Seven Centuries of Economic Growth and Decline[1]

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Abstract

This paper investigates very long run pre-industrial economic development. New annual GDP per capita data for six European countries over the last seven hundred years paints a clearer picture of the history of European economic development. First, it confirms that sustained growth has been a recent phenomenon, but rejects the argument that there was no permanent growth in living standards before the Industrial Revolution. Instead, the evidence demonstrates the existence of numerous periods of economic growth before the nineteenth century - unsustained, but raising GDP per capita. Second, the data also shows that most economies experienced phases of economic decline. Third, from the nineteenth century, these economies started to reduce the risks of experiencing economic declines and to increase the chances of generating economic growth. Finally, analysis indicates positive relationships between levels of economic development, institutions and human capital formation, as well as population changes, and supports the expectation that civil wars harm economic growth.

JEL codes: N13, O11, E01

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1. Introduction

Conventional wisdom, mainly based on Angus Maddison's (1982, 1995, 2003) historical data, holds the view that "sustained growth has existed for at most the past two centuries, while the millennia prior have been characterized by stagnation with no significant permanent growth in living standards." (Hansen and Prescott 2002 p.1214-5). The implication is that European countries did not experience major phases of economic growth (or decline) prior to the Industrial Revolution. Yet, more qualitative accounts of European histories indicate that the Renaissance in Italy and the Golden Age in Holland reflected phases of economic development prior to the Industrial Revolution (Goldthwaite 2009, de Vries and van der Woude 1997). Thus, either conventional wisdom is incorrect or qualitative accounts are misleading.

Building in part on Maddison's bold empiricism, a generation of economic historians has been exploring archives and combining data sets to create more and better evidence on past economic development. Over the last four years, a number of new very long run time series have been completed, connecting the late medieval era with the present using annual data. This opens a new window on our understanding of very long run behavior and potentially of phases of economic growth and decline in history.

Following the publication of successive editions of Maddison's data (1982, 1995, 2003), understanding of long run economic growth and development advanced, as many economists exploited the new information (Baumol 1986, DeLong 1988, Pritchett 1997), which in turn stimulated new economic theories (Hansen and Prescott 2002, Galor 2005). The production of these new very long run data sets may spur an equivalent (or even greater) new wave of understanding of economic growth and development. In particular, for the first time, it is possible to investigate the annual changes in economic growth and development over more than 150 years, potentially identifying multiple major phases of economic growth and decline in one or a series of countries. Furthermore, comparisons of past experiences with more recent ones may suggest commonalities in the relationships with and determinants of economic development.

The new time series have been looked at individually by the researchers that produced the data (Broadberry et al 2011, Malanima 2011, van Zanden and van Leeuwen 2012, Schön and Krantz 2012, Alvarez-Nogal and Prados de la Escosura 2013, Reis et al 2013). Only Broadberry (2013) has begun to pull together some of this annual data, pointing out that the new evidence paints a very different picture to the one presented by Maddison's data. He focuses on explaining the Great Divergence between Europe and Asia and the Little Divergence between North-Western Europe and the rest of Europe from the sixteenth century, offering a broadly similar interpretation to Acemoglu and Robinson (2012). That is, he argues that economic structure and institutions determined how particular economies reacted to and were affected by the pivotal shocks (or critical junctures of Acemoglu and Robinson (2012)) associated with the Black Death in the mid-fourteenth century and the new trade routes between Europe, Asia and the Americas that opened-up at the end of the fifteenth century. Thus, to some, the shocks were curses; to others, they were blessings in the long run. The present paper complements Broadberry (2013) by incorporating two more very long run annual data sets and providing a more formal analysis of the data.

The first aim of the paper is to test the hypothesis that European economies were stagnant prior to the Industrial Revolution, by presenting the trends in per capita GDP over the last 700 hundred years in six European countries. An alternative hypothesis is that there were brief phases of growth in Italy and Holland (and more qualitative accounts are not misleading), but on the whole conventional wisdom holds. Another alternative is that, in fact, there were numerous phases of economic growth (and decline), and conventional wisdom is incorrect.

A secondary aim is to investigate whether any characteristics of growth rates have changed over the centuries. This investigation is inspired by studies of economic downturns, such as Acemoglu et al (2012, 2013), in which the risk of economic decline is related to growth rate distributions (referred to as aggregate volatility). Finally, the paper begins to analyze factors that were correlated with early European economic development and may have possibly influenced it.

The new evidence rejects the conventional wisdom about past European growth rates. Although it confirms that sustained growth was a recent phenomenon, it refutes the belief that economies were stagnant and that there was no permanent growth in living standards before the Industrial Revolution. Instead, the evidence indicates that periods of economic growth existed before the nineteenth century - unsustained, but often leading to long run increases in GDP per capita.

Second, the paper finds that the decline in risks of economic decline in the nineteenth century coincided with more peaked growth rate distributions. Indeed, from the nineteenth century, these economies started to reduce the risks of experiencing economic declines and to increase the chances of generating phases of economic growth. Finally, the paper estimates, as expected, positive relationships between levels of economic development, institutions and human capital formation, as well as population growth. Detailed data on shocks (including plagues, civil wars and major international wars) offers evidence that civil wars are highly disruptive to economic development, while plagues are not.

The next section presents the main data sources and methods used to construct the GDP per capita estimates from the late Medieval and early Modern era until nineteenth century in six European economies (England/Britain, Holland, Italy, Spain, Sweden and Portugal). The next section briefly outlines the trends in GDP per capita in the key European economies before the Industrial Revolution. Section four investigates the time series data – first, identifying broad trends in divergence and convergence of GDP per capita, second, identifying phases of economic growth and decline in specific countries, and, finally, analyzing the characteristics of growth rates over centuries and how they changed. This section helps to address the first two aims of the paper. The penultimate section considers the potential factors influencing pre-industrial European economic development and provides estimates of the relationship between log GDP per capita and explanatory variables. The final section pulls together the evidence and draws conclusions related to the four aims of the paper.

2. Data

This section provides an overview of the main data sources and methodologies used to construct the GDP per capita estimates from the late Medieval and early Modern era until the nineteenth century. There have been six original data sets constructed within the last four years. Each time series is for a different period and uses a different combination of methods to estimate output.

Three main methods have been used to construct historical estimates of GDP and GDP per capita – based on measures of income or of output, or using indirect methods. The first method involves estimating national income from data on individual incomes or, more commonly, wages – particularly by Clark (2007, 2010). However, when using wages, this approach needs to take account of changes in hours per day worked and days per year worked – or else, it offers only limited evidence on variation in living standards through time. A second approach is to estimate national income using output measures. This is the generally preferred approach, provided sufficient information is available on the main sources of production (De Vries and Van der Woude 1997 p.721, Maddison 2007 p.316-319, Broadberry 2011 p.2).

The third, and less reliable, indirect approach depends on modelling or proxies to generate indicators of economic output. Particularly for agricultural production, where demand is deemed to be relatively stable, a model of agricultural demand is used, building on original work by Crafts (1985) and Allen (2000). The exercise involves estimating per capita agricultural consumption based on a model of demand (including income and price elasticties) and data on consumer income levels and real prices of agricultural product and industrial products (as substitutes). Once estimates of agricultural consumption are generated, an assumption is made about imports and exports to calculate an estimate of agricultural production. For industry and service sectors, indirect production estimates often depend on long run trends in urbanization rates - Bairoch's (1988) data set of European towns greater than 5,000 inhabitants going back one thousand years is crucial for this approach. Urbanization rates offer an indicator of the share of non-agricultural activities, since town and city dwellers are not likely to be involved in arable or pastoral activities. Naturally, an indirect approach is generally only used when the other direct two approaches are not possible due to a lack of data. However, given the lack of detailed income and output data, and the growing demand for long run data, indirect methods are starting to be used more.

With an estimate of per capita agricultural output and of the share of non-agricultural (sometimes separated into industrial and service sector) output, it is possible to construct a GDP. This value is then divided by the geographical boundary's population to produce per capita GDP. This is naturally a gross simplification of the complexities involved in estimating historical GDP. For instance, great care is taken in selecting data sources and the assumptions made, as well as in ensuring that prices and basket of goods are comparable and benchmarked over time (Prados de la Escosura 2000, 2014). Again, the reader is directed to Appendix 1, and the original studies, for further detail.

Table 1 summarizes the sources, methods of data construction for agricultural and non-agricultural sectors and crude indicators of accuracy of the data. These indicators of the accuracy of the GDP per capita data are based on applying similar values to the ones presented in van Zanden and van Leeuwen (2012) according to the methodology used for estimating GDP in Holland in different periods.

It is hoped that the reader will get a sense of the mammoth task involved in creating these series. This includes identifying and pulling together hundreds of data sources and making difficult assumptions to generate estimates. For greater detail, the reader is encouraged to consult Appendix 1 or the original papers. Data for these countries (and many others) from the nineteenth century to the present are well known, and information about how they were constructed can be found in a number of sources – probably the most updated discussion of these sources, associated with the Maddison Project, is Bolt and van Zanden (2014).

The times series for GDP per capita in England runs from 1270 to 1700, then for Britain (i.e. England, Wales and Scotland) until 1870, and was produced by Broadberry et al (2011), building on numerous earlier efforts to construct estimates of British economic output, such as Deane and Cole (1967), Feinstein (1972) and Crafts and Harley (1992). The rich accounts of English and British economic history imply that the pre-1870 annual GDP estimates were constructed using an output approach, separated into the agricultural, industrial and service sectors. Broadberry and Klein (2011), for instance, offer estimates of GDP per capita in the United Kingdom (and all other European economies) from 1870 until the present.

Table 1. Methods* for Estimating GDP per capita in Selected European Countries

	Period	Agriculture	Industry	Service	Margin of Error**
England/Britain	1270-1870	Output	Output	Output/Proxies	<10%
Holland	1348-1510	Demand	Proxies	Proxies	<40%
	1510-1807	Output	Output	Output	<10%
Italy (Central & Northern Regions)	1310-1861	Demand	Proxies	Proxies	<40%
Spain	1254-1850	Demand	Proxies	Proxies	<40%
Sweden	1560-1800	Demand	Output	Proxies	<15%
Portugal	1500-1850	Demand	Proxies	Proxies	<25%

* This table offers only broad classification of methodologies used.

** The margins of error are based on applying similar values to the one presented in van Zanden and van Leeuwen (2012) according to the methodology used for estimating GDP in Holland in different periods.

Source: see Appendix.

GDP per capita for Holland from 1348 to 1807 were estimated by van Zanden and van Leeuwen (2012). These were linked to the Netherlands by identifying Holland's share in Dutch economy. The process of estimating Holland's GDP per capita can be separated into two periods: the more approximate estimates for the period between 1348 and 1510, which combines output measures for arable production with proxies for the other sectors, and the more reliable estimates for the period 1510 to 1807 undertaken using detailed output estimates for the agricultural, industrial and service sectors. As mentioned earlier, the authors present indicators of their confidence levels associated with the two main periods estimated (see Table 1).

The long run estimates of GDP per capita series for Central and Northern Italy start in 1310 and were constructed by Malanima (2011). The data is built by combining an indirect demand approach for agriculture with indirect output estimates for industry based on urbanization rates as a proxy. With an estimate of per capita agricultural output and of the share of non-agricultural output, it was possible to construct a GDP per capita series from 1310 until 1861. For consistency, this series is linked to a series for Central and Northern Italy from 1861, the year Italian unification (Daniele and Malanima 2007). While Bolt and van Zanden (2014 p.635) argue that they are a little overestimated, this series provides a valuable (and the only) indicator of long run growth rates related to Italy.

The GDP per capita estimates for Spain are presented in Alvarez-Nogal and Prados de la Escosura (2013). They run from 1270 until 1850. Given the lack of direct output indicators, the estimates were also based on a demand approach for agricultural products and indirect proxies (particularly urbanization rate, taking account of agro-towns) for non-agricultural production. Inevitably, the time series suffers from similar limitations that the Italian series does, despite different assumptions being made. This was the only country of the six presented where the authors were uncomfortable using and supplying annual data, because of the high degree of uncertainty about the estimates (see Table 1). Thus, for Spain, an 11-year average is used in the present paper (as it was in Alvarez-Nogal and Prados de la Escosura (2013)).

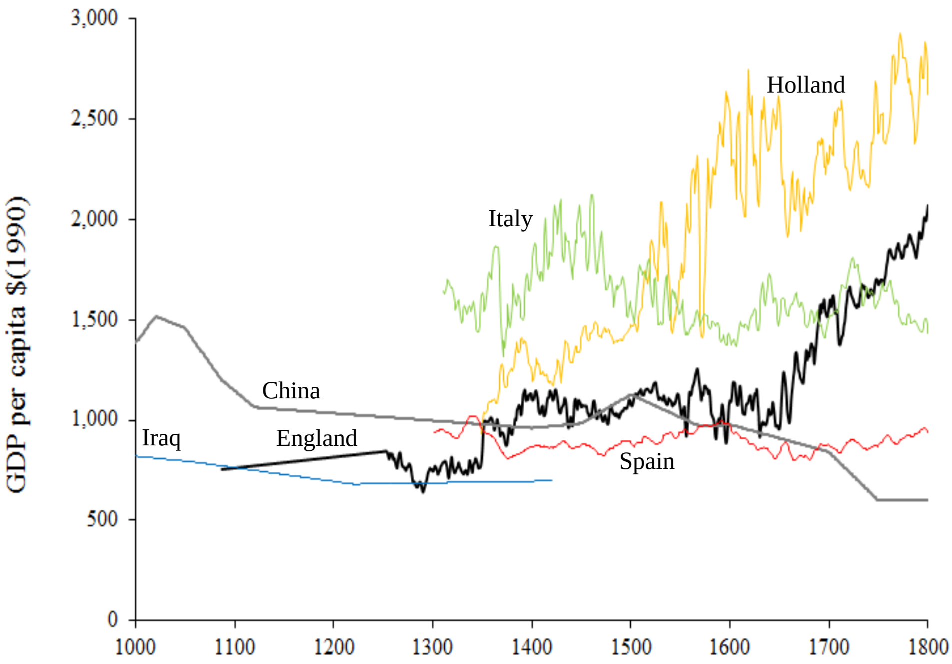
In Sweden, the times series for GDP per capita begins in 1560 and was constructed by Schön and Krantz (2012). The Swedish historical national accounts go back to 1800. Before that, there is only one year, 1571, for which detailed national accounts exist (Krantz 2004). Thus, efforts focused on constructing data between these periods. Because of the lack of evidence on agricultural production prior to 1800, a demand approach was used. Industrial production was based in part on output data. While there are substantial limitations with the data, including the shifts in geographical boundaries as the Swedish Kingdom changed, the combined time series offers a valuable indicator of the fluctuations in the economy’s phases of growth and decline.

The times series for Portuguese GDP per capita was presented in Reis et al (2013) and then modified in Palma and Reis (2014). The annual data series is from 1500 to 1850. Given the limited information about production, the GDP construction in Portugal followed the methodology developed for Italy and Spain. That is, agricultural output was estimated using a demand approach, and non-agricultural output was dependent on urbanization rate proxies taking account of the share of labor in agricultural and the productivity gap between agriculture and other sectors. For Portugal, however, there is a national account for the year 1515 providing a pivotal link between GDP in the nineteenth century and the distant past. Thus, the annual data on GDP per capita in Portugal can be considered more accurate than for Holland before 1510, Italy and Spain.

3. Trends in GDP per Capita

This section discusses briefly the trends in GDP per capita in key European economies. In particular, it briefly outlines factors that have been seen to influence these trends in Central and Northern Italy, Spain, Holland and England. The brief ‘economic histories’ of these countries after the eighteenth century and of Sweden and Portugal (i.e., the other two countries for which annual data is available) for the whole period are not included due to space limitations (see, for instance, Schön and Krantz (2012) about Sweden and Palma and Reis (2014) about Portugal).

Around 1000CE, China was probably the wealthiest economy in the world, on a per capita basis (Broadberry et al. 2014) – see Figure 1. Islamic economies had also probably been wealthier than European economies (Schatzmiller 2011) – around 760CE, Southern Iraq was estimated to have had a GDP per capita between $(1990)890 and $(1990)990, declining gradually in subsequent centuries (Pamuk and Schatzmiller 2014).



Source: see text; * 3-year average (Spain: 11-year average)

Figure 1. GDP per capita in Selected European* and Asian Economies, 1000-1800

3.1. Central and Northern Italy

Starting in the ninth century, a number of agricultural improvements imported from Islamic economies generated larger food production and surpluses in Europe (Mokyr 1990). These, in turn, led to rising populations across many parts of Europe. Agricultural yields in Italy doubled between the tenth and the beginning of the fourteenth century (Malanima 2009 p.6). While food surpluses lasted, they also generated more trade, wealth and social distinction.

For the wealthy, this was an opportunity to consume a finer and broader basket of goods and services. In particular, these wealthy consumers sought more diverse foods. Islamic economies offered a variety of spices, including pepper, cinnamon, saffron and ginger. They also produced a rich variety of smells and perfumes, such as camphor, myrrh, sandalwood and incenses. In return, Europe was supplying timber, iron, grain, meat and woolen cloth (Hodgett 2006 p.62). Thus, opening-up or improving trade routes was a source of new or cheaper products and, ultimately, economic growth.

Italian cities, especially Venice and Genoa, had trade links with the more economically vibrant Near, Middle and Far East (as shown in Figure 1). These links, especially with Constantinople, was strengthened as a result of the role of the Papal States in the Crusades. This also helped forge a mostly overland trade route with China (Hodgett 2006 p.63). By the beginning of the fourteenth century, when data on per capita GDP starts to become available for European countries, the Italian northern and central states had already achieved a higher income levels than other European countries, and perhaps anywhere in the world (see Figure 1).

During the medieval period, the Italian economy had shifted away from the rural feudal system towards a market economy (Malanima 2009 p.9). The high degree of urbanization, with many centers, promoted specialized and diverse commercial and industrial developments within a well-connected network of coastal waters, rivers and roads. Textiles activities, related to wool, cotton and silk, had expanded greatly.

Central to this growth was the opportunity for social mobility (Hodgett 2006 p.64) and developments in the banking system, which enabled savings to be distributed towards profitable activities and converted into capital (Goldwaite 2009). From the mid-thirteenth century, a network of Italian (mostly Tuscan) banks was developed to support Italian merchants across Europe, particularly in France, Flanders and England (Nicholas 2009).

In the 1340s, the Black Death considerably reduced the population across Italy (and the rest of Europe). This reduced resource demands and led to a decline in the demand for money and interest rates, boosting the economy in the first instance. In addition, after the Black Death, unproductive lands were abandoned. Thus, the combination of increasing land productivity, increasing industrial production and expanding commercial networks, all supported by improving credit markets, increased per capita income from around $(1990)1,500 to nearly $(1990)2,000 between 1350 and 1450 (see Figure 1).

Also, after the Black Death, the main cities sought to expand their reach, creating individual regional or city States (Florence, Venice, Milan and Genoa). This led to a concentration of political and economic power, generating intense rivalries and competition (Malanima 2009 p.14). As population grew in the fifteenth century, less productive lands were increasingly being used again. By then, the agricultural system was starting to stagnate and income levels began to fall (see Figure 1).

3.2. Spain

Spain has been considered one of the leading economies in the medieval and early modern era. Before the Black Death, Spain was probably the European economy with the second highest per capita income – though far behind Central and Northern Italy (see Figure 1). Like Italy, the economy was predominantly driven by trade, especially with the presumably wealthier North African cities and the Near East (Schatzmiller 2011).

However, after the Black Death, and turmoil caused by the Hundred Years War, particularly during the second-half of the fourteenth century, it lost its pre-eminence. While other European economies per capita income grew in the second half of the fourteenth century, Spain's level fell considerably. The explanation for the negative impact upon Spanish per capita GDP is that it was a frontier economy (Alvarez-Nogal and Prados de la Escosura 2013 p.2). That is, during and following the Reconquista, population and labour was in short supply. When the Black Death struck, population fell below a threshold level for ensuring sufficient per capita production. This threshold level may have been necessary to maintain national and international commercial networks (Alvarez-Nogal and Prados de la Escosura 2013 p.19).

During the fifteenth and sixteenth century, Spain was in a similar output per capita range as England. Its economic expansion resulted from a growth in wool production, aided by the availability of land, and manufacturing of textiles for the industrial urban population and international markets (Alvarez-Nogal and Prados de la Escosura 2013 p.19).

Then, between 1490 and 1590, the colonization of Latin America and the associated international trade boosted the economy further. However, the increase in silver production from the colonies triggered a form of resource curse (or Dutch Disease), in which the value of the Spanish currency soared in the mid-sixteenth century. Lasting several decades, this led to a major decline of the increasingly expensive Spanish wool exports (Drelichman 2005 p.374).

The lack of international demand for its products forced the economy to turn inwards. This was coupled with a growing burden associated with the management of the colonies. These mounting costs forced the Spanish government to impose raise taxes, which indebted many previously prosperous towns. This pushed the population away from the cities towards the land (Alvarez-Nogal and Prados de la Escosura 2013 p.20). During the seventeenth century, per capita income fell (see

Figure 1). It only started catching-up with other European economies during the nineteenth century.

3.3. Holland

In Europe, the next economic breakthrough occurred in Holland. The evidence suggests that, after the Black Death, until the early seventeenth century, Holland expanded greatly, nearly tripling its per capita GDP (see Figure 1). In particular, during the period between 1540 and 1620, Holland experienced a surge in technological change and, by then, had developed numerous traits of a modern economy (van Zanden and van Leeuwen 2012).

The current series of explanations for the transformation from a poor rural agrarian economy to a prosperous urbanized economy based on industry and trading is a combination of ecological crises and labor shortages (van Babel and van Zanden 2004). Relatively high wages encouraged searches for labor-saving devices and capital-intensive approaches to all economic activities. In the fourteenth and fifteenth century, rising water tables and subsiding peat soils limited its ability to produce grain, particularly for bread. Savings tended to be invested in livestock and in proto-industrial activities in rural areas (van Babel and van Zanden 2004 p.505).

By the beginning of the sixteenth century, only one quarter of the work force was involved in agriculture, with another 12% in fisheries and 3% in peat digging; 38% were in industrial activities, especially textiles, metal-work and brewing; the rest provided mostly trade and transport services (van Zanden 2003 p.1016). Between 1300 and 1500, the urbanization rate increased from 15% to 45% (van Babel and van Zanden 2004 p.504). It specialized in the production of higher-value foods, such as butter, cheese, herring and beer, as well as textiles and construction goods, including bricks and tiles. These were goods in high demand by an increasingly wealthy middle-class. Yet, the lack of local nobility in Holland had implied that much of these goods had also been for export markets.

The Dutch maritime tradition and its improving ability to harness winds on its sailing ships meant that these products were competitive across much of Europe (van Zanden 2003 p.1019). During the second-half of the fourteenth century, a large trade developed with cities in the Baltic which could supply agricultural products in return, reducing land pressures in Holland (van Zanden 2003 p.1022). In other words, the economy in Holland was able to transform itself from a closed agrarian economy to a trading and industrialized economy.

3.4. England

The early periods of growth in England were associated with its development of a cloth industry. For centuries, England had manufactured its own woolen cloth, which was considered of high quality but relatively expensive (van der Wee 2003). However, by the thirteenth century, England had become a major exporter of wool, especially to Flanders, which was very efficient in the production of textiles, and then importing much of its demand for manufactured woolen textiles (Carus-Wilson 1950 p.164). Following a series of wars, in the second half of the fourteenth century, the English woolen textile manufacturers began regaining their market and even started exporting textiles, particularly to Gascony, which sold wine in return (Carus-Wilson and Coleman 1963). By the sixteenth century, England had fully converted to a cloth manufacturing and exporting economy. Increases in England's per capita GDP around the 1370s and the 1480s can be discerned from Figure 1.

The sixteenth century saw the expansion of the two other pillars of economic growth in England, iron and coal. In the 1490s, a number of French Huguenot families, escaping religious repression, settled in the Weald. They introduced the furnace, which produced faster, cheaper and generally better quality iron. Pig iron production in the Weald, which centered on meeting military demands for canons and cannon balls, increased 28-fold between 1530 and 1590 (King 2005 p.7). Furnace pig iron production outside the Weald, which provided tools and smaller items, took-off, and, throughout England, pig iron production increased 30-fold between 1540 and 1620 (King 2005). Since the sixteenth century, many ironmasters had tried to use coal-based fuels to smelt iron, but the fuel needs had made coke iron too expensive, except for specific purposes (King 2011 p.139). Improvements in the efficiency of coke-iron furnaces transformed the industry in the second half of the eighteenth century, reducing variable costs of production and increasing the incentive to build coke iron furnaces – between 1755 and 1760, coke pig iron production tripled, and more than doubled between 1760 and 1780 (King 2005).

The third pillar, which fuelled the iron industry and the cotton industry during the Industrial Revolution, was the coal industry. Yet, the introduction of mineral fuels reduced the burden imposed by a constrained land on a growing population with rising standards of living from the sixteenth century (Allen 2009). As the price of woodfuels rose in London, shipments down the East coast grew substantially throughout the sixteenth century. With rising incomes, as well as improvements in the grates and fireplaces necessary to burn coal in homes, demand grew rapidly (Fouquet 2008). From the fifteenth century to the end of the seventeenth century, the coal mining industry expanded from a niche business to one of the major generators of wealth in the North-East of England (Hatcher 1993). Despite only a few technical improvements in production methods, large and accessible reserves, a diversity of types and qualities of coal, a big labor force to draw from and improving means of transportation, enabled coal supply to expand in line with the growing demand (Church 1987). This ensured that real prices remained relatively stable from the fifteenth to the nineteenth century. The ability to meet highly elastic demands for energy-intensive products and energy services over hundreds of years was arguably Britain's ascendency (Allen 2009).

4. The Dynamics of Economic Growth and Decline

This section examines the data in more detail. It goes from broad observations to specific observations. That is, the broad trends about divergence and convergence are noted first, then, periods of economic growth and decline in specific countries are considered, and, finally, the characteristics of growth rates over time are analyzed. These also reflect the degree of reliability of the observations – broad trends can be accepted, however, care should be taken about identifying growth rates in specific years or even decades.

This section addresses more specifically the first two aims of this paper. The existence of stagnancy in pre-nineteenth Europe can be tested by examining growth rates – identifying major phases of economic growth would reject the stagnancy hypothesis. The question about changes in growth rate characteristics over time can be investigated by comparing the likelihood of economic growth and risks of economic decline with growth rate distributions in different centuries. These two aims will be addressed in sub-sections 4.2 and 4.3.

4.1. Divergence and Convergence

Before addressing these aims, this sub-section will comment on convergence of GDP per capita in the very long run, which is a central question in the literature on economic development. The classic Solow (1956) model predicts convergence of less-developed economies with industrialized economies (Mankiw et al 1992). While some economies have caught-up, many have remained lesser developed and fallen behind relative to the leading economies (Easterlin 1981, Abramovitz 1986, Pritchett 1997).

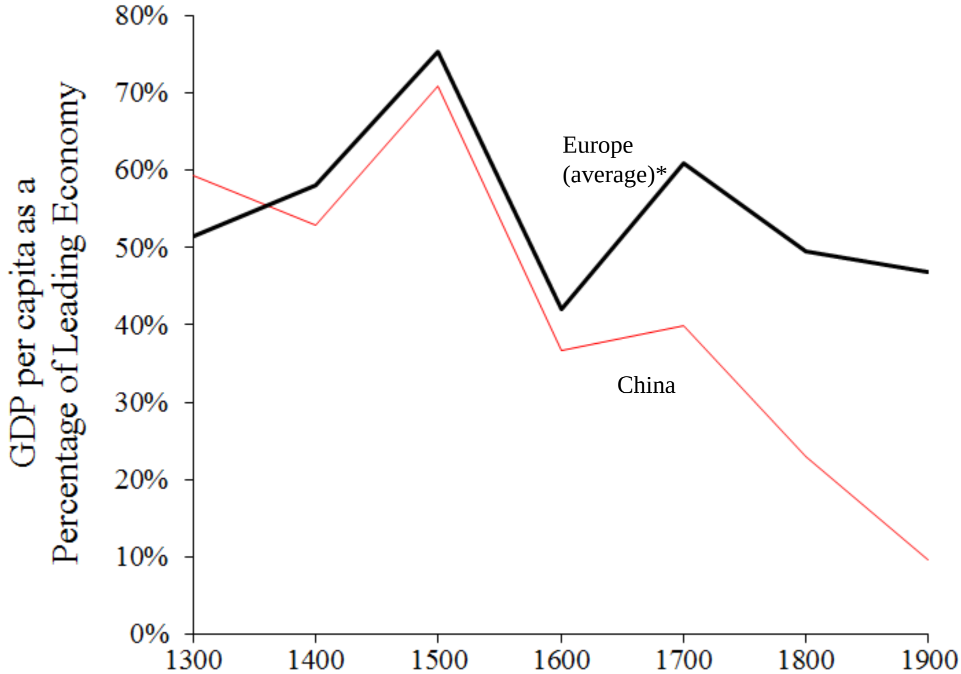
Table 2 shows the relative position (as a percent of the leading economy's GDP per capita) of twelve economies in Europe and Asia (for which very long run data is available, though not necessarily on an annual basis) since 1300. It indicates that phases of divergence are associated with a new economic leader – Figure 2 summarizes the information. The fourteenth century was probably the beginning of a phase of divergence associated with Central and Northern Italy's rise. By 1600, Holland was the new leading economy and the average relative level of followers declines, suggesting divergence. In 1800, England was catching-up with Holland and taking-over shortly afterwards, thus, divergence occurred in 1800 and was accentuated in 1900. Phases of convergence reflect the process of other economies learning from the leader and perhaps gaining from spillovers, and the stagnation of the leader.

Table 2. Relative Levels of GDP per capita in European and Asian Economies, 1300-1900

	1300	1400	1500	1600	1700	1800	1900
Italy	100%	100%	100%	53%	72%	54%	45%
Holland/NL		66%	92%	100%	100%	100%	58%
England/Britain	46%	61%	68%	41%	75%	80%	100%
Spain	57%	48%	56%	37%	42%	36%	31%
Portugal			70%	35%	43%	38%	23%
Sweden				38%	85%	44%	49%
Germany			85%	36%	53%	45%	52%
France			64%	38%	52%	44%	50%
Belgium			92%	59%	66%	56%	66%
Europe (ave.)	**52%**	**58%**	**75%**	**42%**	**61%**	**50%**	**47%**
India				26%	30%	22%	10%
Japan	31%	29%	34%	22%	30%	25%	21%
China	59%	53%	71%	37%	40%	23%	10%

Source: see text; for Germany (Pfister 2011), France (Alvarez-Nogal and Prados de la Escosura 2013 – see also Squicciarini and Voigtländer 2014), Belgium (Buyst 2011), India (Broaderry and Gupta 2012), Japan (Bassino et al 2012), China (Broadberry et al 2014).

With evidence for only a sub-set of economies, a historical analysis of divergence and convergence may suffer from the problems seen in Baumol (1986) – see Delong (1988). Because many economies are not included, and most of these probably were on the low end of the income scale (similar to Japan's level in Table 2), it is unclear whether conclusions can be drawn at a global scale. However, the data availability does not reflect relative success, as some economies fell behind in particular phases. Thus, focusing on specific regions, such as Europe, Figure 2 shows cycles of divergence (fourteenth, sixteenth and eighteenth centuries) and convergence (fifteenth and seventeenth centuries) over the very long run.



Source: see text; * Excludes the leading economy: Italy 1300-1500; Holland 1600-1800; UK: 1900

Figure 3. GDP per capita in Europe and in China relative to the Leading Economy, 1300-1900

Whether this has any universal validity would be interesting to explore. However, this is probably only a regional rather than global phenomenon. The periods of converging appear to have been associated with periods of economic stagnation or even decline of the leading economies (to be discussed in the next section). This may be a tendency of leading economies in the long run, which has major implications for today's leading economy. However, as Pritchett (1997) deduced, many economies with missing data are low income economies with little growth, thus, they were not converging, just falling behind at a faster or slower rate depending on the period.

Another issue of interest is the extent to which economies were able to catch-up with and overtake competitors. A common problem lesser developed economies have suffered from is poverty traps. Building on Quah (1996, 1997), an income mobility matrix is estimated for nine European economies between 1500 and 1800 (Table 3). The ranking of each economy (in terms of their per capita income) are identified every fifty years, their ranking at the beginning and at the end of every fifty years is noted and the frequency of movement between ranks is estimated.

Table 3. Income Mobility Matrix in Europe, 1500-1800

	1	2 and 3	4 and 5	6 and 7	8 and 9
1	83%	17%	0%	0%	0%
2 and 3	17%	50%	33%	0%	0%
4 and 5	0%	17%	33%	42%	8%
6 and 7	0%	17%	17%	33%	33%
8 and 9	0%	0%	17%	25%	58%

Note: rows indicate original year (e.g. 1500); columns indicate final year (e.g. 1600).

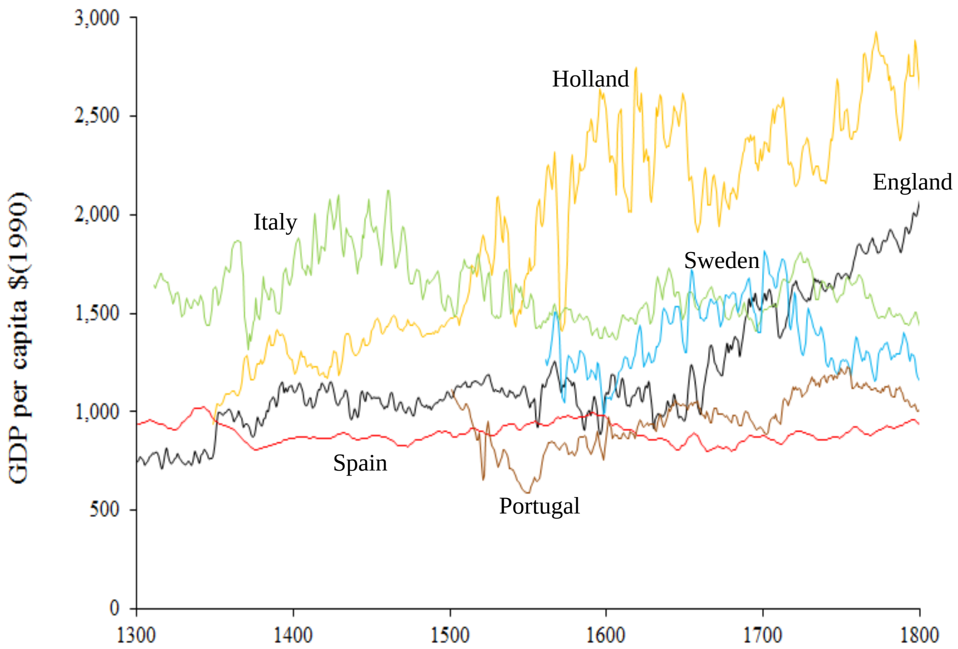
The income mobility matrix confirms Quah's (1993, 1996, 1997) results. First, there was strong polarization. Holland became the wealthiest economy in 1550 and remained the wealthiest throughout the period. Economies can take over the lead, as Holland overtook Italy in the early sixteenth century, as Britain overtook Holland in the ninteteenth century and as other economies overtook Britain in the twentieth century. Nevertheless, the position of wealthiest economy appears to have been a dominant and relatively stable position.

Second, similarly, the poorest economies have tended to remain the poorest 58% of the time. This suggests that at the European level an element of a poverty trap exists. For instance, Spain remained in eighth or ninth position from the sixteenth to the nineteenth century. However, it was not necessarily a permanent trap. Moving upwards was possible. Nevertheless, it took England, in the fastest of accelerations, more than a century to move from the bottom fifth to the second or third position. Third, there was also some additional stratification. Economies in the second and third position remained there 50% of the time. Yet, clearly, the other 50% of the time, these economies slipped downwards or, in the case of Holland moved upwards, this is not a stable position. Fourth, more generally, there was considerable mobility amongst middle income economies. There was a flux of downward and upward movement amongst the middle-income economies. Thus, to reiterate, European history of economic development indicates that poverty and wealth traps existed, with considerable opportunity for mobility amongst middle income economies with successful phases of economic growth.

4.2. Phases of Economic Growth and Decline

Having seen some evidence of divergence and convergence, and relative mobility especially amongst middle income countries, this sub-section tests the stagnation hypothesis. It looks for evidence of minor and major phases of economic growth and decline. By identifying major phases of economic growth, the stagnation hypothesis would be rejected. Furthermore, by estimating the likelihood of experiencing phases of economic growth and the risks of economic decline, this sub-section builds the evidence on the relationship between economic decline and growth rate characteristics.

Figure 3 presents GDP per capita in the six economies for which there are annual data estimates. It clearly shows phases of economic and decline, suggesting that economies were not stagnant before 1800.



Source: see text; * 3-year average

Figure 3. GDP per capita in Selected European Economies, 1300-1800

Using the Penn World Tables, Hausman et al. (2005) found 80 phases of rapid economic growth lasting at least eight years. This implies that, in the second half of the twentieth century, a country had a 25% chance in any decade of experiencing a phase of rapid growth. These phases tended to be associated with rising investment and trade, and real exchange rate depreciations. They also found that regime transformations tended to lead to sustained growth, while external shocks did not. However, ultimately, most phases were not predicted by any of the selected key factors, thus, the phases of rapid economic growth remain highly unpredictable processes.

This section will seek to contribute to this literature by comparing phases of economic growth in different centuries, as well as phases of economic decline. Different criteria for identifying phases of economic growth can be used. These include the number of years of uninterrupted growth, or the number of years with more than 0.5% or 1.5% or even 5% growth in a decade. Easterly (2006) defines a 'take-off' as a period of stagnation (i.e., less than 0.5% annual growth rate) followed by a series of years of annual growth rates of 1.5% or more. Naturally, given the methods used to generate the data, one should be careful about making any more than very broad comparisons. Also, averages across economies in specific centuries can hide very different trajectories.

Table 4. Periods of Economic Growth and Decline, 1300-2000

	1	2	3	4	5	6	7
	% of Years in 4 years consecutive 0.5% annual growth rate	% of Years in 4 years consecutive 1.0% annual growth rate	% of Years in 4 years consecutive 1.5% annual growth rate	No. of Phases of 4 years consecutive 0.5% annual growth rate	No. of Phases of 4 years consecutive 1.5% annual growth rate	% of Years in 3 years consecutive -1.5% annual growth rate	No. of Phases of 3 years consecutive -1.5% annual growth rate
1300s	6.3%	3.0%	1.1%	3	1	1.6%	2
1400s	3.0%	2.0%	1.0%	3	1	8.0%	10
1500s	5.2%	3.2%	2.3%	7	3	8.7%	14
1600s	5.2%	1.3%	1.3%	8	2	4.3%	9
1700s	5.8%	3.8%	1.3%	8	2	5.8%	12
1800s	18.0%	9.2%	5.3%	25	8	2.0%	4
1900s	54.7%	47.7%	40.0%	38	38	3.2%	4

Source: see text.

Table 4 presents, in column 1-3, the percentage of years and, in column 4-5, the number of phases of economic growth in the six European countries. A series of four years of uninterrupted annual growth of at least 0.5% (column 1), 1.0% (column 2) and 1.5% (column 3) will be the criteria for identifying periods of growth. For the six countries analyzed, as conventional wisdom has argued, there is a substantial difference between the pre-1800 period, the nineteenth century and the twentieth century. Each criteria (and column) show that there were considerably more phases of economic growth in the nineteenth century than before. Yet, using the criteria of more than 1.5% annual growth rate in four consecutive years indicates that only 5% of the years in the nineteenth century were phases of economic growth (compared with about 2% before - it should be remembered that there is less data for Holland in the fourteenth century, and no data on Sweden and Portugal until the sixteenth century). The twentieth century stands out – 40% of the time economies were in phases of growth. Thus, in broad terms, sustained economic growth is a twentieth century phenomenon.

However, in general, identifying phases of growth appears more difficult when analyzing mostly agrarian economies or periods before reliable statistical records existed. Because of the high volatility in the GDP per capita series, either because of climate-sensitive agricultural production or the estimation methods, these criteria are not as effective.

In search of major phases of economic growth before the nineteenth century to test the stagnation hypothesis, Table 5 identifies four 'golden ages' in which specific European economies flourished. Here, the criterion was a minimum total growth in per capita GDP of 40% in any fifty year period. While some might argue that, starting from a low base, a rise of 40% is not a great absolute increase, and not very impressive when observed over fifty or more years. Nevertheless, a long run increase in income per capita of 40% must be seen as a major improvement in standards of living in any century (although ideally distributional effects of this increase should be taken into account).

To ensure that this was not an artifact of selecting peaks and troughs in volatile series, the total growth in GDP per capita is measured as the average value in the decade following the 'golden age' divided by the average value in the decade preceding this phase. Again, one should be careful about over-interpreting the exact values. Nevertheless, these are unquestionably extended periods (of between 40 and 90 years) in which economies grew substantially in absolute terms, and can be seen clearly in Figure 3 – in other words, European economies between 1300 and 1800 were not stagnant.

Between the fourteenth and eighteenth century, Italy can be seen as the first economy to have experienced a 'golden age'. From 1350 and 1420, the level of per capita income rose by 40%, achieving a modest but non-negligible 0.8% per year over 70 years. Holland followed with a spectacular sixteenth century – per capita GDP rising by 70%, managing 1.3% per annum between 1505 and 1595. A decade later, Sweden started developing and its per capita GDP grew 41% in the first half of the seventeenth century. In the second half of the century, England became the next vibrant economy - its per capita income growing by more than 50%. It is worth noting that this phase of growth preceded the civil war and preceded the Glorious Revolution, seen as a crucial juncture in which an institutional transformation laid the foundation for economic growth (Acemoglu and Robinson 2012).

Table 5. Golden Ages in European Economies, 1300-1800

Country	Period	Total % Growth in GDP per capita*	Annual % Growth Rate in GDP per capita*
Italy	1350-1420	40%	0.8%
Holland	1505-1595	70%	1.3%
Sweden	1605-1655	41%	0.7%
England	1650-1690	52%	1.3%

Source: see text.

* Average level of GDP per capita in decade following period divided by average level of GDP per capita in decade preceding period.

Interestingly, during almost the entire sixteenth and seventeenth centuries at least one economy was flourishing. It would be worth investigating in greater detail the scale of spillovers to trade partners and the degree of emulation in these early periods (Reinert 2011). Certainly, there is evidence that England was highly dependent on imports of Swedish iron in the sixteenth century (King 2005) and seeking to emulate Holland's economic policies (Thirsk 1976).

Turning now to periods of economic decline, column 6 and 7 of Table 4 offer some evidence. Using a criterion of three consecutive years of less than -1.5% growth rates identifies a number of phases of economic downturn. In these six countries, there were 47 downturns before the nineteenth century, and only 8 after 1800. Between the fifteenth and eighteenth century, there was an average of two economic downturns per country per century. The nineteenth and twentieth centuries experienced less than one economic downturn per country per century. However, in percentage terms, these are not drastically different. In the fifteenth and sixteenth centuries, economic downturns occurred about 8% of the time; in the seventeenth and eighteenth centuries, they were experienced between 4% and 5% of years; and, in the nineteenth and twentieth centuries, downturns occurred 2-3% of the time (which is more often than in the thirteenth century). So, there appears to have been a reduction in the likelihood of experiencing downturns over the centuries (from the fifteenth century), however, the rarity of the events implies the percentage reduction is modest.

Table 6 identifies the economic 'dark ages' – that is, periods of major economic decline. Here the criterion is a decline of more than 16%, which would imply a substantial decline in living standards. Italy was suffered most from periods of major economic decline, from its early period of glory. It experienced three periods of substantial decline (i.e., of around 20%). Portugal suffered a dramatic collapse (around 40%) in the first half of the sixteenth century – though it recovered partially in the subsequent two decades. The Spanish economy also declined from the end of the sixteenth century. Sweden also suffered a collapse in the early eighteenth century, dropping almost 30% in three decades.

Table 6. Dark Ages in European Economies, 1300-1800

Country	Period	Total % Growth in GDP per capita*	Annual % Growth Rate in GDP per capita*
Italy	1470-1495	-19%	-0.8%
Portugal**	1510-1540	-40%	-1.3%
Italy**	1520-1600	-20%	-0.3%
Spain	1590-1640	-16%	-0.3%
Sweden	1710-1740	-28%	-0.9%
Italy	1730-1790	-21%	-0.4%

Source: see text.

* Average level of GDP per capita in decade following period divided by average level of GDP per capita in decade preceding period.

** The economy grew subsequently, though did not recover to the level of GDP per capita at the beginning of the period for more than one century after the end of the period.

There is little understanding of major economic collapses, especially since they are such rare events. In Anna Karenina, Leo Tolstoy proposes that "[a]ll happy families are alike; each unhappy family is unhappy in its own way." It may indeed be the same with economies. Certainly, there has been plenty of effort to find in what way successful economies are alike, but little to understand the ways in which unsuccessful economies decline. Acemoglu and Robinson (2012) have argued for the fundamental impact of the lack of inclusive and tendency of extractive institutions in economic decline. These events deserve more analysis to complement studies of economic failure such as Easterly and Levine (1997) and Rodrik (1999).

4.3. Growth Rates and their Distribution

This sub-section explores the characteristics of growth rates, and how they changed over the centuries. It begins to investigate the relationship between growth rate distributions and the probability of growing or declining, in the spirit of studies of economic downturns, such as Acemoglu et al. (2012, 2013).

Easterly et al. (1993) pointed out that growth performances have tended to be highly unstable. Especially at low levels of economic development, countries experience phases of growth, stagnation, or decline of varying length – and can be characterized as hills, plateaus, mountains, cliffs, plains and valleys (Pritchett 2000). Indeed, he noted that "the rule of growth in developing countries is that anything can happen and often does" (p.247).

This section explores the estimates of growth rates in European economies before the nineteenth century shown in Figure 3 and compares them with later periods. The previous section showed that while some economies were developing, others were regressing. Thus, aggregation of economies in particular centuries does risk losing a great deal of information. Nevertheless, while the growth rates are partly artifacts of the methods used to estimate the GDP per capita levels discussed in Section 2, an analysis can offer some insights into the nature of long run economic growth, and improvements in the ability of economies to achieve sustained growth.

Figure 4 presents a series of historical growth rate distributions. In Figure 4(a), distributions appear to have shifted modestly downwards from 1300s to the 1400s and became somewhat less peaked from the 1400s to the 1500s and the 1600s. Then, in Figure 4(b), the growth rates became more peaked in eighteenth century and shifted rightwards in the nineteenth century and especially in the twentieth century. It could be proposed that the economies in the late medieval era were growing in a relatively stable manner and the transformations and upheavals in the early modern era led to less coherent patterns of growth, from which it took several centuries to recover. While each century's distribution is based on more than 500 observations, from the sixteenth century, care should be taken about over-interpreting these trends. An alternative explanation is that incorporating the distribution from more economies (from four to six in the sixteenth century) implies greater distribution. Also, given that the differences in distributions are not very large, one should be wary of drawing conclusions about the impact of shocks (such as plagues, civil and international wars or other factors) and of changing economic or political systems (e.g., from feudal to modern economies) on the basis of these modest changes in growth rate distributions.

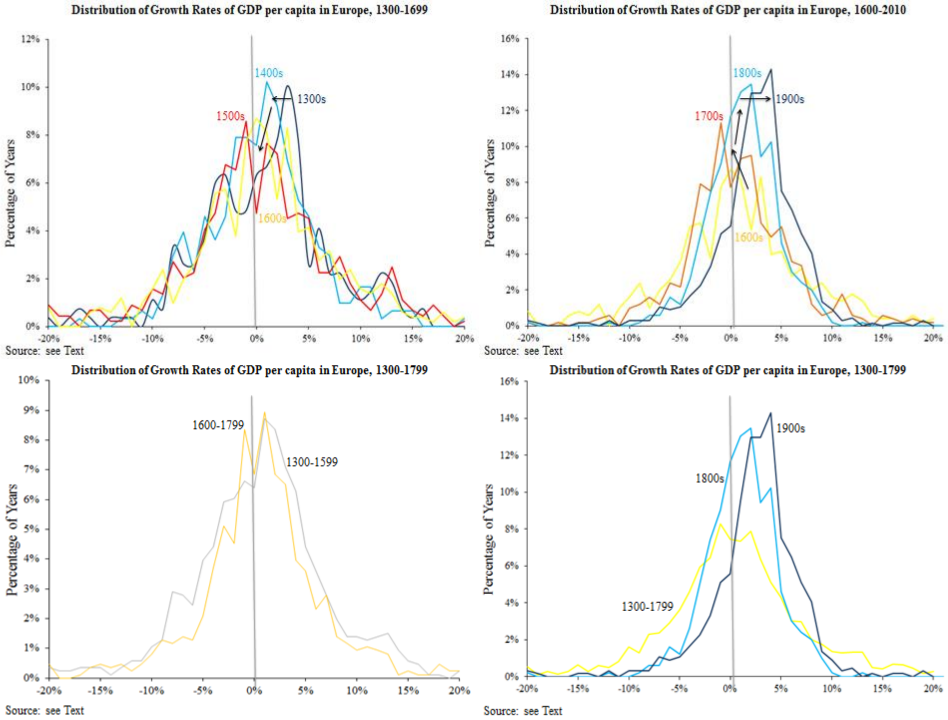


Figure 4. Distribution of Growth Rates in European Economies (a) 1300-1699, (b) 1300-2010, (c) 1300-1799, (d) 1300-2010

Figure 4(c) compares the growth rate distributions in the fourteenth to sixteenth centuries with those in the seventeenth and eighteenth centuries. There is little difference in distributions. More striking is Figure 4(d), which offers a similar but clearer picture to 4(b), comparing the pre-nineteenth century growth rates with the nineteenth and twentieth century. Based on more than 2,500 observations, the 1300-1799 distribution indicates a saddle-point with a slightly negative and a positive peak frequency, and broad range of both positive and negative values. The nineteenth century distribution shifted to the right (i.e., more positive values) and was more peaked. The twentieth century distribution shifted further to the right and was even more peaked – the shift in mean values is shown in column 1 of Table 7. Thus, while there were relatively more years with high growth rates (e.g., above 10% per year) before the nineteenth century, one can comfortably conclude that growth rates in the nineteenth century and especially in the twentieth century were more concentrated on low but positive values. Thus, when compared with column 6 and 7 of Table 2 on the number and probability of economic declines, this offers evidence that flatter distributions (i.e., less kurtosis) are indeed associated with a greater likelihood and severity of economic declines.

At the same time, care should be taken in interpreting distributions and their moments. For instance, the standard deviation for the twentieth century is one of the highest in the last seven hundred years, partly because of the high growth rates associated with rebuilding after World War II (see Table 7). As a result, the distribution in the 1900s was highly skewed to the right (i.e., towards high positive values in column 3). Nevertheless, it did not suffer from kurtosis – its high value (column 4) indicates it was very peaked.

Table 7. Means, Standard deviations, Skewness* and Excess Kurtosis**

	1	2	3	4
	Mean	Standard Deviation	Skewness	Excess Kurtosis
1300s	0.5%	0.07	0.7	4.2
1400s	0.2%	0.06	1.2	6.2
1500s	0.5%	0.10	2.1	28.2
1600s	0.4%	0.08	1.3	7.8
1700s	0.2%	0.05	0.3	2.1
1800s	0.5%	0.03	0.3	0.7
1900s	2.3%	0.06	3.1	33.7

Source: see text.

* ‘Skewness’ identifies the symmetry of the distribution; a negative value indicates the left tail (i.e., negative values) is long relative to the right tail, and vice versa.

** ‘Kurtosis’ measures the width of a random distribution compared to that of a normal distribution with the same mean and variance. For a standard normal distribution, the value is three. ‘Excess Kurtosis’ is the kurtosis value minus three, so, a normal distribution has an ‘excess kurtosis’ of zero. A distribution with a positive (excess) kurtosis will have a sharper peak, while a negative value will imply a flatter peak.

5. Drivers of Levels, Growth Rates and Phases of Growth

5.1. Determinants of Historical Economic Development

This section describes the hypothesized impact of explanatory variables on the level of economic development in Europe from the late medieval period to the beginning of the Industrial Revolution. The objective is not to generate conclusive evidence on the causes of economic growth and development in Europe from the fourteenth century onwards or to offer policy recommendations about how to enable today's developing economies to converge on industrialized economies. Instead, it only seeks to begin the analysis of much longer run time series and panel data than has been traditionally used in the literature on economic growth and development.

A vast literature has tried to identify the approximate and root causes of economic growth based on empirical evidence (Durlauf et al 2006). The current convention is to focus on levels of economic development rather than on growth rates. A central problem with the growth empirics is the high volatility of growth rates (as demonstrated in the previous section).

The framework in this paper builds on conventional studies of economic development, such as Rodrik et al (2004). Economic development is often measured as the natural logarithm of the level of GDP per capita, y_{it} (where i represents the country and t indicates the year). In their framework, a central role is given to indicators of institutional quality, I_{it}, as explanatory variables. Many studies of the history of economic development have emphasized the importance of institution quality (Acemoglu et al. 2002).

A number of other variables have also been seen as crucial for economic development. Changes in population, $DPOP_{it}$, can affect GDP per capita. The obvious way is that rising population lowers the overall economic output per person. Indeed, this has been central to the Malthusian tension. Unified Growth Theory has emphasized population pressures and the process by which economies extricate themselves (Galor 2005). There is first a transition to a post-Malthusian regime where both population and GDP per capita increase, and then a transition to a modern economic growth regime where there is no longer any relationship between economic development and population. Thus, the role of changes in population levels is likely to change through time – at some point, rising population should no longer have a negative impact on GDP per capita.

However, rising population may also boost an economy. First, greater populations imply larger demand. Meeting larger demands leads to economies of scale in production. Larger production may also enable firms to increase Smithian division of labor. So, there might be a link between larger populations and lower costs of production, thus, suggesting possibly also a positive relationship between changes in population and GDP per capita.

A central aspect of the process related to extricating an economy from Malthusian pressures is the ability to improve skills and the stocks of human capital, HK_{it} (Galor 2005). More generally, human capital has tended to have a strong influence on more recent regional economic development (Becker and Woessmann 2009, Dittmar 2011, Gennaioli et al 2013).

Determinants of the past may have been different from today's industrialized economies, however. For instance, here, it is proposed that shocks (such as plagues, civil wars and large international wars) may have had a significant impact on early economic development in Europe. There is evidence from the more recent past in developing economies that disasters can hinder growth. Interestingly, the impact of shocks can decline with improvements in institutional structure and human capital (Noy 2009). In fact, there is evidence that relatively high rates of mortality may have had a positive long run effect. Urbanization-related diseases and wars meant that European economies experienced high wage rates, which led them to find solutions to their factors of production problems, thus, stimulating economic development (Voigtländer and Voth 2013). In the present paper, shocks, S_{it}, are also given a prominent position, as it is suspected that they affected economic development, at times, limiting economic development and, at different times, boosting it.

Other explanatory variables, X_{it}, such as the costs of domestic and international transport, may also be expected to have an influence on economic development.

The model can be represented as:

$$y_{it} = I_{it} + DPop_{it} + HK_{it} + S_{it} + X_{it} + \varepsilon it \qquad (1)$$

A central question in this study is whether the impact of the explanatory variables (e.g., institutional quality, changes in population, human capital, shocks and other variables) remained constant through time. Indeed, as discussed above, a number of potential explanatory variables (e.g., changes in population and shocks) could either have had a positive or negative effect on economic development. Thus, without seeking conclusive evidence, this section also begins to test whether the effects may have even changed from negative to positive forces with the onset of more sustained economic growth.

5.2. Estimation Procedure

With very long run annual GDP per capita data for six European economies, this was an opportunity to analyze the data as a panel study. Given the richness of the data set, numerous approaches could have been taken. In light of the discussion in the previous section about seeking to test changes in the impact of explanatory variables through time, the approach chosen was to estimate coefficients for each century between 1300 and 1799.

The present study focuses on the pre-industrialized era. An important characteristic of this approach is that focusing on pre-nineteenth century data, particularly for individual centuries, rejects the null hypothesis of unit roots. Data for the nineteenth and twentieth centuries cannot reject this hypothesis. Thus, extending the analysis for this latter period raises issues about using alternative methods that address non-stationary data.

Naturally, this type of historical exercise is limited by the variables for which data was available. Fortunately, some prime-contenders as explanatory variables, particularly at low levels of economic development, were available either at annual level or per century, effectively acting as forms of dummy variables. Figures 4 and 5 present the dependent and explanatory variables available for the six European countries between 1300 and 1800.

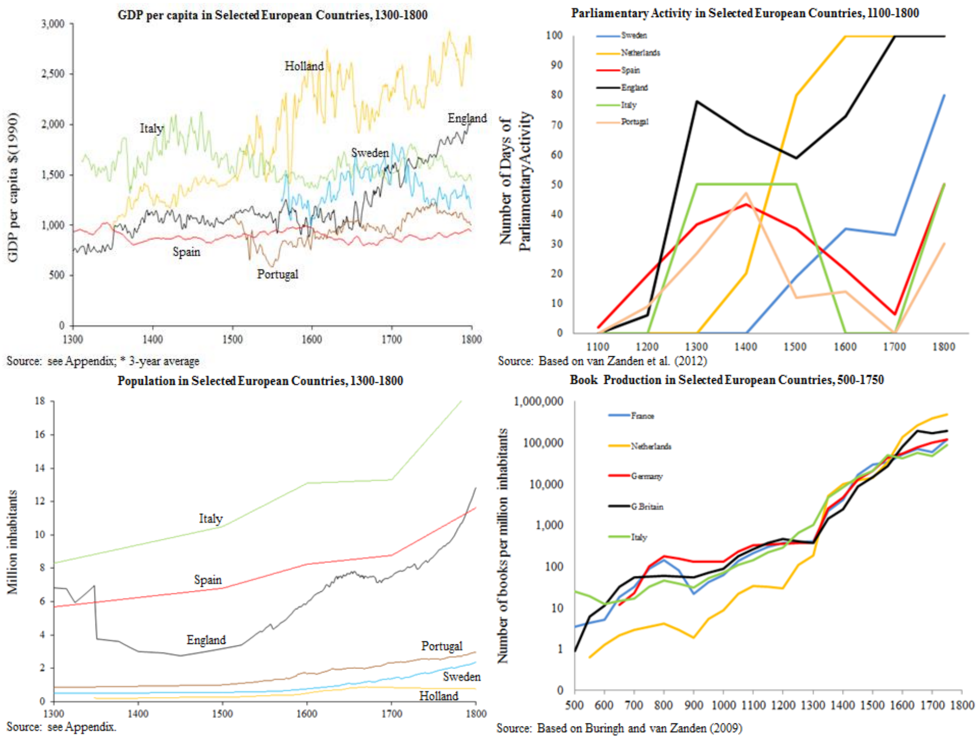


Figure 4. (a) GDP per Capita and its Explanatory Variables (b) Parliamentary Activity 1100-1800, (c) Population 1300-1800 (d) Book Production 500-1750, all in the Six European Countries

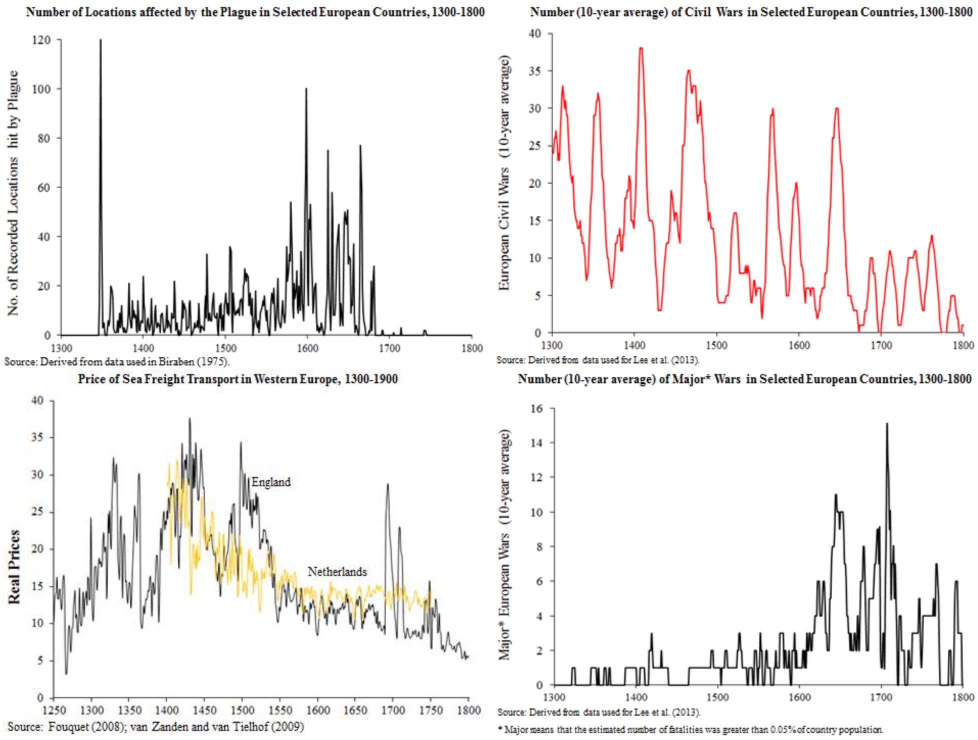


Figure 5. Explanatory Variables of GDP per Capita (a) Plagues in six European countries, 1300-1800, (b) Civil Wars (10-year average) in six European countries, 1300-1800, (c) Price of Freight 1300-1800 in England and Netherlands, (d) Major Wars (10-year average) in six European countries, 1300-1800

5.3. Estimates of the Relationships

This section presents estimates of the relationship between log GDP per capita and explanatory variables discussed in section 5.2 in each century between 1300 and 1800. Table 8 and 9 show the short run and medium run impacts, respectively, of explanatory variables. Those that appear the same sign and significant in both tables indicates a solid and consistent relationship between a variable and GDP per capita.

It is not appropriate to make strong claims about causality. The causality was likely to run in both directions – from the explanatory variables to GDP per capita, and from GDP per capita to explanatory variables, particularly plagues, civil wars, institutions and human capital. For variables which have only a single value per country for the whole century (i.e., institution quality and human capital), the results certainly only indicate possible correlation. For variables where annual data was available, the results might suggest potential indicators of causality, but only when considering the ten-year average results in Table 9. In Table 9, there might some room for causal interpretation because the dependent variable is the average of GDP per capita in years t to t+9. While GDP per capita in year t may have influenced an explanatory variable in year t, GDP per capita in year t+1 to t+9 were unlikely to have any effect on an explanatory variable in year t. Thus, the majority of values (9 out of 10) determining the 10-year average GDP per capita in Table 9 could not have influenced the explanatory variable, implying that any correlation was due to a causality running from explanatory variable to dependent variable.

Table 8. Estimates of Relationships with Annual GDP per capita levels in European countries, 1300-1799 (fixed effects model)

	1300s	1400s	1500s	1600s	1700s
Parliament	1.95***	0.17***	0.49***	0.07***	0.03***
Book Production	-0.02	-0.03***	0.78***	0.11***	-0.10***
Change in Population	-1.07***	4.73**	-0.18***	1.55***	1.36*
Plague	0.00	0.00	0.00	0.00	0.00
Civil Wars	0.07***	-0.17***	-0.09***	-0.02**	-0.02
Large Wars	-0.10	-0.18**	-0.08***	-0.01	0.00
Price of Freight	0.06***	0.03***	0.38***	0.27***	-0.06***
No. of Observations	342	400	540	600	600
Overall R-Squared	0.933	0.915	0.864	0.325	0.777

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9. Estimates of Relationships with 10-year Average GDP per capita levels in European countries, 1300-1799 (fixed effects model)

	1300s	1400s	1500s	1600s	1700s
Parliament	-2.42***	0.16***	0.71***	0.05***	0.48***
Book Production	3.06***	-0.03***	1.25***	0.10***	-0.11***
Change in Population	8.14***	3.72***	32.88	1.84***	1.21***
Plague	-0.01	0.00	-0.02	0.00	0.00
Civil Wars	-0.72***	-0.01***	-0.63***	-0.03***	0.02*
Large Wars	2.27***	-0.02***	0.23	-0.01**	-0.01
Price of Freight	-0.16***	0.02**	0.49	0.01**	-0.08***
No. of Observations	342	400	540	600	600
Overall R-Squared	0.733	0.935	0.732	0.395	0.768

* significant at 10%; ** significant at 5%; *** significant at 1%

However, instrumental variables (IV) have not been used and, thus, the direction of causality has not been formally controlled for in these estimates. In the future, this would be an important follow-up for this research. Irrespective, the richness of the data set makes correlations between the dependent and explanatory variables worthy of investigation. In particular, it is indeed of great interest to identify when the variables stop being correlated, offering evidence about what relationships need to be neutralized before sustained economic growth might become possible.

With this in mind, the results should be interpreted with great caution. The results suggest that parliamentary activity, the indicator of institutional quality, and book production, the indicator of human capital formation, were correlated positively with the levels of GDP per capita. Similarly, between 1400 and 1800, rises in population were correlated with GDP per capita. These explanatory variables only offered a value per century, limiting the interpretation of the results.

The explanatory variables with annual data offer a richer potential for interpretation. Interestingly, plagues appear to have no effect on economies. Civil wars, however, do. Before the eighteenth century, they seem to reduce GDP per capita. Large wars are, generally, negatively correlated. Finally, the role of sea freight costs was ambiguous (though data limitations hamper the estimates).

This econometric analysis needs further work and care. Its role here is only to highlight the potential analysis in the future, given the rich data available for a number of explanatory variables.

6. Conclusion

A first aim of the paper was to test the hypothesis that European economies were stagnant prior to the Industrial Revolution, using annual time series of GDP per capita for six European countries reaching back to the thirteenth century. While the data used has considerable limitations, it offers the first detailed picture of economic development for the five hundred years before the Industrial Revolution. Based on the evidence, the conventional wisdom – which proposes that pre-industrial economies more than two centuries ago were stagnant - was conclusively rejected. The paper demonstrated that these economies had major (and minor) phases of economic growth before the nineteenth century, some lasting more than 50 years. These phases were ultimately unsustained, but often led to substantial long run improvements in per capita income.

A related point is that, since ‘history matters’, an economy with per capita incomes stagnating for five hundred years was very different from the pre-industrial European economies that experienced multiple peaks and troughs. Each important peak and trough in per capita income implied a process of change – of new technologies, institutions, beliefs and behavior, each potentially creating new lock-ins. Thus, pre-industrial European economies were changing, agents adjusting to new incentives and constraints, and becoming locked-into a new economic system roughly every fifty to one hundred years, in the case of the six economies studied in this paper. While it is very possible (perhaps even probable) that economies in other regions of the world experienced major peaks and troughs (as China did in the eleventh century), the dynamism of European economies from the fourteenth century may offer a clue to the Great Divergence – thus, a possible avenue of future research.

Indeed, despite some evidence for the existence of wealth and poverty traps, this paper identified cycles of divergence and convergence within pre-industrial Europe (though not necessarily at a global scale). Divergence was associated with a new leading economy. Convergence was associated with phases of temporary economic stagnation and decline amongst leading economies. After becoming world economic leaders, China in the tenth century, Italy in the fifteenth century, Holland in the eighteenth century and even England in the late nineteenth century struggled to grow beyond a certain range of economic development. In time, a few economies converged on the leader and then, when they developed new technologies and institutions, over-took. Although beyond the scope of this paper, some might argue that Britain might not have continued to grow, had other economies (e.g. Germany and the US) not overtaken it and had it not imported new technologies, modes of management and institutions.

A further aim of the paper was to analyze growth rate distributions, and consider whether they were associated with the risk of economic downturns. The evidence confirms that, in the nineteenth century, the risks of economic decline fell and growth rate distributions changed substantially. While the estimates of the moments of probability distribution (i.e., mean, standard deviation, skewness and kurtosis) only partially support the relationship, this investigation was an opportunity to begin an empirical exploration of these relationships, with the hope that it will stimulate future research.

A final aim of the paper was to identify factors that were correlated with early European economic development and may have influenced it. While the results should be interpreted with great care, they offer some insights. First, they confirm expectations about correlations between institutions and economic development and between human capital and economic development. Second, shocks (i.e., plagues, civil wars and large international wars for which annual time series data was also available) had different impacts on economic development, partially supporting more modern disaster literature. While plagues did not appear to influence GDP per capita, civil wars did strongly and to a lesser extent large international wars did. Especially in this final section of the paper, the aim was not to make strong claims about relationships. Instead, that final section was presented to begin the analysis and discussion of much longer run economic history than has been commonly pursued with econometric methods.

In the Introduction of this paper, it was proposed that the new data sets presented in this paper might bring a new understanding of long run economic growth and development. It is already forcing us to reconsider long run trends in economic activity before the Industrial Revolution, to understand further how the risks of economic decline changed in the long run, and to confirm expectations about variables that are correlated with economic development. Undoubtedly, these new very long run data sets promise to generate many exciting empirical findings and theoretical insights about economic growth and development.

References

Abramovitz, M. (1986) ‘Catching Up, Forging Ahead, and Falling Behind.’ Journal of Economic History 46(2) 385-406.

Acemoglu, D., Carvalho, V.M., Ozdaglar, A. and Tahbaz-Salehi, (2012), ‘The network origins of aggregate fluctuations.’ Econometrica 80(5) 1977–2016.

Acemoglu, D., S. Johnson, and J. Robinson (2002) Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution, Quarterly Journal of Economics 117 1231-1294.

Acemoglu, D., Ozdaglar, A. and Tahbaz-Salehi, A. (2013) The Network Origins of Economic Downturns. Department of Economics Working Paper 13-16. MIT. Cambridge, MA.

Acemoglu, D., and J. Robinson (2012) Why Nations Fail? The Origins of Power, Prosperity and Poverty. Crown Business. New York.

Allen, R. C. (1999) ‘Tracking the agricultural revolution in England.’ Economic History Review 52 209–35.

Allen, R.C. (2000). Economic structure and agricultural productivity in Europe, 1300–1800. European Review of Economic History 4, pp. 1–26.

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

Alvarez-Nogal, C. and L. Prados de la Escosura (2013) ‘The rise and fall of Spain (1270-1850).’ Economic History Review 66(1) 1-37.

Andersson Palm, L. (1992), Vardagsekonomins strukturer: Inrikeshandel 1622-1810, Scandia 65, pp. 213-261.

Bairoch, Paul. (1988) Cities and economic development: From the dawn of history to the present. Chicago: University of Chicago Press.

Basssino, J.P., Broadberry, S.N., Fukao, K., Gupta, B. and Takashima, M. (2012), ‘Japan and the Great Divergence, 730-1870.’ Economic History Department Paper London School of Economics.

Baumol, W. ‘Productivity Growth, Convergence and Welfare: What the Long-Run Data Show.’ American Economic Review 76(6) 1072-85.

Becker S.O. and Woessmann L. (2009). Was Weber Wrong? A Human Capital Theory of Protestant Economic History, Quarterly Journal of Economics, 124 (2): 531-596.

Bolt, J. and van Zanden, J.L. (2014) The Maddison Project: collaborative research on historical national accounts. Economic History Review 67(3) 627-51.

Broadberry, S.N., (2013) Accounting for the Great Divergence. Economic History Department Paper London School of Economics. No. 184.

Broadberry, S.N., Campbell, B., Klein, A., Overton, M. and van Leeuwen, B, (2011) British Economic Growth, 1270-1870: An Output-based Approach. Economic History Department Paper London School of Economics.

Broadberry, S.N., Guan, H. and Li, D.D. (2014) China, Europe and the Great Divergence: A Study in Historical National Accounting, 950-1850. Economic History Department Paper London School of Economics.

Broadberry, S.N. and Gupta, B. (2012) ‘India And The Great Divergence: An Anglo-Indian Comparison Of GDP Per Capita, 1600-1871.’ CAGE Online Working Paper Series 81, Competitive Advantage in the Global Economy (CAGE).

Buyst, E. (2011) 'Towards Estimates of Long Term Growth in the Southern Low Countries, ca.1500-1846' Quantifying Long Run Economic Development. The University of Warwick in Venice, Palazzo Pesaro Papafava, 22-24 March.

Carus-Wilson, E.M. (1950) ‘Trends in the export of English Woollens in the Fourteenth century.’ Economic History Review 3(2) 162–179.

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

Chorley, P. (1987) ‘The Cloth Exports of Flanders and Northern France during the Thirteenth Century: A Luxury Trade?’ Economic History Review 40(3) 349-379.

Church, R. (1986) The History of the British Coal Industry. Vol 3. 1830–1913. Clarendon Press. Oxford.

Clark, G. (2004), “The Price History of English Agriculture, 1209-1914”, Research in Economic History, 22, 41-125.

Clark, G. (2005), “The Condition of the Working-Class in England, 1209-2004”, Journal of Political Economy, 113, 1307-1340.

Clark, G. (2006), “England, Prices and Wages since 13th Century”, Global Price and Income History Group, University of California, Davis, http://gpih.ucdavis.edu/Datafilelist.htm.

Clark, G. (2007) ‘The long march of history: Farm wages, population, and economic growth, England 1209-1869.’ Economic History Review 60(1) 97-135.

Clark, G. (2010) ‘The Macroeconomic Aggregates for England, 1209-1869.’ Research in Economic History, 27, 51-140.

Clay, K., Troesken, W. (2010) ‘Did Frederick Brodie Discover the World's First Environmental Kuznets Curve? Coal Smoke and the Rise and Fall of the London Fog.’ NBER Working Papers 15669. National Bureau of Economic Research.

Crafts, N. F. R., ‘Income elasticities of demand and the release of labour by agriculture during the British industrial revolution’, Journal of European Economic History, 9 (1980), pp. 153–68.

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

Crafts, N.F.R. (2001) Historical Perspectives on Development. In Frontiers of Development Economics, edited by G. Meier and J. Stiglitz. New York: Oxford University Press.

Crafts, N.F.R. and Harley, C.K. (1992), “Output Growth and the Industrial Revolution: A Restatement of the Crafts-Harley View”, Economic History Review, 45, 703-730.

Daniele, V. and Malanima, P. (2007). Il prodotto delle regioni e il divario Nord-Sud in Italia (1861–2004). Rivista di Politica Economica 97 1-49.

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

Delong, J.B. (1988) ‘Productivity Growth, Convergence, and Welfare: Comment.’ American Economic Review 78(5) 1138-1154.

De Vries, J. and Woude A.. The First Modern Economy: Success, Failure and Perseverance of the Dutch Economy, 1500-1815. Cambridge: Cambridge University Press, 1997.

Dittmar JE (2011). Information technology and economic change: the impact of the printing press, Quarterly Journal of Economics, 126 (3): 1133-1172.

Drelichman, M. (2005) 'The curse of Moctezuma: American silver and the Dutch disease.' Explorations in Economic History, 42(3) 349–80.

Durlauf, S.N., Johnson, P.A. and Temple, J.R.W. (2006). 'Growth Econometrics.' Handbook of Economic Growth, in Aghion, P. and Durlauf, S.N. (eds.), Handbook of Economic Growth 1(1) 555-677.

Easterlin, R. (1981) Why isn't the whole world developed.' Journal of Economic History 41(1) 1-19.

Easterly, W. K., P. L. Michael, and L. H. Summers. (1993). "Good Policy or Good Luck? Country Growth Performance and Temporary Shocks," Journal of Monetary Economics 32 459–483.

Easterly, W. and Levine, R. (1997) 'Africa's growth tragedy: policies and ethnic divisions.' Quarterly Journal of Economics, 1203-1250.

Easterly, W. (2006) Reliving the 50s: the Big Push, Poverty Traps, and Takeoffs in Economic Development, Journal of Economic Growth 11(2) 289-318.

Feinstein, C. (1972) National Income, Expenditure and Output of the United Kingdom, 1855-1965, Cambridge: Cambridge University Press.

Fouquet, R. 2008. Heat Power and Light: Revolutions in Energy Services. Edward Elgar Publications. Cheltenham and Northampton, MA, USA.

Goldthwaite, R.A. (2009) The Economy of Renaissance Florence. John Hopkins University Press. Baltimore, MD.

Galor, O. (2005). From Stagnation to Growth: Unified Growth Theory, in: Aghion, P. and S. N. Durlauf (eds.). Handbook of Economic Growth, Volume 1A, Amsterdam: North Holland, 171-293.

Gennaioli N, La Porta R, Lopez-de-Silanes F and Shleifer A (2013). Human Capital and Regional Development, Quarterly Journal of Economics 128(1) 105-164.

Glaeser, E.L., La Porta, R., López-de-Silanes, F. and A. Shleifer (2004). Do Institutions Cause Growth? Journal of Economic Growth 9: 271-303.

Hansen, G.D. and Prescott, E.C. (2002) ‘Malthus to Solow.’ American Economic Review 92(5) 1205–17.

Hatcher, J. (1993) The History of the British Coal Industry. Volume I. Oxford: Clarendon Press.

Hausmann, R., Pritchett, L. and Rodrik, D. (2005) ‘Growth Accelerations.’ Journal of Economic Growth 10(4) 303-329.

Hodgett, G.A.J. (2006) A Social and Economic History of Medieval Europe. Routledge. London.

King, P. (2005) ‘The production and consumption of bar iron in early modern England and Wales.’ Economic History Review 58(1) 1–33.

King, P. (2011) ‘The choice of fuel in the eighteenth-century iron industry: the Coalbrookdale accounts reconsidered.’ Economic History Review 64(1) 132-46.

Krantz, O. (2004) ‘An estimate of Swedish GDP in 1571.’ in Heikkinen/van Zanden (eds.) Explorations in Economic Growth. A festschrift for Riitta Hjerppe on her 60th birthday. Aksant Amsterdam.

Maddison, A. (1982) Phases of Capitalist Development, Oxford University Press. New York.

Maddison, A. (1995) Monitoring The World Economy, 1820–1992. OECD. Paris.

Maddison, A., (2003) The world economy: historical statistics. OECD. Paris.

Maddison, A., (2007) Contours of the world economy 1–2030 AD: essays in macro-economic history. Oxford University Press. New York.

Malanima, P. (2007) Wages, Productivity and Working Time in Italy 1300-1913, Journal of European Economic History, 36, 2007, pp. 127-74.

Malanima, P (2009) The Italian Renaissance Economy (1250-1600). International Conference on Europe in the Late Middle Ages: Patterns of Economic Growth and Crisis. Villa La Pietra, Florence. May 10th-12th 2008.

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.

Malthus, T.R. 1798. An Essay on the Principle of Population as it affects the Future Improvement of Society. London: Ward Lock.

Mankiw, N.G., D. Romer and D.N. Weil (1992) ‘A Contribution to the Empirics of Economic Growth.’ Quarterly Journal of Economics 107(2) 407-437.

Mokyr, J. (1990) Levers of Riches: Technological Creativity and Economic Progress. Oxford University Press. Oxford.

Mokyr J. (2005) 'Long-term growth and the history of technology.' In P. Aghion and S.N. Durlauf (eds.) Handbook of Economic Growth Vol. 1B 1113-1180. Elsevier: Amsterdam.

Munro, J. H. (2003) 'The Western European Woollen Industries, 1500-1750' in D.T. Jenkins (ed.) The Cambridge History of Western Textiles. Cambridge University Press. Cambridge.

Nicholas, D. (1991) 'Of Poverty and Primacy: Demand, Liquidity, and the Flemish Economic Miracle, 1050-1200.' American Historical Review 96(1) 17-41.

North, D. (1990) Institutions, Institutional Change, and Economic Development. Cambridge University Press, Cambridge.

Noy, I. (2009) 'The macroeconomic consequences of disasters.' Journal of Development Economics 88(2) 221-231.

Oster, E. (2012) "Routes of Infection: Exports and HIV Incidence in Sub-Saharan Africa." Journal of the European Economic Association, 10(5): p. 1025–1058.

Palma, N. and Reis, N. (2014) 'Portuguese demography and economic growth, 1500-1850.' Paper for "Accounting for the Great Divergence" Conference. The University of Warwick in Venice. 22-24 May.

Pamuk, S. and Shatzmiller, M. (2014) 'Plagues, Wages, and Economic Change in the Islamic Middle East, 700-1500.' The Journal of Economic History 74(1) 196-229.

Pfister, U. (2011) 'Economic growth in Germany, 1500–1850.' Quantifying Long Run Economic Development conference. University of Warwick in Venice, 22–24 March.

Prados de la Escosura, L. (2000) 'International comparisons of real product, 1820–1990: an alternative data set.' Explorations in Economic History, 37 1-41.

Prados de la Escosura, L. (2014) 'Mismeasuring Long Run Growth: The Bias from Spliced National Accounts.' CAGE Online Working Paper Series 202, Competitive Advantage in the Global Economy (CAGE).

Pritchett, L. (1997) 'Divergence, Big Time.' Journal of Economic Perspectives 11(3) 3-17.

Pritchett, L. (2000). “Understanding Patterns of Economic Growth: Searching for Hills among Plateaus, Mountains, and Plains,” World Bank Economic Review 14(2) 221–250.

Quah, D. (1993) ‘Empirical cross-section dynamics in economic growth.’ European Economic Review, 37(2-3) 426-434.

Quah, D., (1996) ‘Empirics for Economic Growth and Convergence.’ European Economic Review 40(6) 1353-75.

Quah, D., (1997) ‘Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs.’ Journal of Economic Growth 2(1) 27-59.

Reinert, S.A. (2011) Translating Empire: Emulation and the Origins of Political Economy. Cambridge, MA: Harvard University Press.

Reis, J., Martins, C.A. and Costa, L.F. (2013) From Major Power to Economic Backwater: Portugal’s GDP 1500-1850. Paper presented at the CAGE conference on Accounting for the Great Divergence at the University of Warwick, 28 May.

Rodrik, D. (1999) ‘Where Did All the Growth Go? External Shocks, Social Conflict and Growth Collapses,’ Journal of Economic Growth 4(4) 385-412.

Rodrik, D., Subramanian, A., Trebbi, F. (2004) Institutions rule: the primacy of institutions over geography and integration in economic development. Journal of Economic Growth 9(2) 131-65.

Schatzmiller, M. (2011) “Economic Performance and Economic Growth in the Early Islamic World” Journal of the Economic and Social History of the Orient, 54(2011): 132-184.

Schön, L. and Krantz, O. (2012), The Swedish economy in the early modern period. Constructing Historical National Accounts 1560-2000, European Review of Economic History 16 529-49.

Schön, L. (1979), Från hantverk till fabriksindustri. Svensk textiltillverkning 1820-1870. Acad. Diss. Lund: Arkiv.

Solow, R.M (1956) ‘A Contribution to the Theory of Economic Growth.’ Quarterly Journal of Economics 70(1) 65-94.

Squicciarini, M.R. and Voigtländer, N. (2014) Human Capital and Industrialization: Evidence from the Age of Enlightenment. NBER Working Paper. 20219.

Thirsk, J. (1976) Economic Policy and Projects: The Development of a Consumer Society in Early Modern England. Clarendon Press. Oxford.

van Bavel, B.J.P and van Zanden, J.L. (2004) The jump-start of the Holland economy during the late-medieval crisis, c. 1350-c. 1500. Economic History Review 57(3) 503-532.

van der Wee, H. (2003) The Western European Woollen Industries, 1500-1750 in D.T. Jenkins (ed.) The Cambridge History of Western Textiles. Cambridge University Press. Cambridge.

van Zanden, J.L. (2003) ‘The ecological constraints of an early modern energy economy: the case of the Holland 1350-1800’ in Cavaciocchi, S. (ed.) Economia e Energia. Le Monnier. Florence.

van Zanden, J.L., Eltjo Buringh and Maarten Bosker (2012). "The rise and decline of European parliaments, 1188–1789," Economic History Review, 65(3) 835-861.

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, 49 119–30.

van Zanden, J.L. and van Tielhof, M. (2009) 'Roots of Growth and Productivity Change in Dutch Shipping Industry, 1500-1800.' Explorations in Economic History 46(4) 389-403.

Voigtländer, N. and Voth, H.J. (2013) ‘The Three Horsemen of riches: plague, war and urbanization in Early Modern Europe.’ Review of Economic Studies 80(2): 774-811.

APPENDICES

Appendix 1. Data Construction

A1.1. England/Britain/United Kingdom

The times series for GDP per capita series in England (and, then, from 1700, Britain (i.e. England, Wales and Scotland)) was produced by Broadberry et al (2011), and, from 1922, the United Kingdom, by Broadberry and Klein (2011). It runs from 1264 until 2010. Annual GDP estimates were constructed using an output approach, separated into the agricultural, industrial and service sectors.

Agricultural outputs were calculated by multiplying the acreage for each crop by the yield per acre. Broadberry et al (2011) estimate the total acreage. The trends in yields were split into three main time periods, based on the data sources available. These three data sources are: the Medieval Accounts Database (Campbell 2000, 2007), the Early Modern Probate Inventories Database between the mid-sixteenth and the mid-eighteenth centuries (Overton, 1991; 2000; Overton, Whittle, Dean and Haan, 2004); and the Modern Farm Accounts Database of Turner, Beckett and Afton (2001), which runs from 1720 until 1913. For pastoral output, a similar procedure was undertaken, multiplying the number of animals by the share producing and their yields. Prices for individual arable and pastoral products are used to convert the output into current prices and create weights for the agricultural real output index.

Production estimates or indicators existed for the key English industries up to 1700. Crucial sources included Carus-Wilson and Coleman (1963) for wool and woolen cloth, King (2005) for iron, and Hatcher (1973) for tin. Outputs related to leather, food processing, construction and books were estimated by Broadberry et al (2011) and combined with the key industries to generate an index of industrial production from 1264 to 1700. Crafts and Harley (1992) offer an index from 1700 until 1870.

The service sector followed the approach developed by Deane and Cole (1967), with some adjustments. The sector is broken down into commerce, housing, domestic services and government. The commerce indicator is based on combining estimates of domestic and international trade, freight transport and financial services (using the velocity of money). Housing and domestic services were assumed to grow at the same rate as population. Government activity was based on its revenue (O'Brien and Hunt 1999).

The three real output series for the agricultural, industrial and service sectors were combined using a set of weights, based on an input-output table for 1841 (Horrell, Humphries and Weale 1994). The series are reflated to convert them into nominal series. The principal sources for price series used include Clark (2004, 2005, 2006), Beveridge (1939) and Rogers (1866-1902). Then, a set of value-added weight shares for each sector every fifty years, based on a number of historical sources, are used to create a chained index of GDP, following Feinstein (1972). This aggregate series is divided by population (derived from Wrigley and Schofield 1989 and Hallam 1988) to estimate GDP per capita.

A1.2. Holland/Netherlands

GDP per capita for Holland from 1348 and 1807 were calculated by van Zanden and van Leeuwen (2012). These were linked to the Netherlands by identifying Holland's share in Dutch economy. The process of estimating Holland's GDP per capita can be separated into two periods: the more approximate estimates for the period between 1348 and 1510, which combines output measures for arable production with proxies for the other sectors, and the more reliable estimates for the period 1510 to 1807 undertaken using detailed output estimates for the agricultural, industrial and service sectors.

In the years 1510 and 1807, estimates of outputs in most industries offer valuable benchmarks. Therefore, the focus was on identifying variation in sectoral output or value added to link these two dates. Discussions of how these detailed accounts were constructed are presented in van Zanden and van Leeuwen (2012).

The primary sector in Holland was comprised of the agricultural sector, fisheries and whaling. Although the data for agriculture in Holland was not as reliable as it was for other sectors, this was less critical than it would have been for other countries because agriculture in Holland only accounted for 20% of GDP by 1500. Nevertheless, sufficient information was available to produce clear estimates. Agricultural land under cultivation in a particular period was calculated by identifying the land in use in 1832, and subtracting the land reclaimed (i.e. from polders) in particular periods (van Zanden 1985), thus, creating a time series of the number of agricultural hectares. This was then linked to its value per hectare. Rent per hectare was available from 1500 to 1650 and constructed for the remaining period up to 1832 using a number of sources. The authors made the assumption that the rent was a particular (and changing) percentage of the total value added of the land under cultivation. Holland's output of fisheries and whaling in terms of the value added was estimated by Van Bochove and Van Zanden (2006) from 1600 to 1795. These were then extended before and after this period based on a number of data sources.

A rich collection of data existed on industrial output. For example, total wool production in Leiden was available (Posthumus 1908-39), which was combined with prices and a value added to output ratio to generate a value added in Leiden; this was then factored-up using an estimate of the share of Leiden's production in total wool output. The secondary sector included also other textiles (such as linen), clothing, construction, peat digging, food (bread-making, brewing, gin – jenever – distilling, and other foodstuffs, which linked consumption with population), paper, shipbuilding, printing, soap production and sugar refining.

The service sector involved estimating the value added from domestic and international trade, banking, legal services, transportation, housing, domestic services, education and government activities (including the army and the navy). From 1510, each of these sectors had indicators with annual data, providing undoubtedly the richest collection of data on the service sector of any country presented in this paper. For instance, a data set on the value added for the very dynamic shipping sector had already been produced (Van Tielhof and Van Zanden 2009)

A1.3. Italy

The long run estimates of GDP per capita series for Central and Northern Italy were constructed by Malanima (2011). The series starts in 1310 and is linked to a series for these regions of Italy from 1861, the year of Italian unification. The data is built by combining an indirect demand approach for agriculture with output estimates for industry.

The lack of evidence on agricultural production prior to the mid-nineteenth century led Malanima (2011) to use a demand approach. Estimates of agricultural production start with the assumption that they are equal to consumption. While there might be some imports and exports, Malanima (2011) argues that the net value of these imports and exports are negligible for Central and Northern Italy. Thus, estimates of agricultural consumption will provide a close indicator of production.

The exercise involved estimating per capita agricultural consumption based on a model of demand (including income and price elasticties) and data on consumer income levels and real prices of agricultural productions and industrial products (as substitutes). A number of other historical studies, pioneered by Crafts (1980) and more recently developed by Allen (2000), have used estimates of income elasticities of agricultural products ranging from 0.3 to 0.9. Guided by these previous studies, and Italian estimates from 1861 to 1910 (Federico 2003), Malanima (2011) selected an income elasticity of 0.4. The previous historical studies reviewed had used a cross price elasticity of 0.1 - in other words, agricultural and industrial products are seen as weak substitutes for one another. By relying on the 'adding-up' property in linear models (Deaton and Muellbauer 1980 p.16), the sum of the income, own price and cross price elasticities are assumed equal to 0, which helps to guide the value of the own price elasticity (-0.5). Thus, based on these elasticities, and on data for wages (acting as a proxy for income) and for the real prices of agricultural and non-agricultural products, Malanima (2011) estimated the per capita agricultural consumption and, hence, an indicator of production (see above).

To estimate non-agricultural output, urbanization rates are used as the main indirect method, as estimates of towns greater than 5,000 are available back to the thirteenth century (and before) for Central and Northern Italy. The share of non-agricultural output between 1861 and 1936 was regressed on urbanization rates. The coefficient of the relationship was key to estimating output before 1861. However, without taking account of non-urban industry over the centuries, there would have been a risk of over-estimating late medieval output. Thus, combining the coefficient and the urbanization rates with an index of the share non-urban workers (based on Allen (2000)), the share of non-agricultural output was estimated back to 1300.

With an estimate of per capita agricultural output and of the share of non-agricultural output, it was possible to construct a GDP per capita series from 1310 until 1861. For consistency, this series is linked to a series for Central and Northern Italy (Daniele and Malanima 2007). While Bolt and van Zanden (2014 p.635) argue that they are a little overestimated, this series provides a valuable (and the only) indicator of long run growth rates related to Italy.

A1.4. Spain

The GDP per capita estimates for Spain are presented in Alvarez-Nogal and Prados de la Escosura (2013). They run from 1270 until 1850. Given the lack of direct output indicators, the estimates were based on a demand approach for agricultural products and indirect proxies for non-agricultural production.

Inspired by Allen (2000), Alvarez-Nogal and Prados (2007, 2013) sought to estimate agricultural production using the demand approach, showing great care about the limitations of the process and all the assumptions being made. Conscious of relying exclusively on real wages as a proxy for income, the authors offered three estimates of agricultural consumption per capita: the first used changes in real wage rates; the second (based on the assumption that declining real wages will be adjusted for by working longer hours) depended on the relative price of agricultural to non-agricultural products taking account of the own and cross price elasticities of demand; the third (and favored) estimate used a weighted average of real wages rates and real land rents (to take account of changes in proprietors' wealth) – though, like the first estimate, does not take account of labor supply adjustments due to changes in real wages.

The authors also tested a range of elasticities and opted for values reflecting relatively unresponsive consumer demand. They selected an income elasticity of

0.3, an own price elasticity of -0.4 and, therefore, by the adding-up assumption (see above), a cross-price elasticity of 0.1, implying weak substitutability between agricultural and other goods. The changes in the proxies for disposable income and in real prices were fed into the model, and a time series for per capita agricultural consumption was generated. As in the case of Italy, imports and exports were assumed to cancel each other out, implying consumption and production were equal.

For non-agricultural output, less data was available, and an indirect approach was used. As a result, urban population provided the basis for estimating per capita output in industry and services. The authors took account of 'agro-towns', which developed following the re-conquest, particularly of Southern, Spain, and of agricultural population in other towns. Running sensitivity tests, the authors concluded that demographic or output composition did not alter the output levels greatly over time.

The indicators of agricultural and non-agricultural output were combined by using weights to identify the share of these two sectors in total GDP (based on these two output series and current prices). The combined values were divided by population to calculate the GDP per capita estimates. Inevitably, the time series suffers from similar limitations that the Italian series does, despite different assumptions being made, because of the use of a demand approach to estimate agricultural output and urbanization as the main proxy for industrial and service output.

A1.5. Sweden

In Sweden, the times series for GDP per capita begins in 1560 and was constructed by Schon and Krantz (2012). The Swedish historical national accounts go back to 1800 . Before that, there is only one year, 1571, for which detailed national accounts exist (Krantz 2004). Thus, efforts focused on constructing data between these periods.

Because of the lack of evidence on agricultural production prior to 1800, a demand approach was used. The starting points for constructing the time series were the rich data sets on wages and on prices of goods (particularly rye, barley and butter for agricultural products). Income is assumed to be proxied by wage rates[2]. The exercise involved modelling per capita consumption for key agricultural products based on a model of demand (including income and price elasticties) and data on consumer income levels and product prices. The income, own price and cross price elasticities were the same as those used in Malanima (2011) for Italy, discussed

[2] In England, Broadberry et al (2011) argue that hours worked probably increased – this assumption is key to explaining the difference between Clark's (2010) stagnant GDP per capita estimates, based on wages to identify income, and their own estimates, based on output.

above. The estimated consumption levels, plus exports and minus imports are used to determine levels of production.

Industrial production was based in part on output data. Because direct production data was patchy, iron output (in different forms) was constructed by comparing production with export data to generate an annual time series. Copper output was based on Lindroth (1955). Using the ratio between iron and copper prices, a weighting of the two output series was generated. This weighting enabled the two output series to be combined to provide an index of metal production.

The food industry was assumed to follow a similar trend as agricultural production. In 1800, food production accounted for 34% of total industrial output, while the metal industry produced close to 29%. Thus, these sectors, which are felt to be relatively accurate, represent 63% of total industrial activity in 1800, and probably more in earlier times. The other important components of industrial production included the derivatives of the agricultural sector, particularly wool and flax for textiles and skins for the leather industry. These inputs into the textile and leather industry are based on Schön (1979).

The service sector comprised of the construction industry, transport and commerce, including trade, banking, insurance and hotels. The number of dwellings built was assumed to follow population. Other buildings were assumed to follow agricultural and particularly industrial output. Construction was linked to the value of buildings produced in 1800 (Krantz and Schön 2007). Similarly, freight transport was assumed to be driven by agricultural and industrial production, and passenger transport was based on domestic trade. Evidence of domestic trade was based on data on tax collection of market trading (Andersson Palm 1992). Personal (or domestic) services are proxied by urban population and linked to the value in 1800. A series indicating government services, which included the civil service, the court and the military, builds on work by Krantz (1986), and making assumptions about the share of government expenditure on wages and other costs, again using the value in 1800.

While there are substantial limitations to the data, including the shifts in geographical boundaries as the Swedish Kingdom changed, the combined time series offers a valuable indicator of the fluctuations in the economy’s phases of growth and decline.

A1.6. Portugal

The times series for Portuguese GDP per capita was presented in Reis et al (2013) and then modified in Palma and Reis (2014). The annual data series is from 1500 to 1850. Given the limited information about production, the GDP construction in Portugal followed the methodology developed for Italy and Spain. That is, agricultural output was estimated using a demand approach, and non-agricultural output was dependent on the share of labor in agricultural and the productivity gap between agriculture and other sectors.

To model the demand for agricultural produce, Reis et al (2013) use the same coefficients as Alvarez-Nogal and Prados de la Escosura (2013) for Spain; that is, an income elasticity of 0.3, an own price elasticity of -0.4 and a cross price elasticity of demand equal to 0.1 Extensive data on prices, wages and rents for Lisbon, as the 'representative' Portuguese city, from the early sixteenth century until the twentieth century, have been brought together, providing the values for the two explanatory variables of the agricultural estimates. The authors do examine the agricultural trade balance and confirm that the assumption that agricultural imports and exports cancel each other out is close to being accurate, implying that consumption almost equals production.

For non-agricultural output, the authors do not follow the urbanization proxy used by Malanima (2011) and Alvarez-Nogal and Prados de la Escosura (2013), because they are concerned about the role of rural industries and changes in the productivity gap between agriculture and non-agriculture. Instead, they modify a method proposed by Pfister (2009) used for Germany. The argument is that GDP can be calculated as agricultural output divided by the share of agricultural labor in total labor multiplied by the productivity gap between agricultural and non-agricultural sector. Pfister (2009) assumes a constant productivity gap. Instead, Reis et al (2013) propose estimating the productivity gap as a variable based on the ratio of the total factor productivity (TFP) of agriculture and industry, respectively. While this ignores the relative stagnancy of TFP in service sectors, the authors consider this approach superior to a constant productivity gap. This variable enables the authors to estimate GDP and non-agricultural output. These estimates of GDP are then converted into per capita values.

In Reis et al (2013), while they experiment with variations in labor supply over time, they offer estimates based on the assumption that laborers work 250 days per year because of a lack of evidence. Palma and Reis (2014) modify the GDP per capita estimates to take account of increases in labor supply, reflecting the Industrious Revolution (De Vries 1994). Interestingly, Palma and Reis (2014) find that, as with Holland and Sweden, a benchmark year exists with information about production in the sixteenth century, as well as the nineteenth century. For Portugal, the years 1515 (based on Godinho 1968) and 1850 (using Reis 2000) provide pivotal links between GDP in the nineteenth century and the distant past. The two benchmark GDP per capita values are compared with equivalent values modelling GDP from the demand-side. Starting with the assumption of the same number of hours worked as in Spain (Alvarez-Nogal and Prados de la Escosura 2013), that is, 168 days per year in 1515, this exercise indicates that workers had become more industrious by 1850, working 248 days per year. Thus, with this new evidence about the number of days worked per year, new estimates are produced, lowering GDP per capita estimates in the sixteenth century.