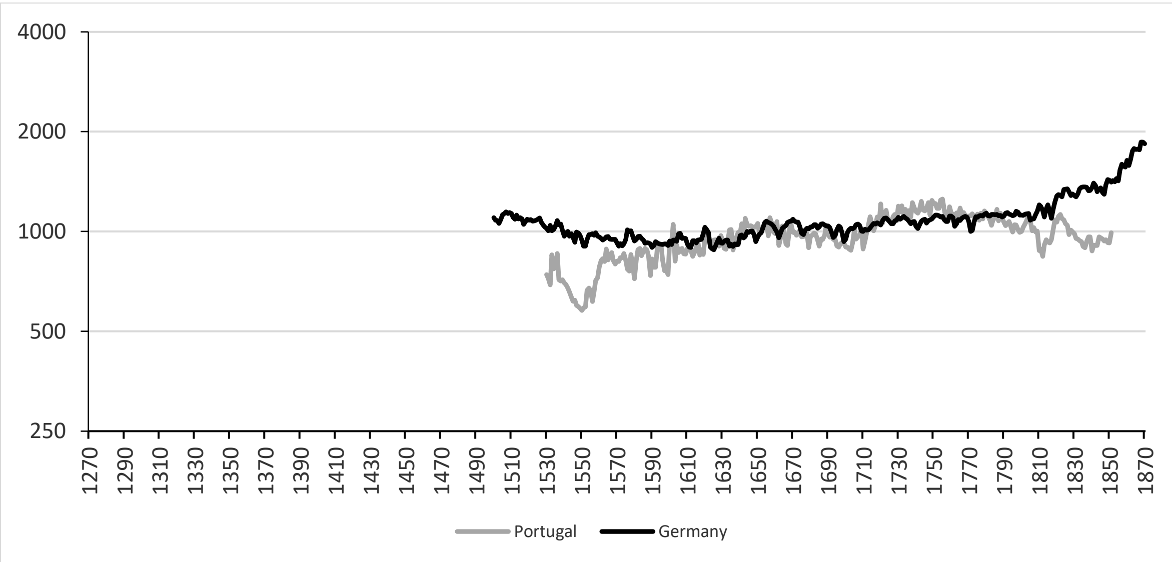
Sources: Great Britain: Broadberry, Campbell, Klein et al. (2015); Walker (2014). Netherlands: van Zanden and van Leeuwen (2012). Italy: Malanima (2002; 2011). Spain: Álvarez-Nogal and Prados de la Escosura (2013).

FIGURE 2: Real GDP per capita in other parts of Europe, 1270-1870 (1990 international dollars, log scale)

A. France, Sweden and Poland

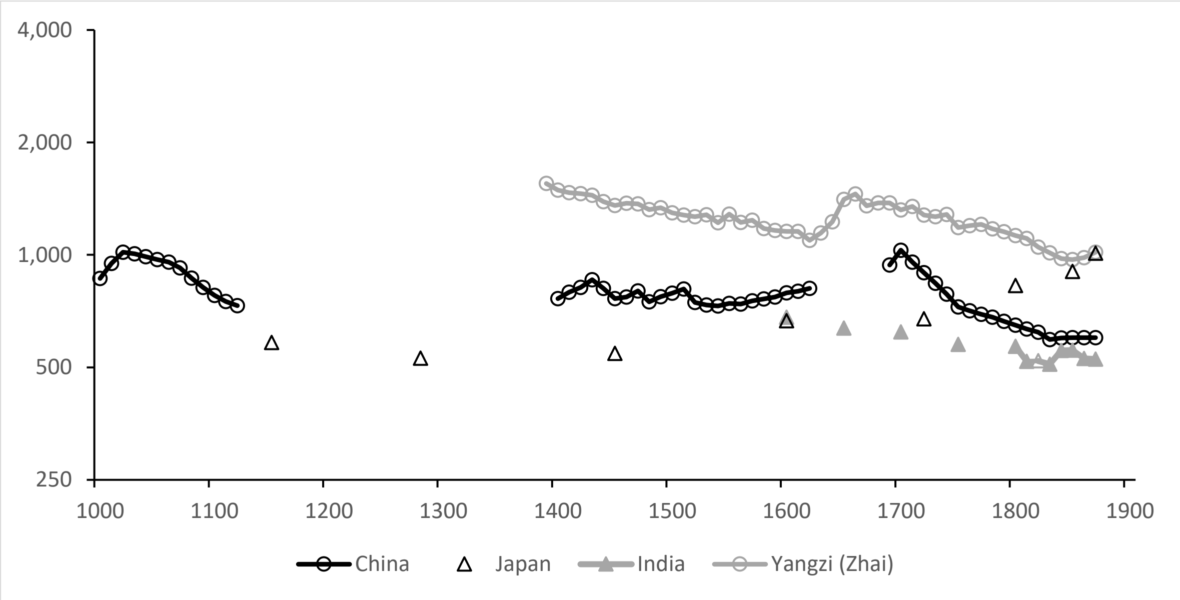


B. Portugal and Germany



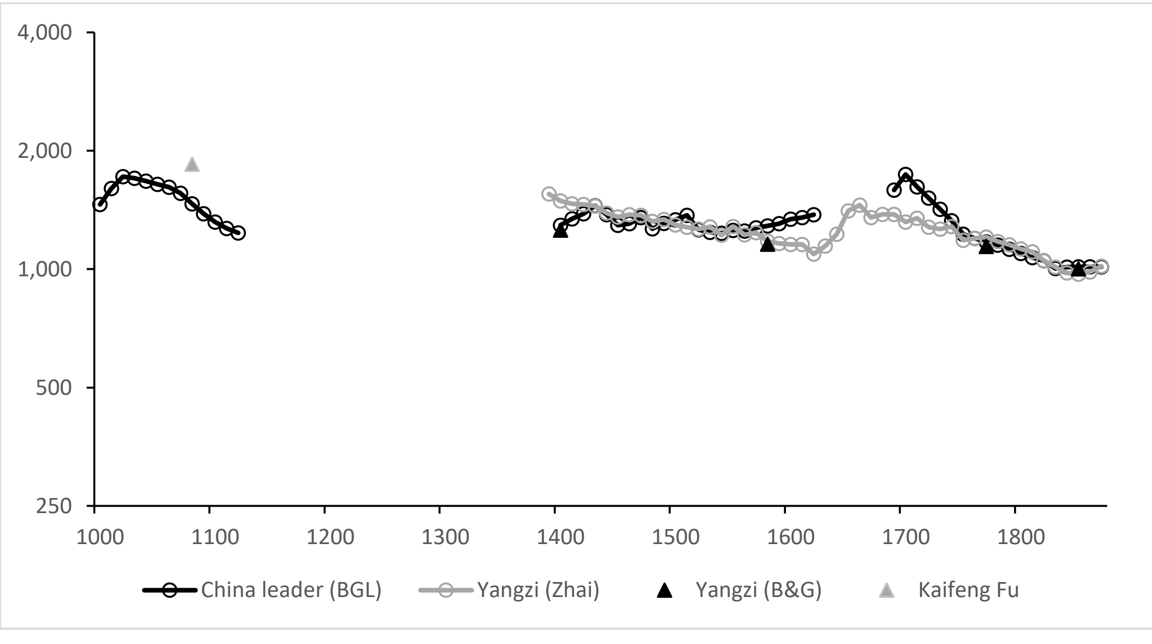
Sources: France: Ridolfi and Nuvolari (2022). Sweden: Krantz (2017), Schön and Krantz (2012). Poland: Malinowski and van Zanden (2017). Portugal: Palma and Reis (2019). Germany: Pfister (2022).

FIGURE 3: GDP per capita in Asia, 1000-1870 (1990 international dollars)



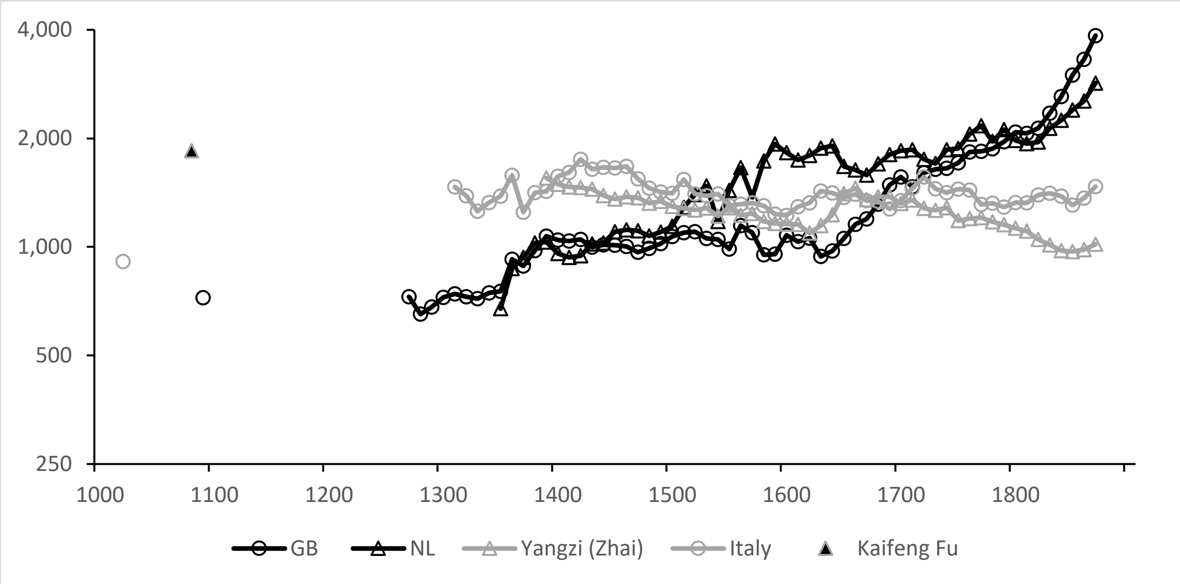
Sources: China: Broadberry, Guan and Li (2021). Japan: Bassino, Broadberry, Fukao et al. (2015). India: Broadberry, Custodis and Gupta (2015). Yangzi: Zhai (2023).

FIGURE 4: GDP per capita in China's leading regions, 1270-1870 (1990 international dollars)



Sources: China leader (BGL): Broadberry, Guan and Li (2021). Yangzi (Zhai): Zhai (2023). Yangzi (B&G) and Kaifeng Fu: Broadberry and Guan (2022).

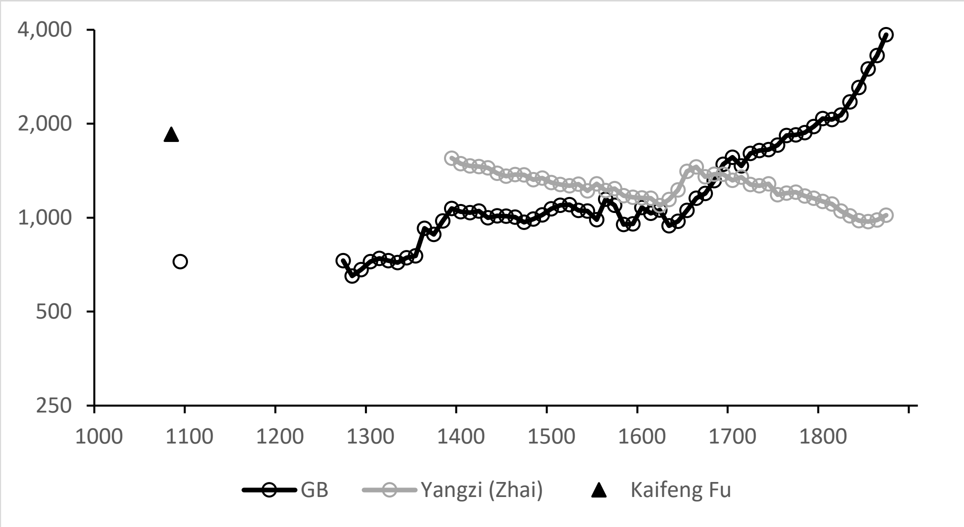
FIGURE 5: GDP per capita in the leading regions of China and Europe, 1000-1870 (1990 international dollars)



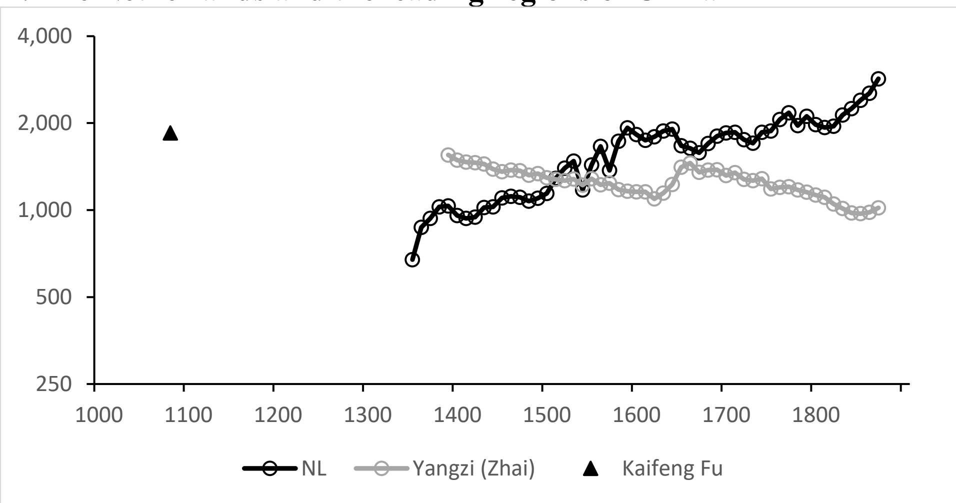
Sources: Great Britain: Broadberry, Campbell, Klein et al. (2015); Walker (2014). Netherlands: van Zanden and van Leeuwen (2012). Yangzi: Zhai (2023). Italy: Malanima (2002; 2011). Kaifeng Fu: Broadberry and Guan (2022).

FIGURE 6: GDP per capita in the leading regions of China and Europe, 1000-1870 (1990 international dollars)

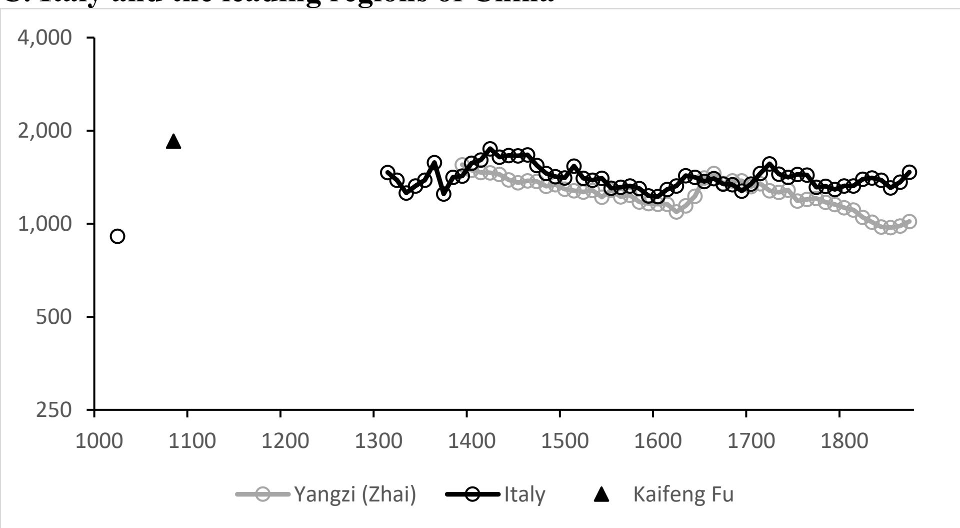
A. Britain and the leading regions of China



B. The Netherlands and the leading regions of China

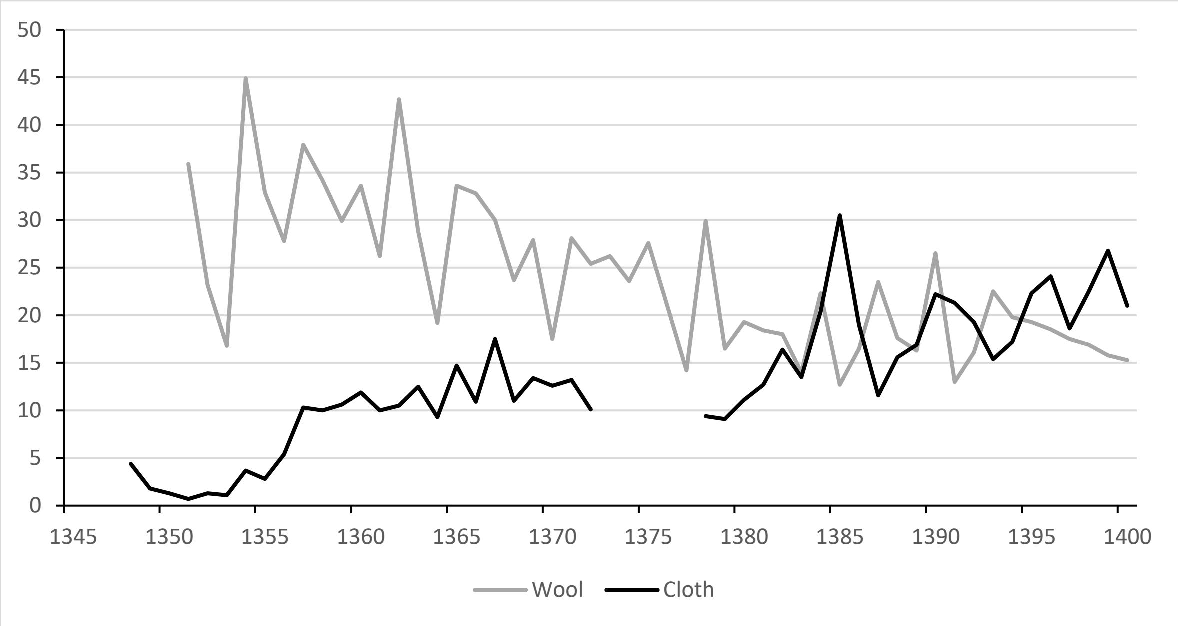


C. Italy and the leading regions of China



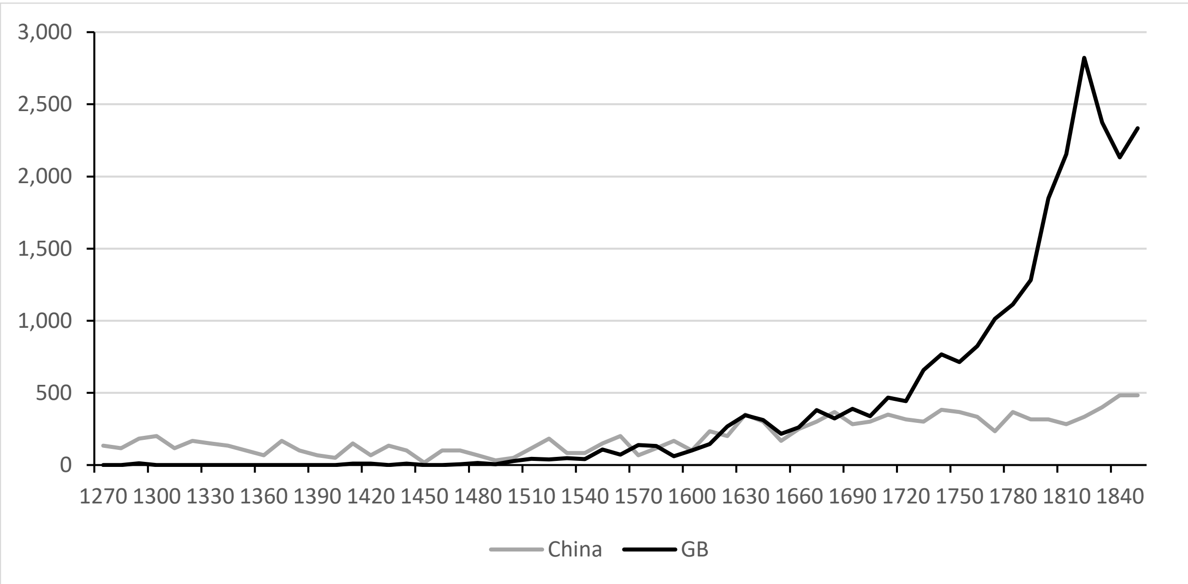
Sources: Great Britain: Broadberry, Campbell, Klein et al. (2015); Walker (2014). Netherlands: van Zanden and van Leeuwen (2012). Yangzi: Zhai (2023). Italy: Malanima (2002; 2011). Kaifeng Fu: Broadberry and Guan (2022).

FIGURE 7: English exports of wool (000 sacks) and cloth (000s), 1300-1400



Source: Mitchell (1988: 358), derived from Carus-Wilson and Coleman (1963).

FIGURE 8: Index of the number of famous scientists in Britain and China, 1270-1850 (1600=100)



Sources: GB: Madsen and Murtin (2017), derived from Gascoigne (1984). China: derived from Li and Zha (2002).

TABLE 1: 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	-1.28	-0.42	-0.52	-0.42	-0.56	-0.98	0.25
1400s - 1450s	-0.21	-0.14	0.27	0.97	-0.45	-0.09	0.14	-0.35
1450s - 1640s	0.50	0.53	0.26	1.31	0.51	0.07	0.69	-0.19
1640s - 1690s	0.84	-0.05	0.44	0.46	0.50	-0.02	0.34	0.49
1690s - 1830s	1.08	0.74	0.19	0.84	0.95	0.23	0.78	0.31
1830s - 1860s	2.28	1.16	0.15	2.66	2.87	0.00	1.92	0.36

B. Accounting for growth of 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	-0.42	0.76	0.85	0.71	0.30	0.25
1400s - 1450s	-0.08	0.27	1.10	-0.32	0.05	0.28	-0.35
1450s - 1640s	-0.03	0.26	0.78	-0.02	-0.46	0.16	-0.19
1640s - 1690s	0.88	0.44	0.50	0.54	0.03	0.39	0.49
1690s - 1830s	0.34	0.19	0.09	0.21	-0.52	0.03	0.31
1830s - 1860s	1.11	0.15	1.50	1.71	-1.16	0.75	0.36

Sources and notes: Growth rates of GDP, population and land from Broadberry, Campbell, Klein et al. (2015). Growth rate of work days from Humphries and Weisdorf (2019). Growth rate of human capital from de Pleijt (2018). Growth rate of capital from Broadberry and de Pleijt (2021).Weights for 1340s-1830s: 0.4 for labour and work effort, 0.2 for human capital, 0.2 for capital and 0.2 for land. Weights for 1830s-1860s: 0.4 for labour and work effort, 0.2 for human capital, 0.3 for capital and 0.1 for land.

TABLE 2: Accounting for Dutch growth, 1540s-1800s (% per annum)

A. Accounting for growth of GDP

	GDP	Population	Human capital	Fixed capital	Land	TFI	TFP
1540s-1620s	1.92	1.05	1.17	1.56	0.17	1.14	0.78
1620s-1660s	-0.18	0.68	1.28	0.75	0.17	0.77	-0.95
1660s-1720s	0.08	-0.04	0.56	-0.26	0.03	0.02	0.06
1720s-1800s	0.04	0.68	-0.10	0.22	0.07	0.33	-0.29

B. Accounting for growth of GDP per capita

	GDP p.c.	Human capital p.c.	Fixed capital p.c.	Land p.c.	TFI p.c.	TFP
1540s-1620s	0.87	0.12	0.51	-0.88	0.09	0.78
1620s-1660s	-0.86	0.60	0.07	-0.51	0.09	-0.95
1660s-1720s	0.12	0.60	-0.22	0.07	0.06	0.06
1720s-1800s	-0.64	-0.78	-0.46	-0.61	-0.36	-0.29

Sources and notes: Derived from van Zanden and van Leeuwen (2012: 126). Weights are 0.4 for labour, 0.2 for human capital, 0.3 for capital and 0.1 for land.

TABLE 3: Accounting for Chinese growth, 980-1840 (% per annum)

A. Accounting for growth of GDP

	GDP	Population	Human capital	Fixed capital	Land	TFI	TFP
980s-1120s	0.78	0.87	0.00	0.78	0.72	0.65	0.13
1120s-1400s	-0.18	-0.20	0.01	-0.18	-0.21	-0.15	-0.03
1400s-1620s	0.35	0.32	1.33	0.35	0.31	0.53	-0.18
1620s-1690s	0.20	-0.01	-0.22	0.20	0.07	0.01	0.19
1690s-1840s	0.40	0.70	0.45	0.40	0.27	0.51	-0.10

B. Accounting for growth of GDP per capita

	GDP p.c.	Human capital p.c.	Fixed capital p.c.	Land p.c.	TFI p.c.	TFP
980s-1120s	-0.09	-0.87	-0.09	-0.15	-0.22	0.13
1120s-1400s	0.02	0.21	0.02	-0.01	0.04	-0.03
1400s-1620s	0.03	1.01	0.03	-0.01	0.21	-0.18
1620s-1690s	0.20	-0.21	0.20	0.08	0.02	0.19
1690s-1840s	-0.30	-0.25	-0.30	-0.43	-0.20	-0.10

Sources and notes: Growth rates of GDP, labour and land from Broadberry, Guan and Li (2018; 2021). Growth rates of human capital from McDermott (2005) and van Leeuwen and Xu (2022). Fixed capital assumed to grow in line with output, as proposed by Kaldor (1963).Weights are 0.4 for labour, 0.2 for human capital, 0.2 for fixed capital and 0.2 for land.

TABLE 4: Accounting for Yangzi Delta growth, 1400s-1840s (% per annum)

A. Accounting for growth of GDP

	GDP	Popu-lation	Human capital	Fixed capital	Land	TFI	TFP
1400s-1620s	0.21	0.35	1.33	0.21	0.05	0.46	-0.25
1620s-1690s	-0.15	-0.48	-0.22	-0.15	0.05	-0.25	0.11
1690s-1840s	0.17	0.40	0.45	0.17	0.06	0.29	-0.13

B. Accounting for growth of GDP per capita

	GDP p.c.	Human capital p.c.	Fixed capital p.c.	Land p.c.	TFI p.c.	TFP
1400s-1620s	-0.14	0.98	-0.14	-0.31	0.11	-0.25
1620s-1690s	0.33	0.26	0.33	0.53	0.22	0.11
1690s-1840s	-0.23	0.06	-0.23	-0.33	-0.10	-0.13

Sources and notes: Growth rates of GDP, labour and land from Zhai (2023). Growth rates of human capital from McDermott (2005) and van Leeuwen and Xu (2022). Fixed capital assumed to grow in line with output, as proposed by Kaldor (1963). Weights are 0.4 for labour, 0.2 for human capital, 0.2 for fixed capital and 0.2 for land.

TABLE 5:Annual entries to apprenticeship in England, seventeenth-eighteenth centuries

	Apprentices in incorporated cities		Apprentices paying premiums	
	c.1600	c.1700	c.1710	c. 1790
Urban	4,359 (3,455-5,238)	5,392 (4,766-6,128)	3,556	2,906
Rural	--	--	2,227	3,746
Total			5,783	6,652
Share of teenage males (%)	8-13	11-14	12	9
Share of teenage males outside agriculture (%)	24-37	21-26	22	15

Sources and notes: Wallis (2019: 256). The apprentices in incorporated cities are based on a sample of cities classified by size, distinguishing between London, towns with at least 10,000 inhabitants and towns with between 5,000 and 10,000 inhabitants. In each category, the number of apprentices is based on the median number per thousand people in the sample multiplied by the total population in all towns of that size and the error bands in brackets are based on the inter-quartile range.

TABLE 6: Share of agriculture in the European labour force (%)

	England	Netherlands	Belgium	Italy	Spain
1300	--	--	--	63.4	--
1400	57.2	--	58.0	60.9	59.0
1500	58.1	56.8	64.4	62.3	65.3
1600	--	48.7	52.0	60.4	63.0
1700	38.9	41.6	47.1	58.8	62.9
1750	36.8	42.1	51.3	58.9	62.0
1800	31.7	40.7	48.7	57.8	63.5

Source: Derived from Broadberry, Campbell, Klein et al. (2015: 344); Allen (2000: 8-9).

TABLE 7: Carrying capacity of European merchant fleets, 1570-1780 (000 metric tons)

	1570	1670	1780
Netherlands	232	568	450
Germany	110	104	155
Britain	51	260	1,000
France	80	80	700
Italy, Portugal, Spain	n.a.	250	546
Denmark, Norway, Sweden	n.a.	n.a.	550

Source: Maddison (2001: 77).

APPENDIX 1: CHINESE CAPITAL STOCK DATA

Here we set out details of the three methods used to derive the capital stock data for China and make a comparison of the results.

1. Perpetual inventory method (PIM)

In the perpetual inventory method, when both the annual flow of investment, I_t, and the end-year gross stock of capital, K_t, are both valued in constant prices of the same year, they can be related through the basic identity:

$$K_t = (1-\delta)K_{t-1} + I_t \quad \text{(A1)}$$

where t denotes time, K_t represents the capital stock in year t, δ is the depreciation rate, and I_t stands for the investment in year t. In our study, the biggest challenge lies in obtaining reliable annual investment flow data for the Chinese economy. Utilizing the GDP accounting equation based on the expenditure approach, we can decompose GDP into components such as household and government consumption, investment, and net exports:

$$I_t = Y_t - C_t - G_t - NX_t \quad \text{(A2)}$$

where Y_t is GDP, C_t denotes household consumption, G_t represents government consumption and NX_t stands for net exports. In Fu's study, per capita household consumption was assumed to be constant over the long term. Hence, he multiplied the lowest recorded subsistence consumption from historical data of different dynasties by the total population to derive total household consumption. This seems unsatisfactory over a long period of time when per capita GDP was changing significantly, so we attempt to estimate consumption using the method of Allen (2000), which allows per capita consumption to change in line with income and relative prices:

$$C = c\,N \quad \text{(A3)}$$

where C represents total consumption, N denotes the total population, and c is per capita consumption of agricultural products. Per capita agricultural consumption is assumed to be a function of its own price in real terms (P^A/P), the price of non-agricultural goods and services in real terms (P^{NA}/P), and real income per head (y). Assuming a log-linear specification, we have:

$$ln\, c = \alpha_0 + \alpha_1 \ln(P^A/P) + \alpha_2 \ln(P^{NA}/P) + \beta\, ln\, y \quad \text{(A4)}$$

where α_1 and α_2 are the own-price and cross-price elasticities of demand, β is the income elasticity of demand and α_0 is a constant. Consumer theory requires that the own-price, cross-price and income elasticities should sum to zero, which sets tight constraints on the plausible values, particularly given the accumulated evidence on elasticities in developing countries (Deaton and Muellbauer, 1980: 15-16, 60-82). Here, the elasticity parameters are based on Bassino, Broadberry, Fukao et al. (2019) for Japan, the other major East Asian economy , i.e., $(\alpha_1, \alpha_2, \beta)$ = (-0.3, 0.1, 0.2).

Per capita income data are proxied by per capita GDP, taken from Broadberry, Guan and Li (2021), which is also the source of data on population and agricultural and non-agricultural prices, as well as the GDP deflator constructed as the weighted average of the two price series.[1] Total household consumption for the entire economy is obtained from information on the ratio between agricultural consumption and total consumption, which is available from ample information about the structure of consumption in China. Broadberry, Guan and Li (2018) provide data on the share of food in total agricultural output, Shi (2017: 148) derives the proportion of seeds deducted for future investment, while Fu (2014) estimates the share of food in total consumption for different dynasties.

Government consumption data includes both service expenditures and non-service expenditures (such as royal expenditure, etc.). Considering the historical fiscal balance principle adhered to by Chinese states in history, where the difference between income and expenditure has been minimal in the long term, we use the latest estimates of Chinese fiscal revenue by Guan, Ma, and Zhai (2023) as an estimate of government consumption. It is important to note that Guan, Ma, and Zhai's calculations include both legal and illegal revenues in the fiscal system. In our calculations, we use the sum of both as the total government consumption.

Data on net exports are scarce, although China has had relatively stable overseas trade since the Song Dynasty. However, according to Li (2010) and Pang, Jin, and Guan (2021),

[1] We made adjustments to the original price data. The cloth price data for 1550–1620, due to limited records, had previously been kept constant in earlier versions. This likely exaggerated the decline in per capita food consumption during this period and contradicted evidence of a nearly century-long rise in cloth prices. In fact, cotton prices increased during this time (Zhai, 2023). To address this, we used the grain-to-cloth price ratio from 1690, assuming it remained applicable in 1620, to calculate a revised cloth price for 1620.

even during the Qing Dynasty when overseas trade was relatively active, net exports may have accounted for less than 0.1 per cent of GDP. This suggests that our results would not be significantly biased even if we ignore net exports. We therefore assume net exports to be zero.

With these data, we can estimate annual investment by subtracting household consumption and government consumption from GDP, as in equation (A2) with net exports set equal to zero. The gross capital stock is then estimated using equation (A1), together with information on the initial capital stock K_0 and the depreciation rate. For data on the initial capital stock we follow Fu's (2014) method, based on Chow's (1993) empirical judgement that the capital-output ratio in a predominantly agricultural economy like 1950s China, varied between 1.5 and 2.5. We therefore assume that at the beginning of each dynasty, the capital-output ratio was approximately 2 in 980, 1400 and 1690. We also follow Fu (2014) is assuming a depreciation rate of 4 per cent, based on information about tools, livestock and housing. This figure is slightly lower than Chow's 5 per cent depreciation rate for 1950s China, which accords with our intuition about pre-modern economies. Using the perpetual inventory method formula, we can then calculate the nominal capital stock for China for the periods 980-1120, 1400-1620, and 1690-1840. The average real capital stock in 1840 prices was approximately 2.1 billion taels during the Northern Song Dynasty, around 5.4 billion taels during the Ming Dynasty, and 8.7 billion taels during the Qing Dynasty.

2. Upper and lower bounds

Perkins (1969: 81) provides a mathematical supplement to his chapters on the factors behind the rise of agricultural production in China between 1400 and 1957, where he presents some rough estimates of the growth of capital in China's largest sector. He uses data on irrigation projects to show that this important component of the capital stock grew relatively slowly and treats this as the lower bound estimate (Perkins, 1969: 61-62). He also uses evidence from agricultural handbooks that were published in China over many centuries to argue that there was no major technological breakthrough during this period, so that farm implements did not grow faster than the population. As Perkins (1969: 57) puts it: "Given little change in tool technology, there was not much increase in productivity per man that could be achieved by simply producing more implements. A man can only use one hoe at a time". He applies the same upper bound rate to the growth of draft animals, which he treats as another farm implement, noting also that "Draft animals represented a large outlay in terms of both fixed and working capital, an outlay that could be lost quickly to disease or roaming armies" (Perkins, 1969: 57).

Perkins's (1969) assumptions apply strictly to the agricultural sector, but since this accounted for 60 to 70 per cent of GDP from the Northern Song to the Qing dynasty, we believe it provides a reasonable guide for the economy as a whole, particularly if our interest is in the rate of change over time. Based on the earlier assumption of an initial capital-output ratio (K/Y) of 2 for each dynasty, we can derive China's capital stock under the upper and lower bound assumptions.

3. Kaldor's stylised facts and the capital–output ratio

Kaldor (1963) established a number of "stylised facts" of economic growth on the basis of data for the nineteenth and twentieth centuries. Although the capital-labour ratio increased over time as GDP per capita grew, Kaldor found that the capital-output ratio remained constant over the long run. Although Kaldor's evidence was limited to the modern period, recent work by Broadberry and de Pleijt (2021) has shown that it also holds for Britain between the fourteenth and nineteenth centuries. Hence in the third approach to the estimation of the capital stock we assume the constancy of the capital-output ratio

4. A comparison of the three methods

Figure A1 provides a comparison of the three methods, which are in most cases reasonably consistent. The one big inconsistency is the perpetual inventory method for the sixteenth century, which has a sharply rising capital-output ratio between 1500 and 1620. This appears to be related to the paucity of data on the non-agricultural price series during the sixteenth century, resulting in a long period of rising agricultural relative prices, which leads to a reduction in estimated consumption and hence an increase in estimated investment. For the Northern Song, early Ming and Qing dynasties, the perpetual inventory and Kaldor methods are very consistent, with the capital-output ratio fluctuating between around 1.5 and 2.0. The Kaldor method also tends to produce results between the Perkins upper bound (population) and lower bound (irrigation) methods.

TABLE A1: China's real capital stock (million taels in 1840 prices)

A. Northern Song dynasty

	Perpetual inventory method	Perkins lower bound (irrigation)	Perkins upper bound (population)	Kaldor method
980	1,341	1,341	1,341	1,341
990	1,225	1,410	1,385	1,379
1000	1,164	1,476	1,415	1,479
1010	1,489	1,543	1,564	1,797
1020	1,485	1,612	1,788	2,192
1030	1,510	1,678	1,966	2,381
1040	1,718	1,747	2,130	2,546
1050	2,009	1,814	2,324	2,726
1060	1,986	1,880	2,532	2,920
1070	2,461	1,950	2,890	3,212
1080	3,457	2,016	3,411	3,576
1090	3,265	2,085	3,828	3,771
1100	3,104	2,152	4,171	3,919
1110	2,806	2,218	4,379	3,960
1120	2,583	2,287	4,514	3,979

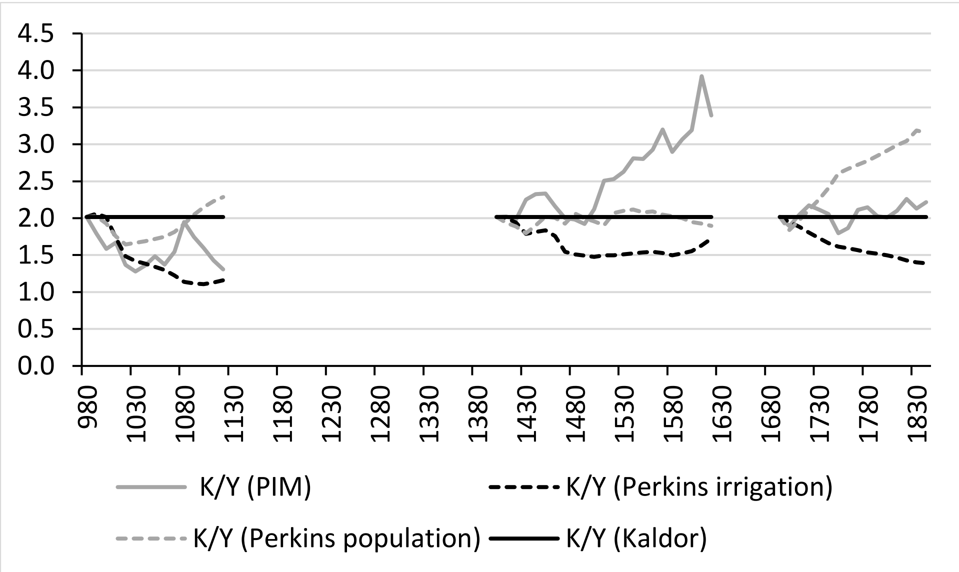
B. Ming dynasty

	Perpetual inventory method	Perkins lower bound (irrigation)	Perkins upper bound (population)	Kaldor method
1400	2,394	2,394	2,394	2,394
1410	2,472	2,448	2,366	2,463
1420	2,560	2,504	2,435	2,604
1430	3,218	2,559	2,572	2,883
1440	3,350	2,615	2,737	2,905
1450	3,393	2,670	2,944	2,934
1460	3,352	2,725	3,109	3,126
1470	3,603	2,781	3,466	3,629
1480	3,729	2,836	3,879	3,790
1490	3,722	2,892	3,879	3,906
1500	4,238	2,947	3,907	4,025
1510	5,140	3,077	3,907	4,136
1520	5,423	3,208	4,443	4,325
1530	5,801	3,339	4,636	4,452
1540	6,391	3,470	4,815	4,588
1550	6,556	3,601	4,870	4,721
1560	7,060	3,731	5,048	4,865
1570	8,084	3,863	5,172	5,092
1580	7,734	3,993	5,406	5,382
1590	8,292	4,124	5,406	5,451
1600	8,742	4,255	5,337	5,526
1610	10,389	4,325	5,103	5,340
1620	8,652	4,396	4,842	5,143

C. Qing dynasty

	Perpetual inventory method	Perkins lower bound (irrigation)	Perkins upper bound (population)	Kaldor method
1690	5,898	5,898	5,898	5,898
1700	5,816	5,983	5,645	6,192
1710	6,636	6,103	6,403	6,534
1720	7,493	6,224	7,280	6,950
1730	7,760	6,343	8,257	7,395
1740	8,004	6,463	9,369	7,843
1750	7,335	6,584	10,633	8,231
1760	7,864	6,704	11,239	8,490
1770	9,194	6,825	11,863	8,777
1780	9,690	6,944	12,520	9,100
1790	9,431	7,064	13,228	9,374
1800	9,617	7,185	13,969	9,659
1810	10,374	7,242	14,761	9,955
1820	11,563	7,301	15,587	10,318
1830	11,174	7,358	16,733	10,586
1840	11,821	7,417	16,851	10,759

FIGURE A1: China's capital-output ratio using three different methods



REFERENCES

Abū ’l-Fazl [1595] (1927), *The Ā’ īn–i-Akbarī*. Translated into English by H.Blochman, Delhi: Low Price Publications.

Allen, D.W. (2002), “The British Navy Rules: Monitoring and Incompatible Incentives in the Age of Fighting Sail”, *Explorations in Economic History*, 39: 204-231.

Allen, R. C. (2000), ‘Economic structure and agricultural productivity in Europe, 1300-1800’, *European Review of Economic History* 3: 1-25.

Allen, R.C. (2009), *The British Industrial Revolution in Global Perspective*, Cambridge: Cambridge University Press.

Allen, R.C., Bassino, J.P., Ma, D., Moll-Murata, C. and van Zanden, J.L. (2011), “Wages, prices, and living standards in China, 1738-1925: in comparison with Europe, Japan, and India”, *Economic History Review*, 64, S1, 8-38.

Álvarez-Nogal, C. and Prados de la Escosura, L. (2013), “The Rise and Fall of Spain (1270-1850)”, *Economic History Review*, 66, 1-37.

Arrow, K.J. (1962), “The Economic Implications of Learning by Doing”, *Review of Economic Studies*, 29, 155-173.

Bassino, J.-P., Broadberry, S., Fukao, K., Gupta, B. and Takashima, M. (2019), “Japan and the Great Divergence, 730-1874”, *Explorations in Economic History*, 72, 1-22.

Baten, J. and van Zanden, J.L. (2008), “Book Production and the Onset of Modern Economic Growth”, *Journal of Economic Growth*, 13, 217-235.

Bernhofen, D., M. Eberhardt, J. Li and S. Morgan (2016), “Assessing Market (Dis)Integration in Early Modern China and Europe”, CEPR Discussion Paper 11288.

Broadberry, S. (2021), “Accounting for the Great Divergence: Recent Findings from Historical National Accounting”, University of Oxford Economic and Social History Discussion Paper No. 187, https://ora.ox.ac.uk/objects/uuid:d11c9af0-4317-436c-8dfd-8b6d67fe7d5e.

Broadberry, S. and Guan, H. (2022), “Regional variation of GDP per head within China, 1080-1850: Implications for the Great Divergence debate”, University of Oxford Economic and Social History Discussion Paper No. 196, https://ora.ox.ac.uk/objects/uuid:9b5ca9ae-0b2f-4d22-9ad2-28d4cd6cfe24.

Broadberry, S. and Gupta, B. (2006), “The Early Modern Great Divergence: Wages, Prices and Economic Development in Europe and Asia, 1500-1800”, *Economic History Review*, 59, 2-31.

Broadberry, S. and Gupta, B. (2009), “Lancashire, India , and Shifting Competitive Advantage in Cotton textiles, 1700-1850: The Neglected Role of Factor Prices”, Economic History Review, 62, 279-305.

Broadberry, S. and de Pleijt, A. (2021), “Capital and Economic Growth in Britain, 1270-1870: Preliminary Findings”, University of Oxford Economic and Social History Working Paper No. 186, https://ora.ox.ac.uk/objects/uuid:28af2918-5612-473d-9900-3579d0c4c811.

Broadberry, S. and Wallis. J. (2025), “Growing, Shrinking and Long Run Economic Performance: Historical Perspectives on Economic Development”, *Journal of Economic History*, 85, 505-540.

Broadberry, S., Custodis, J. and Gupta, B. (2015), "India and the Great Divergence: An Anglo-Indian Comparison of GDP per capita, 1600-1871", *Explorations in Economic History* 55, 58-75.

Broadberry, S. Guan, H. and Li, D. (2018), "China, Europe and the Great Divergence: A Study in Historical National Accounting", *Journal of Economic History*, 78, 955-1000.

Broadberry, S. Guan, H. and Li, D. (2021), "China, Europe and the Great Divergence: A Restatement", *Journal of Economic History*, 81, 958-974.

Broadberry, S.N., Campbell, B., Klein, A., Overton, M. and van Leeuwen, B. (2015), *British Economic Growth, 1270-1870*, Cambridge: Cambridge University Press.

Carlos, A. and Neal, L. (2011), "Amsterdam and London as Financial Centers in the Eighteenth Century", *Financial History Review*, 18, 21-46.

Carus-Wilson, E.M. (1952), "The Woollen Industry", in Postan, M. and Rich, E.E. (eds.), *The Cambridge Economic History of Europe, Volume II: Trade and Industry in the Middle Ages*, Cambridge: Cambridge University Press, 355-428.

Carus-Wilson, E.M. and Coleman, O. (1963), *England's Export Trade, 1275-1547*, Oxford: Oxford University Press.

Chaudhuri, K.N. (1978), *The Trading World of Asia and the English East India Company, 1660-1760*, Cambridge: Cambridge University Press.

Chao, K. (1986), *Man and Land in Chinese History: An Economic Analysis*, Stanford, California: Stanford University Press.

Chen, F. (2013), *Zhongguo caizheng tongshi, Vol. 7: qingdai caizhengshi* (Chinese Fiscal History, Vol. 7: Qing Dynasty), Changsha: Hunan People's Publishing House.

Chen, T. and Kung, J. (2022), "War Shocks, Migration, and Historical Spatial Development in China", *Regional Science and Urban Economics*, 94, 103718.

Chen, Z., Lin, Z. and Peng, K. (2025), "Rise of the South: How Arab-Led Maritime Trade Transformed China, 671-1371 CE", *Asia-Pacific Economic History Review*, (forthcoming).

Chow, G. (1993), "Capital Formation and Economic Growth in China", *Quarterly Journal of Economics*, 103(3), 809-842.

Crafts, N.F.R. (1985), *British Economic Growth during the Industrial Revolution*, Oxford: Clarendon Press.

Crafts, N.F.R. (2021), "Understanding Productivity Growth in the Industrial Revolution", *Economic History Review*, 74, 309-338.

David, P.A. (1975), *Technical Choice, Innovation and Economic Growth*, Cambridge: Cambridge University Press.

Deane, P. and Cole, W.A. (1962), *British Economic Growth, 1688-1959*, Cambridge: Cambridge University Press.

Deaton, A. and Muellbauer, J. (1980), *Economics and Consumer Behaviour*, Cambridge; Cambridge University Press.

Easterly, W., Kremer, M., Pritchett, L. and Summers, L.H. (1993), "Good Policy or Good Luck?," *Journal of Monetary Economics*, 32, 459-483.

Elvin, M. (1973), The Pattern of the Chinese Past, Stanford, CA: Stanford University Press.

Feinstein, C.H. (1978), "Capital Formation in Great Britain", in Mathias, P. and Postan, M.M. (eds.), *The Cambridge Economic History of Europe, Volume VII: The Industrial Economies: Capital. Labour, and Enterprise, Part I, Britain, France, Germany and Scandinavia*, Cambridge: Cambridge University Press, 28-96.

Feinstein, C.H. (1988), "National Statistics, 1760-1920: Sources and Methods of Estimation for Domestic Reproducible Fixed Assets, Stocks and Works in Progress, Overseas Assets, and Land", in Feinstein, Charles H. and Sidney Pollard (eds.), *Studies in Capital Formation in the United Kingdom, 1750-1920*, Oxford: Oxford University Press, 257-471.

Frank, A.G. (1998), *ReOrient: The Silver Age in Asia and the World Economy*, Berkeley: University of California Press.

Fu, L. (2014), "A Study of China's GDP per capita 980-1840: Historical National Accounting", Ph.D. Thesis, Tsinghua University.

Gascoigne, ,R.M. (1984), *A Historical Catalogue of Scientists and Scientific Books: From the Earliest Times to the Close of the Nineteenth Century*, New York: Garland.

von Glahn, R. (2016), *The Economic History of China: From Antiquity to the Nineteenth Century*, Cambridge: Cambridge University Press.

Guan, H. Ma, D. and Zhai. R. (2023), "State Capacity in Imperial China - Quantifying a Millennium of Public Finance, 997-1911 AD", unpublished working paper.

Hanley, S.B. (1983), "A High Standard of Living in Nineteenth-Century Japan: Fact or Fantasy?", *Journal of Economic History,* 43, 183-192.

Hartwell, R. (1962), "A Revolution in the Chinese Iron and Coal Industries During the Northern Sung, 960–1126 A.D", *Journal of Asian Studies,* 21, 153–162.

Huang, P.C.C. (2002), "Development or Involution in Eighteenth-Century Britain and China?: A Review of Kenneth Pomeranz's The Great Divergence: China, Europe and the Making of the Modern World Economy", *Journal of Asian Studies*, 61, 501-538.

Humphries, J., and Weisdorf, J. (2019), "Unreal Wages? Real Income and Economic Growth in England, 1260-1850", *Economic Journal*, 129. 2867-2887.

Kaldor, N. (1963), "Capital Accumulation and Economic Growth", in Lutz, F.A. and Hague, D.C. (eds.), *Proceedings of a Conference Held by the International Economics Association*, London: Macmillan.

Krantz, O. (2017), "Swedish GDP 1300-1560: A Tentative Estimate", Lund Papers in Economic History; No. 152, Department of Economic History, Lund University, http://portal.research.lu.se/portal/files/21081639/LUP_152.pdf.

Landes, D.S. (1969), *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*, New York: Cambridge University Press.

van Leeuwen, B. and Xu, Y. (2022), "The Printing Industry in China, ca. 1368-1912: An International Comparison", (unpublished working paper, IISG).

Li, B. and van Zanden, J.L. (2012), "Before the Great Divergence? Comparing the Yangzi Delta and the Netherlands at the Beginning of the Nineteenth Century", *Journal of Economic History,* 72, 956-989.

Li, D. and Zha, Y. (2002), *Zhongguo Lidai Keji Renwu Shengzu Nianbiao (*Chronology of Birth and Death Years of Historical Chinese Scientific Figures*)*, Beijing: China Science Publishing House.

Li, L. (2010), *Qingdai de guoji maoyi: baiyin liuru, huobi weiji he wanqing gongyehua* (International Trade in Qing China: Silver Imports, Monetary Crisis, and Late Qing's Industrialisation). Taipei: Xiu Wei Technology Co.

Lin, J.Y. (1995), "The Needham Puzzle: Why the Industrial Revolution Did Not Originate in China", *Economic Development and Cultural Change*, 43, 269-292.

Liu, W.G. (2015), *The Chinese Market Economy, 1000-1500*, Albany: SUNY Press.

McCloskey, D. (1981), "The Industrial Revolution 1780-1860: A Survey", in Floud, Roderick and D. McCloskey (eds.), *The Economic History of Britain Since 1700, Volume 1: 1700-1860*, Cambridge: Cambridge University Press, 103-127.

McDermott, J. (2005), "The Ascendence of the Imprint in China", in Brokaw, C.J. and Chow, K.-W. (eds.), *Printing and Book Culture in Late Imperial China*, University of California Press, 55-107.

Maddison, A. (2001), *The World Economy: A Millennial Perspective*, Paris: Organisation for Economic Co-operation and Development.

Maddison, A. (2010), "Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD", Groningen Growth and Development Centre, https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-database-2010.

Madsen, J.B. and Murtin, F. (2017), "British Economic Growth since 1270: the Role of Education", *Journal of Economic Growth,* 22, 229-272.

Malanima, P. (2002), *L'economia italiana: dalla crescita medieval all crescita contemporanea*, Bologna: Il Mulino.

Malanima, P. (2011), "The Long Decline of a Leading Economy: GDP in Central and Northern Italy, 1300-1913", *European Review of Economic History*, 15, 169-219.

Malinowski, M. and van Zanden, J.L. (2017), "Income and its Distribution in Preindustrial Poland", *Cliometrica*, 11, 375-404.

Mitchell, B.R. (1988), *British Historical Statistics*, Cambridge: Cambridge University Press.

Mokyr, J. (1990), *The Lever of Riches: Technological Creativity and Economic Progress*, New York: Oxford University Press.

Mokyr, J. (2009), *The Enlightened Economy: Britain and the Industrial Revolution 1700-1850*, London: Penguin.

Munro, J.H. (2003a), "Medieval Woollens: Textiles, Textile Technology and Industrial Organisation, c. 800-1500", in Jenkins, D. (ed.), *The Cambridge History of Western Textiles*, Cambridge: Cambridge University Press, 179-227.

Munro, J.H. (2003b), "Medieval Woollens: The Western European Struggle for International Markets, c. 1000-1500", in Jenkins, D. (ed.), *The Cambridge History of Western Textiles*, Cambridge: Cambridge University Press, 179-227.

Needham, J. (1981), *Science in Traditional China: A Comparative Perspective*, Cambridge, MA: Harvard University Press.

North, D.C. and Thomas, R.P. (1971), *The Rise of the Western World: A New Economic History*, New York: Cambridge University Press.

Palma, N. and Reis, J. (2019), "From Convergence to Divergence: Portuguese Economic Growth, 1527-1850", *Journal of Economic History*, 79, 477-506.

Pang, H. Jin, X. and Guan, H. (2021), "China's Trade Surplus and Foreign Exchange Reserves in A Historical Perspective", *China Journal of Economics*, 8(2), 93-128.

Parthasarathi, P. (1998), "Rethinking Wages and Competitiveness in the Eighteenth Century: Britain and South India", *Past and Present*, 158, 79-109.

Parthasarathi, P. (2011), *Why Europe grew Rich and Asian did not*, Cambridge: Cambridge University Press.

Perkins, D. (1969), *Agricultural Development in China, 1368-1968*. Chicago: Aldine.

Pfister, U. (2022), "Economic Growth in Germany, 1500–1850", *Journal of Economic History*, 82, 1071-1107.

de Pleijt, A.M. (2018), "Human Capital Formation in the Long Run: Evidence from Average Years of Schooling in England, 1300-1900", *Cliometrica*, 12, 99-126.

Pomeranz, K. (2000), *The Great Divergence: China, Europe, and the Making of the Modern World Economy*, Princeton: Princeton University Press.

Pomeranz, K. (2011), "Ten years after: responses and reconsiderations", *Historically Speaking*, 12(4), 20-25. Project Muse, https://muse.jhu.edu/login?auth=0&type=summary&url=/journals/historically_speaking/v012/12.4.coclanis.html.

Pomeranz, K. (2017), "The Data We Have vs. the Data We Need: A Comment on the State of the "Divergence" Debate (Part I)", The NEP-HIS Blog, https://nephist.wordpress.com/2017/06/06/the-data-we-have-vs-the-data-we-need-a-comment-on-the-state-of-the-divergence-debate-part-i/#comments.

Pritchett, L. (2000), "Understanding Patterns of Economic Growth: Searching for Hills among Plateaus, Mountains and Plains", *World Bank Economic Review*, 14, 221-250.

Ridolfi, L. and Nuvolari, A. (2022), "*L'histoire immobile?* A Reappraisal of French economic growth using the demand-side approach, 1280-1850", *European Review of Economic History*, 25, 405-428.

Schön, L. and Krantz, O. (2012), "The Swedish Economy in the Early Modern Period: Constructing Historical National Accounts", *European Review of Economic History*, 16, 529-549.

Schumpeter, J.A. (1934), *The Theory of Economic Development*, Cambridge MA: Harvard University Press.

Shi, Z. (2017), *Qingdai nongue de fazhan yu bufazhan, 1661-1911* (Agricultural Development in Qing China, a Quantitative Study, 1661-1911). Beijing: Social Science Literature Press.

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, 39, 312-320.

Takashima, M. (2017), "Keizai seichō no nipponshi: Kodai kara kinsei no chō chōki GDP suikei 730-1874" [Japan's History of Economic Growth: Utra-Long Term GDP

Estimation from Ancient Times to Early Modern Times 730-1874] , Nagoya: Nagoya University Press.

de Vries, J. (1994), "The Industrial Revolution and the Industrious Revolution", *Journal of Economic History*, 54, 249-270.

de Vries, J. and van der Woude, A. (1997), *The First Modern Economy: Success, Failure and Perseverance of the Dutch Economy, 1500-1815*, Cambridge: Cambridge University Press.

Walker, J.T. (2014), "National Income in Domesday England", in Allen, M. and Coffman, D. (eds.), *Money, Prices and Wages: Essays in Honour of Professor Nicholas Mayhew*, Basingstoke: Palgrave Macmillan, 24-50.

Wallis, P. (2019), "Apprenticeship in England", in Prak, M. and Wallis, P. (eds.), *Apprenticeship in Early Modern Europe,* Cambridge: Cambridge University Press, 247-281.

Wang, Y., Liu, C., Guo, S. and Lin, Y. (1991), *Zhongguo Tunken Shi: Vol 3* (History of Chinese Reclamation: Vol. 3), Beijing: Agriculture Press.

Weber, M. (1930), *The Protestant Ethic and the Spirit of Capitalism*, London: Allen and Unwin.

Wrigley, E.A. (1985), "Urban Growth and Agricultural Change: England and the Continent in the Early Modern Period", *Journal of Interdisciplinary History*, 15, 683-728.

Yang, C. (2022), "A New Estimate of Chinese Male Occupational Structure During 1734-1898 by Sector, Sub-sector Pattern, and Region", *Economic History Review*, 75, 1270-1313.

van Zanden, J.L. and van Leeuwen, B. (2012), "Persistent but not Consistent: The Growth of National Income in Holland, 1347-1807", *Explorations in Economic History*, 49, 119-130.

Zhai, R. (2023), "Toward the Great Divergence: Economic Growth in the Yangzi Delta, 1393-1953", D.Phil Thesis, University of Oxford.

de Zwart, P. and van Zanden, J.-L. (2018), *The Origins of Globalization: World Trade in the Making of the Global Economy, 1500-1800*, Cambridge: Cambridge University Press.