THE ROLE OF HUMAN CAPITAL IN THE TRANSITION TO MODERN ECONOMIC GROWTH, 1300-1900

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The role of human capital formation in the transition to modern economic growth, ca. 1300-1900

De rol van menselijk kapitaal in de transitie naar moderne economische groei, ca. 1300-1900
(met een samenvatting in het Nederlands)

Proefschrift ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof.dr. G.J. van der Zwaan, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op vrijdag 19 februari 2016 des middags te 4.15 uur door Alexandra Marianne de Pleijt geboren op 8 juli 1986 te Voorburg.

Promotor: Prof.dr. J.L. van Zanden

Acknowledgements

There are numerous people who have directly, as well as indirectly, contributed to my thesis. All of them offered remarkable help with its completion, and I am more than grateful to have the opportunity to thank them here.

I had the good fortune of having a supervisor, Jan Luiten van Zanden, whom I enjoyed working with and learned a lot from. He very skilfully provided me with comments and suggestions, which improved the various chapters of my dissertation. Furthermore, he knows how important it is to present your research at (international) conferences and workshops. Consequently, after the first month of my employment as a PhD-candidate in Utrecht, Jan Luiten gave me the opportunity to present part of our joint-paper at the seminar series of the London School of Economics. I remember being very nervous about it and not sure whether to thank him for that opportunity or not! Multiple other conferences and workshops followed this, which really helped to strengthen my study. He was always willing to assist if I encountered any problems, and, perhaps more importantly, his confidence in my work gave me the freedom to develop my own research agenda. It gives me pleasure to be able to continue working with Jan Luiten in the near future, and am confident that many high-quality research papers will be produced.

In addition, I am greatly indebted to Jacob Weisdorf with whom I also enjoyed working. Jacob also significantly contributed to my dissertation by providing me with intelligent suggestions, and by discussing the outcomes of the empirical analyses. He also knows how important it is to 'sell' your research to the economic community as such, and has taught me how to do this. Jacob and I are still working together on topics related to human capital formation in England, and I hope we can continue to do so in the future.

I have had a wonderful three years at Utrecht University. It was great fun to be part of a large group of PhD-candidates, whom, like me, know how hard academic life sometimes can be. Of the group I am most grateful to Selin Dilli who is not just a colleague, but who has also became a friend over the years. Apart from running regressions, we also used to go for drinks and dinners, reinforcing the importance of social activity within the academic community. The same applies to Bram van Besouw, Winny Bierman, Alberto Feenstra, Miguel Laborda Peman, Michalis Moatsos, Danielle Teeuwen, Lotte van der Vleuten and Pim de Zwart. We have had memorable evenings together, stretching from dining at the Greek restaurant to celebrating the Dutch tradition of Sinterklaas. I furthermore want to thank Bas van Bavel, Anita Boele, Christiaan van Bochove, Bram Bouwens, Eltjo Buringh, Dan Curtis, Joost Dankers, Fia Dieteren, Jessica Dijkman, Oscar Gelderblom, Joost Jonker, Heleen Kole, Bas van Leeuwen, Mikolaj Malinowski, Tine de Moor, Maarten Prak, Auke Rijpma, Ruben Schalk, Sarah Simmelink, Keetie Sluyterman, Charlotte

Stormer, Annelies Tukker, Rene van Weeren and Gerarda Westerhuis. It has been a real pleasure working with all of you and thank you for keeping me going to the end!

There are also several colleagues from outside of Utrecht University whom I want to acknowledge: Jutta Bolt, Stephen Broadberry, Ewout Frankema, Bishnu Gupta, Jane Humphries, Herman de Jong, Jelle van Lottum, Debin Ma, Jaime Reis, Sebastian Keibek, Alessandro Nuvolari, Paul Sharp, Leigh Shaw-Taylor, Sjak Smulders, Peer Vries, and Patrick Wallis. Their willingness to provide me with their (knowledgeable!) feedback and/or datasets has improved my work significantly.

Last but not least I would like to thank my friends. First of all I want to thank my boyfriend Friso Huizinga. He is always supportive of me and I am very grateful for that (voor altijd saams!). I also want to thank my jaarclub, Royaal '05: Lotte Bosman, Inge Bulthuis, Floor van Geuns, Hanna van Hoeven, Caroline Houben, Hilde de Kluiver, Annemieke van Kooten, Elise Muijsert, Aukje van Nuland, Frederique van de Pol, Ilze van Roozendaal, Marjolein Schuurman, Anne Fleur Swart, Marije Veenhuizen en Philippine de Wit (het is raar om jullie 'echte' namen zo op te schrijven). In addition, I want to thank the Keizerchicks: Floor Beckman, Geertje Hesseling, Marlies Kreukniet, Marjolein Looije en Kim Wolfswinkel. I am moreover grateful to the 'meisjes van de research master' - Krista Bruns and Joyce Delnoij - and Emre Akgunduz. We have seemed to survive two years of hard work! And also, of course, not forgetting the other friends I have met over the past ten years whilst living in Utrecht: Bob Barre, Jorrit Bakker, Marianne de Beer, Alexander Colenbrander, Matthijs Hoekstra, Mette de Jonge, David Kalksma, Cedric Proctor, Nikki Remkes, Koen van Riemsdijk, Wijnand Roessingh, Rudolf van der Weijde.

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Chapter 1: Introduction

1.1 The European growth experience 1300-1900

The English industrial revolution is the most important break in world history. There is general agreement among economic historians on some of the aspects of the industrial revolution. For instance, the break that it represented was the appearance for the first time of continuous technological progress. However, its timing, location and causes are a matter of debate. Can we explain the industrial revolution by looking at growth in the 18th century only, or is a much longer time-span required? Is growth a sub-national/regional phenomenon, is the 'nation' state the appropriate unit of analysis, or is growth not limited by 'national' borders? Were 'efficient' institutions the main cause of the industrial revolution, or are there other important determinants of growth that need to be considered? These are highly relevant questions when studying the transition from an economy dominated by Malthusian forces to one characterized by 'modern economic growth' as it supposedly occurred in England in the 18th century.[1]

The first question concerns the location of economic growth. The concept of the 'Little Divergence' is relevant here. A substantial body of evidence – starting with the real wage estimates of Allen (2001), and including the new generation of per capita GDP (see overview in Bolt and van Zanden 2014) – points to the fact that there was a divergence in levels of economic performance within Europe between 1500 and 1800. North-Western Europe, notably the Low Countries and England, showed more or less stable real wages after the increase in real wages in the 14th century following the Black Death, whereas real wages in Eastern and Southern Europe declined in the long run. In terms of per capita GDP there is a similar divergence between the North Sea region and the rest of the continent: in the latter per capita GDP stagnated or declined, whereas Holland and England show a lot of economic progress: they were substantially richer in 1750 than in 1500 (Broadberry et al 2015, van Leeuwen and van Zanden 2012).

The 'Little Divergence' is also evident from other indicators of economic progress. The latest estimates on urbanisation show that cities grew in the North Sea region, whereas city growth petered out in the rest of Europe (Bosker et al 2012). Similarly, the development of political institutions (measured by the activity of European Parliaments) declined almost everywhere in Europe between 1500 and 1800, except in the Netherlands and England (van Zanden et al 2012). Finally, estimates on per capita book production and rates of literacy illustrate that the growth in human capital formation was faster in the North Sea region than elsewhere in Europe (Reis 2005, Baten and van Zanden 2008).

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[1] Section 1.1 is partly based on de Pleijt and van Zanden (2013).
[2] Unfortunately there are no detailed statistics to test for growth in these regions.
[3] Other opponents of this view, such as, amongst others, Clark (1996), argue that there is little evidence

Economic growth between 1300 and 1800 was an international phenomenon originating in the region bordering the North Sea. Of this region, the Low Countries and England formed the core, but parts of Belgium, Northern France, North West Germany, and Scotland, were probably also experiencing growth.[2] The North Sea region was strongly integrated; in the late middle ages, England for example supplied the wool for the textile industry of the Low Countries, which was by then the main source of employment of the large Flemish cities. In the 14th – 15th centuries Flanders formed the urban core of this economic system – and England its 'periphery'. In the 16th century Antwerp took over the role of being the core. After 1585 the urban center moved to Holland, a switch that resulted in the Dutch 'Golden Age' of the 17th century. After 1650 London gradually replaced Amsterdam as the central hub in the commercial network of North-Western Europe, and the urban core switched to England, as a result of which the Netherlands in the 18th century started to specialize on livestock products for the English market; thereby confirming its role as 'new' periphery.

The second issue, concerning the beginning and periodization of the process of economic growth in the North Sea region, is related to the above. On the basis of the latest estimates on per capita GDPt a division into three periods can be suggested: before the Black Death ('classic Malthusian economy'), between 1347 and 1820 (slow but consistent growth that was limited to the regions bordering the North Sea region), and after ca. 1820 (rapid 'modern'industrialgrowth that started in England and from there spread to the rest of the continent). In explaining the transition from a Malthusian economy to modern growth it is therefore necessary to focus on two transformations: the late middle ages, and the early 19th century.

The third issue is related to the causes of the industrial revolution. There is probably no bigger question in economic history, so there are numerous explanations. To address the debate, I divide it into five broad categories: The role of institutions 'constraining the executive' (North and Weingast 1989); the importance of 'useful knowledge' in preparing the industrial revolution (Mokyr 2002, 2009); the demand for labour saving technologies in the 18th century (Allen 2009); the 'deep' causes of the industrial revolution (van Zanden 2009); and, finally, the role of human capital formation as key source for the transition to modern growth (Galor 2011). I shall now turn to a brief discussion of the various explanations.

In their seminal paper, North and Weingast (1989) stress the importance of the Glorious Revolution of 1688 for changing the 'rules of the game'. As of 1688 the Parliament gained control over the financial system, and new institutions, such as the Back of England, were introduced to balance the power between the Crown and the members of Parliament. These 'constraints on the executive' created for the first time

[2] Unfortunately there are no detailed statistics to test for growth in these regions.

security of property rights immune from political interfering and so created the incentives to innovate. North and Weingast (1989) thus mark the Glorious Revolution as a watershed between 'absolutism' and some sort of 'parliamentary' government, and see this event as the main cause of the industrial revolution of the 18th century (see also Acemoglu and Robinson 2012).

Mokyr (2002, 2009) does not refute the importance of efficient institutions for economic growth.[3] However, he argues that the presence of efficient institutions alone were not enough for an economic take-off to take hold: the industrial revolution was the results of an interaction between favourable institutions and the arrival of a new set of 'ideas and believes'. The Scientific Revolution of the 17th century produced 'useful knowledge', such as, amongst others, knowledge about mathematics, that laid the foundation for 'Industrial Enlightenment'. This Industrial enlightenment, which he defines as 'the application of scientific and experimental methods to study of technology' (Mokyr 2009, pp. 29), connected the Scientific Revolution to the waves of technological innovations after 1760. In other words, the take-off of England depended on what people knew and believed, which in turn affected their economic behaviour.

Allen (2009) argues that institutions favourable to growth cannot have caused the industrial revolution, because property rights in England were as secure as in France and China. Neither does Allen (2009) believe that the Scientific Revolution and the 'Industrial Enlightenment' were of key importance.[4] Both were Europe-wide phenomena that do not distinguish England from the continent. Therefore, instead of focussing on the *supply* of technologies as Mokyr (2002, 2009) does, Allen shifts focus to explaining the *demand* for technology: i.e. why did Britain invented the technologies she did? According to Allen (2009) Britain invented the 'steam engine, the water frame, the spinning jenny and the coke blast furnace' because entrepreneurs were induced to implement labour saving technologies since 'labour was expensive and coal was cheap' (pp. 2). It was not profitable to invent the industrial revolution in France, because energy was expensive and labour relatively cheap.

The above-mentioned studies devote a lot of attention on the century or century and a half before the industrial revolution. However, as argued at the beginning of this section, relatively high wages do, to some extent, reflect economic success. Therefore, arguing that the industrial revolution was the result of 'high' wages is quite similar to arguing that England got economically successful because it was successful. Key is thus to explain how the high wage economy of England in the 18th century came about, for which the concept of the Little Divergence is relevant: The English industrial revolution was to some extent the result of trends going back to the late

[3] Other opponents of this view, such as, amongst others, Clark (1996), argue that there is little evidence of significant insecurity among private owners before 1688.
[4] More specifically, according to Allen, industrial enlightenment would have caused a single increase in productivity and not sustained growth in productivity levels of workers.

medieval period. Therefore, when considering the causes of the English industrial revolution, a much longer time-span is required. The next two explanations for the industrial revolution do consider the long run.

Van Zanden (2009) links the 'take-off' of the industrial revolution to the institutional developments of the late medieval and early modern period (ca. 900 – 1500). Almost all European countries experienced economic growth between 900 and 1300, but it were only the counties bordering the North Sea that managed to sustain these high levels during the period of the Little Divergence (1500 - 1800). The emergence of 'efficient' institutions in the medieval period is key to the growth experience: The north-western part of Europe, notably the Low Countries and England, was different from the rest of the continent because of the favourable characteristics of the 'European Marriage Pattern' (EMP). The North Sea area enjoyed a relatively high degree of female agency, which was the outcome of two core institutions: consensus based marriage and neo-locality of the household (De Moor and Van Zanden 2010). This resulted in a relatively high age of marriage for women, a high percentage of singles and a low share of complex households, which was favourable to emerging commercial environment and investments in human capital formation (via the lowering of fertility rates). Van Zanden thus explains the industrial revolution as a consequence of the gradual development of efficient institutions and the accumulation of human capital, but these ideas have not remained uncontested. Dennison and Ogilvie (2014) for example, have argued that there is no evidence of a link between the EMP and the Little Divergence.

A final body of literature linked to 'unified growth theory' stresses the importance of human capital as driver of economic growth. The theory, originally developed by Galor and Moav (2002), disentangles three stages of economic development. The first stage is the Malthusian regime that is characterized by slow growth in population levels and per capita incomes. A transition to the second stage of development, the Post-Malthusian regime, occurs when the growth in the population level reaches a critical threshold. Since population growth is positively related to technology, this results in an increase in per capita GDP. In this second phase workers endowed with relatively high levels of human capital are better able to cope with technological change and the implementation of new machinery than unskilled workers (cf. Nelson and Phelps 1966, Schultz 1975). Therefore the wages of skilled workers increase relative to the wages of unskilled workers. In this framework, individuals are assumed to optimize their utility with respect to the 'quantity' and 'quality' of their offspring (cf. Becker 1981). Increases in the wages of skilled workers induces individuals to shift away from the number of children to investing in the education of their children. Additional accumulation of human capital translates into technological progress. This positive feedback mechanism between technological change and increases in human capital triggers the demographic transition that moves the economy to the third phase of development: the Modern Growth regime. This final stage is characterized by low rates of fertility and high rates of investment in human capital and technological change (see Galor 2011 for an overview of the literature).

The studies of van Zanden (2009), Mokyr (2002, 2009) and 'unified growth theory' all clearly state the importance of human capital formation for the onset of modern economic growth. In this dissertation I therefore focus on the link from human capital formation to economic growth, for which, as I shall set out in the next section, very little research has been done so far.

1.2 Human capital formation and economic growth: empirical evidence

For the second half of the 20th century, the role of human capital as an essential input in the production function (proximate cause) is undisputed and explained by education facilitating technology adoption and innovation (Nelson and Phelps 1966, Schultz 1975). Although it has been proven difficult to establish a causal relationship from human capital to growth (Barro 2001), there is general agreement that human capital is positively correlated with economic growth (Benhabib and Spiegel 1994).[5]

Evidence for a positive human capital to growth relationship for the period before and during the transition to modern growth is less conclusive (cf. Galor and Moav 2002). The debate can be divided into three broad categories: i) studies that infer information about the general level of formal education such as literacy and numeracy rates; ii) research that focuses on informal skills such as on the job learning and apprenticeships; iii) and studies that highlight the importance of 'the density in the upper tail of professional knowledge' vis-à-vis the average level of human capital present in the workforce (cf. Mokyr 2005, Mokyr and Voth 2009). An additional distinction should also be made between those analysing the human capital relationship in Europe during the pre-industrial period (roughly the period before 1800) and those who focus on England during the classic years of the industrial revolution (ca. 1750-1850). I shall now turn to a discussion of previous findings.

Economic historians considering the evolution of levels of formal education in the English Industrial Revolution have described its role as minor (Mokyr 1990, Mitch 1993, Crafts 1996, Clark 2005). To start with, literacy rates in England were not exceptionally high by western European standards. Around 1800, literacy rates were about 60% for males and 40% for females (Cressy 1980). Reis (2005) has shown that this was slightly higher than France, but significantly lower than the Netherlands, Sweden and Germany. For instance, Sweden was fully literate by the early 19th century.[6] There was not much improvement in literacy during the Industrial

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[5] See Barro (1991), Mankiv et al (1992), Krueger and Lindahl (2001), Cohen and Soto (2007), Hanushek and Woessmann (2008) and Sunde (2011) for more confirmations of the human capital to growth relationship for the 20th century.

[6] Sandberg (1979) argues that Sweden became Europe's 'impoverished sophisticate'. Although literacy rates were round about 100%, its industrialization was relatively late.

Revolution itself: male literacy rates fluctuated around 60% between 1750 and 1850 (Mitch 1993). Similar conclusions can be drawn from school enrolment figures. Out of the male population in the age bracket between 5 and 14, 28% were enrolled in schools in 1830. In 1850, by the end of the first Industrial Revolution, it had increased to 50%, but this was equal to France (51%) and considerably less than Prussia (73%) (Lindert 2004).

On this basis, economic historians have concluded that formal schooling did not play an important role in the British Industrial Revolution, which encouraged them to measure 'informal skills'. Literacy, numeracy and enrolment figures do not include the acquisition of skills which did not involve formal schooling but which could have nevertheless been important for the productivity of workers, such as on the job learning and apprenticeships (Humphries 2003, Wallis 2008, Mokyr 2009). Economic historians have made some headway in measuring working skills: Kelly et al (2014) show that on the eve of the Industrial Revolution, English labourers were taller, heavier, savvier and more productive than elsewhere on the continent. Jacob (2013, pp. 157) documents a significant increase in scientific training believed to be important in facilitating the Industrial Revolution; and Mitch (2004) argues that as many as one out of four boys went through some kind of apprenticeship in 1700.

The conclusion that formal education for the masses was unimportant in the process of industrialisation has moreover led to the search for alternative theories on the role of human capital in the transition to modern growth. According to Mokyr (2005) and Mokyr and Voth (2009) it is not the average level of (formal and informal) human capital that is important for the process of industrialisation, but rather the upper tail of the human capital distribution. Technical change and the adoption to machinery affected the demand for high-quality workmen such as engineers, mechanics, (mill)wrights, instrument makers and chemists. These well-educated workers, comprising of about 3% to 5% of the labour force in terms of skills, supported innovation and helped to bring about the industrial revolution (Meisenzahl and Mokyr 2011).

The recent paper of Squicciarini and Voigtländer (2014) tests the theory of Mokyr (2005) by making the distinction between the 'density in the upper tail of professional knowledge' and more widespread education (literacy). They show that the Industrial Revolution in France was not induced by a broad distribution of skills, but rather by a small, highly knowledgeable elite. Squicciarini and Voigtländer argue that, if human capital contributes to technological progress, then it is likely that the Industrial Revolution depended on a concentrated core of skilled workers rather than on the average level of human capital in a broader sense. Contrary to the study of Squicciarini and Voigtländer (2014), however, Franck and Galor (2015) document a significant effect of industrialisation (measured by the number of steam engines) on the average level of formal education (proxied by literacy, the number of schools and the number of teachers) in early 19th century France. For England Van der Beek

(2012) shows a significant increase in the number of apprenticeships among those professions deemed important by Mokyr and Meisenzahl (2011) in facilitating the industrial revolution.

A severe limitation of the above mentioned studies is that they focus exclusively on the period of the industrial revolution itself.[7] As set out in Section 1.1, there is arguably a lot of economic growth within the North Sea region between ca. 1500 and 1800 that requires explanation. The contributions of Van Zanden (2009) and Galor and Moav (2002) stress the key role of human capital formation in the transition to modern growth. Hence, the studies that consider the human capital to growth relationship for the period of industrialisation are likely to underestimate the growth of human capital that occurred in the period before 1800.

Very little research has been performed that considers the human capital to growth relationship over the very long run, and, on top of that, the empirical results of these studies are rather mixed.[8] Allen (2003) for instance sets out to explain the Little Divergence comparing the performance of 9 European countries in the period 1300-1800. His regression results, however, suggest that human capital, measured as literacy, 'was generally unimportant for growth' (pp. 433). The recent contributions of Baten and van Zanden (2008) and Boucekkine et al (2007) introduce more comprehensive measures of formal schooling such as book production and the number of (secondary) schools and even trace their evolution back to the medieval period. What these results illustrate is that the growth of schooling was far greater than previously assumed and that it significantly contributed to pre-industrial economic growth.

1.3 Relevance and contribution of the dissertation

The empirical results from studies confronting the human capital to growth relationship for the period before the 20th century seem rather mixed. To start with, previous results seem to vary with the geographical scope: there appears to be a negative relationship between human capital and economic growth in England during the period of the industrialisation, whereas there seems to have been a positive association during the French industrial revolution. Secondly, the results vary with the time-period that is under consideration: the conclusions of previous research points to a negative human capital to growth relation in the period after ca. 1750 (e.g. Mitch 1993), whereas human capital may have contributed to growth before the onset of modern growth (e.g. Boucekkine et al 2007, Baten and van Zanden 2008). Finally, the conclusions of previous studies seem to depend on the proxies for human capital used. Literacy appears to be of less importance in facilitating the industrial revolution than

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7 An important exception stems from Kelly and Ó Gráda (2014) who acknowledge a steady increase in human capital in England between 1500-1750.

8 It should be said here that Reis (2005) considers the long run. His estimates on literacy are however largely based on the evidence of Allen (2003) under review here.

were more advanced levels of human capital (a.o. measured by book consumption) (see Baten and van Zanden 2008).

The aim of my study is to revisit previous conclusions on the role of human capital in the transition to modern economic growth. Therefore the overarching research question of my dissertation is as follows: *To what extent is there a relationship between human capital formation and economic growth in the long run*?

To be able to study the human capital to growth relationship, focus is first of all on trends within pre-industrial Europe. Next, the focus shifts to England. England was the first country that fully industrialised, which makes it a relevant case to study the human capital to growth relationship in more detail. The main question is therefore broken down into two specific questions:

1. Can human capital formation help to explain why the Low Countries and England were able to break through the Malthusian constraints and generate a process of almost continuous economic growth between 1300 and 1800?
2. Did human capital contribute to the process of industrialization that began in England in the second half of the 18^{th} century?

In my thesis several indicators of human capital are introduced which allows me to give a far more coherent picture on the contribution of human capital to economic growth than previous studies were able to (e.g. Mitch 1993, Lindert 2004, Reis 2005). I shall now turn to a brief discussion of the various measures and explain how they could provide new insights for the debate on the origins of modern economic growth.

To find out if human capital helps to explain the 'Little Divergence', a dataset on book consumption per capita is used. The dataset on book consumption includes observations for a large set of European countries between 1300 and 1800. Allen (2003) suggests that human capital, measured as literacy, did not contribute to economic growth before industrialisation. This negative result might be explained by his estimates of literacy: for 1500, his estimates are based on the urbanisation ratio, which assumes that 23% of the urban and 5% of the rural population was literate (pp. 415). Most of his estimates between 1500 and 1800 are then based on intrapolation. The estimates of book consumption per capita are a more robust measure of human capital in the early modern period. It is furthermore argued to proxy more advanced reading and writing abilities than do literacy and numeracy (see discussion in Baten and Van Zanden 2006). The data on book consumption per capita is related to various measures of pre-industrial economic growth to explore the human capital to growth relationship over the very long run.

Studying the 'Little Divergence' is first of all relevant for the debates about the 'Great Divergence'. The finding of a positive effect of human capital on growth before the industrial revolution may inform us about why the industrial revolution happened in this particular part of the world and not in China (Pomeranz 2000). It is furthermore relevant for our understanding of the roots of the industrial revolution, especially since the growth that occurred in England after 1750 was to some extent a continuation of the trends going back to the Middle Ages (Van Zanden 2009). In that way, the finding of a positive human capital to growth relationship in the period before the industrial revolution may provide evidence for the theories of Van Zanden (2009) and Unified Growth Theory (Galor and Moav 2002) that stress its key role in the growth process. Finally, it may provide insights for the debate on how to measure human capital formation in the early modern period. Literacy rates are derived from evidence on signatures and therefore likely to capture only part of the human capital variable – i.e. very basic reading and writing abilities (see discussion in Schofield 1968). Book consumption captures more advanced levels of human capital than do literacy as it includes ‘new book editions per capita’. The concept of edition and re-edition is important here as it captures re-edited books that were considered important for the transfer of scientific knowledge. Book consumption is furthermore linked to the demand for books in pre-industrial societies, because ‘it reflects the degree to which a society has become literate and in which mass demand for books has emerged’ (Baten and van Zanden 2008, pp. 2). Hence, the finding of a positive effect of book consumption on economic progress may inform us that more advanced levels of human capital were more important for growth to occur than were very basic skills such as reading and writing abilities (Allen 2003).

One of the determining factors behind the growth of human capital before industrialisation is the European Marriage Pattern (De Moor and van Zanden 2010). To test this idea, it is necessary to measure this institution. Dennison and Ogilvie (2014) put together a dataset with information on average age of marriage, the share of singles and the share of complex households in Europe between 1500 and 1900 – the classical features of the EMP according to Hajnal (1965). That this is not the right way to test this link, is explained in Chapter 3, where an alternative dataset measuring institutions concerning marriage and the family system in EurAsia is introduced (from Carmichael and van Zanden 2015). This Female-Friendly index measures female agency within marriage, and is a much better indicator of the role women played in decision making about their own education and in particular the education of their children.

When considering the human capital to growth relationship in England, I follow the literature and distinguish between three different kinds of human capital. This results in the following set of hypotheses:

> 2a. Increases in formal education contributed to economic growth in England;
> 2b. Increases of working skills contributed to economic growth in England;
> 2c. The ‘specialized professional knowledge’ contributed to economic growth in England.

To analyse the contribution of formal education to long run economic growth in England, I introduce a new measure which is the stock of average years of education present in the population between 1300 and 1900. The stock of formal schooling incorporates extensive statistical evidence on literacy rates, the number of primary and secondary schools and their average class sizes, and matriculations to the University of Cambridge, Oxford and London. Demographic key figures, such as survival rates of individuals, are applied to estimate average years of education present in the total population. An additional distinction is made on the basis of gender (years of education of males and females) and of level (formal primary secondary and tertiary education). Average years of education are then related to the latest estimates of per capita GDP of Broadberry et al (2015) to find out if increases in schooling helped to facilitate the industrial revolution.

The estimates on educational attainment allow me give a far more coherent picture on the evolution of formal schooling than was possible before. First of all, previous research has mainly focused on the trends in (male) literacy (Nicholas and Nicolas 1992, Mitch 1993, Reis 2005). As mentioned already, literacy rates are likely to underestimate the level of formal education present in the population as they only proxy primary schooling levels. The stock of average years of education is a better measure for formal education as it adds information on secondary and tertiary education. Secondly, previous studies have mainly focussed on the period of the industrial revolution (e.g. Mitch 1993). The stock of average years of schooling captures the spread of formal schooling in the centuries prior to 1750, which makes it less likely to underestimate the spread of schooling on the eve of the industrial revolution.

To examine the evolution of working skills before and during the industrial revolution, I make use of occupational titles. The occupational titles, as collected by the *Cambridge Group for the History of Population and Social Structure*, come from historical marriage registers covering three centuries of English history, from 1550 and 1850. The so-called HISCLASS system, developed by Van Leeuwen and Maas (2011), is employed to code the occupations of over 30,000 English male workers according to the skill-content of their work. This not only captures investments in general educational development (such as reading and writing abilities), but it also includes vocational training (a.o. on the job learning). The methodology enables me to study the evolution in average working skills used in productive activities across England over the long run. It also allows me to analyse the prevalence of the 'density in the upper tail of professional knowledge' by focusing on the evolution of a set of occupations that Mokyr (2005) deemed necessary to facilitate the industrial revolution such as joiners, turners, wrights, engineers and machine makers.

Studying the evolution of working skills in England allows me to give a better picture on the role of informal skills in the transition to modern economic growth than was possible before. First of all, the studies of Van der Beek (2012) and Mitch (2004) have focused on statistics regarding apprenticeships. It is a competent measure to study the training of people with lengthy education, but when the apprenticeship era was at its height (around 1700), only four per cent per year of the English population signed a contract, and over 50% who signed failed to complete it (Wallis 2008). In addition, since only rather affluent families were able to afford them, apprenticeships tell us very little about the human capital of the (more numerous) lower socio-economic ranks. Secondly, since the measure of working skills captures vocational training, it is likely to supplement more basic education such as reading and writing abilities. The fact that any skills obtained were not necessarily used productively, such as a farmers worker's ability to read and write, makes the potential discrepancy between the *acquisition* of skills and the *application* of skills in productive activities a relevant matter, and one which is difficult to address using measures of very basic skills such as literacy and numeracy. Finally, previous studies mainly focused on the evolution of skills during the period of the industrial revolution (e.g. Van der Beek 2012), which, as argued above, is likely to underestimate the growth in human capital before the 18th century. The focus on working skills makes it possible to trace the evolution of informal skills over three centuries of English history, from 1550 and 1850.

To sum up, the datasets presented here capture three of the important elements of the 'human capital' variable over the long run – i.e. formal schooling, working skills, and specialized professional knowledge (cf. Mokyr 2005). In the various contributions to this thesis, these variables are related to measures of pre-industrial development and modern economic growth, such as per capita GDP. In that way, this allows me to give a far more coherent picture on the evolution of human capital than previous studies were able to. Moreover, regarding the human capital to growth relationship, it informs us which part of the human capital variable contributes to growth. This approach also tells us during which stages of the development process human capital contributed to growth.

The analysis of the role of human capital in the transition to modern growth may furthermore provide fruitful insights for the debate about the origins of the English industrial revolution more generally. If human capital is found to be a key input in the production function, then future research should take this factor into account when analysing growth over the long run. It could also add further evidence to theoretical studies stressing its role in the transition to modern economic growth (Galor and Moav 2000, Galor 2011).

1.4 Datasets and methodology

To find out if human capital can explain the divergent development of north-western Europe between 1300 and 1800, chapter 2 makes use of the per capita book production as collected by Baten and van Zanden (2008) that I briefly introduced in the previous section. It includes observations for 13 European countries for the period

1450-1800. The estimates of Baten and van Zanden are combined with observations on book production of Buringh and van Zanden (2009) for the medieval period (1300-1450). The years thus include 1300, 1400, 1500, 1600, 1700, 1750 and 1800. The countries included are: Spain, Italy, England, The Netherlands, Germany, France, Austria, Poland, Belgium, Switzerland, Sweden, Portugal and Ireland.

Since the data on per capita book production is available for such a large set of European countries and for such a long period of time, it becomes possible to apply panel regression techniques to explore the effect of human capital on pre-industrial economic growth. Per capita book consumption is first of all related to the latest estimates of per capita GDP (Bolt and van Zanden 2013). However, because per capita GDP may be subject to margins of errors, book consumption is also related to urbanisation, which is another frequently used indicator of economic progress in the early modern period (Acemogelu et al 2005, Bosker et al 2012).

In estimating the effect of book consumption on economic development, an important concern is endogeneity. The human capital to economic growth relationship may be prone to reverse causality, as relatively rich countries such as Holland and England may have been able afford this higher level. Another endogeneity issue is related to measurement error in the book consumption variable. It is likely that book consumption captures only part of the 'true' human capital formation that occurred (see discussion in Section 1.2). The variable is lagged for one period in the regression analysis to somewhat limit the reverse causality issue. To deal with measurement error, Random-Effects / Two-Stage least-squares (RE/2sls) regressions are performed where human capital is treated as endogenous. Moreover, Protestantism is introduced as an instrument for book consumption per capita. The premise is that Protestantism had a strong and positive effect on human capital formation, whilst having no direct effect on economic growth (Becker and Woessmann 2009). Instrumenting book consumption with Protestantism makes it possible to say something about the causal relationship between those variables.

The dataset on book consumption per capita is used once more to find out if the European Marriage Pattern can explain the increases in human capital between 1300 and 1800. In chapter 3 the EMP is measured by the 'female-friendliness' index as constructed by Carmichael and van Zanden (2015). Carmichael and van Zanden have redefined the EMP in ethnographic terms and used ethnographic information (Murdock's database and Todd's studies) to classify the societies of EurAsia on various marriage and family-related institutions, such as monogamy, consensus, female inheritance, exogamy and neo-locality. All these institutions have a 'female-friendly' version: monogamy is from this perspective to be preferred to polygamy; consensus to arranged marriage; female inheritance to systems without them; exogamy to endogamy (which restricts the choice of marriage partners to kin-members) and neo-locality to patri-locality. Carmichael and van Zanden classify societies to let them score on these five dimensions. For instance, societies that are monogamous score one point here, and societies with polygamy do not score a point. Female inheritance, exogamy, matrilocality and consensus all score similar points. In that way the ‘female-friendliness’ of family systems in Eurasia can be established: the more points a country scores on the range between 0 and 5, the more its institutions favour female agency.

The female-friendliness index is a good proxy for testing the ‘Girlpower’ version of the EMP hypothesis, as it is clearly based on the underlying institutions. In testing for the relation between the EMP and increases in human capital formation, a simple linear regression model is estimated. Since the female-friendliness index captures the underlying institutions of the EMP, reverse causality is not a real concern in the regression analysis. The female-friendliness index is therefore directly related to per capita book consumption. To test for the robustness of the results, several control variables are added to the analysis. These include, amongst others, proxies for political institutions (van Zanden et al 2012), the contribution of colonies (Acemoglu et al 2005), and the effect of warfare (Tilly 1990).

In order to revisit the debate on the contribution of formal education to long run growth in England, this study measures the stock of average years of education of the population between 1300 and 1900 (Chapter 4). The estimate of this stock is a direct application of the concept because formal schooling is directly linked to individuals: assuming the lifetime of humans (and therefore the lifetime of their human capital) to be finite, it is possible to apply the perpetual inventory method to compute the stock of human capital (Clemens et al 1996). This is essentially the same way as building stocks of physical capital. An individual’s human capital (the number of years of schooling) enters the stock when he/she finishes school and leaves the stock at the time of death depending on his/her life expectancy. To estimate the flow of years of primary, secondary and tertiary schooling entering the human capital stock, statistical source material on literacy rates, the number of primary and secondary schools and their average class sizes, and matriculations to the University of Cambridge and Oxford.

More specifically, to estimate the annual flow of years of primary education entering the human capital stock between 1550 and 1900, existing statistical evidence on literacy rates are combined. The statistics on literacy of Cressy (1980, 1981) are used for the years 1550 to 1754; those of Schofield (1981) for the years 1754 to 1840; those of Stephens (1987) for the years 1840 to 1885; and, finally, those of Cressy (1980) for the years after 1885. Hoeppner Moran (1985) traces the evolution of schooling in the Diocese of York between 1300 and 1548 by quantifying the number of primary schools (notably song- and reading schools). The statistics provided by Hoeppner Moran (1985) allow me to estimate the annual flow of years of primary schooling in the middle ages.

In order to estimate the flow of secondary schooling, I make use of evidence on the number of secondary schools and their average population level. Orme (2006) provides a very detailed list of (endowed) schools between 1300 and 1530. All secondary schools listed are coupled to a specific date at which the institution was first encountered in the records. Detailed statistics on the number of secondary schools after 1530 are available from the report of the Schools Inquiry Commission (SIC 1968). The studies of Stowe (1908), Hoeppner Moran (1985), Vincent (1969) and Owen (1964) provide me with estimates on the average population level of these institutions which makes it possible to calculate annual enrolment in secondary schooling.

Finally concerning the data of chapter 4, to estimate the annual flow of tertiary education entering the human capital stock between 1500 and 1900, I make use of the study of Stone (1974). Stone collected statistics on freshmen admissions to Oxford University and the University of Cambridge. Stone's figures allow me to differentiate between the number of students that completed the bachelor programme, those that made it up to the masters' level, and those who did not graduate at all. To the best of my knowledge, no such detailed dataset exists for the period before 1500. Population estimates for both universities are however available from the analyses of Aston (1977) and Aston et al (1980) that allows me to quantify the flow of tertiary education between 1300 and 1500.

Combining the evidence on the flows of primary, secondary and tertiary education gives me the stock of human capital between 1300 and 1900. To formally test the relation between average years of education and economic growth, a time series analysis is conducted. Johansen tests of cointegration are performed to test for the possibility of a long-term relationship among educational attainment and per capita GDP (Johansen 1995). In the cases where cointegration is found, bivariate cointegrated VAR models are estimated. The model does not include other relevant determinants of per capita GDP such as international trade (Allen 2003), the quality of institutions (North and Weingast 1989, Acemoglu et al 2005), physical capital, and the like, so the results must be interpreted with some care. It is however possible to interpret the cointegrating relationship as robust correlation coefficient, because underspecification does not affect the consistency of the estimated cointegrating vectors (Pashoutidou 2003).

Finally in chapter 5, in order to estimate the evolution of working skills in England between 1550 and 1850, the occupational titles out of the dataset of the Cambridge Group's *Family Reconstitution Data* (Wrigley et al 1997) are combined with the HISCLASS scheme (Van Leeuwen and Maas 2011). The HISCLASS scheme builds on two main scores used in the DOT: the *General Educational Development* score and the *Specific Vocational Training* score. The score concerning the general educational development captures three key features regarding the intellectual competencies necessary to fulfil the tasks and duties of an occupation: the incumbent's reasoning abilities; his or her ability to follow instructions; and the acquisition of language and mathematical skills needed to conduct the work. The score concerning specific vocational training captures the time investments needed in three main areas: the time required by the worker to learn the techniques necessary for the job; the time needed to acquire the relevant information to conduct their work; and the time necessary to develop the competencies required for an average performance in a job-specific working situation. These abilities implicitly capture any formal and informal training needed to carry out the work.

Van Leeuwen and Maas used the two DOT scores to code the occupational titles categorised in HISCO according to the skill-content of the work, as part of the procedure to create the HISCLASS scheme. In the HISCLASS scheme, occupational titles were grouped into four skill-groups: *unskilled, lower-skilled, medium-skilled,* or *higher-skilled*. The sampled English workforce contains 284 different occupational titles identified by the HISCO and hence 'codeable' in the HISCLASS scheme.

The sampled observations are split into fifty-year intervals covering the period from 1550-1850 to study the evolution of working skills before and during the industrial revolution. To find out if there was skill-formation in industry, agriculture, or both, the occupational titles are divided for each of the three main sectors of production: Primary, Secondary and Tertiary (Wrigley 2010). Within each sector, the occupational titles are then divided into the four major skill-groups in HISCLASS: high-, medium-, low-, and unskilled workers. This methodology allows me to study the skill developments *within* the main sectors of production. By focussing on a set of occupations that Mokyr (2005) deemed necessary to facilitate the industrial evolution, such as joiners, turners, and wrights, it is also possible to study the prevalence of highly skilled professionals.

1.5 Overview and findings

Chapter 2 explores the link between human capital and economic growth between 1300 and 1800. It is first of all shown that per capita GDP is a better proxy of economic development than is the real wage series of Allen (2003). Real wages are affected by the 'Black Death bonus', the sudden increase in real wages after 1348, induced by increased labour scarcity. Consequently, the highest real wages are found in Eastern Europe in 1400, not the region that first comes to mind as being economically advanced. Thereafter a number of alternative theories about the root causes of early modern growth are discussed. These include international trade (Acemoglu et al 2005), the quality of political institutions (North and Weingast 1989), human capital formation (Baten and van Zanden 2008), and productivity increases in the agricultural sector (Overton 1996). This is then followed by a discussion about the datasets that have been collected to test the various hypotheses: The tonnage size of the merchant fleet is used as a proxy for international trade, parliamentary activity indices are introduced to capture the quality of political intuitions, and yield ratios measure efficiency gains in agriculture. As is the case with the variable on book production, these variables suffer from ‘reverse causality’: For instance, the richer the country, the more likely it was to engage in international trade. The empirical analysis therefore starts by introducing the set of instruments used to control for endogeneity problems. Thereafter I report on the results from the Instrumental Variable regressions explaining per capita GDP. The outcomes are evaluated using the Maddison (2001) estimates on per capita GDP and the latest data on urbanisation ratios (Bosker et al 2012).

In Chapter 2 it is found that economic growth before 1800 was, as already argued by De Vries and Van der Woude (1997) in their book on the Dutch economy between 1500 and 1800, caused by the same drivers as modern economic growth of the 19th and 20th centuries. The first significant finding is that the differential evolution of parliamentary institutions helps to explain the Little Divergence. This result adds evidence to the empirical findings of Acemoglu et al (2005) and van Zanden et al (2012) stressing the importance of political institutions for early modern growth. Constraints on the executive, such as an active Parliament, contributed to economic development via the protection of property rights (North 1981, North and Weingast 1989). The empirical results also show that book consumption explains a large part of the per capita GDP growth that occurred between 1300 and 1800. It is furthermore suggested that Protestantism had no direct effect on per capita income levels, but it seemed to have worked via the channel of human capital formation.

Chapter 3 empirically tests for the relationship between the European Marriage Pattern and human capital formation in the period before the industrial revolution. Section 3.2 reviews the evidence presented by Dennison and Ogilvie (2014) that the EMP did not contribute to economic growth between 1300 and 1800. It is shown that Dennison and Ogilvie do not conceptualize the link between the EMP and pre-industrial development correctly. In Section 3.3 we suggest a proper test of the link between the EMP, economic growth and human capital, starting from the alternative interpretation of the EMP as a system that allows for relatively high levels of female agency. This is then followed by the introduction of the dataset on the ‘female-friendliness’ capturing the underlying institutions of the EMP, such as, amongst others, monogamy and female-inheritance practices. Thereafter a regression analysis is conducted that tests for the links between female agency, economic development and human capital formation.

The findings in Chapter 3 show that the EMP hypothesis cannot be tested in the way suggested by Dennison and Ogilvie. For instance, Dennison and Ogilvie have related average age of marriages to measures of economic development. However, a serious problem is that the age of marriage is not only determined by the presence or not of the EMP but also related to the degree of economic stress (due to low living standards) that marriage partners face. Similarly, it is also argued that Dennison and Ogilvie do not test the new interpretation of the EMP that has been postulated in the study of de Moor and van Zanden (2010), which focussed on the underlying institutions instead of on the features of the EMP. The results following the regression analysis show that there was a strong, consistent link between female friendly institutions at the micro level, economic performance and human capital formation. The analysis of Chapter 3 therefore supports the hypothesis of de Moor and van Zanden that the EMP was based on two core institutions: neo-locality and consensus marriage. These institutions were favourable to female agency, and hence to investments in human capital and economic growth.

The estimates on the stock of formal schooling in England between 1300 and 1900 are introduced in Chapter 4. The chapter starts by explaining the procedure to quantify the stocks of average years of education in the population. It elaborates on the use of literacy rates as a proxy for primary schooling, and discusses the applied method to convert them into primary school enrolment. Similarly, it also discusses the assumptions underlying the estimates on average years of secondary and tertiary schooling. Thereafter the stocks of human capital per capita according to the attainment data are analysed. The trends in the datasets are discussed and compared to the findings of previous research (e.g. Humphries 2010). A time series analysis is carried out in Section 4.3 to find out if increases in human capital formation contributed to economic growth. The Section starts by introducing the Vector Error Correction Model and discusses its properties. There is also tested for cointegration (i.e. the existence of a causal long term relationship among the human capital and per capita GDP). In the cases where cointegration is found, the restricted cointegrating vectors and adjustment coefficients are estimated. The obtained results are evaluated by testing for normality in the residuals and by testing for autocorrelation.

Regarding the role of formal education in the English Industrial Revolution, some interesting findings follow the stock of average years of schooling between 1300 and 1900. The years of schooling measure began to increase at a fast rate after the 1530s. Between 1530 and 1700, secondary education accounted for over half of the share of the education stock of males. One out of six boys went up to the secondary level by the turn of the 17th century. A pronounced shift occurred after 1700 resulting in stagnation in average years of primary schooling and a vast decline in attainment levels of secondary and tertiary schooling. Only one out of thirty boys went up to the secondary level in the second half of the 19th century. The educational attainment levels of females were well below those of males, but it is the only stock that shows consistent growth until 1800. Over the course of the 19th century, females rapidly caught up with males in terms of average years of primary schooling. Overall, from the evidence on the evolution of the stock of human capital, it can be concluded that the first Industrial Revolution coincided with a pronounced decline in formal secondary schooling levels of males. The results following the time series analysis suggest a positive educational attainment to per capita GDP relationship in the 17th century. During the 18th and 19th centuries, the relationship was clearly negative.

Chapter 5 introduces the data on working skills derived from the occupational data. Section 5.2 starts with a discussion on the method applied to combine the occupational titles with the HISCLASS scheme to derive working skills. Thereafter the evolution of the share of unskilled workers between 1550 and 1850 is shown. The larger part of Chapter 5.2 is devoted to the robustness of the obtained results. The 26 sampled parishes where originally selected by the Cambridge Group for the demographic quality of their registers rather than for the quality of their occupational information. This raises three concerns regarding their suitability for the purpose at hand: the under-recording of the occupational status (in particular when moving backwards in time); the representativeness of the sample of national occupations over time (see Wrigley et al 1997, pp. 41); and, finally, compositional effects. The section therefore presents regressions that (i) control for systematic under-recording of occupational titles and (ii) control for compositional effects. To deal with the representativeness of the sample, the share of unskilled workers in the sample are compared with evidence from census data and social tables, which covers much larger shares of the English male workforce. It is however shown that the results from the occupational data appear to be robust. Section 5.3 seeks to establish if there was skill-formation in industry, agriculture, or in both sectors of production. Here focus is on two of the largest parishes in the sample: Banbury, an industrial parish, and Gainsborough, an agricultural parish. Studying the parishes individually allows me to avoid potential problems arising from compositional effects. Banbury and Gainsborough have furthermore enough observations to control for occupational under-recording.

It is found that the sampled workforce was relatively well trained during the 16th century, with 20% on average of all sampled workers coded as 'unskilled' according to the HISCLASS scheme. But I also find a dramatic rise of the share of unskilled workers after 1700: by the 19th century the share of unskilled workers had almost doubled, comprising 39% of the sampled workforce. These estimates chime with those derivable from social tables and census data, which cover much larger shares of the English workforce. The 'deskilling' observed is robust to a large variety of regression model specifications, including the controls for compositional effects and the restriction that at least 95% per year of the sampled males were recorded with an occupational title.

By splitting the sampled workforce into blue-collar (manual) and white-collar (non-manual) workers, it becomes clear that the deskilling observed was chiefly a blue-collar phenomenon. On average, the shares of lower- and medium-skilled blue-collar workers declined substantially over the period of observation, while the share of unskilled blue-collar workers grew from 24% to 42%. The skill structures among white-collar workers, however, remain largely constant during the period of observation. It is also established that some degree of skill formation takes place among the sampled workforce that can be attributed to upward social mobility across the life-cycle, and that some of the loss of skill observed is associated with having an immigrant background.

By studying the most populous parishes in the sample individually, it becomes clear that deskilling was rather widespread, both geographically and across the main sectors of production. However, the loss of skill was more pronounced in agriculture than in industry. In Gainsborough, the disappearance of low-skilled husbandmen and cottagers occurred in parallel with a growth in the shares of unskilled farmworkers and farmers. These findings suggest that deskilling in agriculture emerged from organisational changes linked to land concentration, which occurred in combination with a shift of labour out of agriculture. As the example of Banbury illustrates, the deskilling in industry occurred alongside an increase in the demand for highly-skilled professionals such as instrument makers, joiners, turners, engineers, mechanics and wrights (i.e. machine erectors and installers). The data illustrated that the share of highly-skilled workers modestly increased from 11% to 14% of the manufacturing workforce between 1700 and 1850. Similarly, new occupational titles emerged in Banbury at the time, including, amongst others, 'engine operators' and 'watch makers', comprising up to nearly 3% of the Banbury manufacturing workers by 1800-50. However, this skill-formation was not enough to counterbalance the vast decline in the shares of lower- and medium-skilled weavers, tanners, and smiths in manufacturing.

1.6 Summary and implications

I return to the main question of my dissertation: to what extent is there a relationship between human capital formation and economic growth in the long run? To systematically address the research question, I have proposed a breakdown of the main question along two dimensions. The first was to reconsider the contribution of human capital to early modern growth, for which I focus on economic trends in pre-industrial Europe. It was argued that the economies of The Low Countries and England showed a lot of progress between 1300 and 1800, whereas the economies of the countries on the Continent stagnated after the arrival of the Black Death. The second question was to find out to what extent human capital contributed to industrialisation in England during the 18th century. England was the first country that fully industrialised, which made it a highly relevant case for studying the human capital to growth relationship more in-depth. In doing so I followed the existing literature and broke down the human capital variable into three: 'formal education', 'working skills' and 'highly skilled professionals'.

It can be concluded that before the onset of modern economic growth human capital formation contributed to economic development. This conclusion is first of all evident from the analysis explaining the divergent path of economic progress in Europe between 1300 and 1800. The regression results in Chapter 2 nicely illustrated that per capita book consumption contributed to per capita and urbanisation ratios. It is furthermore clear from the analysis focused on England's early industrialisation. The time series analysis of Chapter 4 has shown that there was a positive association between average years of education and per capita GDP in England before the 1750s. It was not possible to empirically test for the link between working skills and economic development; in particular as there was not a sufficient number of observations to perform a meaningful regression analysis with. Nevertheless, the results presented in Chapter 5 clearly demonstrate that the level of average working skills in the English work force was relatively high on the eve of the industrial revolution: only one out of five workers could be classified as unskilled according to the HISCLASS scheme (compared to two out of five in the 1850s). It can thus be concluded that average working skills were on par with levels of formal education such as the stock of average years of education. Overall the results presented in my thesis are in line with Baten and van Zanden (2008), Dittmar (2011) and Boucekkine et al (2007) showing that human capital formation significantly contributed to pre-industrial growth.

What then were the causes of the increase in human capital levels in Holland and England in the period before industrialisation? The analysis in Chapter 2 has established a positive relationship between Protestantism and per capita book consumption. This finding confirms the hypothesis of Becker and Woessmann (2009) that economic success and human capital were driven by the spread of Protestantism after the Reformation. Chapter 3 has moreover empirically demonstrated a link between female friendly institutions and per capita book consumption. The empirical evidence therefore suggests that female agency and greater say of women in decision making at the household level was favourable to investment in human capital. This finding lends ample support to the study of de Moor and van Zanden (2010) who have stressed the importance of such a link.

When analysing the human capital to growth relationship in England during the classic years of the industrial revolution, it is first of all shown that there was a decline in the demand for formally educated workers. The time series analysis of Chapter 4 has documented a negative relationship between average years of education and per capita GDP. In Chapter 5 the evidence on the evolution of average working skills over the long run illustrated that there was an increase in the share of unskilled workers used for productive activities between 1700 and 1850.

The finding of a negative human capital to growth relationship during the age of cotton and steam provides further evidence to the predominant view that the average level of human capital did not increase between ca. 1750 and 1850 (Nicholas and Nicholas 1992, Mitch 1993, Lindert 2004, Reis 2005, Clark 2005). Relative to this literature several contributions have been made. First of all, previous conclusion are derived from the observation of a pause in the growth rate of male literacy during the first industrial revolution. Evidence from the stock of primary education of males indeed suggests that this must have been the case. However, the movement away from secondary and tertiary schooling during the first phases of industrialisation is a factor that should not be overlooked: it demonstrates that the decrease for educated workers was more pronounced than the evidence on the spread of literacy alone would suggest. Secondly, this finding is not only apparent from the evidence on the general level of formal education, it is also clear from the evidence on working skills presented in Chapter 5. There was a decline in the average level of working skills used for productive activities, notably in agriculture. Third, the analysis of the professions believed to be vital to England's industrial revolution has documented an increase in the share of highly skilled professionals between 1700 and 1850. This finding may suggest that the industrial revolution was not facilitated by a broad distribution of skills, but rather by a small minority of technically trained workers.

Overall the evidence presented in my thesis is suggestive of the human capital to growth relationship changing over time. Average levels of human capital contributed to pre-industrial economic development, but its role during the industrial revolution was limited. At the same time, however, it is likely that there was a positive association between highly skilled professionals and industrialisation. What then seems to be a reasonable picture of the nature of technological progress during the industrial revolution is, as already suggested by O'Rourke et al (2013), a situation in which skill biased and skill saving technical change coexisted. The two types of technological change are not mutually exclusive, but the average propensities of skill-biased and unskilled-biased technological change varied over the course of industrialisation.

The findings presented here moreover reinforce the pessimistic interpretation of living standards in England during the industrial revolution. Indeed, working hours went up (Voth 1998, Allen and Weisdorf 2011); child labour increased (Humphries 2010); heights declined (Cinnirella 2008); and wages stagnated (Clark 2007). The dip in schooling and the loss of skill would certainly have contributed to a less stimulating work-life among English workers.

1.7 Limitations and avenues for future research

In Chapter 5 it is documented that the share of highly-skilled workers modestly increased between 1700 and 1850 thereby providing evidence for the view of Mokyr (2005) that the density in the upper tail of the knowledge distribution was important to England's' early industrialisation. However, the analysis focused on the level of the parish, and therefore the sampled workforce only makes up a minute (and possibly even biased) fraction of the entire English workforce at the time. A potential fruitful avenue for future research is to find out if the increases in the share of highly-skilled workers applies more broadly. If it is found that a concentrated core of skilled workers were important for technological change during the industrial revolution, then this might imply that too much attention is given to average human capital levels when we talk about economic development, whereas not enough research has been performed to figure out when and how countries achieved a critical mass of highly skilled workers.

Another relevant topic for future research is to examine the relationship between the nature of technological change and demography. Most theoretical models assume an ever-increasing level of human capital in the workforce during the industrial revolution (Becker et al 2011, Galor 2012). In my thesis I have documented that the larger part of the technological advances were unskilled labour biased. Hence, if the nature of technological change initially reduced the (in)direct cost of rearing children, for instance by turning them into a source of revenue to support the family, it becomes much easier to square stagnant wages (and perhaps the flat skill premium) with increases in fertility rates.

It should be said here that my thesis focused on the relationship between human capital and growth before and during the first industrial revolution (up to ca. 1820). The results of Chapter 4 highlight the acceleration of human capital over the course of the 19th century. The stock of average years of schooling of males had almost doubled, and the stock of females had even quadrupled. This finding gives rise to the notion of Mokyr (2013), Goldin and Katz (1998) and Acemoglu (2002) that high levels of human capital were more important in later stages of the industrial revolution. Most of the revolutionary macro-inventions were implemented during the second industrial revolution, which required a more formally educated workforce. The applied methodology in my thesis did not allow me to fully address this hypothesis. Therefore another potential fruitful direction for future research is to examine the human capital to growth relationship during the second industrial revolution.

The pronounced decline in the general level of human capital during the English industrial revolution must not necessarily hold for other countries making the transition to modern growth. For the 20th century Krueger and Lindahl (2001) have documented that while human capital mattered for a large and global sample of countries, it did not significantly contributed to economic growth in OECD countries. Their findings suggest that countries that are close to the technological frontier benefit little from growth in the average level of human capital, whereas countries that are catching up and adopt the most advanced technologies may benefit from increases in human capital. Something quite similar may have been true for Europe between ca. 1820 and 1900. For example, Becker et al (2011), studying 19th century Prussia, empirically demonstrate that primary education helps to explain the technological catch-up of follower nations. England was the first country to make the transition to modern economic growth, which makes it the technological frontier. Hence, it may well be that we observe a process of deskilling in England during its early industrialisation, whereas counties that caught-up after the 1820s were less prone to such a process.[9] In that way, this study provides no 'credible counter factual' to fully address this issue.

[9] This may also help to explain why Franck and Galor (2015) document a positive relationship between the basic levels of schooling and industrialisation in 19th century France.

Chapter 2: Accounting for the 'Little Divergence'. What drove economic growth in pre-industrial Europe, 1300-1800?
(With Jan Luiten van Zanden)

2.1 Introduction

The Industrial Revolution is arguably the most important break in global economic history, separating a world of at best very modest improvements in real incomes from the period of 'modern economic growth' characterized by rapid growth of GDP per capita. The debate about this phenomenon has recently been linked to the study of long-term trends in the world economy between 1300 and 1800. One of the issues is to what extent growth before 1750 helps to explain the break that occurs after that date; the idea of a 'Little Divergence' within Europe has recently been suggested as part of the explanation why the Industrial Revolution occurred in this part of the world. This 'Little Divergence' is the process whereby the North Sea Area (the UK and the Low Countries) developed into the most prosperous and dynamic part of the Continent. Studies of real wages – the classic paper is by Robert Allen (2001) – and of GDP per capita (e.g. Broadberry et al 2011, Van Zanden and Van Leeuwen 2012, Alvarez-Nogal and Prados de la Escosura 2012) charting the various trajectories of the European countries in detail, demonstrated that the Low Countries and England witnessed almost continuous growth between the 14th and the 18th century, whereas in other parts of the continent real incomes went down in the long run (Italy), or stagnated at best (Portugal, Spain, Germany, Sweden and Poland). This 'Little Divergence' is also quite clear from data on levels of urbanization (De Vries 1981), book production and consumption (Buringh and Van Zanden 2009) and agricultural productivity (Slicher van Bath 1963a, Allen 2000). The idea of a comparable divergence in institutions (in the functioning of Parliaments) has also been suggested (Van Zanden et al 2012). In sum, the 'Little Divergence' between the North Sea area and the rest of the continent is now a well-established fact, which is also relevant for debates about the 'Great Divergence' (it is not Europe as a whole that diverged from the rest of EurAsia, but 'only' the north-western part of it), and obviously for understanding the roots of the Industrial Revolution (which was to some extent a continuation of trends going back to the late Middle Ages).

The question about the causes of this divergent development of north-western part of Europe is therefore highly relevant for our interpretation of its specific growth path. Why were the Low Countries and England already long before 1800 able to break through Malthusian constraints and generate a process of almost continuous economic growth? In 1750, at the dawn of the Industrial Revolution, the level of GDP per capita of Holland and England had increased to 2355 and 1666 (international) dollars of 1990 respectively, compared with 876 and 919 dollar in 1347 (just before the arrival of the Black Death), and 1454 and 1134 in 1500 (Bolt and Van Zanden 2013). What made possible this doubling or nearly tripling of real incomes in the pre-industrial world? Various hypotheses have been suggested: institutional change (two versions:

socio-political institutions such as Parliaments, demographic institutions such as the European Marriage Pattern), the impact of the growth of overseas – in particular – transatlantic trade (Acemoglu et al 2005), and the effect of human capital formation (Baten and Van Zanden 2008).

The most comprehensive test of these various hypotheses was published by Robert Allen (2003). He set out to explain the Little Divergence in terms of real wages (of skilled workers), comparing the performance of a set of 9 countries (Spain, England and Wales, Italy, Germany, Belgium, the Netherlands, France, Austria-Hungary and Poland) in the period 1300-1800. Real wages, agricultural productivity, urbanization, proto-industrialization, and population growth are explained by each other and six exogenous variables: land-labour ratios, enclosure movements, trade levels, representative governments, rates of literacy and productivity in the manufacturing industry. The reported regression results explaining the development of real wages show a positive effect of land-labour ratios (according to Malthusian expectations), and also generally positive coefficients for urbanization and agricultural productivity. But neither growing literacy nor the expansion of international trade appears to contribute directly to real wage growth. The international trade boom and agricultural productivity do however help to explain trends in the rate of urbanization, and via this link also affect real wages. Finally, by combining regression results into one simulation model, Allen finds a large effect of international trade on the development of north-western Europe, whereas representative governments and rates of literacy are unable to explain economic success: 'The intercontinental trade boom was a key development that propelled north-western Europe forwards' (p. 432), but 'the establishment of representative government has a negligible effect on government in early modern Europe' (p. 433) and 'likewise, literacy was generally unimportant for growth' (p. 433). This conclusion – the rise of the North Sea area is due to international trade and not caused by human capital formation and/or institutional change – has moreover been the starting point of his analysis of the causes of the Industrial Revolution (Allen 2009).

The aim of this Chapter is to explain the process of differential growth in early modern Europe on the basis of new data that have become available recently. We first of all focus on the explanation of trends in GDP per capita of the countries concerned, which is we argue a better proxy of economic performance than the real wage estimates (see the discussion below). However, because these GDP estimates are subject to margins of error, we perform the same experiment with the estimates of the urbanization ratio as the dependent variable. We have also more detailed estimates of the various independent variables used in the regression analysis; this includes new data for human capital formation, the quality of political institutions, overseas trade, and agricultural productivity. On top of this, more countries are added to the analysis (i.e. Sweden, Norway, Denmark, Portugal, Switzerland and Ireland). We apply Random-Effects/Two-Stage least-square regression techniques to explore the effect of the independent variables on per capita GDP. The empirical results lead to different conclusions. GDP growth (where it occurs) is basically driven by political institutions and human capital formation: two factors that were not contributing to real wage growth in the Allen (2003) regressions. Moreover, our conclusions are robust when switching to urbanization rates as the dependent variable.

2.2 The Little Divergence: Per capita GDP

The starting point is that we try to explain patterns of GDP growth in Western Europe between 1300 and 1800. Recently, much new research charting the long-term evolution of GDP per capita in various parts of Europe has been carried out, which now makes it possible to systematically analyse patterns of real income growth. Moreover, we think that GDP is a better proxy of economic performance. Real wages, an alternative proxy, are affected by systematic changes in income distribution, and trends between 1400 and 1800 are strongly influenced by the ‘Black Death bonus’, the sudden increase in real wages after 1348, due to increased labour scarcity. As a result, in most countries the trend in real wages between 1400 and 1800 is downward, whereas GDP per capita is stagnant or growing (see figures 2.1 and 2.2). A similar situation of labour scarcity is affecting real wages in Eastern Europe as a result of which, for example, the highest real wages in the Allen dataset are found in Vienna in 1400, not the region that comes to mind first as being highly successful (Allen 2003, p. 407).

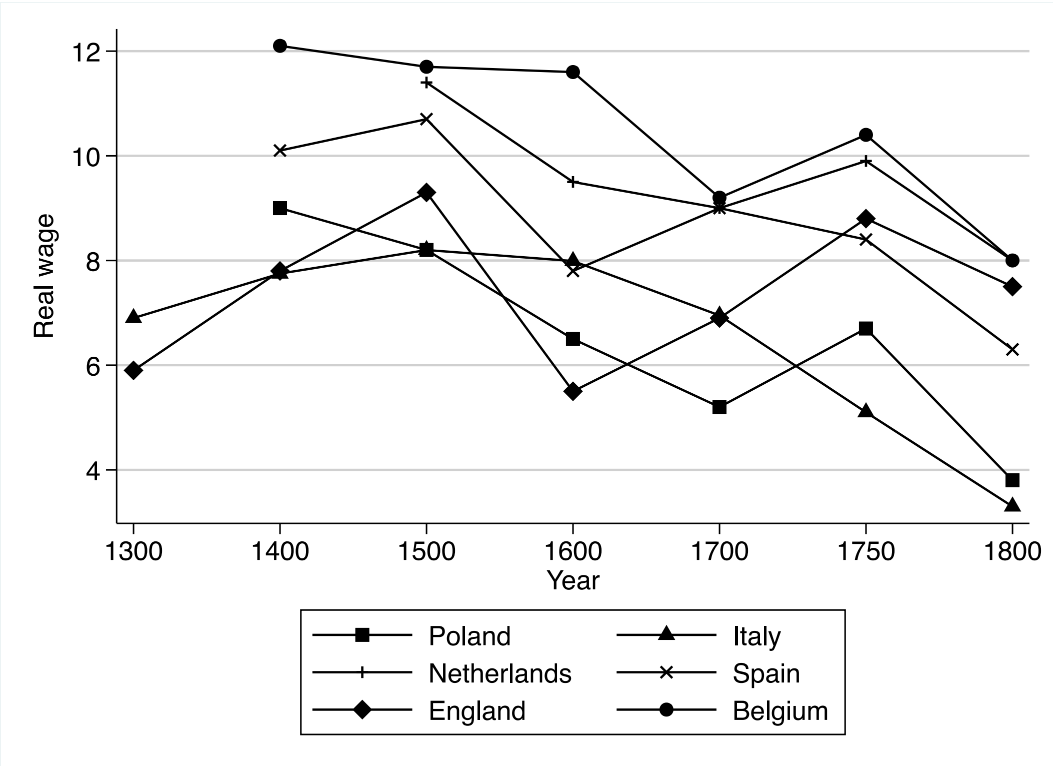

Figure 2.1. Real wages, 1300-1800

Notes and sources: Allen (2003).

We prefer to use the GDP estimates made within the framework developed by Angus Maddison (2001), which links all series of GDP per capita to the 1990 benchmark (all estimates are therefore presented in 1990 GK dollars). This has important drawbacks as in principle the GDP estimates are expressed in 1990 prices, but this approach has developed into the common standard of historical national accounting.[10] Thanks to studies carried out by Broadberry et al (2015) (England/Britain), Van Zanden and Van Leeuwen (2012) (Holland), Buyst (Belgium), Schön and Krantz (2012) (Sweden), Pfister (2011) (Germany), Malanima (2011) (Italy), Alvarez-Nogal and Prados de la Escosura (2013) (Spain and France), Reis, Martins and Costa (2011) and Palma and Reis (2014) (Portugal), Pamuk and Shatzmiller (2011) (Ottoman Empire) we now have a set of estimates of GDP per capita for those countries. To complete the dataset, we used previous estimates by Maddison for Austria, Switzerland, Ireland, Denmark and Norway, but we also carried out a robustness check for the inclusion of these data by assuming that these countries grew at the same rate as their closest neighbours (see next section). The pattern that emerges from this is the well-known 'Little Divergence': Figure 2.2 shows the development of real per capita GDP for six European countries between 1300 and 1800. No advances in levels of GDP were made in southern and central Europe between 1500 and 1800 – although income levels were high in Italy between 1300 and 1500, there was no growth after the 15th century. By contrast, per capita GDP in England and Holland grew after 1500, such that it more than doubled between 1300 and 1800. The timing of the Little Divergence is dependent on the country: the Netherlands already has a much higher level of GDP than the rest of the continent at about 1600, but England only distances itself from the other European countries during the 18th century, but it is also the country that grows consistently during the whole period.

[10] See Maddison (2001) and Bolt and van Zanden (2013) for overviews of this approach, and Prados de la Escosura (2000) for an alternative.

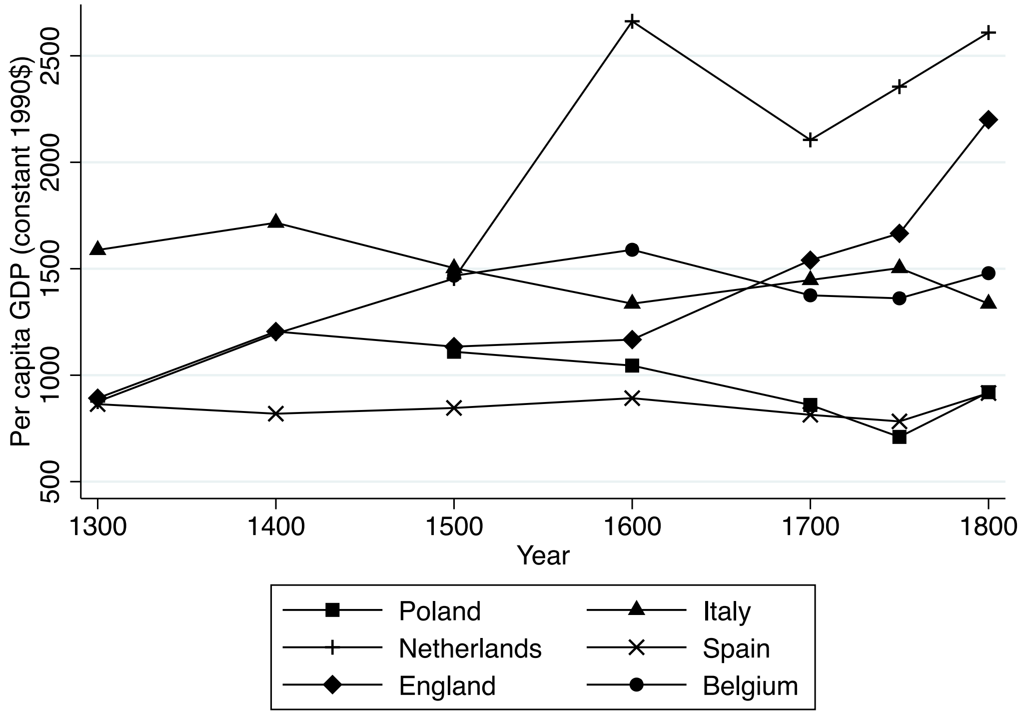

Figure 2.2. Gross Domestic Product per capita, 1300-1800
Notes and sources: See main text.

To explain these trends we test a number of alternative (or to some extent supplementary) theories and ideas about why certain parts of Western Europe experienced relatively rapid pre industrial economic growth. The hypotheses we test are derived from institutional economics (stressing the importance of political institutions constraining the executive), and new/unified growth theory (focusing on human capital formation). Moreover, we link GDP growth to international trade (the Smithian dimension), to agricultural productivity, and finally we try to establish if Protestantism had a significant effect on growth (indirectly via its effect on human capital formation). We will now review these various explanations and discuss the various improved datasets we have collected to test them.

2.3 Explanations of the Little Divergence

Intermediate causes

International trade has often been identified as the main driver of the growth of north-western Europe (Acemoglu et al 2005). Reliable data on the growth of international trade are however not available. Allen's conclusion was based on estimates of the value of imports and exports of the countries active in the Atlantic trade that were however highly 'tentative'. Thanks to the research by Unger (1992) and others, we have relatively good estimates of the size of the merchant fleet of various regions and

Europe as a whole, which can be used as a proxy of the growth of overseas trade. Table 2.1 shows these estimates, converted into tonnage per capita. The size of merchant fleets captures more general trade flows, and it is for that reason a better measure of international trade. Moreover, it is available for more countries and a longer period.[11] However, the correlation between merchant fleet and international trade is far from perfect; Belgium in the 16th century was, for example, highly dependent on trade, but this was carried by Dutch ships. As a robustness check, we therefore also used the estimates of the value of Atlantic trade by Allen.

Year	1500	1700	1800
England	5.9	18.7	84.0
Netherlands	55.6	210.0	198.9
Italy	5.0	6.9	16.4
Iberia	5.2	12.0	21.9
Germany	5.0	8.1	8.6
France	1.7	5.3	25.2
Scandinavia	-	21.0	158.0

Table 2.1. Per capita size of the merchant fleet, 1500-1800

Notes and sources: See appendix I. Iberia: Spain and Portugal; Scandinavia: Sweden, Norway and Denmark.

Although the Italian fleet dominated the Mediterranean area during the 15th century, its per capita size was equal to that of Spain, England and Germany. The Dutch fleet was ten times as large by then, and it kept this leading position until the 18th century. After 1500 stagnation occurred in Venice and Genoa, whilst the Dutch managed to quadruple per capita tonnage between 1500 and 1700. Rapid expansion in English and French shipping started after 1670s, although the French fleet was rather small compared to England and Holland by the 18th century. Increases in European shipping were even faster after 1750, since the Scandinavian and English fleet managed to catch-up with the Dutch. By the year 1800, tonnage in Europe's merchant fleet not only surpassed anything seen before, but the rise of north-western Europe in shipping was obvious too: the Dutch, English and Scandinavian fleets were by far the leading ones.

Agriculture was the most important input in the process of economic development before the 19th century, as it produced by far the largest share of GDP. Population growth, and especially the increase in urban demand, raised the demand for food,

[11] The size of the merchant fleet is available for the following countries and periods. Germany, France, Italy, England: 1300-1800; Netherlands, Spain and Portugal: 1500-1800; Ireland, Norway, Sweden and Denmark: 1700-1800. There is no data for Austria, Switzerland, Poland, and Belgium. Austria and Switzerland are landlocked, and it is for that reason assumed to have had no merchant fleet. Belgium and Poland are set fixed at zero, because both countries did not engage in shipping during the early modern period (shipping services for both Gdansk and Antwerp were carried out by German and Dutch skippers).

which required higher levels of agricultural production. Increases in production were possible by expanding land use, but the amount of land that can be used was limited in the long run. Rising agricultural productivity was therefore necessary to feed a growing population. It worked in the opposite direction as well: productivity growth in agriculture contributed to development, because it supplied the manufacturing industry with raw materials and labour (Overton 1996).

To find out how important increases in agricultural productivity were for explaining the Little Divergence Allen uses an index of agricultural productivity to compute gains in efficiency (Allen 2000). This measure of technological progress however depends on the process of urbanization, real wages and the land-labour ratio, which means that it is already correlated with these variables. We therefore prefer another indicator, the yield ratio, of which Slicher van Bath has collected a large dataset in the 1960s, which was updated with more recent evidence by Van Zanden (1998). Slicher van Bath demonstrated that an increase in the yield ratio reflects progress in the efficiency of farming.

Figure 2.3 presents the yield ratios for different parts of Europe. Levels of productivity in Western and Southern Europe were more or less similar until the 17th century. The yield ratios of Central and Eastern Europe were lower and almost constant over time – i.e. indicating little advances in productivity. Agricultural productivity stagnated in Southern Europe after the 17th century, whilst an increase in efficiency is visible for Western Europe. Countries bordering the North Sea thus ended up with the highest yield ratios at the end of the 18th century. Productivity in Eastern and Central Europe was just as high as Western Europe during the middle ages.

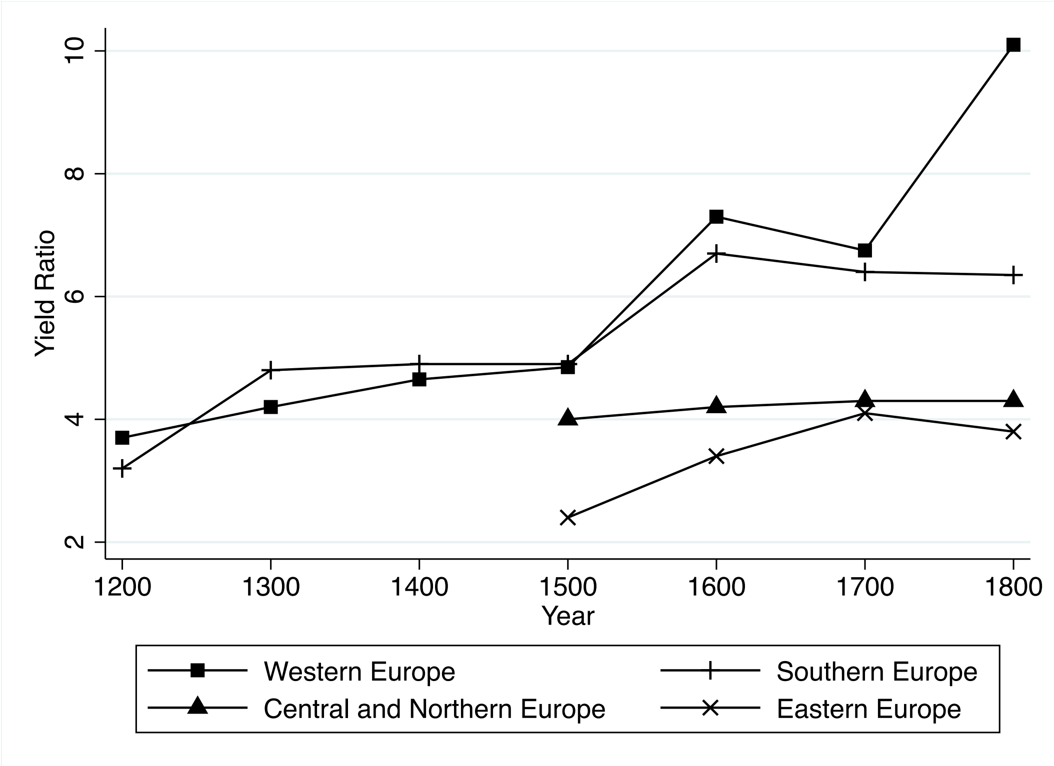

Figure 2.3. Yield ratios, 1200-1800

Notes and sources: Slicher van Bath (1963a, 1963b). Observations concern unweighted averages of wheat, rye and barley. See appendix I for the construction of this series. Western Europe: Great Britain, Ireland, Belgium and the Netherlands; Southern Europe: France, Italy, Spain and Portugal; Central and Northern Europe: Germany, Switzerland, Austria, Denmark, Sweden and Norway; Eastern Europe: Poland. Central, Northern and Eastern Europe enter the dataset in 1500.

The variables considered so far, the size of the merchant fleet and agricultural productivity, can be considered as 'intermediate' causes of the Little Divergence. We now turn to a number of 'ultimate' causes, such as the quality of political institutions, demographic changes (resulting into more human capital formation) and religion, which in the literature play an important role as root causes of economic growth.

Ultimate causes

An influential body of literature argues that it is the specific political economy of Western Europe and in particular the balance of power between sovereigns and societal interests represented in Parliaments that created the right institutional conditions for Europe's specific growth pattern. Two versions of this hypothesis can be distinguished. The first one stresses the Glorious Revolution as the watershed between 'absolutism' and some form of 'parliamentary' government, and sees this event as the main cause of the Industrial revolution of the 18th century (North and Weingast 1989, Acemoglu and Robinson 2012). The other one argues that these institutions that resurfaced in 1688 has a much longer history and that forms of power sharing between the Prince and his (organized) subjects go back to the Middle Ages and are rooted in the feudal power structures of that period (Van Zanden et al 2012). The general idea shared by this literature is that the sovereign had to be constrained in order to protect the property rights of citizens; in republican systems with a strong Parliament property rights were more secure than in states ruled by absolutist kings. This translated itself into, for example, lower interest rates at the capital market (Hoffman and Norberg 1994).

Previous research (e.g. Allen 2003) used a dummy variable derived from De Long and Shleifer (1993) to distinguish states governed by 'Princes' and those without (absolute) monarchs, the 'Republics'. Poland is however classified as a 'Republic' which may help to explain why this variable turned out to be insignificant in the regressions (see Allen 2003, p. 415-416). We use the activity index of the various Parliaments (defined as the number of years they were in session during a century) as the proxy for the quality of political institutions. As demonstrated by Van Zanden et al (2012) this measure varies from zero (in the 13th century, before the first 'modern' Parliament was convened in Leon in 1188) to close to 100 for post-Glorious Revolution England and the Dutch Republic. The averages of the south, central and north-western parts of Europe show a clear 'institutional divergence' within the continent: parliamentary activity contributed to growth in the north-west, but declined due to the rise of absolutism in particular in the south, but also in the central parts of Europe (with the exception of Switzerland) (see Figure 2.4). The question we address therefore is to what extend this institutional divergence within Europe helps to explain the growing economic disparities observed.

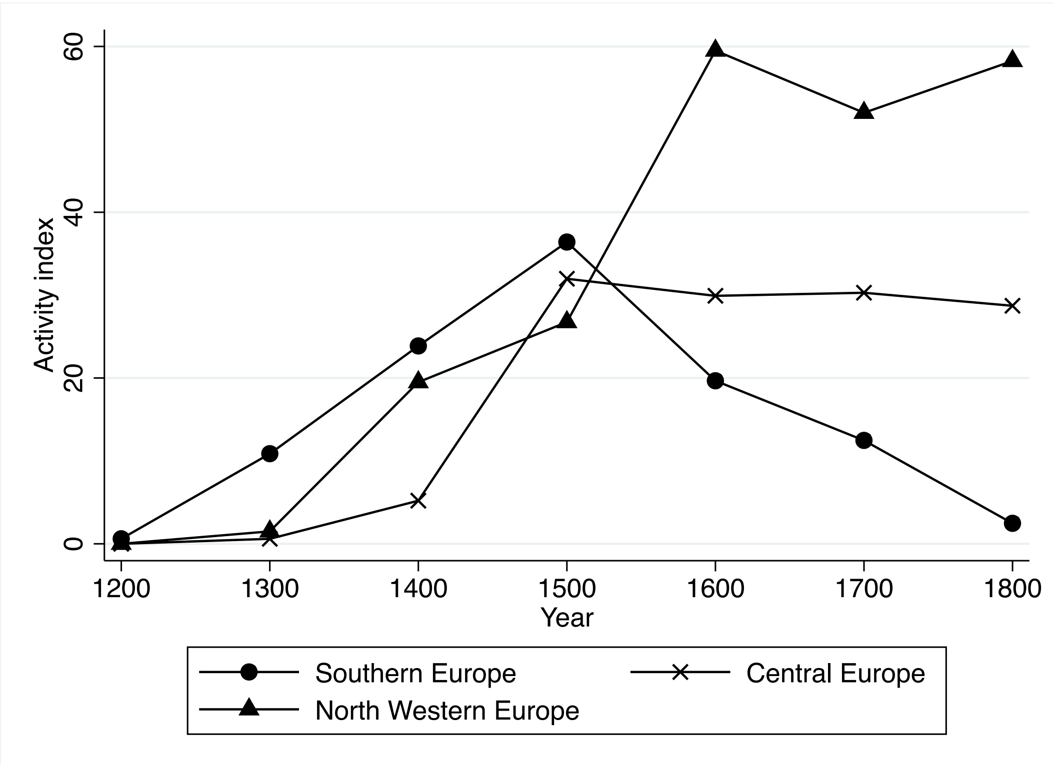

Figure 2.4. Parliamentary activity, 1200-1800

Notes and sources: Variable taken from Van Zanden et al 2012. Southern Europe: Portugal, Spain and France; Central Europe: Poland, Switzerland, Austria and Germany; Northern Europe: England, Netherlands, Belgium and Sweden. Observations include century averages (e.g. 1300 refers to activity between 1200 and 1300).

An additional institutional variable can be derived from information of the self government of cities. The communal movement that started in the Middle Ages (the first communes date from the 11th and 12th centuries) has been seen as an essential precondition for the rise of parliaments in the late Middle Ages, and important in its own right, as it created stable systems of property rights in the cities concerned (a recent overview in Stasavage 2014). In another study the number of self-governing cities (with more than 10,000 inhabitants) and the share of cities with communal status have been quantified (Bosker et al 2012). Cities can gain 'independent' status, which they do on a large scale between 1100 and 1500, but can also lose it again, as a result of conquest by another city (as happened on a certain scale in Italy), or by the abolishment of city right by absolutist rulers. . We use this information in two ways: the share of cities with self-government is used as an index of the 'republican' nature of the polity, similar to the activity index of the parliaments, because strong self-government clearly constrains the sovereign. Moreover, we use the number of communes (per capita) between 1200 and 1300 as a proxy of the institutional starting point of the country concerned. The latter variable has the advantage of being clearly exogenous to the economic growth between 1300 and 1800.

An equally influential body of literature suggests that the root causes of 'modern economic growth' should be found in an interplay of demographic and economic changes, affecting the 'quality-quantity' trade off (Becker 1981, Galor 2011), and resulting in on the one hand, limitations on fertility and population growth, and on the other hand in increased human capital formation. The emergence of the European Marriage Pattern in the North Sea area in the Late Middle Ages has been hypothesized as the crucial demographic change, which also resulted in increased investment in education of the (less) children (Hajnal 1965, De Moor and Van Zanden 2010a, Voigtländer and Voth 2012). An important part of the mechanism was the increase in the average age of marriage of women (and men), which both limited fertility and increased opportunities for human capital formation. Ideally, we would like to have a dataset of the spread of the European Marriage pattern to test this hypothesis, but data limitations are particularly severe here.[12] Instead, we focus on the results of the switch from quantity to quality, that is on developments in human capital formation. Allen used highly tentative estimates of literacy as measures of the increase in human capital that occurred. For 1500, for example, his 'guestimates' were directly based on the urbanization ratio, assuming that 23% of the urban and 5% of the rural population was literate (Allen 2003, p. 415); and most of the estimates

[12] We are of course aware of the recent contribution by Dennison and Ogilvie (2014), but for reasons we will explain in Chapter 3 their work does not make it possible to test the EMP-hypothesis systematically.

between 1500 and 1800 were then based on intrapolation. Instead, we use much more robust estimates of book consumption per capita as our measure of human capital formation. This measure has already proven itself as a reliable guide to changes in human capital (Baten and Van Zanden 2008), and the underlying data (of actual book production) are, especially for the earlier period, much better than the proxies for literacy. Moreover, book consumption also measures more advanced reading and writing skills than just literacy rates do.

Table 2.2 shows book consumption for European countries and underlines differences between the regions. During the middle ages, Flanders and Italy, the two core areas of Western Europe, had relatively high levels of book consumption. The Netherlands, Germany, France and Switzerland approximated or even surpassed Belgian and Italian levels of consumption by the early 16th century, whereas England, Ireland, Spain, Poland and Sweden lagged behind. The picture is different for the 18th century. Levels of book consumption were highest in Holland, followed by England and Sweden, whilst Belgium and Italy fell behind. The large increases of book consumption per capita presented in Table 2.2 are the results of two changes, the growth of human capital (resulting in a shift of the demand curve) and the decline of book prices, following a.o. the invention of movable type printing (resulting in a move along the demand curve).

Year	1300/99	1500/49	1750/99
England	0.3	18.0	196.4
Netherlands	0.2	19.5	501.5
Belgium	0.8	35.4	45.3
Iberia	0.4	5.7	29.0
Italy	0.8	29.3	88.7
Sweden	-	1.1	214.1
Ireland	-	-	79.5
Switzerland	0.1	71.6	33.6
France	0.3	40.3	120.8
Germany	0.3	28.6	125.3
Poland	-	0.3	23.1

Table 2.2. Book consumption per thousand inhabitants, 1300-1800

Notes and sources: Book consumption is taken from Buringh and van Zanden (2009) and Baten and van Zanden (2008). England refers to Great Britain and Iberia to Spain and Portugal. Ireland enters the sample in 1600. There are no observations for Norway and Denmark.

A third 'ultimate' cause of growth is possibly religion. Since Max Webers writings on 'The Protestant ethic and the spirit of capitalism' (1905/1930) the link between religious change and economic development has been much debated. Recently this debate has received new attention as a result of econometric research trying to confirm such a relationship. Becker and Woessmann (2009) have tested this relationship for early 19th century Prussia, and concluded that Protestantism may have had a strong positive effect on human capital formation. In our approach such an effect would be included in the book production estimates (which are indeed strongly correlated with Protestantism). We will test for this indirect effect, by including, starting in 1600, dummies for Protestantism.[13]

2.3 Empirical analysis

What accounts for the process of differential economic growth in pre-modern Europe? To find out, we explain per capita GDP by the 'candidates' discussed above: the quality of political institutions, agricultural productivity, international trade, and human capital formation. The unit of observation are countries at intervals of approximately a century. The years include 1300, 1400, 1500, 1600, 1700, 1750 and 1800. Observations in 1300 and 1400 are only available for Spain, Italy, England and the Netherlands. Germany, France, Austria, Poland, Belgium, Switzerland, Denmark, Ireland and Norway enter the dataset in 1500; Sweden and Portugal enter the sample in 1600.

An important concern with our analysis is endogeneity. Relative successful economies such as Holland and England might have had higher levels of productivity in agriculture, larger merchant fleets and/or more human capital formation, as rich countries may have been able to afford those higher levels. A second endogeneity issue is related to the omission of other important determinants of per capita GDP that may correlate with our independent variables.

The independent variables are lagged for one period in the regressions to somewhat limit the reverse causality problems, e.g. agricultural productivity in 1600 refers to the average level of productivity between 1500 and 1600.[14] We furthermore include a set of control variables to alleviate the bias stemming from the omission of variables (introduced below). Finally, we report on the Random-Effects / Two-Stage least-squares (RE/2sls) estimation results where we treat productivity in agriculture, international trade and human capital as endogenous. A Random-Effects (RE) specification is preferred here, as it enables us to say something about the time-invariant, mostly geography-related, country-specific variables in our regressions.

To estimate the effect of the endogenous variables on per capita income levels, we introduce a set of instruments. To start with, we use Protestantism as an instrument for book consumption per capita. We hypothesise that Protestantism had a strong and positive effect human capital formation, whilst having no direct effect on economic

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[13] The variable takes values 1 for countries that are more or less fully protestant (England, Netherlands, Denmark, Sweden, Norway) and 0.5 for Germany and Switzerland which are about 50% protestant.

[14] For the size of the merchant fleet we have only point estimates: see the discussion in appendix I.

success (Becker and Woessmann 2009).[15] Second, we measure the maximum surface of land that could potentially be used for agricultural production for the 15 countries in our dataset and divide it by the population. The variable measures land scarcity in the countries concerned, and is based on Buringh et al (1975) who classify the landmass of the world into six categories based on their maximum agricultural potential. It explicitly focuses on soil quality, vegetation and climate conditions. Land scarcity serves as an instrument for productivity in agriculture; the hypothesis is that it enhances the increase of yields.[16] Finally, we follow the literature (e.g. Sachs and Warner 1997) that uses the coastline-to-area ratio as an instrument for international trade. Our theory is that these instruments work via the corresponding independent variables.

Ideally we would like to introduce an instrument for the parliamentary activity index, but it is difficult to find a convincing one.[17] As a solution, we introduce two supplementary proxies of political institutions: the share of cities (with more than 10,000 inhabitants) which have some kind of self-government, and the number of communes per capita between 1200 and 1300. The argument for the latter variable is that this is the starting point of our analysis and that this variable reflects the strength of the movement on which the parliamentary movement of the late Middle Ages builds (Van Zanden et al 2012). In this way we find out to what extent the communal movement had a long-term impact on economic development (directly or via the strength of parliaments). In the regressions the number of communes per capita in the 13th century is directly related to per capita GDP. Reverse causality issues are less likely, because economic growth in the centuries following the Black Death cannot have influenced the number of medieval communes. It should be stressed here that the results of the economic development and Parliamentary activity relationship cannot be interpreted as causal, but it is however possible to interpret the correlations between the variables.

Figure 2.5 presents the various hypotheses in a schematic way. The exogenous factors are Protestantism, land scarcity and the ratio between coastline and land area. We test four hypotheses about the direct drivers of growth: agricultural productivity, human capital, trade, and political institutions. Each hypothesis is tested separately, and we do not aim at integrating the various hypotheses into one model.

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[15] Van Zanden et al (2012) show that Protestantism had no direct effect on economic development between 1300 and 1800.

[16] It is a time-invariant geographical characteristic of the country and therefore not directly linked to economic outcomes.

[17] We have considered several instruments for parliamentary activity that are suggested by the (empirical) literature: We have related the parliamentary activity index to the Meersen-line and to the absolute size of the countries involved as suggested by Stasavage (2011), but all these possible instruments are however not independent from the left-hand side variables and can therefore not be used in the regressions.

Exogenous variables Endogenous variables

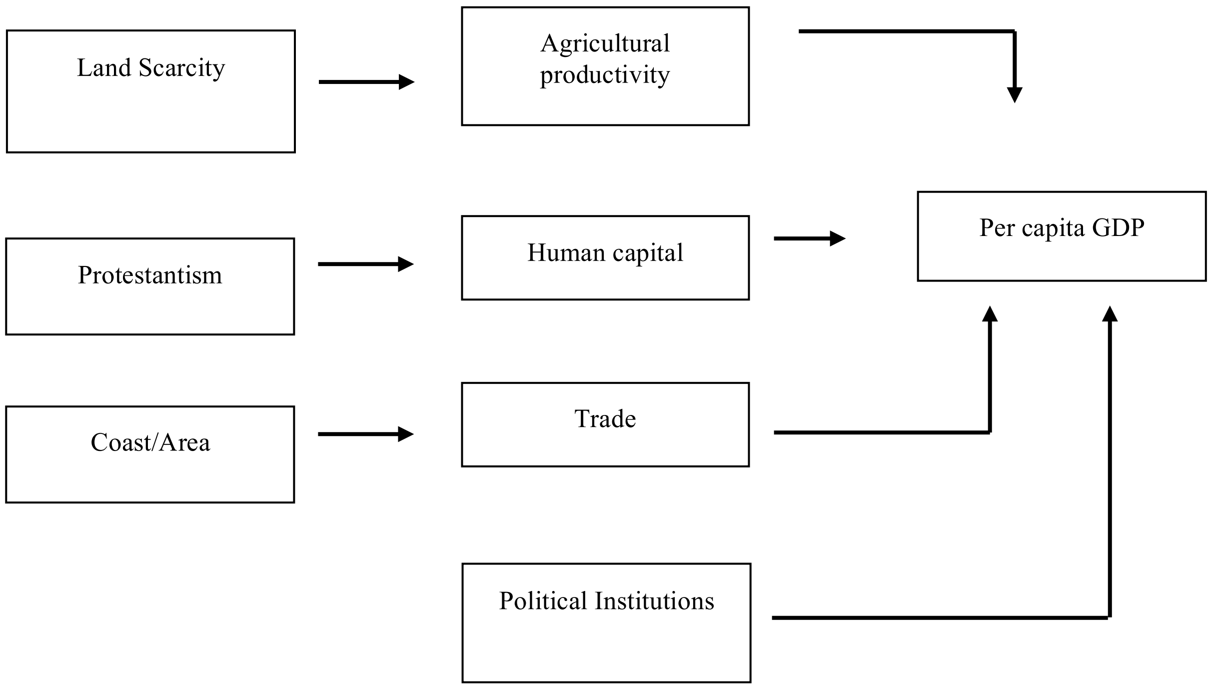

Figure 2.5. Overview of hypotheses

We estimate the simple linear regression model given in (1). To estimate the effect of our endogenous variables on per capita income levels, we introduce the set of instruments discussed at the beginning of this section. The first stage regressions are given in (2) – (4).

$$\ln Y_{it} = \alpha_i + \alpha_t + \gamma_1 Z_{it} + X_{it} \beta + \varepsilon_{it} \quad (1)$$

$$\ln yield_{it} = \alpha_i + \alpha_t + \eta_1 \ln LS_{it} + X_{it} \beta + \varepsilon_{it} \quad (2)$$

$$\ln book_{it} = \alpha_i + \alpha_t + \eta_2\, prot_{it} + X_{it} \beta + \varepsilon_{it} \quad (3)$$

$$\ln fleet_{it} = \alpha_i + \alpha_t + \eta_3 \ln coast_{it} + X_{it} \beta + \varepsilon_{it} \quad (4)$$

$\ln Y_{it}$ denotes the log of per capita GDP of country i in century t, and Z_{it} is a vector that includes the endogenous variables of interest: the activity index of parliaments ($\ln par_{it}$), the yield ratio ($\ln yield_{it}$), the size of the merchant fleet ($\ln fleet_{it}$), and book consumption ($\ln book_{it}$). We estimate the effect of each endogenous variable separately since the number of observations (69-81) does not make it possible to include all variables in one single regression. X_{it} is a vector including several control variables that we will introduce below. Unless otherwise noted, we include a full set of century dummies in our estimations. ε_{it} captures all other unobserved (or unmodelled) variables related to economic development. The logarithm of the variables is used in the regressions to ensure that extreme values do not play a disproportionate role.[18]

η_1, η_2, and η_3 in equations (2), (3) and (4) capture the effect of the instruments on the endogenous variables. The log of land scarcity (ln LS_{it}) serves as an instrument for the yield ratio; Protestantism ($prot_{it}$) for book consumption; and, finally, the log of the coast-to-area ratio (ln $coast_{it}$) for the size of the merchant fleet. The exclusion restriction is that the instruments do not appear in the second stage regression as given in (1).

The first control variable that is included in X_{it} is average years of war. Research stresses the importance of war-making for state building and subsequent economic development (e.g. Tilly 1990). We therefore control for the average number of years at war during the previous period (a century or half-century) (Acemoglu et al 2005). We specifically control for the devastating effect of the Thirty Years' war on the German economy by including a dummy variable that equals 1 during the century after the war (Baten and van Zanden 2008). Furthermore, we include latitude (absolute distance to the equator) in our regressions to control for geography.

It should be stressed here that the GDP estimates used in this paper of Denmark, Norway, Austria and Switzerland are taken from Maddison (2001). For the remaining countries in the sample we use the updated estimates of Bolt and van Zanden (2013). The latest series, which are based on more and better information, show that per capita GDP must have been higher than the previous estimates of Maddison suggest: he estimated the average income of Western Europe in 1500 at 771 dollars, whilst the updated database suggest that it must have been around 1200 dollars.

We therefore evaluate our conclusions by assuming that economic growth in Denmark, Norway, Austria and Switzerland was at a similar rate as their neighbouring countries: per capita GDP of Austria and Switzerland is put equal to the average of Italy and Germany and that of Denmark and Norway to Sweden. As a result, average income levels of these four countries are slightly higher than the original estimates of Maddison. This approach allows us to re-estimate the models using this alternative dataset on per capita GDP (denoted LnGDP_R in the regressions).

Previous studies have also shown a close association between urbanization and per capita GDP (e.g. Acemoglu et al 2002).[19] Figure 6 indeed shows relatively high urbanization rates in Italy and Belgium during the middle ages. After the 15th century, however, the Netherlands became the most urbanized country in Europe. More people moved to cities in England after 1700, so that it approximated Holland by the end of

[18] An exception is the urbanization ratio and the share of cities with self-government.

[19] The correlation between per capita GDP and urbanization rates in our dataset is 0.81.

the 18th century. Other parts of Europe, such as Poland, had no growth in the share of people living in cities. The Little Divergence is thus quite evident from the evidence on urbanization patterns as well. As a second set of robustness checks, we re-estimate the models using urbanization rates as left-hand side variable (denoted URB in the regressions).

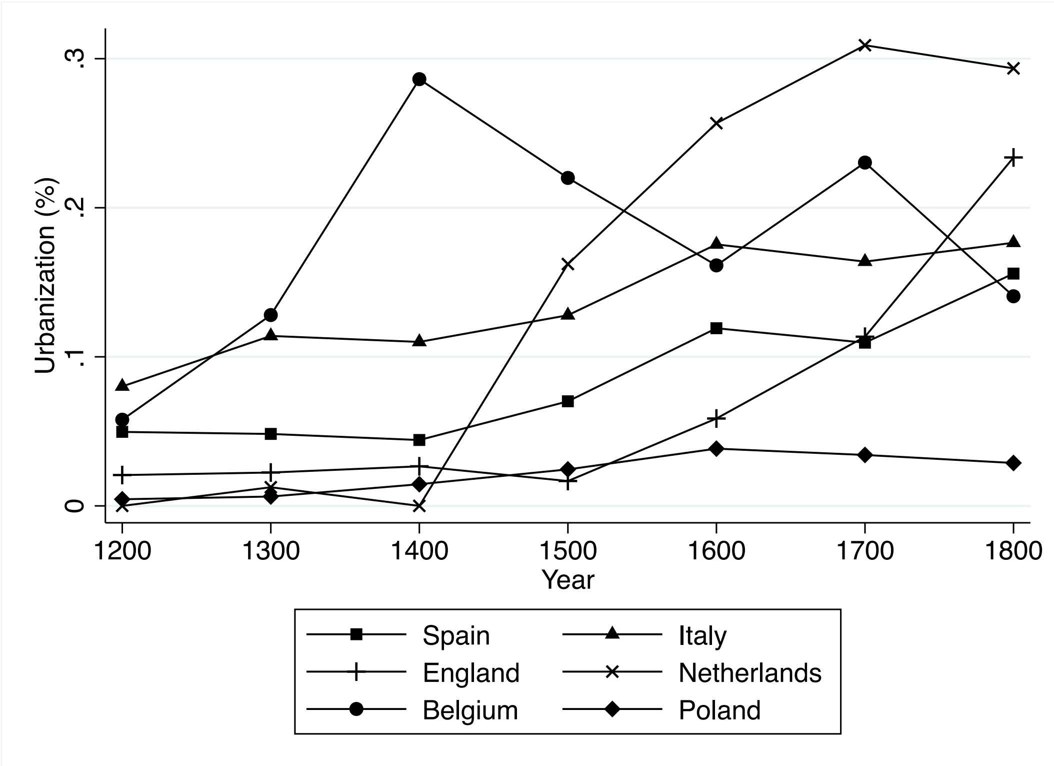

Figure 2.6. Urbanization rates, 1200-1800

Notes and sources: Cities are defined as settlements with more than 10.000 inhabitants. Absolute number of people living in cities is taken from Bosker et al (2012). Population levels are taken from the same source. Belgium includes Luxemburg and observations for England refer to the United Kingdom.

Table 2.3 reports on the first set of regressions explaining the impact of political institutions on the three measures of economic development: per capita GDP (Equation 1), the alternative per capita GDP estimates (Equation 2), and the urbanisation ratios (Equation 3). We have included as an additional control variable the absolute size of the country (Ln Area). Studies have argued that relatively small states were more likely to develop democratic institutions than relatively large ones (Stasavage 2011). The size of a country may therefore be negatively related to the Parliamentary activity index.

The coefficient on the log of Parliamentary activity index enters the regression in Equation (1) with the correct sign and is statistically significant at the 1% level. Interestingly, there is also a strong and positive association between self-government of cities and economic development as the estimated coefficient on the share of cities with self-government indicates. The results in Equation (1) furthermore suggest that there was strong persistent effect of political institutions on economic development over time: Initial political institutions, captured by the number of medieval communes per capita, is positively related to per capita GDP. The regression results in Equations (2) and (3) indicate that the positive relation between political institutions and economic development is robust to switching to other left-hand side variables: Ln GDP_R and URB.

Estimator Dependent variable	(1) RE Ln GDP	(2) RE Ln GDP_R	(3) RE URB
Ln Parliamentary activity	0.08*** (0.02)	0.07*** (0.02)	0.01** (0.00)
Share cities self-government	0.81*** (0.14)	0.83*** (0.19)	0.10** (0.05)
Ln Medieval communes p/c	0.49*** (0.09)	0.39*** (0.12)	0.10*** (0.02)
Ln Area	0.08 (0.06)	0.07 (0.07)	-0.01 (0.01)
Latitude	3.37*** (0.97)	2.71** (1.22)	0.50*** (0.18)
D30	-0.13*** (0.04)	-0.18*** (0.07)	-0.04*** (0.01)
Years at war	-0.04 (0.04)	-0.03 (0.06)	0.02** (0.01)
D1300	-0.14* (0.07)	-0.09 (0.08)	-0.09*** (0.01)
D1400	-0.09 (0.08)	-0.03 (0.08)	-0.11*** (0.02)
D1500	-0.25*** (0.07)	-0.09 (0.09)	-0.06*** (0.02)
D1600	-0.21*** (0.04)	-0.17*** (0.04)	-0.04*** (0.01)
D1700	-0.09* (0.05)	0.02 (0.08)	-0.02* (0.01)
D1750	0.07* (0.04)	-0.02 (0.04)	-0.02*** (0.01)
D1800	Ref	Ref	Ref
Constant	3.06*** (0.90)	3.68*** (1.15)	-0.29 (0.22)
R^2	0.51	0.30	0.71
No. of observations	81	79	81

Table 2.3. Political institutions and economic development, 1300-1800

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively.

Table 2.4 shows the regression results measuring the effect of productivity in agriculture on per capita GDP (Equation 4), the alternative per capita GDP estimates

(Equation 5) and urbanisation rates (Equation 6). Columns (II) of the table present the 2sls estimates of the coefficient of the yield ratio, and Columns (I) show the corresponding first stages. In the set of regressions we have included a variable capturing the proportion of agricultural land that was enclosed (Allen 2003). It is expected that the enclosure movement enhanced efficiency in agriculture, which would be reflected by higher yield ratios. The enclosure movement may also directly contributed to growth by enhancing productivity levels of the agricultural sector of the economy and release labour that promoted the development of other sectors of the economy (e.g. the growth of cities) (Brenner 1976).

The first stage results in Column (I) of Equation (4) are indicative of a large negative effect of land scarcity on the yield ratio: higher yields indeed occurred when agricultural land became scarcer. This finding supports our hypothesis that growing populations reduced the availability of land suitable for agricultural production, which in turn increased additional incentives to implement new technologies to increase agricultural production. The coefficient on enclosures has the correct sign, but is not statistically significant. Since it is significant at the 15% level it is perhaps fair to conclude that the enclosure movement slightly affected productivity levels in agriculture. The coefficient on the yield ratio in the corresponding second stage is significant, suggesting that increases in agricultural productivity did contribute to early modern economic growth. The coefficient on enclosures again enters with the correct sign, although it is insignificant suggesting that it had no direct effect on pre-industrial development. The results are again robust to using the alternative GDP estimates (Equation 5) and urbanisation ratios (Equation 6).

Estimator Dependent variable	(4) RE/2sls Ln GDP		(5) RE/2sls Ln GDP_R		(6) RE/2sls URB	
	(I)	(II)	(I)	(II)	(I)	(II)
Ln Yield ratio	-	0.94** (0.45)	-	1.36*** (0.50)	-	0.17** (0.08)
Ln Land Scarcity	-0.28*** (0.09)	-	-0.28*** (0.08)	-	- 0.28*** (0.09)	-
Enclosures	0.31 (0.22)	0.30 (0.29)	0.31 (0.22)	0.15 (0.40)	0.31 (0.22)	0.07 (0.05)
Latitude	-0.01 (0.90)	-0.63 (1.32)	-0.13 (0.86)	0.26 (1.96)	-0.01 (0.90)	-0.27 (0.22)
D30	-0.04 (0.04)	-0.03 (0.25)	-0.04 (0.03)	-0.06 (0.27)	-0.04 (0.04)	-0.01 (0.05)
Years at war	0.02 (0.05)	-0.02 (0.07)	0.00 (0.05)	-0.00 (0.07)	0.02 (0.05)	0.02 (0.01)
D1300	-0.26* (0.14)	0.05 (0.24)	-0.26* (0.15)	0.33 (0.28)	-0.26* (0.14)	-0.04 (0.05)
D1400	-0.11 (0.15)	0.16 (0.22)	-0.11 (0.15)	0.41 (0.25)	-0.11 (0.15)	-0.06 (0.04)
D1500	-0.14	0.11	-0.16	0.47**	-0.14	0.00

	(0.10)	(0.18)	(0.10)	(0.21)	(0.10)	(0.03)
D1600	0.04 (0.09)	-0.07 (0.09)	0.04 (0.09)	0.02 (0.10)	0.04 (0.09)	-0.02 (0.02)
D1700	-0.03 (0.09)	0.04 (0.10)	-0.02 (0.09)	0.20* (0.11)	-0.03 (0.09)	0.00 (0.02)
D1750	-0.08 (0.07)	0.07 (0.10)	-0.08 (0.07)	0.18* (0.11)	-0.08 (0.07)	0.01 (0.02)
D1800	Ref	Ref	Ref	Ref	Ref	Ref
Constant	3.62*** (0.69)	5.60*** (1.28)	3.73*** (0.72)	4.39*** (1.62)	3.62*** (0.69)	-0.07 (0.23)
R^2	0.30	0.32	0.29	0.19	0.30	0.52
F-statistic		9.98		12.17		9.98
No. of observations		81		79		81

Table 2.4. Agricultural productivity and economic development, 1300-1800

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively. The F-statistics report on the strength of the instrument.

Table 2.5 captures the impact of international trade on economic growth. Columns (II) of the table again present the 2sls estimates of the coefficient on the size of the merchant fleet, and Columns (I) report on the corresponding first stages. We have included 'Colonial realm' in the regressions, which is measured as the size of the colonial population compared to the population of the colonizing country (Bosker et al 2012). Colonial realm therefore not only captures any effect coming from having colonies, it also measures the contribution of (or perhaps dependency on) the growth of overseas colonies after 1600 to the domestic economy. It can also be argued that smaller states have a greater tendency towards openness and are more likely to engage in international trade and shipping than larger ones. We therefore control for this possibility by including the absolute size of the countries in our sample (Ln Area).

The first stage results given in Columns (I) are indicative of a positive effect of the coast-to-area ratio on the size of the merchant fleet. This finding confirms our hypothesis that countries with a relatively large coast-to-area ratio were more likely to engage in international trade than countries with small coast-to-area ratios. Countries with overseas territories indeed had larger fleets, as indicated by the positive coefficient on colonial realm in the first stages. Its effect on economic growth is however ambiguous: It has no effect on per capita GDP (Equation 7); it is significant at the 10% level in the regressions using the alternative per capita GDP estimates as left-hand side variable (Equation 8); and, finally, it is highly significant in the equation explaining urbanisation ratios (Equation 9). This finding might suggest that the colonies contributed to city growth, but not to income levels. The absolute size of countries (Ln Area) is positively correlated with the per capita size of the merchant fleet, which contradicts with the theory predicting a negative association among the two. The coefficient on Ln Area enters Equation (9) with a negative sign, indicating that city growth was lower in relatively large countries than in smaller states. The 2sls estimates in Columns (II) of Equations (7) to (9) report on the coefficient of the size of the merchant fleet; our main variable of interest. Although it enters the equations with the expected sign, it was never found to be statistically significant.

	(7)		(8)		(9)	
Estimator	RE/2sls		RE/2sls		RE/2sls	
Dependent variable	Ln GDP		Ln GDP_R		URB	
	(I)	(II)	(I)	(II)	(I)	(II)
Ln Size of the Merchant fleet p/c	-	0.18 (0.22)	-	-0.06 (0.03)	-	0.05 (0.04)
Ln Coast/Area	1.93*** (0.36)	-	2.09*** (0.36)	-	1.93*** (0.36)	-
Colonial realm	1.48* (0.88)	0.10 (0.08)	1.59** (0.68)	0.18* (0.10)	1.48* (0.88)	0.05*** (0.02)
Ln Area	1.55** (0.65)	-0.08 (0.07)	1.44** (0.57)	-0.05 (0.11)	1.55** (0.65)	-0.03** (0.01)
Latitude	-12.15 (8.59)	-0.67 (0.85)	-7.20 (6.75)	0.52 (1.29)	-12.15 (8.59)	-0.20 (0.14)
D30	0.86 (0.83)	-0.07 (0.21)	1.01 (0.67)	-0.13 (0.23)	0.86 (0.83)	-0.02 (0.04)
Years at war	0.60 (0.93)	0.01 (0.06)	1.21* (0.63)	0.01 (0.07)	0.60 (0.93)	0.02** (0.01)
D1300	-5.07* (2.96)	-0.22 (0.17)	-4.71* (2.52)	-0.25 (0.20)	-5.07** (2.96)	-0.06** (0.03)
D1400	-5.20** (2.54)	-0.06 (0.17)	-4.97** (2.29)	-0.09 (0.21)	-5.20** (2.54)	-0.07** (0.03)
D1500	-2.32 (1.61)	-0.15* (0.09)	-0.81 (0.76)	-0.02 (0.09)	-2.32 (1.61)	-0.03* (0.02)
D1600	-2.41 (1.53)	-0.11 (0.09)	-2.39 (1.52)	-0.12 (0.11)	-2.41 (1.53)	-0.01 (0.02)
D1700	-0.77*** (0.23)	-0.06 (0.07)	-0.96*** (0.29)	-0.04 (0.08)	-0.77*** (0.23)	-0.01 (0.01)
D1750	-0.33 (0.22)	-0.05 (0.07)	-0.30 (0.19)	-0.01 (0.07)	-0.33 (0.22)	-0.01 (0.01)
D1800	Ref	Ref	Ref	Ref	Ref	Ref
Constant	-11.61 (9.26)	8.12*** (0.95)	-13.98* (7.95)	7.73*** (1.43)	-11.61 (9.26)	0.46*** (0.16)
R^2	0.57	0.33	0.64	0.10	0.57	0.56
F-statistic		28.68		33.32		28.68
No. of observations		81		79		81

Table 2.5. International trade and economic development, 1300-1800

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively. The F-statistics report on the strength of the instrument.

The regressions in Table 2.5 thus indicate that the merchant fleet (as a measure of the importance of international trade) does not play a role in explaining the Little Divergence, which contrasts with the previous findings of Allen (2003) and Acemoglu et al (2005). We however do find some evidence that large colonial possessions (as measured by 'colonial realm') is positively correlated with economic growth and in particular urbanization. As a robustness-check, we have included two alternative measures for trade and shipping in the regressions: (a) the log of per capita non-specie trade of Allen (2003) and the volume of Atlantic trade of Acemoglu et al (2005). It should be stressed here that our regressions result do not fully compare with the previous results of Acemoglu et al. The hypothesis tested by Acemogelu et al is that international trade worked via the channel of institutions (measured as 'constraints on the executive'), whereas we are interested in the direct effect of trade on economic growth. Tables 10-11 in Appendix III report on the results using trade per capita and the volume of Atlantic trade. The results indicate that non-specie trade cannot explain per capita GDP, whereas it is positively correlated at the 10% level with urbanisation levels. Allen (2003) treated this variable as exogenous, but for reasons outlined at beginning of the Section, it is clearly endogenous. It would therefore been interesting to relate international trade to the coast-to-area ratio, but there is no correlation between the two and our coast-to-area measure can therefore not be used as an instrument. Regarding the volume of Atlantic trade on pre-industrial development, we find it to correlate with per capita GDP, but it is unrelated to urbanization. The results are therefore rather mixed: it might well be that Atlantic trade works via the channel of institutions, as predicted by Acemoglu et al (2005), but testing for such a link is beyond the scope of our paper. For now it is reasonable to conclude that the growth of Atlantic trade did not directly contribute to economic growth.

Finally, Table 2.6 estimates the contribution of human capital formation to early modern growth. To control for advanced levels of human capital, we have added the number of universities per capita to the regressions. It is expected that the number of universities may have been positively correlated with book consumption, but also to economic growth in the broader sense as it proxies the upper tail of the knowledge distribution. It should be mentioned here that the book consumption data is highly correlated with the set of time-dummies (ca. 0.80). The robustness of our results are therefore evaluated by (a) removing the time-dummies from the estimated model and (b) by including a time-trend. Instead of using log of book consumption in the regressions, we have furthermore estimated the effect of absolute levels of book consumption per capita. The latter is less strong correlated with the time-dummies (ca. 0.40). The obtained regression results are similar to the ones given in Table 2.6 below and are reported on in Appendix III (Table 12).

The first stage results show a positive association among the Protestantism and book consumption, which adds support to the empirical findings of Becker and Woessmann (2009) that suggests a similar link between the variables. It furthermore shows that the number of universities is positively related to book consumptions, although it appears to have no direct effect on economic development: the coefficient enters Equations (10) to (12) with the wrong sign and is statistically insignificant. The estimation results of the second stage indicate that book consumption contributed to per capita

GDP, as its coefficient is significant at the 1% level. The results are again robust to using the alternative GDP dataset (Equation 11) and urbanisation ratios (Equation 12).[20]

The first stage results indeed indicate the strong effect of the time dummies on per capita book consumption: book consumption was significantly lower in the ages prior to 1800 (the reference category). Interestingly, the size of the coefficient on the dummies for the 14th and 15th centuries (D1300 and D1400), which are large and negative, nicely illustrate the impact of the invention of the printing press; after 1454 these coefficients typically become much smaller.

Estimator Dependent variable	(10) RE/2sls Ln GDP		(11) RE/2sls Ln GDP_R		(12) RE/2sls URB	
	(I)	(II)	(I)	(II)	(I)	(II)
Ln Book consumption p/c	-	0.28*** (0.11)	-	0.25*** (0.07)	-	0.60** (0.25)
Protestantism	1.69*** (0.51)	-	1.69*** (0.51)	-	1.69*** (0.51)	-
No of Universities p/c	0.26* (0.14)	-0.05 (0.09)	0.26* (0.14)	-0.00 (0.06)	0.26* (0.14)	-0.01 (0.02)
Latitude	-3.22 (3.32)	-0.44 (1.00)	-3.22 (3.32)	-0.31 (0.63)	-3.22 (3.32)	-0.31 (0.25)
D30	0.34* (0.18)	-0.19 (0.34)	0.34* (0.18)	-0.40 (0.32)	0.34* (0.18)	-0.03 (0.07)
Years at war	0.29 (0.23)	0.01 (0.09)	0.29 (0.23)	0.01 (0.09)	0.29 (0.23)	0.02 (0.02)
D1300	-5.62*** (0.59)	1.48** (0.69)	-5.62*** (0.59)	1.37*** (0.48)	-5.62*** (0.59)	0.27* (0.16)
D1400	-5.05*** (0.27)	1.44** (0.64)	-5.05*** (0.27)	1.33*** (0.44)	-5.05*** (0.27)	0.22 (0.15)
D1500	-2.92*** (0.45)	0.83** (0.40)	-2.92*** (0.45)	0.87*** (0.28)	-2.92*** (0.45)	0.17* (0.09)
D1600	-2.17*** (0.65)	0.44* (0.26)	-2.17*** (0.65)	0.42** (0.20)	-2.17*** (0.65)	0.09 (0.06)
D1700	-0.97*** (0.23)	0.16 (0.16)	-0.97*** (0.23)	0.18 (0.14)	-0.97*** (0.23)	0.03 (0.03)
D1750	-0.51*** (0.10)	0.08 (0.10)	-0.51*** (0.10)	0.09 (0.12)	-0.51*** (0.10)	0.02 (0.03)
D1800	Ref	Ref	Ref	Ref	Ref	Ref
Constant	12.13*** (1.84)	4.21*** (1.17)	12.13*** (1.84)	4.43*** (0.77)	12.13*** (1.84)	-0.39 (0.28)
R^2	0.77	0.33	0.77	0.38	0.77	0.34
F-statistic		10.82		10.82		10.82

[20] All versions of the tested model are highly significant, except for the second stage of (10), which is only barely significant at the 10% level; this is in our view due to the problems with the strong time trend in book consumption; to deal with this, we present alternative specifications of the time trend in Table 12 of the Appendix III.

No. of observations		69		69		69

Table 2.6. Human capital formation and economic development, 1300-1800

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively. The F-statistics report on the strength of the instrument. The regressions measuring the impact of book consumption on log per capita GDP have no observations for Denmark and Norway. The results in Tables (1) – (3) do not change when putting the sample size equal to that of Table (4).

Overall the regression results of Tables 2.3 to 2.6 indicate a strong and significant effect of political institutions, productivity in agriculture, and human capital formation on per capita GDP in the centuries leading up to the Industrial Revolution. The effect of international trade, however, was only mediocre: growth in the size of merchant fleets cannot account for the differences in economic performance of the countries observed.

Finally, the question should be addressed how big the effects are that we find: to what degree can these relationships help to explain the divergence between, for example, England and Spain between 1500 and 1800. In 1500 both countries were at a similar level of economic development, and the gap in terms of GDP per capita was relatively small. The English yield ratio did not differ much from that of Spain, and levels of book consumption were also similar. The English Parliament was more active (score 59) than the Spanish Cortez (43), but also that difference was relatively small. Between 1500 and 1800 English/British GDP per capita almost doubled, the Spanish level remained by and large the same. How can we explain this, using the regressions of Tables 3-6? In the 18th century the British activity index had increased to 100, the Spanish had fallen to 6; this 94-points difference explains 40% to 50% of the difference between the two income levels (via the coefficients of table 2.3, columns 2 and 4). A gap also opened up in book consumption: in the 18th century English citizens consumed 7 times more books than inhabitants of Spain, which combined with the coefficients of Table 2.6 explains 60% of the income gap. Finally, in the 18th century British yield ratio's had increased to twice the Spanish level, which in itself is already sufficient to explain the whole income gap between the two countries. Summing up, the effects we find here are big and more than explain the 'Little Divergence'.

2.4 Conclusion

We return to the question: what were the causes of the Industrial Revolution? It is one of the key questions of economic history that is debated intensely. Almost all recent interpretations however take as their starting point an economy that is already highly developed, and characterized by a high level of urbanization, a well-developed commercial infrastructure, a skilled labour force, by international standards high real wages, low interest rates and relatively 'modern' institutions, although they may identify different factors which lead to the real industrial break through (Allen 2009, Mokyr 2009). The issue of this paper was to explain how the relatively advanced economy of the 18th century North See area came about. This explanation focuses on the Little Divergence, in particular the strong performance of the North Sea region that drove this process. For the first time in recorded history, levels of GDP per capita surpassed the 1500 dollars (of 1990) threshold, thanks to a process of consistent growth that began in the 14th century. The Industrial Revolution of the late 18th century can be seen as a culmination of this development path (Van Zanden 2009).

We have tested various hypotheses about the causes of the Little Divergence, using new data of, amongst others, human capital formation and the quality of political institutions, and focusing on the explanation of trends in GDP per capita, but adding the same regressions for urbanization as the dependent variable. The results are that institutional changes, in particular the rise of active Parliaments and the 'underlying' communal movement, human capital formation and agricultural productivity growth are the primary drivers of the growth that occurred. We were able to find instrument variables (Protestantism for human capital formation and the scarcity of land) to test the causal relationship between human capital formation and agricultural productivity on the one hand and GDP per capita and urbanization on the other hand. We carried out a number of robustness checks that confirmed the found relationships.

The most surprising and perhaps contentious result is that we did not find a strong relationship between our proxy for the development of international trade – the size of the merchant fleet – and economic growth (or urbanization). The use of other data for estimating the importance of international trade did not fundamentally change this result; only the 'colonial realm' variable (estimating the size of the colonized population in relation to the population of the colonial power) had a relatively weak effect on growth and urbanization. The result that we do not find a strong correlation between international trade and growth may of course be due to either the weaknesses of the used data (what we really need are systematic, reliable data on international trade flows of this period), or to the fact that trade mattered much less than we usually assume. Until we have the improved data, it will not be possible to answer this question satisfactory. Moreover, the fact that we come to different conclusions than Allen (2003) can perhaps be attributed to our focus on trends in GDP per capita and urbanization instead of on real wages.

Concerning the role of international trade our conclusions remain tentative, but we can be frim about the other factors contributing to growth before 1800. First, our empirical result that human capital formation contributed to pre-modern growth contrasts with earlier conclusions of Mitch (1993), Allen (2003) and Reis (2005) that pointed to an insignificant relationship. These studies focused on literacy rates as a proxy of human capital, which suffers from the disadvantage of measuring only very basic skills (reading and writing abilities). Our results lend ample support to recent findings that use estimates for more advanced skills: book production (Baten and van Zanden 2008) and secondary schooling (Boucekkine et al 2007, 2008). The increased human capital formation, which was linked to the emergence of the EMP after the

Black Death, contributed to the rise of the North Sea region. This conclusion supports growth theories that stress the importance of human capital formation for the onset of modern growth (Nelson and Phelps 1966, Schultz 1975, Galor 2011).

Second, a finding of equal importance is the effect of culture/religion on human capital formation. Protestantism had no direct effect on per capita income levels, but it seemed to have worked via the channel of human capital formation, which is consistent with recent research on this issue (Becker and Woessmann 2009).

Thirdly, we also established a consistent relationship between agricultural productivity and economic growth (and urbanization). Finally, our arguably most significant finding is that the differential evolution of parliamentary institutions (the 'institutional Little Divergence') helps to explain the Little Divergence as it occurred in Western Europe between 1300 and 1800, which adds further evidence to the empirical findings of Acemoglu et al (2005) and Van Zanden et al (2012). Constraints on the executive, such as an active Parliament and urban self-government, contributed to economic development via the protection of property rights (North 1981, North and Weingast 1989).

Summing up, growth before 1800 was, as already argued by De Vries and Van der Woude (1997) in their book on the Dutch economy between 1500 and 1800, caused by the same drivers as the modern economic growth of the 19th and 20th centuries.

Chapter 3: The European Marriage pattern and the Little Divergence

(With Sarah G. Carmichael, Jan Luiten van Zanden and Tine de Moor)

3.1 Introduction

Do institutions matter for economic growth? And which institutions enhance economic development, and which impede it? This is, in a nutshell, arguably the most fascinating debate in economics, in which economic historians participate on a large scale. The debate is dominated by the representatives of New Institutional Economics, such as North (1981), Greif (2006), and Acemoglu and Robinson (2012), who have argued that institutions are the main drivers of economic change, and more specifically, that certain Western European institutions help to explain the 'Rise of the West' in the centuries between 1000 and 1800. But this assessment has not gone unchallenged, and in particular Ogilvie has criticized the 'new orthodoxy' in a number of important papers and books (Ogilvie 2007; 2011; 2012; Edwards and Ogilvie 2012). Her main point is that we should not assume that 'whatever is, is right', that, more specifically, institutions that exist in dynamic economies necessarily contribute to development (Ogilvie 2007). She has particularly concentrated on the (dis)advantages of guilds (and other trade related institutions) to make this point (Ogilvie 2008), but recently – in the paper co-authored with Tracy Dennison –has focused on the European Marriage Pattern, in a similar critique.

Dennison and Ogilvie (2014) essentially follow the classic papers by John Hajnal who argued that that the European Marriage Pattern can be identified on the basis of a number of distinctive features: high age of marriage for women, a high percentage of singles, and a low percentage complex households (as most households are nuclear) (Hajnal 1965).21 Hajnal found these features in Europe west of the famous Hajnal line, running from Trieste to St. Petersburg. The EMP has resurfaced in the recent discussions of the institutional determinants of the Great Divergence as one of the factors contributing to the long-term economic performance of the region. In various ways, we have argued in the 'Girlpower' paper (De Moor and Van Zanden 2010), this institution (or interrelated set of institutions) enhanced economic growth: by restraining population growth (the classical argument found in Hajnal's original contribution), by strengthening the position of women, by enhancing human capital formation (of women and their offspring) and by encouraging their access to labour and capital markets. We return to the details below, but the point here is that D & O test these ideas by looking at the correlation between the mentioned features of the EMP and the pattern of economic growth in early modern Europe. When looking for this correlation they subdivide countries into three categories: pure, moderate and extreme forms of the EMP. They have put together a large dataset on some of the features of the marriage pattern as discussed by Hajnal, but on that basis arrive at the conclusion that the presence of the European marriage pattern has no explanatory

[21] Hajnal also mentioned a large share of the population working as life-cycle servants and a low age gap between marriage partners.

power when it comes to economic growth. The institution as such does not seem to matter.

Their paper can be read as an attempt to test Hajnal's original hypothesis (although there are many problems with such a reading of the paper), but they have not taken seriously the new interpretation of this hypothesis that we have presented in our paper(s) (De Moor and Van Zanden 2010; Carmichael et al. 2011; Carmichael and Van Zanden 2015). We firstly argue that the Hajnal version of the EMP hypothesis cannot be tested in the way they suggest, as the age of marriage is not only determined by the presence or not of the EMP but also related to the degree of economic stress (due to low living standards) that marriage partners face. Moreover, they do not test the new interpretation of the EMP that we have proposed in the Girlpower paper, which focuses on the underlying institutions instead of the features of the EMP. We suggest a way to test the latter hypothesis directly, and present evidence that the EMP enhanced the economic performance of Western European countries between 1300 and 1800. Below we will start our analysis with discussing the underlying theory -or rather theories- and then move on to present some further empirical material to support our own arguments. But before doing so we want to stress the importance of the contribution made by Dennison and Ogilivie. It allows us, and no doubt other frequently mentioned authors, to develop our ideas more clearly. Thanks to the additional research done since the publication of the Girlpower paper in 2010, we are now able to link the EMP with broader debates among development economists.

3.2 Conceptual Issues: what is the EMP and how to measure it?

Hajnal's hypothesis of the EMP can be seen as a special case of the more encompassing theory of the family system. This broader theory – mainly developed by ethnographers, sociologists (such as Todd 1985; 1987) and demographers – maintains that there are important international (and regional) differences in the norms and values that determine behavior at the micro level concerning marriage, family, reproduction, and upbringing, which tend to persist over time and change only slowly and in a highly path dependent way. Family life in central Africa is differently organized than in China or Western Europe, and the various institutions (as 'rules of the game') determining behaviour at the micro level are to some extent interdependent and form a coherent whole. In patriarchal societies women usually also do not inherit (or even own) property, for example (except for their dowry). This clustering of institutions makes it possible to use the concept of a family system to describe such sets of more or less coherent institutions (about which more below). The literature on the EMP has given rise to a large debate about the classification and regional variation of such family/marriage systems in Europe, focusing on the nuclear family, the stem family and the extended family as the main systems to be distinguished (Laslett and Wall 1972; Engelen and Wolf 2005). An extended classification for family systems of the world was developed by Emmanuel Todd (1985; 1987).

These sets of rules have a substantial impact on behaviour at the micro level: it matters if marriage is arranged and girls marry at age 12 or if it is based on consensus and marriage is at age 25. One of the links between the family system and such 'societal outcomes' is the degree of agency (autonomous decision making power) women have in a family system. In the Girlpower paper (De Moor and Van Zanden 2010) we argued that the EMP, as it was based on consensus and neo-locality as the two core institutions, resulted in and was a reflection of a relatively high degree of female agency, and that, by contrast, in most pre-modern family systems female autonomy is quite limited. Consensus, introduced by the Catholic Church as a norm, meant that the young woman (and obviously also the young man) had to agree with the choice of a marriage partner, or actually engaged in the search for a partner herself, which strengthened the position of (young) women. Neo-locality meant that partners set up an independent household after marriage, and were not living in with either set of parents; again, this created a lot of opportunities for autonomous decision making by man and wife.

Female agency is, moreover, an important driver of development. Many studies have demonstrated that high female agency tends to result in lower fertility and higher levels of human capital formation, basically because the opportunity costs of childrearing for women differ from those of men, as they are the ones who bear most of the costs of having and rearing children. A central hypothesis in this literature is that there are strong links between the level of female education, women's demographic behaviour (in particular fertility), and the level of investment in the human capital of the next generation. Behind this reasoning is the famous switch from 'quantity' to 'quality' of offspring, introduced by Becker and his associates (Becker 1960; Becker and Lewis 1973; Becker and Tomes 1976; see also Schultz 1961). The idea of the quantity-quality trade-off is that parents choose to have fewer children, but increase investment in the human capital of those fewer children. This trade-off is driven by the opportunity cost of childrearing for women. Thus, more female agency and greater say of women in decision making at the household level, will further the switch to quality of offspring. Moreover, the higher the level of female education, the larger the costs will be of having more children, in terms of their productivity and the opportunity costs of their time (Becker 1965). These arguments have received support from modern demographic research (e.g., Becker et al. 2010; Vogl 2013; Rosenzweig and Wolpin 1980; Rosenzweig and Zhang 2009). It has also been demonstrated that the level of education of children is determined to a significant extent by the human capital of the mother – and less so by that of the father (e.g., Brown 2006). Moreover, the valuation of children, and especially son preference, differs between family systems, which has a direct impact on the quantity-quality trade-off (Mason 2001). There are, therefore, close connections between family systems, gender inequality, fertility and human capital formation at the micro level; or in other words, female agency is an important driving force behind the quantity-quality trade off.

The literature suggests more arguments for the crucial importance of female agency. Amartya Sen conceptualizes development as ‘freedom’, implying that agency for women in itself is valuable. New Institutional Economics, however, has been less sensitive to gender issues; seminal studies by North (1981), North et al. (2009), and Acemoglu and Robinson (2012) do not mention the gender dimension, and the NEI literature only pays occasional attention to the topic. That is strange, to say the least, as power issues have been a central concern: North focused on how to constrain the executive and as a result safeguard property rights, and Acemoglu and Robinson saw power imbalances resulting in extractive institutions as a key problem in economic development. One can argue that in a similar way power balances between genders matter; that the property rights of 50% of mankind can only be respected if the power of men is institutionally constrained, making it possible for women to freely participate in market exchanges, invest and innovate (Teignier and Cuberes 2014; Currie and Moretti 2003). This insight has attracted considerable attention recently – the Worldbank for example coined the phrase ‘smart economics’ for it (World Bank 2011).

Against this background the Girlpower paper analysed the European Marriage Pattern as a family system characterized by consensus and neo-locality as the two key institutions, but related and perhaps almost as important is that women can own property and have a share in inheritance, that marriage is strictly monogamous (even, de jure, for the elite), and exogamous (one marries outside the kin-group, leaving more room for choice). All these institutions strengthen the position of women – as we will see below, for a pre-modern family system the EMP is exceptionally ‘girlfriendly’. This analysis differs substantially from Hajnal’s classic interpretation of the EMP. As we saw already, he focused on a number of features that were characteristic of marriage in Western Europe between 1600 and 1900, in particular high ages of marriage for women (over 23 years on average), a high share of single women, and a large group of life-cycle servants. We argue that these ‘superficial’ features result from the underlying institutions, of which consensus is probably the most important; it is these institutions that really make the difference.

There is another strand of literature that analyses the EMP as a ‘homeostatic regime’, which not only limits population growth (via the postponement of marriage by women to age 23-27, and through a large group of single women), but also stresses that age of marriage (and share of singles) responds to economic pressures (Wrigley and Schofield 1981; Clark 2007). Couples have to save for setting up a household after marriage (as neo-locality is the norm); when real wages are high and the demand for labour is booming, age of marriage will be lower than when wage levels are low. In other words, the degree of economic stress faced by men and women active on the labour market, will affect the outcomes of the ‘system’. Demographic behaviour will adapt to a situation of high pressure (low employment and low real wages, land scarcity) as much as to one of low pressure (land abundance and high real wages). The interaction between real wages and age of marriage will tend to stabilize the economy at a relatively high equilibrium, helping to explain the relatively high income levels earned in the region between the Black Death and the Industrial Revolution.

These supplementary perspectives on the EMP are relevant for understanding what went wrong with the attempt by D&O to test the hypothesis that EMP contributed to the economic development of Western Europe before the Industrial Revolution. They assume that the EMP is a system with high average age of marriage of women, a large share of singles and nuclear (non-complex) households, and that the degree to which these features appear makes a country more EMP-ish. To begin with, we have serious reservations about the coverage and the quality of the data used, the weights used, and more generally, how data have been processed to get the country-wide averages they present and analyse. But we did not get access to their dataset for reasons which remain rather unclear. We regret this, and think this conflicts with the open access and data availability policies adopted by leading academic institutions and journals (including Journal of Economic History), and more generally, with good academic practices.

However despite this obstacle we do have some specific criticisms of the way that the data in the Dennison and Ogilvie database have been used. For some countries the observations in given years are based on a few, even solitary observations. Of the 40 regional units they cover, over a quarter have 10 observations or less for female age at first marriage.22 They also do not seem to have weighted the observations for the population density of a given region to come to a national value. The earlier, working paper version of the paper presented a more complete set of summary statistics than the currently published paper does, but it is unclear what has changed between the calculations in the working paper and those in the final version. Their paper presents a far-ranging, but at the same time patchy, summary of the numbers available in the literature. However they do not appear to cover the proliferation in recent years of databases of demographic information at the individual level, often made available via websites (such as the Mosaic, Napp and Ipums, and the EHPS network).23

More importantly, however, is that their interpretation of the data is based on a serious misunderstanding of the literature. Perhaps it is possible to interpret Hajnal's version of the EMP as arguing that the EMPishness of a country increases with the average age of marriage and the share of singles in the population (although such an interpretation is already doubtful). But as D&O wish to test hypotheses from the recent literature about the consequences of the EMP for economic development, this 'simple' interpretation is plainly wrong. The key issues is that the average age of marriage is the result of two factors: whether or not marriage is based on the

[22] Croatia, Belarus, Baltics, Iceland, Italy (all), Malta, Romania, Serbia, Slovakia, Slovenia, Spain (all), Ukraine

[23] See for an overview of datasets: http://www.ehps-net.eu/databases

underlying institutions analysed in the Girlpower paper (primarily consensus and neo-locality), and the standard of living of the population, potentially resulting in further postponement of marriage. If an economy is highly successful in generating economic growth and rising standards of living thanks to, (a.o.) the EMP, this will result in relatively low ages of marriage – that is, low within the context of marriage behaviour based on consensus, i.e. around 20 years. This was the situation in the late Middle Ages after the Black Death, when (we argue) consensus became the norm for large parts of the population of North Western Europe, but real wages and employment opportunities were such that it was relatively easy to marry. The available data show an average age of marriage of 18-21 years for both England and Holland (De Moor and Van Zanden 2010, pp. 16-17; Dennison and Ogilvie 2014, p. 662, also find a significant lower age of marriage for the 16th century). The 16th century price inflation brought an end to this favorable situation – although real wages in the Netherlands and England declined less than those elsewhere in Western Europe, they did go down. There is substantial evidence pointing to a strong rise in age of marriage during the 16th century – not because marriage institutions became more EMPish (which they did not, in fact the Reformation and the Counter-Reformation strengthened the position of parents), but due to the increase of economic stress resulting in the deterioration of living standards. 24 From our agency-based perspective the rise in age of marriage due to the decline in real wages in the 16th century was not a strengthening of the EMP, but a weakening.

A similar example can be derived from the emigration experience of men and women in early modern Europe. When emigrants from the North Sea area settled in the Cape Colony or North America, they did not change their values and norms concerning marriage behaviour (consensus remained the central notion), but they soon began to marry much earlier due to the different economic circumstances, because in these parts of the world land was abundant and real incomes were relatively high. In the Cape Colony, for example, mean age of marriage for women was as low as 19-20 years during the 18th century (perhaps it is not a coincidence that this is comparable to the level found in late Medieval Europe) (Cilliers 2013).

In other words, women's average age of marriage is influenced by both the economic circumstances and the underlying institutions. The introduction of the consensus marriage must have resulted in a strong rise of the age of marriage (say from 12-16 years to 18-30 years), but within the EMP a lot of variation was possible, dependent on the employment prospects and the real incomes of the working population. The other indicators (share of singles and of complex households) used by D&O suffer from the same problems: they are endogenous and measure both the presence of the institutions underlying the EMP and the large degree of variation within the EMP. It

[24] Dennison and Ogilvie 2013 also present 15th century evidence that points in the same direction: the average age of marriage of the 15th century studies is 18,8 years, for the 16th century this is 21,8 years and for the 17th century 24,8 years, confirming the rise in age of marriage during the period in which real wages decline steeply; see for this link also Wrigley and Schofield (1981).

is therefore no accident that D&O do not find a correlation between economic growth and marriage ages – it is exactly what we would expect. Economically successful regions with EMP institutions will have relatively lower marriage ages than stagnating EMP regions. The growth spurt that began in England after 1650 and that brought about the Industrial Revolution of the late 18th century, resulted in a long term decline of marriage ages, whereas at the same time, when the 'Golden Age' of Holland turned into a 'silver' 18th century, ages of marriage went up (Wrigley and Schofield 1981; Van der Woude 1980).

3.3 Testing the EMP hypothesis

That D&O came to an incorrect conclusion, does not imply, in our view, that the question about the long term economic effects of the EMP is not right. But how can we test the hypothesis that the EMP affected economic growth before 1800? Obviously, we have to focus on the underlying institutions, and try to measure them, but that is not an easy job. In a related paper 'Towards an ethnographic understanding of the European Marriage Pattern' Sarah Carmichael and Jan Luiten van Zanden (2015) have tried to do this. We have redefined the EMP in ethnographic terms, and used ethnographic information (Murdock's database and Todd's studies) to classify the societies of Eurasia on various marriage and family-related institutions, such as monogamy, consensus, female inheritance, exogamy and neo-locality). All these institutions have a 'girlfriendly' version: monogamy is from this perspective to be preferred to polygamy; consensus to arranged marriage; female inheritance to systems without them; exogamy to endogamy (which restricts the choice of marriage partners to kin-members), and neo-locality to patri-locality. An easy and transparent way to classify societies is to let them score on all five dimensions; societies which are monogamous score one point here, and societies with polygamy do not score a point. Female inheritance, exogamy, matrilocality and consensus all score similar points (see for full details Carmichael and Van Zanden (2015)). The scoring is presented in the table below:

Variable	Lowest Score	Intermediate Scores	Highest Score
Domestic Organisation	Extended – 0	Stem – 0.5	Nuclear – 1
Cousin Marriage	Endogamy – 025		Exogamy – 1
Monogamy	Polygamy – 0		Monogamy – 1
Marital residence	Patrilocal and Virilocal – 0	Avunvulocal – 0.25 Ambilocal – 0.5 Neolocal – 0.75	Matrilocal - 1
Inheritance	Patrilineal – 0	Children daughters less – 0.5	Children equally – 1 Other matrilineal - 1

Table 3.1. Scoring for the ‘girl-friendly index’

The data used for this is derived from a combination of three sources. First and foremost we use Murdock’s Ethnographic Atlas. The atlas was featured in Ethnology from 1962 to 1980. In 1967 the data was compiled into a book.26 It contains data on 1267 societies for a wide range of characteristics. These were then translated to country-level indicators by Jutta Bolt, using the Atlas Narodov Mira (Bolt 2012). The dataset used here is largely as classified by Murdock, with a number of corrections made on the basis of comparing his categorisations to those of Emmanuel Todd. This is only relevant for the domestic organisation and cousin marriage variables.27

Using this index, the ‘girl-friendliness’ of family systems in Eurasia can be established: the more points a country scores on the range between 0 and 5, the more its institutions favour female agency. It is a bit arbitrary to weight all institutions in the same way, but we do not have a method to differentiate the impact of different marriage and family related institutions. This results in the map 3.1 presented below, showing that Europe to the west of the Hajnal line is clearly very ‘girlfriendly’, but so is South-East Asia (in Carmichael and Van Zanden (2015) we present qualitative information confirming this pattern). When looking more closely, we find that in the other margins of the EurAsian landmass – in south India (Kerala is a famous case), Sri Lanka, Japan, marriage systems also allow for female agency. The map below presents this visually at the country level for Eurasia.

[25] Assigning a score to the extended family variable and the endogamy is complicated as in some cases living in extended, endogamous families can be beneficial to women as it keeps their natal kin close-by and can provide them with a support mechanism in times of need. An argument could therefore be made for assigning a half point for the combination of the two however for simplicities sake this has not yet been implemented here (moreover it has only a marginal effect on the Eurasian distribution).

[26] A revised Ethnographic Atlas was used that has been published by the *World Cultures* journal: <eclectic.ss.uci.edu/~drwhite/worldcul/world.htm>. The data is available at <intersci.ss.uci.edu/wiki/pub/XC/EthnographicAtlasWCRevisedByWorldCultures.sav>.

[27] For further details on the derivation of country level variables and the process of checking and correcting please see Rijpma and Carmichael (2015).

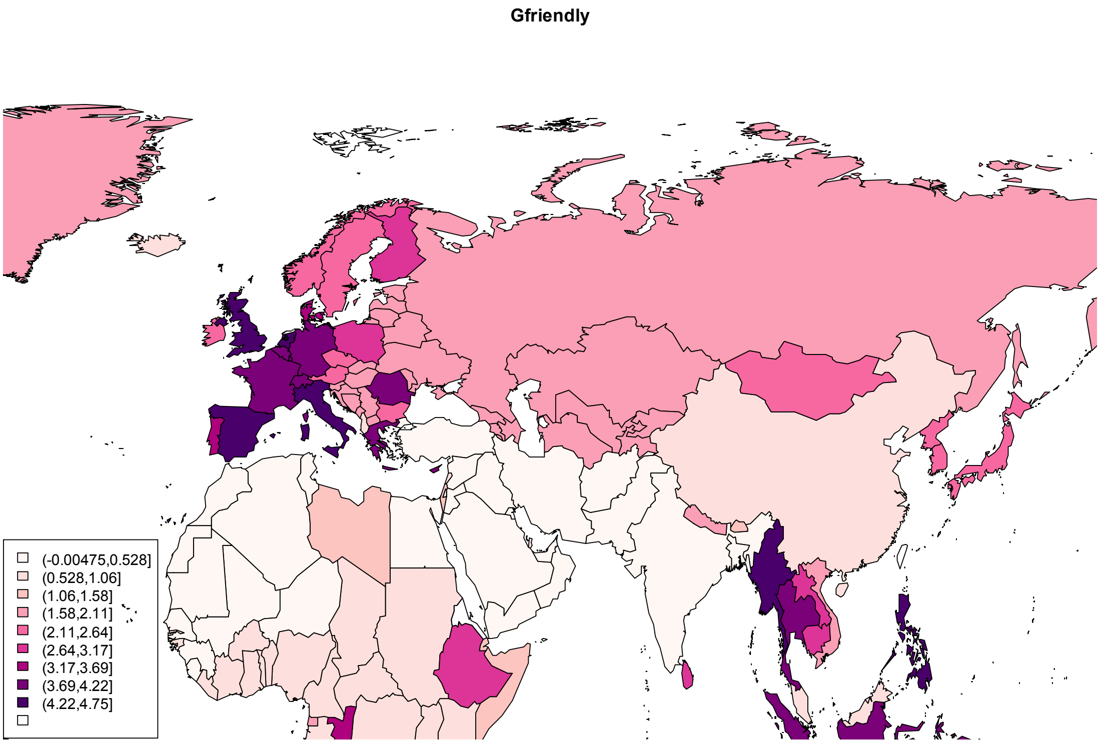

Figure 3.1: Girl-friendliness Index mapped for Eurasia

Shifting the focus to Europe we find, with the exception of Romania and Greece, the pattern is remarkably similar to the Hajnal line, with Poland, the Czech Republic and Austria displaying an intermediary pattern and the UK and the Netherlands, along with Italy and Spain attaining the highest scores. A somewhat similar 'patriarchy index' was constructed by Siegfried Gruber and Mikołaj Szoltyzek (2015); although the focus and methodology are rather different, constructed as it is of large micro-datasets concerning demographic behavior, measuring 14 different dimensions, such as 'familial behavior, including nuptiality and age at marriage, living arrangements, postmarital residence, power relations within domestic groups, the position of the aged, and the sex of the offspring'. Their results, which are however available for only 12 countries and can therefore not be used for the regressions shown below, demonstrate the same West-East gradient in patriarchy as was found in our reconstruction of the 'girlfriendly' index. Their results, averaged at the country level, correlate strongly, but obviously negatively, with our index (R2 = .53).28 Another check can be conducted using the correlation with current day measures of gender inequality. For this we use the Historical Gender Equality Index developed by Selin Dilli, Sarah Carmichael and Auke Rijpma (2015). This measure captures gender differences in life expectancy, labour force participation, infant mortality, educational attainment, marriage ages, and political participation. Again, our index is highly

[28] Here the Turkish sample has been excluded as it is based solely on Istanbul. Similarly Italy is based on only one location (Legano) in 1430, and therefore has also been left out of this correlation.

correlated with contemporary measures of gender inequality, although the correlation is far from perfect (R2=.33); Sweden, for example, is currently world leader in gender equality, but did not score very well on the girlfriendly index.

We think our measure for female agency within the family system is a good proxy for testing the Girlpower version of the EMP hypothesis, as it is clearly based on the underlying institutions. We focus on the question of whether this index can help to explain the Little Divergence within Europe, which is (implicitly) also the issue addressed by D&O. In Chapter 2 we have tested the various hypotheses for explaining the divergent development of the North Sea area between 1300 and 1800. The results of that paper indicate that political institutions and human capital formation were the main underlying causes of economic growth in this period. We add to this analysis here by directly testing the EMP-Girlpower hypothesis, building on the results of that paper.[29]

The key independent variable in our regression is the girl-friendliness index which shows substantial differences between European countries: North-western Europe, notably England and The Netherlands, had institutions favouring more female agency than countries located in Southern- and Central-Europe. We regress this on three sets of dependent variables. First of all on the latest estimates of per capita GDP for these European countries in the period 1300-1800 (see Bolt and van Zanden 2014 for an overview). Secondly, to evaluate the robustness of our results we follow earlier studies (e.g., Acemoglu et al. 2005; Bosker et al. 2013) by taking the urbanization ratio as an alternative dependent variable. Finally, we relate the girl-friendliness index to per capita cook consumption dataset introduced in Chapter 2 to find out if female agency helps to explain the increase in human capital formation in the pre-industrial period as postulated by De Moor and Van Zanden (2010) (see also Van Zanden 2009).

The unit of observation are countries at intervals of approximately a century. The years included are 1300, 1400, 1500, 1600, 1700, 1750 and 1800. Observations for 1300 and 1400 are only available for Spain, Italy, England and the Netherlands. Germany, France, Austria, Poland, Belgium, Switzerland, Denmark, Ireland and Norway enter the dataset in 1500; Sweden and Portugal enter the sample in 1600. The girl-friendliness index is related to per capita GDP and the urbanisation ratio by estimating the simple linear regression model given in equation (1). To test for the relationship between female agency and human capital formation, we estimate the linear regression model given in equation (2).

$$\ln Y_{it} = \alpha_i + \alpha_t + X_{it}\beta + \gamma_1 GF_i + \varepsilon_{it} \quad (1)$$

[29] In Chapter 2 we have performed Random-Effect/Two-Stage least-square regressions, whereas in this paper we have estimated a linear regression model.

$$\ln Book_{it} = \alpha_i + \alpha_t + X_{it}\beta + \gamma_1 GF_i + \varepsilon_{it} \quad (2)$$

where Y_{it} denotes GDP per capita or the urbanisation rate of country *i* in century *t,* and ln $Book_{it}$ represents per capita book consumption of country *i* in century *t*. GF_i is our main variable of interest, the girl-friendliness index. X_{it} is a vector of control variables related to economic development or human capital formation, α_i is the country-specific effect, and α_t denote the century specific effects. We include a full set of country and century dummies to allow for unobserved country-specific as well as century-specific heterogeneity. ε_{it} captures all other unobserved (or unmodelled) variables related to economic growth or investments in human capital, and we assume that it is uncorrelated with the girl-friendliness index. The standard errors are clustered at the country level to control for serial correlation in the unobservables. It should be mentioned here that the book consumption dataset does not include observations for Denmark and Norway. The regressions explaining human capital formation therefore have a slightly smaller number of observations (70) then the regressions explaining pre-industrial growth (81). The obtained regression results are therefore evaluated by putting the sample sizes equal.

Figure 3.2 shows the basic correlation between the girl-friendliness index and per capita GDP (left panel) and urbanisation ratios (right panel). The Figure nicely illustrates a strong positive relationship between the two: countries with female friendly institutions were also the ones with the highest levels of per capita GDP and urbanisation.

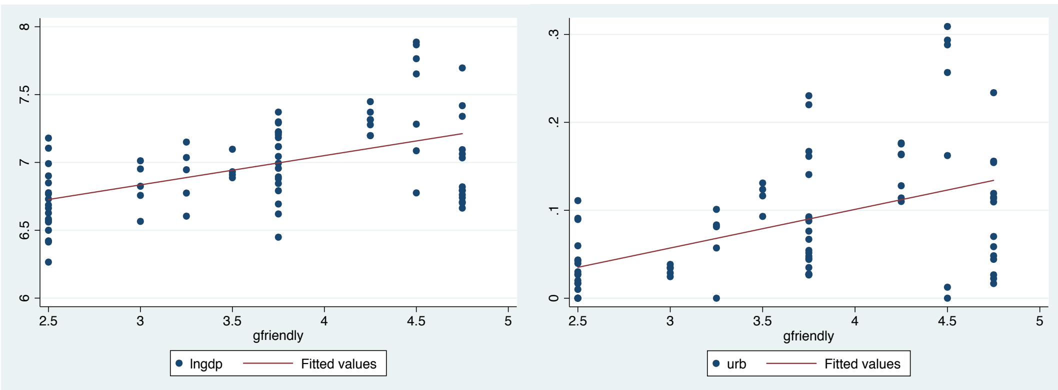

Figure 3.2. Basic correlation between girlfriendly index and log of GDP per capita (left) and Urbanization ratio (right)

Notes and sources: See main text.

Table 3.2 presents the baseline estimation results including the set of country and century dummies. The regression results in Column (1) suggest a strong and positive effect of female friendly institutions on per capita GDP (denoted Ln GDP): the coefficient on the girl-friendliness index is highly significant at the 1% level. Column (2) shows that this result is robust to the use of the urbanisation ratio as left-hand side variable (denoted URB). The coefficient on the index again enters with the expected sign and is statistically significant. The equation measuring the effect of female agency on human capital formation is depicted in Column (3). The coefficient on per capita book consumption is significant at the 1% level suggesting a strong correlation between human capital and female friendly institutions. Finally, Columns (4) and (5) show that the results on the relationship between female agency and economic growth given in Columns (1) and (2) are robust to switching to the sample of the book consumption variable.

	(1)	(2)	(3)	(4)	(5)
Estimator	OLS	OLS	OLS	OLS	OLS
Dependent variable	Ln GDP	URB	Ln Book	Ln GDP	URB
Girl-friendliness index	0.22***	0.05***	0.56***	0.10***	0.04***
	(0.03)	(0.01)	(0.13)	(0.03)	(0.01)
Century dummies	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES
Constant	6.05***	-0.22***	2.36*	6.17***	-0.18**
	(0.25)	(0.07)	(1.14)	(0.27)	(0.07)
R2	0.78	0.81	0.82	0.74	0.79
No. of observations	81	81	70	70	70

Table 3.2: Female agency and economic development 1300-1800.

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively.

To check for the robustness of our results, the next step is to control for other important determinants of economic growth and human capital formation. The control variables capture the development of political institutions, the impact of colonies, and the incidence of warfare. We now turn to a brief discussion of the various variables that we include.[30]

Research stresses the importance of political institutions in ‘constraining the executive’ as a root cause for early modern growth (cf. North and Weingast 1989; Acemoglu and Robinson 2012). To proxy the quality of political institutions, we use the activity index of Parliaments of Van Zanden et al (2012). The activity index is defined as the number of years Parliaments were in session during a century and varies from zero, when no Parliament convened, to 100, when the Parliament met every year during a given century. The idea is that in republican systems with a strong Parliament (such as England after the Glorious Revolution of 1688) property rights

[30] Ideally we would like to include the spread of Protestantism in the regressions to control for the effect of culture on book consumption and economic development (see Chapter 2). Unfortunately it was not possible to include this variable in the regressions because it is time-invariant.

were more secure than in states ruled by absolutist kings (such as France). Active Parliaments, constraining the actions of the sovereign, are therefore expected to have contributed to economic development between 1300 and 1800.

As a second variable capturing political institutions, we include the share of cities with self-government (Bosker et al 2013). The communal movement that started in the 11th and 12th centuries is important for economic growth as it created a stable system of property rights in cities (Stasavage 2014). Between 1100 and 1500 many European cities obtained city rights, but they could also lose their status as a results of conquest by another city or by the abolishment of the independent status by absolutist rulers. The share of cities with self-government is therefore argued to proxy the 'republican' nature of the polity as self-government constraints the executive.

Another body of literature stresses the significant contribution of colonies to pre-industrial development (Acemoglu et al. 2005; Pedreira 1993; Daudin 2004). We therefore introduce 'Colonial Realm' in the regressions. This variable captures the size of the colonial population compared to the population of the colonizing country (Bosker et al. 2013).

We also include the number of universities per capita in the regressions to control for the very advanced levels of human capital (Van Zanden et al 2012). The number of universities may have been positively affected book consumption. Likewise, it may have influenced economic development in the broader sense, because it measures the upper tail of the knowledge distribution.

A final set of control variables included in the regressions is related to the effect of warfare. Research has found an important effect of war on state formation and subsequent economic development (Tilly 1990; Voth and Voigtländer 2012). We therefore first of all add the average years of war during the previous period (a century or half-century) (Acemoglu et al. 2005). Secondly, we control for the Thirty Years' war by including a dummy variable that equals 1 for Germany during the century after the war (Baten and Van Zanden 2008).

Table 3.3 reports on the regressions including the set of control variables. Although the standard errors become slightly larger, the coefficient on the girl-friendliness index never becomes statistically insignificant. Interesting is the finding of a strong relation between political intuitions and our measures of economic development: the coefficients on the Parliamentary activity index and on the share of cities with self-government enter with correct sign and are highly significant in the regressions explaining economic development (Columns 6, 7, 9 and 10). The regressions in Columns (7) and (10) suggests a positive relationship between colonial realm and urbanisation, which indicates that the growth of overseas land contributed to city growth.[31] With respect to warfare, we indeed find a weak negative effect of the Thirty Years' war on economic growth in Germany. The results reported on in Columns (6) and (9) furthermore show that average years of war did not contribute to per capita GDP; it was, however, positively related to the process of urbanisation (Columns (7) and (10)), which adds evidence to the hypothesis of Voth and Voigtländer (2012) stressing the importance of this relationship.[32]

The regression results in Column (8) show that female friendly institutions were conductive for human capital formation between 1300 and 1800. Regarding the effect of political institutions on pre-industrial human capital formation, the results suggest that active parliaments did not contribute to levels of per capita book consumption. The coefficient on the share of cities with self-government is however significant at the 1% level, indicating that levels of human capital were higher in 'republican' cities compared to cities without some sort of self-rule. The coefficient on the number of universities appears with the correct sign in Column (8), but is never found to be significant.

Estimator Dependent variable	(6) OLS Ln GDP	(7) OLS URB	(8) OLS Ln Book	(9) OLS Ln GDP	(10) OLS URB
Girl-friendliness index	0.18*** (0.05)	0.04** (0.02)	3.38* (1.95)	0.32*** (0.10)	0.06* (0.03)
Ln Parliamentary	0.10*** (0.03)	0.01** (0.00)	-0.34 (0.52)	0.08** (0.03)	0.01* (0.00)
Share cities self-government	0.97*** (0.15)	0.19** (0.07)	6.26** (2.77)	1.01*** (0.17)	0.19** (0.07)
Colonial Realm	0.04 (0.06)	0.03* (0.02)	-0.74 (0.63)	0.04 (0.06)	0.03 (0.02)
No of universities p/c	-0.07 (0.12)	-0.00 (0.03)	1.83 (1.42)	0.01 (0.11)	0.01 (0.03)
Years at war	-0.06 (0.05)	0.01 (0.01)	-0.06 (0.28)	-0.05 (0.06)	0.02* (0.01)
Thirty Years' war	-0.10** (0.04)	-0.02*** (0.01)	-0.14 (0.28)	-0.09 (0.06)	-0.02** (0.01)
Century dummies	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES
Constant	6.10*** (0.20)	-0.14* (0.06)	-10.8 (8.52)	5.00*** (0.46)	-0.38** (0.13)
R2	0.91	0.92	0.87	0.90	0.92
No. of observations	81	81	70	70	70

[31] The coefficient on Colonial realm in Column (10) is significant at the 11% level.
[32] The coefficient on Average years of war in column (7) is significant at the 12% level.

Table 3: Female agency and economic development 1300-1800: Controlling for other determinants of economic development

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively.

4.4 Conclusion

Dennison and Ogilvie have in our view misunderstood the EMP hypothesis about the relationship between this family system and economic development. Hajnal does not postulate that there is a simple, linear relationship between the basic features of the family system (age of marriage, share singles, and share of complex households) and economic development. It is immediately clear from the fact the (for example) age of marriage is also determined by the standard of living of the population, that this relationship is not linear. So their failure to find a clear link between these features and economic development is exactly what might be expected. In addition, we have suggested a proper test of the link between the EMP, economic development, and human capital in early modern Europe, starting from the alternative interpretation of the EMP as a system that allows a lot of female agency (as already suggested in the paper on 'Girlpower'). Making use of recent estimates of GDP per capita, urbanization and human capital (and a series of control variables), we show that there was a strong, consistent link between female-friendly institutions at the micro level, economic performance, and human capital formation, thereby confirming our version of the EMP hypothesis.

Chapter 4: Human capital and long run economic growth: Evidence from the stock of human capital in England, 1300-1900

4.1 Introduction

Economic models of the Industrial Revolution increasingly emphasize the key role of human capital in promoting economic growth (Becker et al 2011, Galor 2011), and empirical studies have shown that education is a strong predictor of per capita GDP (Barro 2001, Cohen and Soto 2007, Sunde and Vischer 2011). The logic behind this is that human capital facilitated technological adoption and innovation (cf. Nelson and Phelps 1966, Schultz 1975). Contrary to the theory and evidence, however, economic historians have described the role of human capital in the English Industrial Revolution as minor (Mokyr 1990, Mitch 1993, Crafts 1996, Clark 2005). Literacy rates were at best mediocre. Around 1800, literacy rates were about 60% for males and 40% for females (Cressy 1980). Reis (2005) has shown that this was slightly higher than France, but significantly lower than the Netherlands, Sweden and Germany. For instance, Sweden was fully literate by the early 19th century.[33] There was not much improvement in literacy during the Industrial Revolution itself: male literacy rates fluctuated around 60% between 1750 and 1850 (Mitch 1993). Similar conclusions can be drawn from school enrolment figures. Out of the male population in the age bracket between 5 and 14, 28% were enrolled in schools in 1830. In 1850, by the end of the first Industrial Revolution, it had increased to 50%, but this was equal to France (51%) and considerably less than Prussia (73%) (Lindert 2004).

The conclusion that human capital did not play an important role in the British Industrial Revolution draws upon records of school enrolment and literacy.[34] Literacy rates are likely to underestimate the level of human capital as they only proxy primary schooling (reading and writing abilities) and enrolment rates do not take into account the age structure of the population. What is more, by largely focussing on the period after 1750, these measures are expected to understate the growth of literacy, and that of schooling in general, which occurred in the centuries leading up to the Industrial Revolution.[35] The recent studies of Baten and Van Zanden (2008) and Boucekkine et al. (2007) introduce more comprehensive measures of human capital formation such as book production and the number of (secondary) schools and even trace their evolution back to the medieval period. What these studies show is that the growth of human capital was far greater than previously assumed and that it significantly contributed to pre-industrial economic growth.[36]

[33] Sandberg (1979) argues that Sweden became Europe's 'impoverished sophisticate'. Although literacy rates were round about 100%, its industrialization was relatively late.

[34] Notably the records of school enrolment of Flora et al (1983) and the literacy rates of Schofield (1981) and Cressy (1980).

[35] An important exception stems from Kelly and Ó Gráda (2014) who acknowledge a steady increase in human capital between 1500-1750.

[36] Allen's (2003) regressions however suggests that 'literacy was generally unimportant for growth' between 1300 and 1800 (pp. 433). This non-result might be explained by his estimates of literacy: for

In this paper the stock of human capital for England over the long run (1300-1900) is quantified. The human capital stock incorporates extensive statistical evidence on literacy rates, the number of primary and secondary schools and their average class sizes, and matriculations to the University of Cambridge, Oxford and London. Demographic key figures, such as survival rates of individuals, are applied to estimate average years of education present in the total population. An additional distinction is made on the basis of gender (years of education of males and females) and of level (formal primary, secondary and tertiary education). It is shown that the stock of years schooling can be quantified rather well. The estimates presented in this paper are therefore able to give a far more coherent picture on the evolution of formal schooling in the long run.[37] In that way, it becomes possible to examine the formation of human capital before as well as during the Industrial Revolution.

Some interesting conclusions stand out. The years of schooling measure began to increase at a fast rate after the 1530s. Between 1530 and 1700, secondary education accounted for over half of the share of the education stock of males. One out of six boys went up to the secondary level by the turn of the 17th century. A pronounced shift occurred after 1700 as indicated by stagnation in average years of primary schooling and a vast decline in attainment levels of secondary and tertiary schooling. Only one out of thirty boys went up to the secondary level in the second half of the 19th century. The educational attainment levels of females were well below those of males, although it is the only stock that shows consistent growth until 1800. Over the course of the 19th century, females rapidly caught up with males in terms of average years of primary schooling. Overall, from the evidence on the evolution of the stock of human capital, it can be concluded that the first Industrial Revolution coincided with a pronounced decline in formal secondary schooling levels of males.

To formally test the relation between human capital and economic growth, a time series analysis is conducted. Johansen tests of cointegration are performed to test the possibility of a long-term relationship among educational attainment and per capita GDP (Johansen 1995).[38] In the cases where cointegration is found, bivariate cointegrated VAR models are estimated. The model omits other relevant determinants of per capita GDP, so the results must be interpreted with some care. It is however possible to interpret the cointegrating relationship as robust correlation coefficient, because underspecification does not affect the consistency of the estimated cointegrating vectors (see Pashoutidou 2003). The overall results suggest a positive

1500, his estimates are based on the urbanization ratio, which assumes that 23% of the urban and 5% of the rural population was literate (pp. 415). What is more, most of the estimates between 1500 and 1800 are based on intrapolation.

37 The information available forces me to focus on formal education. It thus ignores the part of the stock of human capital the acquisition of which did not involve formal schooling but which could have been important for the productivity of workers, such as apprenticeships or on the job learning (see: Humphries 2003, Wallis 2008 and Mokyr 2009).

38 The analysis uses the latest estimates on per capita GDP of Broadberry et al (2015).

educational attainment to per capita GDP relationship in the 17th century. During the 18th and early 19th centuries, the relationship was clearly negative.

The results presented in this paper are in line with Baten and Van Zanden (2008) and Dittmar (2011) who show that book production and book printing significantly contributed to pre-industrial economic growth. The finding of a negative human capital to growth relationship during the age of cotton and steam provides further evidence to the predominant view that formal education did not contribute to England's early industrialisation (Nicholas and Nicholas 1992, Mitch 1993). Relative to this literature several contributions are made. First of all, previous conclusions are derived from the observation of a pause in the growth of male literacy between 1750 and 1850. Evidence from the trends in the stock of primary education of males indeed suggests that this must have been the case. However, the movement away from formal secondary and tertiary schooling on the eve of the Industrial Revolution is a factor that should not be overlooked. It demonstrates that the decrease in human capital was more pronounced than the evidence on the spread of literacy alone would suggests, and therefore it may indicate that the reduction in the demand for educated (male) workers was more severe than previously assumed by scholars. Secondly, and related to the above, the regression results demonstrate that formal education constrained per capita GDP growth. This finding may support McCloskey's (2010) notion that investment in human capital can be massively misallocated and therefore have a negative impact on economic development.

The remainder of the paper is organised as follows. Section 2 presents the data on the stock of human capital, and discusses the assumptions underlying the estimates. Section 3 presents the main empirical results following the time series analysis. Section 4 concludes by discussing the implications of the findings for the debate on the nature of human capital formation in England, and that for the relation among human capital and economic growth more generally. The conclusion also proposes avenues for future research on the topic.

4.2 Data on the stock of human capital

The stock of human capital is computed in 'physical' units - that is as years of formal education present in the population.[39] In that way, the estimate of the human capital stock is a very direct application of the concept, since human capital is directly linked to individuals. Assuming the lifetime of humans (and therefore the lifetime of their human capital) to be finite, it is possible to apply the perpetual inventory method to compute the stock of human capital.[40] This is essentially the same way as building stocks of physical capital. An individual's human capital (the number of years of

[39] The method applied in this paper is originally developed by Clemens et al (1996).

[40] It is required to make this assumption to estimate the initial 1300 stock. From the mid-14th century onwards (i.e. roughly one asset life on), the estimates of the stock of human capital are independent of the initial assumption.

schooling) enters the stock when he/she finishes school and leaves the stock at time of death depending on his/her life expectancy. To estimate the annual flow of years of primary, secondary and tertiary schooling entering the human capital stock, statistical source material on literacy rates, the number of primary and secondary schools, and enrolment figures are used. The current section describes the procedure and discusses the outcomes.

Primary education

To estimate the annual flow of years of primary education entering the human capital stock between 1550 and 1900, existing statistical evidence on literacy rates are combined. Literacy rates are measured as the capacity of individuals to sign their names on documents. The estimates of literacy are derived from church and secular records for the period prior to 1754 and marriage contracts for the years thereafter. The statistics on literacy of Cressy (1980, 1981) are used for the years 1550 to 1754; those of Schofield (1981) for the years 1754 to 1840; those of Stephens (1987) for the years 1840 to 1885; and, finally, those of Cressy (1980) for the years after 1885. All details regarding the availability of literacy rates can be found in Appendix I.

Preference for literacy rates is for a variety of reasons. To begin with, the capacity to sign documents is said to give a fair indication of the share of the population that could read at an advanced level, as well as a certain ability to handle writing materials.[41] Unlike nowadays, reading and writing were taught in separate and successive periods of about two to three years at a time. Signature evidence is therefore argued to proxy a relatively sustained and prolonged effort of learning in primary schooling (Schofield 1968, Reis 2005). Secondly, it has the merit of being fairly homogeneous across space (Albers 1997). With respect to the history of schooling in England, there were different ways for children to learn basic reading and writing skills. Children could have learned to read and write at churches, at work, or informally at home (Williams 1961, Schofield 1981). If children were sent to school, then there were different types of elementary schools were they could choose from: ABC-, song-, reading-, writing-, and petty schools. Even more types of school started to emerge after 1700. Examples of these include Sunday-, charity-, monitorial-, industrial-, and workhouse schools. It is not only uncertain how skills of basic and reading and writing were learned, there were also differences in the learning objectives of the schools. ABC-, song-, and reading schools were concerned with reading, whilst charity- and Sunday schools taught moral and religious courses (Jewell 1998). The use of signature evidence has the advantage of making it possible to assume a certain level of primary education that ignores the way in which these skills were obtained in the first place. Finally, and related to the above, it would be practically impossible to proxy primary schooling covering the whole of England

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[41] Literacy rates do however overestimate the share of the population with advanced writing skills (see discussion below).

without the use of evidence on literacy rates. The charity schools are relatively well documented in the records (see Boucekkine et al 2007): London and Westminster had 54 charity schools teaching about 2000 pupils in 1704, which had increased to 179 schools teaching 7108 children in 1799. Unfortunately, no such detailed evidence exists for the number of other types of primary schools and their average class sizes.[42]

Statistical evidence on literacy rates for the medieval period is harder to come by. What is known from qualitative studies is that around 1300 literacy was mainly restricted to the clergy. Following the Black Death, however, lay literacy gradually started to increase. The English economy became more commercialised and economic specialisation rose: for instance, over the course of the 15th century, England became a significant producer of finished cloth (Lawson and Silver 1973). Centralisation of the state stimulated the growth in royal administration and common law. Both developments required more educated laymen, leading to human capital formation. On top of this, church controlled education started to decline after 1400, which made it appealing for middle class children to enter the schooling programme (Leach 1915). Due to these three (to some extent interrelated) factors, literacy spread among the upper- and middle classes. There is even evidence of growing literacy among groups of lower social status. For instance, Graff (1987) shows that male literacy was as high as 40% in London during the 1460s, of which craftsmen formed a significant group of literate people.[43]

Statistics provided by Hoeppner Moran (1985) allow for an estimation of the annual flow of years of primary education during the medieval period. Hoeppner Moran (1985) traces the evolution of schooling in the Diocese of York between 1300 and 1548 by quantifying the number of primary schools (song- and reading schools) and the number of secondary schools (notably Latin grammar schools). The results are presented in Figure 4.1 and illustrate that the trends in the number of schools compare rather well with what we know from the more qualitative studies on the spread of literacy, in particular the rise in school foundations over the course of the 15th century. Based on the increase in the number of primary schools, Hoeppner Moran estimates the average literacy rate to have been around 15% in the 1530s. Her estimate is higher than Cressy's (1980) figure of 8.2% for this period.[44] In order to quantify the stock of primary schooling, it is important to make the two datasets comparable. Therefore I now turn to the two reasons accounting for the disparities in the numbers – the applied

[42] A limitation of the use of literacy rates is that it does not capture improvements in the quality of schooling across time that were clearly there. One may therefore expect a year of schooling obtained in say, 1500, to be of lower quality than a year's schooling in 1900. As I discuss in more detail in Section 2.3, allowance is made for increases in years of schooling when estimating the stock.

[43] Buringh (2014) furthermore shows that the price of information (measured by the price of books) sharply fell in the years following the Black Death. He therefore concludes that schooling became much cheaper for large groups within the society.

[44] According to Moran, 22.5% of the males and 7.5% of the females were literate. Following Cressy (1980), this was round about 13.6% and 2.8% respectively.

definition of literacy and the slight underestimation of the spread of literacy by Cressy.

Figure 4.1. The growth in elementary and secondary (grammar) education in York diocese, pre-1300 to 1548
Source: Hoeppner Moran (1985, p. 118).

About two-thirds of the difference can be attributed to the applied definition of literacy.[45] Whereas the literacy estimates of Cressy are quantified from evidence on signatures, those of Hoeppner Moran are derived from the growth in the number of song- and reading schools. Since song- and reading schools were mainly concerned with teaching pupils on how to read, Hoeppner Moran concludes that her estimates are likely to capture 'reading-literacy' rather than 'signature-literacy' as those of Cressy do (see Hoeppner Moran 1985, pp. 225).

In order to make them comparable, the next step is to convert reading-literacy into signature-literacy for which it is required to combine the length of the primary schooling programme with the estimates on literacy. As explained at the beginning of this section, signature-literacy gives a fair suggestion of the share of the population that could read easily. Certainly more people were able to read than could sign their

[45] Converting the reading-signature estimates of Hoeppner Moran into signature-literacy gives the following results: 7.6% of the population was literate in 1500 (11.4% of the males and 3.75% of the females). In 1530 this had increased to 11.3% (16.9% of the males and 5.6% of the females). The estimates of Cressy (1980) suggest a literacy rate of 5.5% in 1500 (10% of the males and 1% of the females), which had increased to 8.2% (13.6% of the males and 2.8% of the females) by 1530. Comparing the estimates implies that round about 58% to 65% of the difference can be explained by the applied definition of literacy. See Appendix I for more details.

name on a (marriage) contract, so the capacity to sign a document is likely to underestimate the share of the population that could read at a basic level (see the discussion in Schofield 1968 and Stephens 1987). The official length of the primary schooling programme was 3 years at the time, during which children first learned how to read and thereafter how to write at an advanced level (writing was taught at a later stage than reading) (Stone 1964). The ability of an individual to sign a (marriage) contract does not infer anything about the writing capabilities of that person. Whereas signature-evidence is said to underestimate reading capabilities, it is very likely to overestimate advanced writing skills. Hence, the share of the population able to sign documents must have been higher than the share able to write at a reasonable level. Since it is known that children learned to read in about 1.5 years (Jewell 1998), reading-literacy is set equal to 1.5 years of primary schooling. Signature-literacy is likely to capture more advanced reading skills, whereas at the same time it is unclear whether the individuals were able to write. It is thus not plausible to set signature-literacy equal to the length of the primary schooling programme (3 years), but it is fair to give it 2 years of education.

Combining the years of schooling with the estimates on signature- and reading literacy indeed removes the largest part of the difference.[46] There is still one third of the disparity that cannot be explained by the applied definition of literacy. This implies that either Hoeppner Moran's figures are too optimistic, or those of Cressy are too pessimistic. The study of Hoeppner Moran shows that the 15th century expansion of song- and reading schools was followed by an increase in the number secondary schools: from 25 in 1500 to 68 in 1548 (see Figure 4.1). As discussed in Section 4.2 about the growth in secondary and tertiary schooling, scholars tend to agree on the extraordinary expansion of higher education over the 16th and 17th century, which was labelled the 'educational revolution in higher education' by Stone (1964) (see also Jordan 1959 and Simon 1960). Unfortunately the studies do not explain where the demand for secondary and tertiary schooling came from, but the onset and magnitude of the revolution squares rather well with the trends that Hoeppner Moran sets out for the York Diocese: the growth of song- and reading schools over the 15th and early 16th century, in which 50 schools were founded between 1400 and 1500, and 54 more between 1500 and 1548, must have paved the way for an expansion in grammar schooling.[47] In other words, the enthusiasm for higher education in the 16th and early 17th centuries would have been unlikely without enough primary schools to feed them, and the revolution in secondary and tertiary schooling can therefore be better understood given the preceding developments.

[46] See calculations in footnote 12.

[47] The focus of the studies of Jordan (1959) and Simon (1960) is on the period after 1500, which may help to explain why they do not consider where the growth in secondary and tertiary education came from.

Taking the trends in secondary and tertiary schooling into account, it is suggested here that Cressy slightly underestimates the spread of literacy by the early 16th century.[48] On top of this, it might well be that Hoeppner Moran (1985) slightly underestimates the magnitude in the growth of (secondary) schooling - most probably caused by the focus on trends at the level of the York diocese. The evidence on the number of secondary schools as documented by Orme (2006) cover the whole of England during the medieval period and indicate that the growth of secondary schools must have been twice as high as the results of Hoeppner Moran suggest.[49] Hence, if the expansion of secondary and tertiary schooling was indeed fed by the growth in primary schooling, then it is even possible that the estimates of reading-literacy underestimate the growth in literacy between 1300 and 1530.[50]

The reading-literacy rates of Hoeppner Moran (1985) are projected backwards in time by taking the growth in primary schools into account (i.e. the trends as set out in Figure 4.1).[51] In order to make it comparable with the evidence for the period after 1550, 'reading-literacy' is converted into 'signature-literacy' using the assumption about the attainment levels, i.e. reading-literacy is equal to 1.5 years of education and signature-literacy is equal to 2 years of education. The calculations can be found in Appendix IV. Table 4.1 reports on the results.[52]

[48] Converting the literacy rate of Cressy for 1500 into enrolment in primary schooling and comparing it to the enrolment figures in secondary education of Orme (2006), suggests that as many children were sent up to the secondary level as were able to read and write – a results that seems very unlikely. This finding once more suggests that Cressy slightly underestimates the spread of literacy by the early 16th century. For the period after 1550, Cressy's estimates correspond well with the figures of Stone (1969, pp. 101) and Schofield (1981).

[49] Orme (2006) shows an increase of 69% in the number of secondary schools between 1500 and 1548. The estimates of Hoeppner Moran suggest this was round about 37%.

[50] The literacy rates worked with in this paper are therefore a lower bound.

[51] It would of course be better to use the trends at the national level to project the literacy rates backwards in time. Unfortunately, to follow Orme (2006), whilst secondary schools are well recorded in the records, evidence on the number of primary schools is relatively scant.

[52] It is possible to perform a robustness-check for the level of literacy in the 14th century. Lawson and Silver (1973) state that there were around 30,000 ordinary clergy, about 15,000 monks, canons and friars, and 7,000 nuns. If all these people were literate, then they comprised up to 1.5% of the population. Including part of the lay civil servants, lay judges and some common lawyers, a part of the magnates, knights and leading burgesses, merchants and craftsmen, brings the figure up to round about 3%. This corresponds rather well with the estimates as set out in Table 1: Taking the average of male and female literacy implies that 1.4% of the population was literate in 1300. In 1400 this had increased to 2.2%.

Year	Men	Women
1300	2.0	0.7
1400	3.3	1.1
1500	11.4	3.8
1600	25	9.3
1700	42	24
1750	56	36
1800	64	42
1850	69	54
1900	95	94

Table 4.1. Literacy rates, 1300-1900
Notes and sources: See main text. Percentages are rounded up to the nearest digit.

Equation (1) is used to convert literacy into primary school enrolment, h_t^1. Schooling opportunities opened up around the age of 5 and closed again as children entered the labour market around the age of 15 (Cressy 1980). Since 72% of the spouses were in the age bracket between 20 and 29 when signing their marriage contracts, a lag of 15 years is employed to control for the time difference between schooling and marriage (Schofield 1968). h_t^1 thus is a function of literacy in $t+15$ (l_{t+15}). The next step is to calculate the absolute number of children that enrolled in year *t*. Wrigley et al. (1997) provide estimates on the share of the English population that was in the age bracket between 5 and 14 for the period 1541 to 1871: $\gamma_{(5\text{-}14),\,t}$. The share is quite constant over time: it had only slightly increased from 21% in the 16th century to 22% in 1871. It is therefore assumed that 21% of the population was in the age bracket between 5 and 14 before 1541 and 22% of the population after 1871. These shares are then multiplied by the latest population figures of Broadberry et al (2015), n_t, and divided by 10 (we need one year instead of 10) to calculate primary school enrolment.[53]

$$h_t^1 = l_{t+15}\frac{\gamma_{(5-14),t}}{10}n_t \qquad (1)$$

Secondary and tertiary education

Regarding secondary education, Orme (2006) provides a very detailed list of (endowed) schools between 1300 and 1530. All of the secondary schools that he includes are coupled to a specific date at which the institution was first encountered in the records. Following the statistics derived from the appendix of Orme, there were 156 grammar schools in 1480 and 234 of such schools by the early 1530s. About 50% of the secondary schools recorded by Orme became endowed in the last two decades

[53] The population estimates of Broadberry et al. (2015) cover the period up to 1870. They concern annual estimates for sub-period 1540-1870; for the period before 1540 point estimates are available. The estimates of Maddison (2003) are used to cover the years after 1870.

of the 15th century, and nearly all schools were still in existence by the 1530s. Not only do these findings correspond with the picture that Hoeppner Moran depicts for the York Diocese, it is also illustrates the continuing and long-lived tradition of the secondary schools stressed in the literature (Stone 1964, Vincent 1969, Jordan 1959).[54]

Detailed statistics on the growth of secondary schooling after 1530 are available from the report of the School Inquiry Commission (Henceforth SIC) that was published in 1868. The SIC examined the quality of all endowed secondary schools between 1864 and 1868. The report includes the number of schools founded per decade between 1480 and 1860. The statistics not only include classical Latin grammar schools, but any endowed institution that offered education beyond the elementary level (Owen 1964). This is important to note, in particular because Vincent (1969) argues that the focus on Latin grammar schools alone would underestimate the growth of secondary schooling (see also Stone 1964). England had many private fee-paying institutions in the early modern period: as many as 857 grammar schools, 301 private schools, and 63 private tutors sent boys up to the four Cambridge colleges between 1600 and 1660. A possible disadvantage coming from the use of the SIC statistics is that it only reports on those schools that were still in existence by the 1860s. It is thus likely to underestimate the increase in the number of secondary schools when moving backwards in time. The number of secondary schools is therefore slightly adjusted upwards to control for this possibility (see discussion in Appendix IV).

Figure 4.2 plots the number of recorded secondary schools by the SIC in 1868. The data shows that the growth in the number of new school foundations slowed down between 1660 and 1720. Strikingly, there is a strong decline in the growth rate that sets in after this date, and to follow the report of the SIC, the 18th and 19th centuries saw a further decay in schooling. 799 secondary schools were of direct concern to the commission in 1868. 500 of these schools were more than two centuries old and were supposedly classical grammar schools, but a mere 27% taught Greek and/or Latin, and fewer than 40 sent boys up to Oxford and Cambridge (Owen 1964).[55] The trends in the growth of schooling as depicted in Figure 4.2 are very similar to those as set out by Vincent (1969). His careful analysis of the Cambridge student body shows that, between 1660 and 1720, the number of grammar schools and private schools sending boys up to the four Cambridge colleges had fallen from 857 to 738 and from 301 to

[54] Of the grammar schools listed by Orme (2006), 35 out of 156 of them were endowed in 1480, which had increased to 116 out of 234 by the 1530s. This might also highlight the increase in demand for secondary education by the turn of the 16th century. The closing date of 14 schools from the list is unknown. It is assumed that these schools existed for 100 years. Omitting them from the dataset does not change the results.

[55] Although it is a lower bound estimate, it is possible to perform a robustness-check: If 500 of the schools were more than 200 years old by the 1860s, then it implies that there were at least 500 schools by the 1660s. Interpolating the growth in the number of schools for boys between 1660 and 1868 (from 500 to 786) gives similar results: i.e. there is still a decline in the educational attainment level of males during the classic years of the Industrial Revolution.

201 respectively. The real deterioration sets in after this date, when it had decreased further to 406 and 130 in 1800.

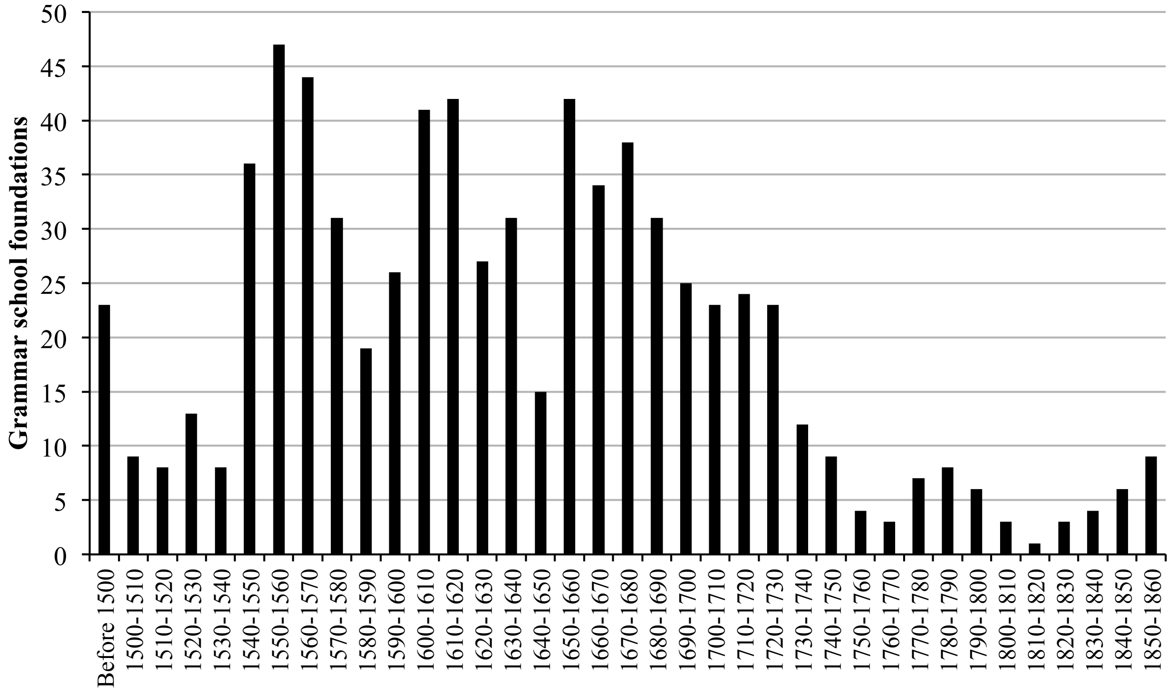

Figure 4.2. Number of secondary schools found per decade, 1500-1860

Notes and sources: Boucekkine et al (2007, pp. 214). The statistics summarize those of the Schools Inquiry Commission (1868a, 1868b).

The number of secondary schools from the SIC report as set out in Figure 4.2 are added to the data derived from the study of Orme (2006). The results suggest that there were 776 secondary schools by the 1660s and 842 by the 1720s. Following the results of the SIC, the number of schools for boys had fallen to 786 in 1868. The investigations of the SIC furthermore revealed the poor provision of secondary education, the uneven geographical distribution of schools, the misuse of endowments, and that there were only 13 secondary schools for girls in the country (SIC 1868b).[56] After 1868, most probably based on the alarming conclusions of the SIC regarding the quality of schooling at the time, government policies were implemented to enhance the quality of the educational system and to increase the number of schools. The policies were quite effective as indicated by a staggering

[56] Girls were not admitted to secondary and tertiary education before the 19th century (Stone 1969). The findings of the SIC show that there were 13 secondary schools for girls by the 1860s. Since it is unknown when these schools were established, I decided to not include it in the stock. In 1878 the examinations of the University of London opened up for women. The number of female graduates between 1878 and 1900 is however included in the stock. It is also assumed that these women had completed the secondary schooling programme. There was only a handful of women that made it up to the secondary and tertiary level: in 1878 only 4 female students graduated from the University of London, which had increased to 160 in 1900. Hence, the inclusion or exclusion of these estimates does not change the results.

increase in the foundation of secondary schools after 1868: there were as many as 1353 schools in 1905 (Bolton 2007).[57]

Equation (2) is used to calculate enrolment in secondary schooling, h_t^2. The number of boys entering secondary schooling in year t is a simple function of the number of schools, s_t, and the average population level of the schools, p_t. Following Stowe (1908), the average population level of these schools was 75 between 1500 and 1600. This corresponds with the estimates of Hoeppner Moran (1985) for the Middle Ages and the estimates of Vincent (1969) for sub-period 1660-1720. The average population level declined from round about 75 in 1720 to 50 by the 1860s (Vincent 1969). In 1868 there were on average 47 boys per school (Owen 1964).[58] Bolton (2007), working with official government statistics, estimates the average population level to be 178 by the year 1909. Since the official length of the secondary-schooling programme was 6 years (Stone 1964), the population estimates are divided by 6 to calculate annual enrolment in secondary education.

$$h_t^2 = \frac{P_t S_t}{6} \qquad (2)$$

To estimate the annual flow of years of tertiary education entering the human capital stock between 1500 and 1909, the analysis of Stone (1974) is used. His study includes statistics on the decennial averages of freshmen admissions to Oxford University and the University of Cambridge. As Stone points out, Oxford had two groups of students. The first group opted for a career in church or in teaching, whereas the second group studied for a career in commercial professions (e.g. secretary, accountancy, public politics, etc.). The latter group of students came to Oxford for about two years and used it primarily as a kind of finishing school. Stone distinguishes between the number of students that completed the bachelor programme (denoted h_t^3) and those that made it up to the masters' level (denoted h_t^4), which makes it possible to correct for those students who did not receive a degree (denoted h_t^5). On average 724 freshmen a year came to the University of Oxford or Cambridge during the late 16th century, of which a mere 25% actually graduated.[59] Although the share of graduates gradually increased to round about 70% by the mid-19th century, the average number of matriculations had only slightly risen to 811. Considering the significant growth of the English population at the time (from ca. 4,0 to 17,3 million between 1600 and

[57] The growth in the number of secondary schools is added exponentially as it is reasonable to assume that it takes time for government policies to be implemented.

[58] The population figures of Owen (1964) are derived from the SIC report.

[59] The same set of weights is used for enrolment in the University of Cambridge. The contribution of tertiary education to the stock of human capital of males was very minor. In 1641, the year where the growth in tertiary education was fastest, it adds a mere 0.046 years to the stock. Hence, even if the assumption about the share of graduates at Cambridge is a rather crude one, it does not change the results presented in this paper.

1850), this reveals further that tertiary schooling had lost among its popularity over the centuries.[60]

No such detailed dataset exists for the period before 1500. It was not until the mid-15th century that provisions were made for what is known as matriculation. Freshmen were required to enter their names on a role of a master during the Middle Ages, but not a single example of such roll survived (Leader 1988). Population estimates for both universities are however available. Aston (1977) estimates the Oxford student body round about 1500 by the early 14th century, which had fallen in the centuries following the Black Death: to 1200 in 1400 and 1000 by the 1450s. Aston et al. (1980) provide estimates of the student body of Cambridge. This was about 500 in 1500, 400 in 1400 and between 755-810 in 1450. It is known that 20% of the student body was enrolled into tertiary education (Aston 1977), which makes it possible to calculate the student population. For both universities this was 250, 200 and 223 respectively. Only 20% of the students entering one of the universities graduated, and of those who did 40% left after obtaining the bachelor's degree and 60% went up to the master's level (Aston 1977). These shares are applied to convert population levels into annual matriculations. The annual number of matriculates was 115 in 1300. After the Black Death this had decreased to 92, though climbed back somewhat closer to its pre-plague level by the mid-15th century to 103.

There is not much evidence for the years between 1450 and 1500. Qualitative studies indicate that the universities benefited from the upsurge in grammar schooling between 1450 and 1530. This is especially apparent from the number of colleges founded, notably at Cambridge. Whereas Cambridge was only one third of the size of Oxford by the early 15th century, it approximated Oxford in size by 1530: Cambridge had 14 colleges and Oxford 13 colleges (Cobban 1988). The years between 1450 and 1500 are interpolated, where the growth in matriculations are added exponentially to match the trends as set out by the qualitative studies as well as the trends in the growth of secondary schooling of Orme (2006). Although tentative, the results imply that there was a staggering increase in the number of freshmen admissions: from 103 in 1450 to 238.[61]

Estimating the stock of average years of education

The estimate of the gross stock of human capital (H_t) is the weighted sum of past investment in human capital:

$$H_t = H_{t-1} + IH_t - \delta H_t \quad \text{and} \quad H_{t-1} = \sum_{i=l-1}^{t-1} IH_i \tag{3}$$

[60] The University of London was established in 1836. Harte (1986) provides the number of graduates (men and women) between 1839 and 1900, which are also included in the stock of human capital.

[61] Emden (1957, 1963) estimates the total number of alumni at 22,000 for the period before 1500 (7,000 at Cambridge and 15,000 at Oxford). The sum of all matriculates between 1300 and 1500 brings the number of students to 21,250, which is very close to the estimate of Emden.

where IH_t are investments in human capital, δH_t is the depreciation of human capital, and l the average lifetime of human capital.[62]

The next step is to apply a set of weights to the annual flows of primary (h_t^1), secondary (h_t^2) and tertiary schooling (h_t^3, h_t^4 and h_t^5) that enter the gross stock. As discussed in the previous section, the estimates of attainment levels assume 2 years of education for primary education. It is however necessary to make three exceptions to the assumed number of years. First, the share of the boys entering one of the secondary schools had completed the primary schooling programme (Stone 1969). Since the length of the official programme was 3 years, it is reasonable to assume that the share of the boys that went up to the secondary level had followed 3 years instead of 2 years of primary schooling. Secondly, to follow Stone (1969 pp. 129), 'the 18th century was a period of growth rather than of stagnation, and the quality of literacy of a significant proportion of the population is evident in any comparison of the clumsy signatures in 1675 with the polished and flowing hands of 1775'. The increase in quality of signatures reflects the rise in basic educational opportunities that opened up during the 18th century (Schofield 1981, see also discussion in section 2.1). Therefore one additional year of education between the dates is allowed for.[63] Third, mass education became a nationwide concern in the 19th century. Several Factory Acts and Elementary Education Acts were implemented to reduce children's working hours and subsequently increase their school attendance. For instance, the 1860 Elementary School Code stipulated the leaving age at 12, and the 1870 Elementary Education Act introduced free and compulsory education for all children aged 5 to 13. As a consequence, school attendance, as well as the average years of schooling, increased significantly over the course of the 19th century: from 2.5 years in 1825 to 4.8 years in 1870.[64]

The length of the secondary schooling programme was 6 years (Stone 1964). The estimates of attainment levels therefore assume 6 years of education for secondary schooling. Regarding tertiary education, the proportion of the students that did not graduate at one of the universities stayed for about 2 years; those students obtaining a

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[62] The equation follows Albers (1997, pp. 3).

[63] Boys entering secondary education: increase from 3 to 3.5 years between 1675 and 1750, and 3.5 to 4 years between 1750 and 1775. Those that did not enrol in secondary schooling: increase from 2 to 2.25 years between 1675 and 1750, from 2.25 to 2.5 between 1750 and 1775, and from 2.5 to 3 between 1775 and 1825. This follows the phases in the increase in quality of signatures that Stone (1969) identifies. When keeping it constant to 2 years of education, the decline in the stock of human capital of males becomes more severe during the years of the first Industrial Revolution.

[64] Research points to further increases in the length of the primary schooling programme between 1825-1900. It indicates that years of schooling had increased from ca. 2.3 in 1805 (Sanderson 1995), to ca. 3.8 in 1850 (Sanderson 1995), to ca. 4.8 in 1870 (Lawson and Silver 1973), to 5.5 in 1905 (Lawson and Silver 1973). When keeping literacy equal to 2 years of primary schooling, there is still significant growth in schooling after ca. 1825, although the growth rate becomes smaller.

bachelor degree studied 2 more years; and finally, those who made it up to the master's level had 5 additional years (Stone 1974). The estimates of attainment levels thus assume 2, 4 and 7 years of schooling respectively.

A final step is to estimate the average lifetime of human capital (l), for which life expectancy estimates are used. The data of Russel (1948), Hatcher (1986), Harvey (1995) and Jonker (2003) are used for the period before 1640; the data of Wrigley and Schofield (1981) for the years between 1640 and 1809; and, finally, the estimates of The Human Mortality Database for the years after 1809.[65] The estimates used refer to life expectancy at the age of 25 years.

Figure 4.3 depicts the stock of human capital per capita according to the attainment data, h_t^1 - h_t^5. The stock of total years of education is the average of males and females. Before 1878, the years of schooling measure of females is based on the development of literacy and primary schools, because they were not admitted to secondary and tertiary institutions. Figure 4.4 illustrates the stock of average years of males, where it differentiates between primary education, h_t^1, and higher education, h_t^2 to h_t^5.

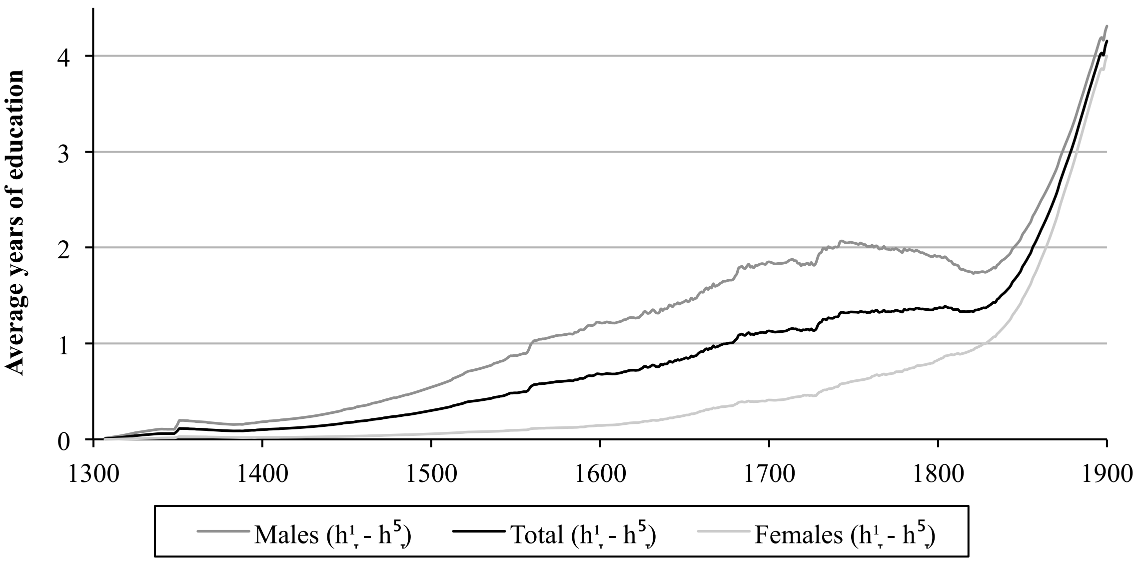

Figure 4.3. The stock of human capital per capita, 1300-1900.
Notes and sources: See main text.

[65] Regarding the years between 1300 and 1477, the life expectancy estimates of Russel (1948), Hatcher (1986) and Jonker (2003) are used. Harvey (1995) provides observations for the years between 1440 and 1595. Her life expectancy estimates are derived from evidence on English monasteries, and are indicative of high mortality rates between 1470 and 1530. Regarding the representativeness of the data, Harvey (pp. 142) concludes that high mortality was 'a case of roughly equal vulnerability to disease, shared between those inside the cloister and those outside'. However, the mortality of monks was enhanced by their exposure to infectious diseases: the vast majority of the people living outside the cloister enjoyed more favorable conditions (see discussion in Hatcher et al 2006). I am grateful to Jim Oeppen for pointing this out. For the above mentioned reason, the years between 1477 and 1540 are interpolated.

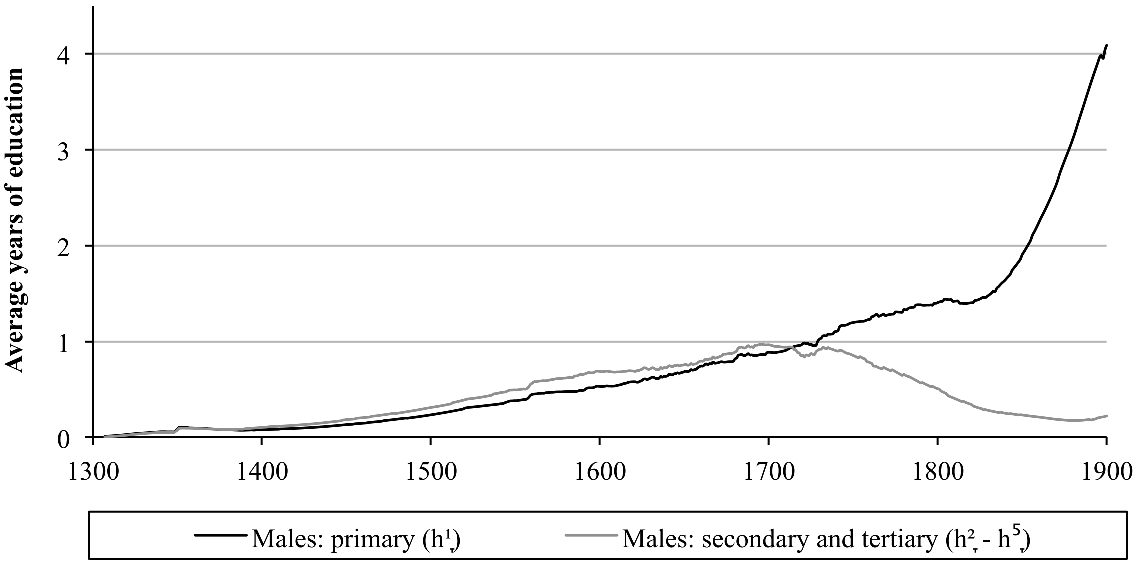

Figure 4.4. The stock of human capital per capita, 1300-1900: Primary and secondary attainment levels of males.
Notes and sources: See main text.

Figure 4.3 illustrates that the stock of human capital accumulated long before the Industrial Revolution began to take hold. Between ca. 1560 and 1740, the stock of average years of education of males had almost doubled. On the eve of the Industrial Revolution, however, there was a decline in the level of educational attainment. A closer look to Figure 4.4 reveals that the decline in the average year of schooling of males can be attributed to a staggering decrease in the stock of secondary and tertiary education: between ca. 1720 and 1880 it had fallen by 80%. There was some improvement in primary attainment levels over the course of the 18th century as indicated by an increase in the stock of roughly 50%, but this was not fast enough to counterbalance the fall in attainment levels of secondary and tertiary education. Stone's (1964, pp. 69) observation that "English higher education did not get back to the level of the 1630s until after the first World War; did not surpass it after the second" seems therefore rather acceptable.

Strikingly, as Figure 4.3 shows, the stock of human capital of females in the period before 1740 were about one-fifth of the level of males. In contrast to the stagnation in educational attainment levels of males, the stock of human capital of females accelerated during the Industrial Revolution: it had more than doubled between ca. 1740 and 1830. The slow growth in the overall human capital stock as set out in Figure 4.3 can therefore be completely attributed to increases in the educational attainment level of females.

The estimates on the educational attainment levels of males correspond with the findings of previous research focussing on male literacy rates (Nicholas and Nicholas

1992, Mitch 1993, Clark 2005). It is furthermore consistent when the evidence of Humphries (2010, pp. 314). Humphries derives average years of schooling of boys from autobiographical evidence, and documents a similar dip in schooling during the first Industrial Revolution. However, as the results in Figure 4.4 revealed, the fall in human capital levels of males can be mainly attributed to the strong decline in secondary and tertiary schooling. The evidence presented in this section therefore suggests that the demand for formal education had fallen remarkably. It seems that human capital for the masses was of limited use in the transition towards modern economic growth.

Interestingly, research has found a close correlation between working-skills and literacy rates. Houston (1982) and Nicholas and Nicholas (1992) demonstrate that medium- and high-skilled professional groups had much higher literacy rates than unskilled ones, and Chapter 5 empirically shows that skilled workers were more likely to be literate than unskilled workers. Since the stock of primary schooling is largely based on the evidence from literacy rates, the findings presented in this section may therefore also support the view of Sanderson (1995) that during the Industrial Revolution a whole range of new occupations opened up that required less formal and informal skills than the old ones. Likewise, the decline in the stock of human capital of males may be indicative of a process of 'deskilling'- i.e. that the transition from artisan workshops to factory production reduced the need for skilled workers (Goldin and Katz 1998, Nicholas and Nicholas 1992). Finally, although more indirect, it may also help to explain the increase in demand for and supply of unskilled child labour used in production (Kirby 2005, Humphries 2010).

Finally, the results in Figure 4.3 highlight the acceleration in human capital over the course of the 19th century. The stock of education of males doubles, whereas the stock of females even quadruples. This finding gives rise to the notion of Mokyr (2013) that high levels of human capital were more important in later stages of the Industrial Revolution. Most of the important macro-inventions were implemented during the second Industrial Revolution, which required more formally educated workers (see also Goldin and Katz 1998).

4.3 The contribution of human capital to early modern growth

This section carries out a time series approach to find out if the growth in human capital formation contributed to pre-industrial economic growth. The latest attempts to estimate British output and productivity reveal an upward trend in per capita GDP that began long before the Industrial Revolution. Between 1650 and 1850, per capita income levels had increased by about 30% (Broadberry et al 2015: see Figure A1 in Appendix II). Hence, if a positive per capita GDP to human capital relationship is found for the years preceding the Industrial Revolution, then this could add support to recent studies stressing the role of human capital in facilitating pre-industrial growth (Baten and van Zanden 2008, Dittmar 2011). However, as discussed in the previous section, there was a movement away from formal schooling that started in the first half of the 18th century, whilst there was additional growth in per capita GDP. The finding of a significant negative per capita GDP to educational attainment relationship during the age of cotton and steam could provide statistical evidence to the view of Mitch (1992) that the contribution of human capital to economic growth was moderate. He has argued that the stock of human capital was well in excess of what was called for by the jobs performed: only 2% of the females and 5% of the males were employed in occupations for which literacy was required.

The focus of the empirical analysis is on the period after 1600 due to the quality of the underlying datasets: The annual population estimates are available only for the period after 1540; observations on literacy and elementary schooling for the medieval period are based on the diocese of York and might therefore not be representative for England as a whole (it is likely to underestimate the growth in primary schooling as discussed Section 4.2); and, finally, whereas there is very detailed information on the growth of secondary schooling between 1300 and 1530, information on matriculations to Oxford and Cambridge is relatively scant. From 1600 onwards, the estimates of the stock of human capital are independent of these datasets.

It should be stressed here that the statistical models presented in this section are underspecified, and the obtained estimates of the stock of human capital and per capita GDP relationship might therefore not be robust. A fully specified model would include other important determinants of per capita GDP, such as international trade (Allen 2003), the quality of institutions (North and Weingast 1989, Acemoglu et al 2005), physical capital, and the like.[66] The focus on a simple two-variable model reduces the possibility to identify cointegration and affect the consistency of the estimators of the adjustment coefficient matrix. However, cointegration as a property is robust to the omission of relevant variables, which makes it possible to draw conclusions upon the estimated cointegrating relationships (Pashoutidou 2003).

Research has also indicated a relationship among human capital formation and skill premiums – i.e. the wage rate paid to unskilled workers relative to skilled ones (Clark 2005, Van Zanden 2009, Allen 2009). The idea is that if there was a rise in the reward to skills, this should be reflected by an increase in the demand for human capital. Ideally it would have been interesting to relate the stock of human capital to real wages (as well as to skill premiums in the broader sense), but the wage series of skilled building labourers is stationary (see Figure A1 in Appendix V). This finding indicates that there was no long-run relationship between real wages and human capital formation.[67]

[66] Unfortunately it is not possible to include these variables in the statistical model, as there are no annual estimates available.

[67] The real wage of building workers is not the ideal group of labourers for testing the effects from increases in formal education upon the skill premium. It would perhaps be better to relate it to the wage earnings of those professions for which formal education was required.

The two variables used in the time series analysis are therefore the natural logarithm to the level of per capita GDP (*gdp*) and the natural logarithm of stock of human capital (*h*).[68] In order to model the long-run relationship among *gdp* and *h*, the following model is estimated:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \Gamma\Delta Y_{t-1} + \gamma + \alpha\beta_0' t + \varepsilon_t \,, \qquad (4)$$

where $Y_t = (gdp_t, h_t)'$ and t is the trend. The model assumes that the $p = 2$ variables in Y_t are related through r equilibrium relationships with deviation from equilibrium $u_t = \beta' Z_t$, and α characterizes the equilibrium correction. β and α are pxr matrices and the rank of $\prod = \alpha\beta'$ is $r \leq p$. Γ is the autoregressive parameter which models the short-run dynamics. It is furthermore assumed that $\varepsilon_t \sim \text{iid}N_p\ (0, \Omega)$. The analysis uses a lag-length of 2 in the model. Using information criteria, it is found that $k = 2$ lags is sufficient to characterize the systematic variation in the model.[69]

The model assumes constant parameters, but the results presented in Section 4.2 are indicative of the human capital and per capita GDP relationship changing over time: there was a decrease in the stock of human capital of males after ca. 1740, which was mainly the result of the sharp decline in secondary and tertiary education that set in after about 1700 (see Figures 3 and 4). The Quandt-Andrews unknown breakpoint test is performed to identify the structural breaks in the per capita GDP and human capital relationship (Quandt 1960, Andrews 1993). The results report on two breakpoints: 1696 and 1743. The sample is therefore divided into three sub-periods: 1600-1696, 1696-1743 and 1743-1900.

The next step is to determine *r*, i.e. the number of equilibrium relationships. It is expected $r = 1$ if there is a causal relationship, because there are only two variables. A necessary condition for cointegration is that each of the variables should be integrated of the same order (more than zero) (Engle and Granger 1987). Figure A1 in Appendix V gives the levels and differences of *gdp* and the human capital stocks. The growth rates of *gdp* (first differences) are clearly stationary I(0), implying that the levels of per capita GDP seems to be a I(1) non-stationary process in all sub-periods. The growth rates of *h* follow a I(0) stationary process, although it appears to be a I(1) process in the period after 1811. The results from the Augmented Dickey-Fuller tests verify the conclusions (upon request from the author). It was therefore necessary to split sub-period 1743-1900 into two: 1743-1811 and 1811-1900. There can never be cointegration in sub-period 1811-1900, since the variables are not integrated of the same order.

[68] The analysis makes use of the per capita GDP series of Broadberry et al (2015): See Figure A1 in Appendix V.
[69] This applies to all sub-periods in the analysis.

Given that the integration of both per capita GDP and the stock of human capital variables is of the same order for sub-periods 1600-1696, 1696-1743 and 1743-1811, Johansen cointegration tests are conducted to examine the possibility of a long-term relationship (Johansen 1995). The maximum eigenvalue test gives similar results (with an exception of male education in the sub-period 1743-1811: see discussion below), but these test results are not reported on.

For sub-period 1600-1696 there is evidence of one cointegrating vector for the overall human capital stock, educational attainment levels of males, and the series capturing formal secondary and tertiary schooling. For sub-period 1743-1811 there seems evidence for one cointegrating vector for the overall stock, as well as for the stock capturing educational attainment of males. No support is found for a cointegrating vector for the stock of human capital of females and of primary attainment levels of males, neither is there any evidence for a cointegrating relationship in sub-period 1696-1743. Since the models are not fully specified, the failure to find a significant cointegrating relationship does not imply none existed.

Tables 4.2 and 4.3 report on the restricted cointegrating vectors and the adjustment coefficients for sub-periods 1600-1696 and 1743-1811. The model given in (4) assumes that the residuals are iid and normally distributed. The robustness of the obtained results is therefore evaluated by using the Jarque-Bera normality residual test (*N*) and the Lagrange Multiplier autocorrelation test (LM). There is no indication of autocorrelation. The most serious misspecification occurs in the case of non-normality of the residuals in the cointegrating relationship of the stock of human capital of males and per capita GDP in sub-period 1743-1811 (Equation 5 in Table 4.3).

	Adjustment parameters		**Cointegrating vector**	**Test results**
1)	Overall: h_t^1 - h_t^5			
	Δgdp_t	$-\underline{0.42}$		
	Δh_t	0.01	$(y - \underline{7.90}h + \underline{0.02}t - 3.02)$	*J*: 27.93
				N: $\chi^2(4) = 5.302$
				(0.2577)
				LM: $\chi^2(4) = 1.08$
				(0.8976)
2)	Males: h_t^1 - h_t^5			
	Δgdp_t	$-\underline{0.39}$		
	Δh_t	0.01[1)]	$(y - \underline{7.37}h + \underline{0.02}t - 1.27)$	*J*: 28.62
				N: $\chi^2(4) = 5.525$
				(0.2376)
				LM: $\chi^2(4) = 1.24$
				(0.8719)
3)	Males: h_t^2 - h_t^5			
	Δgdp_t	$-\underline{0.49}$		
	Δh_t	0.01	$(y - \underline{6.20}h + \underline{0.01}t - 3.85)$	*J*: 31.82

		N: $\chi^2(4) = 5.543$ (0.2360) LM: $\chi^2(4) = 0.55$ (0.9688)

Table 4.2. Results for sub-period 1600-1696

Notes: Underlined typeface indicates that the parameter is significant at the 1% level. *J*: Johansen cointegration test for $r = 1$; *N*: Jarque-Bera normality test; LM: Lagrange Multiplier autocorrelation test. *P*-value in parentheses. 1) Coefficient is significant at the 10% level.

	Adjustment parameters		Cointegrating vector	Test results
4)	Overall: h_t^1 - h_t^5			
	Δgdp_t	$-\underline{0.35}$		
	Δh_t	-0.02[1)]	$(y + \underline{8.83}h - \underline{0.01}t - 14.90)$	*J*: 28.00 N: $\chi^2(4) = 8.225$ (0.0837) LM: $\chi^2(4) = 2.10$ (0.7169)
5)	Males: h_t^1 - h_t^5			
	Δgdp_t	$-\underline{0.59}$		
	Δh_t	-0.00	$(y + \underline{3.80}h + 0.00t - 11.72)$	*J*: 24.05[2)] N: $\chi^2(4) = 20.037$ (0.0005[3)] LM: $\chi^2(4) = 2.71$ (0.6069)

Table 4.3. Results for sub-period 1743-1811

Notes: Underlined typeface indicates that the parameter is significant at the 1% level. *J*: Johansen cointegration test for $r = 1$; *N*: Jarque-Bera normality test; LM: Lagrange Multiplier autocorrelation test. *P*-value in parentheses. 1) Parameter is significant at the 10% level. 2) Cointegration is found at the 10% level. Unlike the Johansen cointegration test, Maximum Eigenvalue test does suggest cointegration at 5% level. 3) The residuals are non-normal.

The results for sub-period 1600-1696 as reported in Table 4.2 are indicative of a positive educational attainment to per capita GDP relationship. For sub-period 1743-1811 (Table 4.3), there seems to be a negative relationship. Regarding the short-run dynamics, the adjustment coefficients of per capita GDP are significant at the 1% level, whereas those of the stock of human capital are not significantly different from zero. This result therefore indicates that per capita GDP responded more quickly than did human capital between 1600 and 1811.

Overall the regression results presented in this section suggest a changing relationship among human capital and per capita GDP over the course of England's early industrialisation. Formal education was positively related to the phases of growth that occurred over the course of the 17th century. During the Industrial Revolution itself, the association among the years of schooling measure and per capita GDP became clearly negative. The finding of a negative relationship, as well as the result that economic growth adjusted more quickly than did human capital, implies that a decrease in educational attainment would have caused faster per capita GDP growth. This conclusion therefore rather supports the view of McCloskey (2010) that investment in human capital can be massively misallocated and even have a negative impact on economic performance. It also supports the controversial notion of Mitch (1992) that England was grossly overeducated during the age of cotton and steam.

4.4 Discussion and conclusion

Economic historians have long debated whether human capital formation contributed to the Industrial Revolution. Almost all studies however take as their starting point 1750 and focus on the trends in (male) literacy (Nicholas and Nicholas 1992, Mitch 1993). The finding of a pause in the rise of male literacy rates between 1750 and 1850 led to the conclusion that human capital was irrelevant to England's early industrialisation. The contribution of this paper was to re-evaluate this conclusion by quantifying the stock of human capital of the population between 1300 and 1900. In contrast to previous studies on the topic, the stock not only take into account the evidence from literacy rates but also the growth in secondary and tertiary schooling.

It is shown that the stock of human capital can be quantified rather well, in particular for the early modern period. The data on the stock of years of schooling suggest that the growth in human capital before the Industrial Revolution must have been far greater than previously assumed from evidence on literacy: secondary education comprised up to half of the stock of educational attainment of males. After ca. 1700, however, a profound decline in the average years of schooling began to take hold as indicated by stagnation in primary educational attainment levels and a vast decline in the years of secondary and tertiary schooling.

The results from the time series analysis indicated that human capital contributed to economic growth before ca. 1750. This finding adds further evidence to the work of Baten and Van Zanden (2008) stressing the importance of human capital formation for pre-industrial growth. During the Industrial Revolution itself there seems to have been a negative relation between average years of education and per capita GDP growth. This finding supports the predominant view that human capital was not key to England's industrialisation (Mitch 1993, Mokyr 1990, Clark 2005). Relative to this view several contributions have been made. Incorporating the evidence from secondary and tertiary schooling informs us that the movement away from formal schooling was much larger than the trends in (male) literacy alone would suggest. Consequently, the fall in the demand for educated workers during the classic years of the Industrial Revolution must have been more pronounced than previously assumed by scholars (e.g. Mitch 1992). On top of this, the results following the regression analysis suggested that a decline in average years of education would have caused higher levels of per capita GDP. It is likely then that this paper is therefore the first to empirically demonstrate that England's relatively high level of human capital on the eve of the Industrial Revolution may have actually hampered its economic take-off.

The conclusion that formal education for the masses was unimportant for per capita GDP growth during the Industrial Revolution has implications for future research on the topic. It should be stressed here that the stock of human capital focussed on the average level of formal education present in the population. It does not include the acquisition of those elements which did not involve formal schooling but which could have nevertheless been important for the productivity of workers such as on the job learning and apprenticeships (see Humphries 2003, Wallis 2008, Mokyr 2009). In analysing the role of human capital during the Industrial Revolution, future research should therefore shift focus to measures capturing more informal skills. Economic historians have made some headway in this regard: Kelly et al (2014) show that on the eve of the Industrial Revolution, English labourers were taller, heavier, savvier and more productive than elsewhere on the continent; Jacob (2013, pp. 157) documents a significant increase in scientific training believed to be important in facilitating the Industrial Revolution; and Mitch (2004) argues that as many as one out of four boys went through some kind of apprenticeship in 1700.

Following the empirical findings of recent studies, an additional distinction should also be made between the 'density in the upper tail of professional knowledge' (cf. Mokyr 2005 and Mokyr and Voth 2009) and more widespread education. In Chapter 5 the occupations of more than 30,000 English male workers according to the skill-content of their work are quantified. These results demonstrate an increase in the share of unskilled workers alongside a constant share of 'high-quality workmen' such as machine erectors and engineers deemed necessary by Meisenzahl and Mokyr (2012) in bringing about the Industrial Revolution. Similarly Squicciarini and Voigtländer (2014) show that the French Industrial Revolution was not spurred by a broad distribution of skills, but rather by a small highly knowledgeable elite. Hence, if we believe that human capital contributes to technological progress, then it is likely that the Industrial Revolution depended on a concentrated core of skilled workers rather than on the average level of human capital in a broader sense. In that way, as recently suggested by Squicciarini and Voigtländer (2014), too much attention is given to average human capital levels when we talk about economic growth, whereas not enough research has been performed to figure out when and how countries achieved a critical mass of educated workers.

Chapter 5: Human capital formation from occupations: The 'Deskilling Hypothesis' revisited

(With Jacob Weisdorf)

5.1 Introduction

Economic historians have long debated whether early modern England's technical and structural changes were largely skill saving or skill demanding. One view holds that the transition from artisan workshops to factory production reduced the need for skilled workers (Goldin and Katz 1998), a notion that has received support from four sides: with Humphries (2010, 2013) and Kirby (2005) showing that mass production raised the demand for female and child labour; with Mitch (1999, 2004) and Nicholas and Nicholas (1992) observing a pause in the rise of male literacy rates during the late eighteenth century; with Nuvolari (2002) noting that early industrialisation witnessed a considerable number of machine-breaking riots conducted by workers who feared that machines would render their skills redundant; and with Clark (2005), Van Zanden (2009), and Allen (2009) arguing that the skill premium remained surprisingly flat until the mid-nineteenth century. Another side contrastingly stresses the importance of knowledge and working skills to facilitate the innovations and mechanising that made industrialisation possible in the first place (Mokyr 2009; Mokyr and Voth 2009: Meisenzahl and Mokyr 2012). This view has received support from the work of van der Beek (2012) documenting a rising number of apprentice contracts within 'high-quality' trades, such as joiners, turners, and wrights, in eighteenth-century England, and from Squicciarini and Voigtländer (2014) linking the French Industrial Revolution to a small and highly knowledgeable elite.

Previous work attempting to quantify the evolution of average working skills in England during the Industrial Revolution has mainly focused on literacy rates, either inferred from signatures or self-reported. Though meticulously documented (e.g. Nicholas and Nicholas 1992), literacy skills measure only very basic competencies. For example, the literacy rate assigns the same skills to a literate farm worker and a literate university professor, with no distinction being made between the enormous variation in ability required of these two very different roles. It is also questionable whether the rising standards in literacy in the centuries leading up to the Industrial Revolution increased the workers' ability to perform work of economic value, i.e. they could have resulted from the rise and spread of Protestantism rather than from a demand for this ability by employers (Clark 2007). Last but not least, the fact that any skills obtained were not necessarily used productively, such as a farm worker's ability to read and write, makes the potential discrepancy between the *acquisition* of skills and the *application* of skills in productive activities a relevant matter, and one which is difficult to address using the existing measure.

In this paper we propose to use a far more substantial source of data to explore the formation of human capital in the past: occupational titles. We employ the so-called

HISCLASS system, developed by Van Leeuwen and Maas (2011), to code the occupations of over 30,000 English male workers according to the skill-content of their work. The occupational titles come from historical marriage registers covering three centuries of English history, from 1550 to 1850. Our methodology enables us to quantify the evolution in average working skills used in productive activities across a sample of 26 different parishes scattered across England. These data, collected and provided by the *Cambridge Group for the History of Population and Social Structure*, allow us to investigate trends in the share of unskilled workers among different social groups (blue-collar versus white-collar workers) and within the main sectors of production (primary, secondary, and tertiary). We are also able to study the prevalence of the 'density in the upper tail' of professional knowledge by focusing on a set of occupations that Mokyr deemed necessary to facilitate the Industrial Revolution, such as joiners, turners, and wrights (Mokyr 2005).

We find that our sampled workforce was remarkably well trained during the sixteenth century, with 20% on average of all sampled workers coded as 'unskilled' according to the HISCLASS scheme. But we also find a dramatic rise in the share of unskilled workers after 1700: by the nineteenth century the share of unskilled workers had almost doubled, comprising 39% of our sampled workforce. These estimates chime with those derivable from (sporadic) social tables and census data, which cover a much larger share of the English workforce than our data. The deskilling observed is robust to a large variety of regression model specifications, including our controls for compositional effects and the restriction that at least 95% per year of the sampled males were recorded with an occupational title.

By splitting our sampled workforce into blue-collar (manual) and white-collar (non-manual) workers, it becomes clear that the deskilling we observe was chiefly a blue-collar phenomenon. On average, the shares of lower- and medium-skilled blue-collar workers declined substantially over the period of observation, while the share of unskilled blue-collar workers grew from 24% to 42%. The skill structures among white-collar workers, however, remain largely constant during the period of observation. We also establish that some degree of skill formation takes place among our sampled workforce and can be attributed to upward social mobility across the life-cycle (notably in agriculture), and that some of the loss of skill we observe is associated with having an immigrant background (notably in parishes mainly engaged in non-agricultural activities).

By studying the most populous parishes in the sample individually, it becomes clear that deskilling was rather widespread, both geographically and across the main sectors of production. That is, the loss of skill can be observed in agriculture and industry alike, and sometimes also in services. This is true regardless of how the large group of uncategorised, unskilled 'labourers' is allocated between the main sectors of production. In two of the most densely populated parishes in the sample, Banbury and Gainsborough, we also observe that the share of 'high-quality' professions, including machine erectors and operators, displayed modest growth. This skill-formation was, however, not enough to counterbalance the vast decline in the shares of lower- and medium-skilled weavers, tanners, and smiths in manufacturing. In Gainsborough, the concentration of land, which is linked to the disappearance of lower-skilled husbandmen and cottagers and the rise in the share of medium-skilled farmers and unskilled farm workers, also contributed to the loss of skill. The sampled parishes cover only a tiny fraction of the entire country. But the deskilling that we observe indicates that the loss of skills among English workers could have been much more widespread than hitherto assumed, and also that it started much earlier than the classical years of the Industrial Revolution.

4.2 Data

The key source of the data used in our analysis is the Cambridge Group's *Family Reconstitution Data*. This dataset was built around information derived from ecclesiastical events recorded in 26 English parishes (Wrigley et al. 1997).[70] The full data set covers more than three centuries of English demographic history, from the first emergence of parish registration, in 1541, until population censuses became common, in 1871. The parishes represent a variety of locations in England, ranging from large market towns to remote rural villages, including proto-industrial, retail-handicraft, and agricultural communities.

The sampled occupational titles were recorded on the occasion of three ecclesiastical events: marriage, burial, or baptism (or burial) of offspring. Some individuals were recorded several times, others only once. Multiple entries, notably in the context of baptising offspring, introduce a potential bias in the data since individuals who baptise many children appear in the data more often. Previous research has shown that the rich were not only more skilled than the poor but they also had more children (Clark and Hamilton 2006; Boberg-Fazlic et al. 2011). That raises the risk that the rich will be over-represented in the sample, and hence that we thus overestimate the skill acquisitions of the sampled population. We eliminate the bias by including each individual only once, at the time of their earliest recorded occupation. Among our sampled males, 27% had their first occupation recorded at the time of their marriage; 53% when baptizing a child; and 20% at the time of their burial. In our later regression analysis we control for potential composition effects arising from the fact that some were recorded early in life and others later.

Four occupational recordings – 'Gentleman', 'Esquire', 'Pauper', and 'Widower' – were excluded from the original dataset. These titles, which make up 4% of the sampled population, do not refer to an actual profession, and hence cannot be coded

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[70] These parishes are: Alcester, Aldenham, Ash, Austrey, Banbury, Birstall, Bottesford, Bridford, Colyton, Dawlish, Earsdon, Grainsbro, Gedling, Great Oakley, Hartland, Ipplepen, Lowestoft, March, Methley, Morchard Bishop, Odiham, Reigate, Shepshed, Southill, Terling, and Willingham.

using the HISCLASS scheme (see the description below). Our findings are robust to the inclusion of three of those titles on the assumption that paupers are unskilled and gentry and esquires are (highly) skilled.

The 26 sampled parishes were originally selected for the demographic quality of their registers rather than for the quality of their occupational information. This raises two concerns regarding their suitability for the purpose at hand. The first concern is the fact that occupational status was not systematically recorded in the past. Fortunately, there are ways of dealing with this problem, as we explain below. The second concern is that the occupational structure of the sampled parishes might not provide a representative sample of national occupations over time. Wrigley et al. (1997) faced the same problem and have discussed this issue at length (*ibid*., pp. 41*ff*). By comparing the occupational structure of the sampled parishes to that obtainable from the 1831 national census, Wrigley et al. concluded that 'the proportional distribution of occupations in the 26 parishes as a whole compares with the national picture and with England without the metropolis'. They further noted that 'the discrepancy between the occupational structures […] reflects the influence of the presence of a single parish, Birstall' (*ibid*., p. 43). Our sensitivity analysis handles this issue in the same way as Wrigley et al., namely by either removing Birstall entirely from the sample or changing its weight.[71] As we will demonstrate further below, it makes no difference to our conclusion whether we include or exclude Birstall in our analysis.

Still, we cannot be certain that the sampled parishes represent the occupational distribution in England equally well as we move back in time from 1831, a problem that Wrigley et al. also confronted. Nonetheless, we are encouraged by how well the shares of unskilled workers in our sample match the scattered data points derived from social tables dating back to 1688, as Figure 5.3 below will illustrate. In any case, until more historical parish registers have been transcribed and analysed, the sample of 26 parishes serves as an important and unique starting point for understanding the long-term evolution of working skills in early modern England.

The other issue mentioned above – that of unsystematic occupational recording – is clearly visible in Table 5.1. Although on average two out of five of the sampled males were tagged with an occupational title, the propensity to report the occupational status varied greatly from year to year between no one, someone, and everyone. What is more, the share of males recorded with an occupation grew gradually over time, from 13% in the first sub-period (1550-99) to 69% in the final sub-period (1800-49). This presents a problem for the study of skill formation across time: if the parish ministers

[71] Birstall had on average 100 occupations per fifty years, except for the period of 1750-99 when it had a staggering 2,200 observations making up more than one-fourth of all the sampled occupations (of all the parishes) in that period. The inclusion of Birstall would thus heavily distort the skill-structure in 1750-99. Including Birstall without the 1750-99 period does not alter our conclusions below. Wrigley et al. also changed the weight of the parish of Shepshed (*ibid*., p. 45). This change does also not alter our conclusions (see below).

initially recorded only high-status occupations, but later included everyone, then it would appear as though the workforce becomes less skilled over time. But, in reality, the deskilling would simply emerge from a higher proportion of lower status males (especially 'labourers') being tagged with an occupational title. Fortunately, there is an easy solution to this problem. Namely by using only those individuals years where 95% or more of the sampled males attracted an occupational descriptor (Shaw-Taylor 2012). Our later regression analysis shows that our findings are robust to controlling in this way for any systematic under-recording of occupational titles.

Parish	1550-49		1600-49		1650-99		1700-49		1750-99		1800-50		1550-1850	
	Obs	Share	Obs	Share	Obs	Share	Obs	Share	Obs	Share	Obs	Share	Obs	Share
Alcester	392	0%	617	1%	614	6%	531	5%	546	1%	764	82%	3464	20%
Aldenham	338	6%	425	11%	386	11%	359	9%	377	15%	365	29%	2250	14%
Ash	.	.	3	33%	493	8%	706	27%	719	34%	1255	52%	3176	36%
Austrey	103	96%	123	55%	129	48%	154	84%	169	48%	182	87%	860	70%
Banbury	734	8%	1140	26%	813	41%	1055	87%	1580	96%	1886	88%	7208	66%
Birstall	148	2%	1350	5%	1498	5%	2149	5%	4836	46%	22	55%	10003	25%
Bottesford	153	3%	382	55%	377	29%	308	26%	342	66%	411	91%	1973	51%
Bridford	77	0%	114	3%	97	29%	100	19%	101	41%	96	94%	585	31%
Colyton	545	4%	934	17%	655	11%	484	9%	588	44%	698	86%	3904	30%
Dawlish	.	.	5	20%	263	1%	267	4%	338	54%	438	69%	1311	38%
Earsdon	5	40%	82	63%	210	30%	301	71%	785	85%	767	87%	2150	78%
Gainsborough	583	14%	1193	62%	1362	74%	1365	52%	2317	92%	719	86%	7539	70%
Gedling	206	3%	333	7%	293	5%	319	5%	454	5%	984	9%	2589	6%
Great Oakley	195	13%	179	13%	161	32%	299	72%	332	7%	312	77%	1478	39%
Hartland	432	0%	475	0%	402	0%	384	0%	440	0%	329	0%	2462	0%
Ipplepen	.	.	.	.	87	56%	148	9%	209	55%	178	84%	622	52%
Lowestoft	759	31%	838	28%	875	29%	565	48%	20	100%	.	.	3057	33%
March	480	1%	630	2%	1119	5%	1140	12%	14	7%	.	.	3383	6%
Methley	289	0%	377	0%	353	0%	315	0%	495	0%	176	0%	2005	0%
Morchard Bishop	.	.	.	.	334	13%	495	10%	480	4%	757	66%	2066	30%
Odiham	625	12%	636	23%	473	39%	544	35%	697	44%	1095	76%	4070	43%
Reigate	436	69%	760	55%	742	48%	828	42%	161	22%	2	.	2929	50%
Shepshed	229	13%	272	60%	250	36%	355	57%	751	28%	1365	84%	3222	57%
Southill	519	3%	714	39%	637	43%	738	84%	776	70%	882	85%	4266	58%
Terling	260	0%	336	3%	285	1%	283	0%	289	4%	298	37%	1751	8%
Willingham	329	7%	401	2%	381	2%	277	6%	325	22%	108	18%	1821	8%
Total	7837	13%	12319	24%	13289	25%	14469	32%	18141	50%	14089	69%	80144	38%

Table 5.1. The Share of Males with an Occupational Descriptor, by Period and Parish
Notes: The number of observations reports all sampled males except paupers and gentry. The shares concern those males that have an occupational descriptor. *Source:* CAMPOP Data.

With these caveats in mind, our goal in the following is to construct an index of the share of unskilled workers among the sampled population based on their occupational titles. Next, we use the index to study the evolution of working skills across time. We are not only interested in the classic years of the Industrial Revolution (1750-1850) but also in the two centuries preceding the Industrial Revolution (looking back as far as 1550). That enables us to study skill formation during a time when structural and technical change in England has recently been said to have emerged (Broadberry et al. 2015). To this end, we code the sampled occupational titles using the so-called HISCO-/HISCLASS schemes. The HISCO (Historical International Standard Classification of Occupations), developed by Van Leeuwen et al. (2002, 2004), comprises 1,675 distinct job categories. In a follow-up book, entitled *HISCLASS: A historical international social class scheme*, Van Leeuwen and Maas (2011), building on the expertise provided by Bouchard (1996) and a team of labour historians (to avoid issues of anachronism), applied the principles of the Dictionary of Occupational Titles (DOT) to extract information about the working skills of incumbents of historical occupations coded in the HISCO system. The DOT was developed in the 1930s by the US Employment Service in response to a rising demand for standardised occupational information to assist job-placement activities (US Department of Labor, 1939). In order to efficiently match jobs and workers, the public employment service system required that a uniform occupational language be used in all of its local job service offices. Through an extensive occupational research programme, occupational analysts collected and provided data to job-market interviewers, to help them match the specifications given in job openings to the qualifications of job applicants. Based on the data collected by occupational analysts, the first edition of the DOT was published in 1939, containing some 17,500 job definitions, presented alphabetically, by title, with a coding arrangement for occupational classification.

The transformation of occupational titles into working skills in the HISCLASS scheme builds on two main scores used in the DOT: the *General Educational Development* score and the *Specific Vocational Training* score. The score concerning general educational development captures three key features regarding the intellectual competencies necessary to fulfil the tasks and duties of an occupation: the incumbent's reasoning abilities; his or her ability to follow instructions; and the acquisition of language and mathematical skills needed to conduct the work. The score concerning specific vocational training captures the time investments needed in three main areas: the time required by the worker to learn the techniques necessary for the job; the time needed to acquire the relevant information to conduct the work; and the time necessary to develop the competencies required for an average performance in a job-specific working situation. These abilities implicitly capture any formal (or, as was often the case, informal) training needed to carry out the work.

Van Leeuwen and Maas used the two DOT scores to code the occupational titles categorised in HISCO according to the skill-content of the work, as part of a procedure to create the HISCLASS scheme. In the HISCLASS scheme, occupational titles were grouped into four categories: *unskilled*, *lower-skilled*, *medium-skilled*, or *higher-skilled*. Our sampled workforce contained 284 different occupational titles identified by the HISCO and hence 'codeable' in the HISCLASS scheme. Table A1 in Appendix VI lists the most common professions and shows how they are coded in the HISCLASS scheme.

We split our sampled observations into fifty-year intervals covering the period from 1550 to 1850. Figure 5.1 shows the share of workers in the sampled workforce whose professions were deemed 'unskilled' in the HISCLASS scheme. Table A2 in Appendix VI reports the exact shares. Figure 5.1 speaks a very clear language: up until 1700, the sampled workforce was rather well educated, with only one in five workers coded as unskilled. But between 1700 and 1850 a profound process of deskilling took place, with the share of unskilled workers increasing to two in five workers in the first half of the nineteenth century. In light of the inherent problems discussed above regarding compositional effects and occupational under-recording, there is good reason to believe that the loss of skills observed in Figure 5.1 is based on a misreading of the data. The remainder of this paper is thus devoted to studying how robust the deskilling result is to controlling for these and other issues.

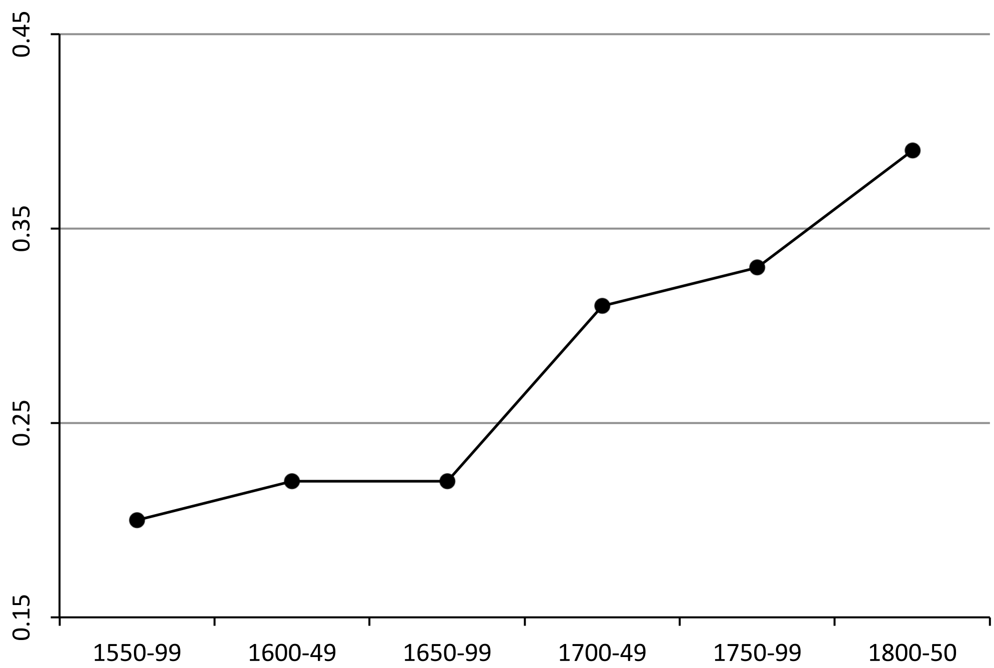

Figure 5.1. The Share of Unskilled Male Workers, 1550-1850

Note: Unskilled workers are workers whose occupational title is labelled 'unskilled' in the HISCLASS scheme (see van Leeuwen and Maas 2011). *Source*: CAMPOP data (see text).

An obvious explanation for the loss of skills among the sampled workforce is that the sampled parishes are located in the provinces. Thus, it may be that what we observe is that skilled workers simply left the provinces to pursue jobs in urban or industrial centres. Although the sampled parishes include anything from large market towns to rural villages, no large urban centres appear in the sample. Fortunately, work by

Newton (2007) and Newton and Baker (2007) allow us to gain a better idea about the evolution of working skills among male workers captured in seven parishes in London. The sampled London parishes combine the very wealthy Cheapside parishes and the much poorer suburb of Clerkenwell. The predominantly merchant and artisanal population of Cheapside remained fairly static over the period in which the parishes can be observed, while that of Clerkenwell, inhabited mainly by migrants, grew substantially to eventually dominate the London sample (exclusively so after 1710). The fact that many of these migrants held low-status occupations already informs us that large numbers of unskilled workers migrated to London during this period. This is confirmed by Figure 5.2 showing the share of unskilled workers in the London sample compared to that in the provincial parishes. Although the London data only runs up until 1750, it nevertheless informs us that (as expected) the sampled Londoners were even more highly trained than their provincial counterparts before 1600, with barely any unskilled workers among them. However, the share of unskilled workers in London grew remarkably over the period of observation: from 8% in 1600-49 to 16% in 1700-49 (Table A3 in Appendix VI). Hence, no immediate support is provided for the possibility of a 'brain drain' from the provinces to the city.

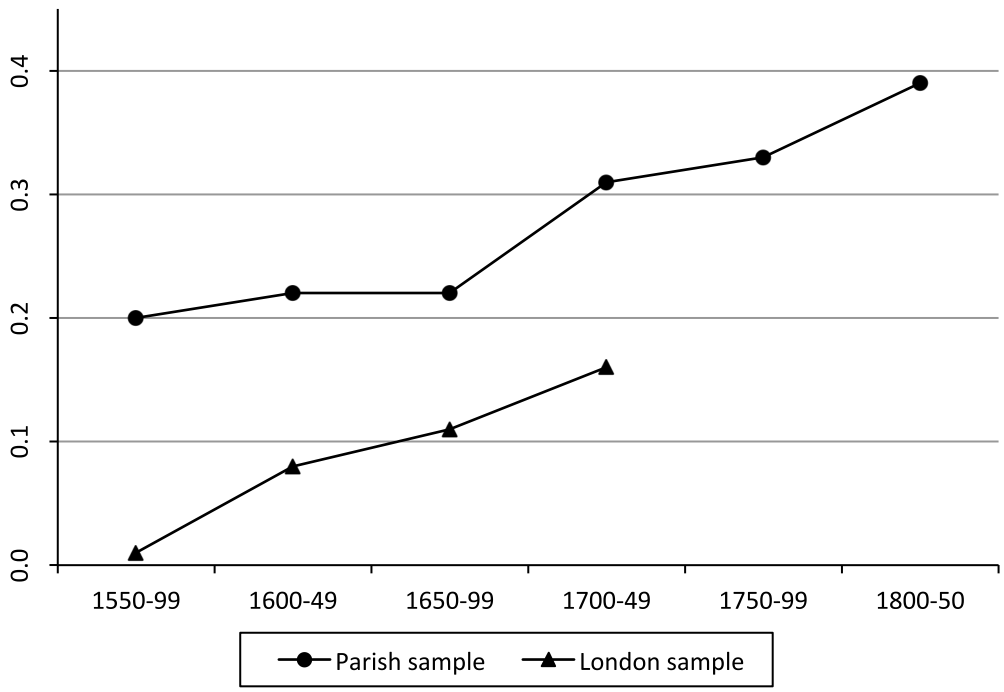

Figure 5.2. The Share of Unskilled Workers in London and the Provinces, 1550-1850
Note: Unskilled workers are workers whose occupational title is labelled 'unskilled' in the HISCLASS scheme (see van Leeuwen and Maas 2011). *Sources*: Province data (Wrigley et al 1997). London data: Newton (2007) and Newton and Baker (2007).

If skilled workers left the provinces, but not for London, did they go, then, to one of England's industrial centres? Lancashire and Cheshire are known as the birthplaces of the Industrial Revolution, but are not represented by the provincial parishes. The Cambridge Group's occupational data for Lancashire and Cheshire covering two periods, c. 1725 and c. 1812, can help shed light on this.[72] Table 5.2 shows that Cheshire was subject to considerable deskilling: its share of unskilled workers increased from 17% to 34% between 1725 and 1812, fed by declining shares of lower-, medium-, and highly-skilled workers. In Lancashire, despite considerable growth in the size of the workforce, the skill shares were largely constant. As expected, a great deal of the lower-skilled workers in Lancashire consisted of weavers and spinners (23% in 1725 rising to 34% in 1812). There was a modest drop in the share of unskilled workers, from 11% down to 10%, but a comparatively larger growth in the share of lower-skilled workers. The share of medium-skilled workers declined from 40% to 38%, and the share of highly-skilled workers remained constant. Again, no immediate support is provided to the idea that skilled workers moved from the sampled parishes (or elsewhere in England) to the centres of the Industrial Revolution.

	Un-skilled	Low-skilled	Medium-skilled	High-skilled	*N*
Lancashire					
c. 1725	0.11	0.48	0.40	0.01	15,486
c. 1812	0.10	0.51	0.38	0.01	79,233
Cheshire					
c. 1725	0.17	0.30	0.51	0.02	7,691
c. 1812	0.34	0.19	0.45	0.01	15,254

Table 5.2: The Share of Workers by Skill Status
Source: Cambridge Data (see text)

A more general assessment of the representation of the sampled parishes can be made by comparing our sampled workforce with England more broadly. To this end, we undertake three spot checks using occupational information from pre-existing census data and social tables. The English social table of 1688, revised and reported in Lindert and Williamson (1982), can be used to calculate the share of unskilled workers for that year. This social table includes some 1.39 million male workers, of which 29% are classified as 'unskilled' in the HISCLASS scheme. Furthermore, the account of Shaw-Taylor et al. (2010) of adult male employment in England and Wales c. 1710 leaves us with 1.48 million workers (after removing 'gentry', 'paupers' and those of 'no occupation'). Among these, 31% were coded as 'unskilled' workers in the HISCLASS scheme. Finally, Booth's grouping of the occupational titles included in the 1841 census of the English population provides a share of unskilled workers

[72] These data were kindly made available to us by the Cambridge Group, courtesy of Leigh Shaw-Taylor.

equal to 42% (Booth 1886). Booth's census data is particularly interesting since it covers the entire English male workforce at the time: 6.63 million men. Figure 5.3 plots the three independent shares of unskilled workers against our sampled workforce (see the exact numbers in Table A3 in Appendix VI). Not only do the independent data compare rather well to ours in terms of shares of unskilled workers; they also follow the same trend, displaying the same episode of deskilling that is captured in Figure 5.1. Interestingly, our sampled workforce slightly underestimates the shares of unskilled workers in the general population.

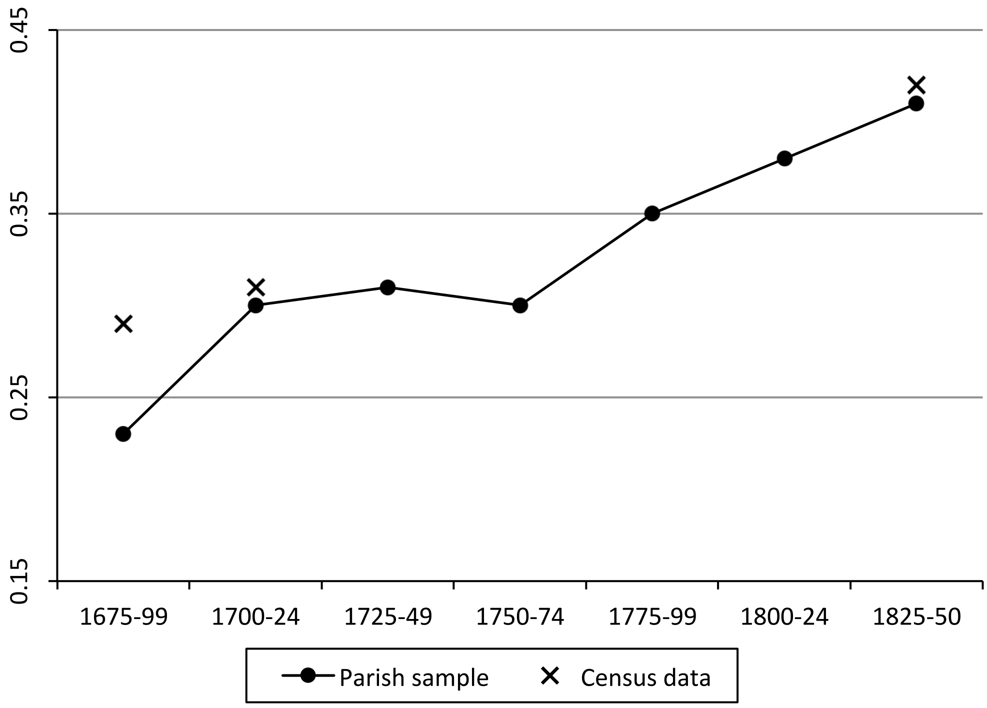

Figure 5.3. Comparison between the Provinces and Social Tables and Census Data, 1675-1850

Sources: CAMPOP data (see text); social tables: Lindert and Williamson (1982); church book data: Shaw-Taylor et al (2010); census data Booth (1886).

The increase in the share of unskilled workers does not tell us whether deskilling was a general phenomenon, or whether it was confined to certain groups of workers. To shed some light on these matters, we now use the HISCLASS scheme to decompose the sampled population into blue-collar and white-collar workers to study the evolution of skills within each group. White-collar work includes semi-professional office, administrative, and sales-coordination jobs, such as 'Clerk', 'Salesman', and 'Manager'. In contrast, blue-collar work refers to jobs requiring manual labour and includes professions in fields such as construction, mining, and farming. Blue-collar workers make up 87% of the sampled population in 1550-99, growing to 91% in 1800-50.

White-collar workers have no category for unskilled labour in the HISCLASS, so Figure 5.4 tracks the evolution of the shares of lower-, medium-, and highly-skilled white-collar workers. The share of lower-skilled white-collar workers remains largely constant over time, with one in five workers falling into this category. Among the white-collar workers there were 54-70% that were deemed medium-skilled and 24-33% that were deemed highly-skilled. The early seventeenth century saw a rise in the share of medium-skilled white-collar workers and a comparable fall in the share of lower-skilled white-collar workers (Table A4 in Appendix VI). After 1700, the share of medium-skilled white-collar workers rose again, this time fed primarily by a fall in the share of highly-skilled white-collar workers, implying a weak deskilling effect among the white-collar sample during the Industrial Revolution.

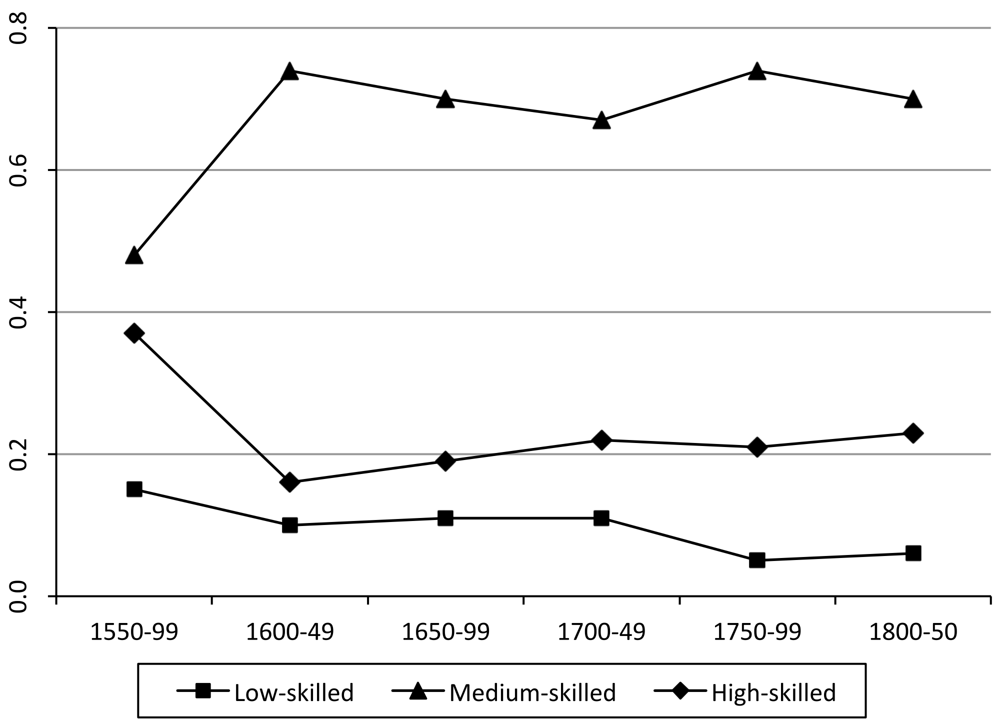

Figure 5.4.The Share of Skills Among White-Collar (Non-Manual) Workers, 1550-1850

Source: CAMPOP data (see text).

There were far more dramatic changes occurring among blue-collar workers (Figure 5.5). This group of workers has no category for highly-skilled workers. To begin with, the blue-collar workforce is dominated by medium-skilled workers (42%) and lower-skilled workers (36%), with less then one out of four workers coded as unskilled. Up until 1700, the shares of medium- and unskilled blue-collar workers rose modestly, fed by a falling share of lower-skilled blue-collar workers (see also Table A5 in Appendix VI). After 1700, the share of unskilled blue-collar workers rose substantially, from 26% in around 1700 to 42% in around 1850. This came with a modest fall in the share of lower-skilled blue-collar workers (from 31% to 26%) and a considerable drop in the share of medium-skilled blue-collar workers (from 43% to 31%). From this, it is clear that the deskilling was mainly a blue-collar phenomenon.

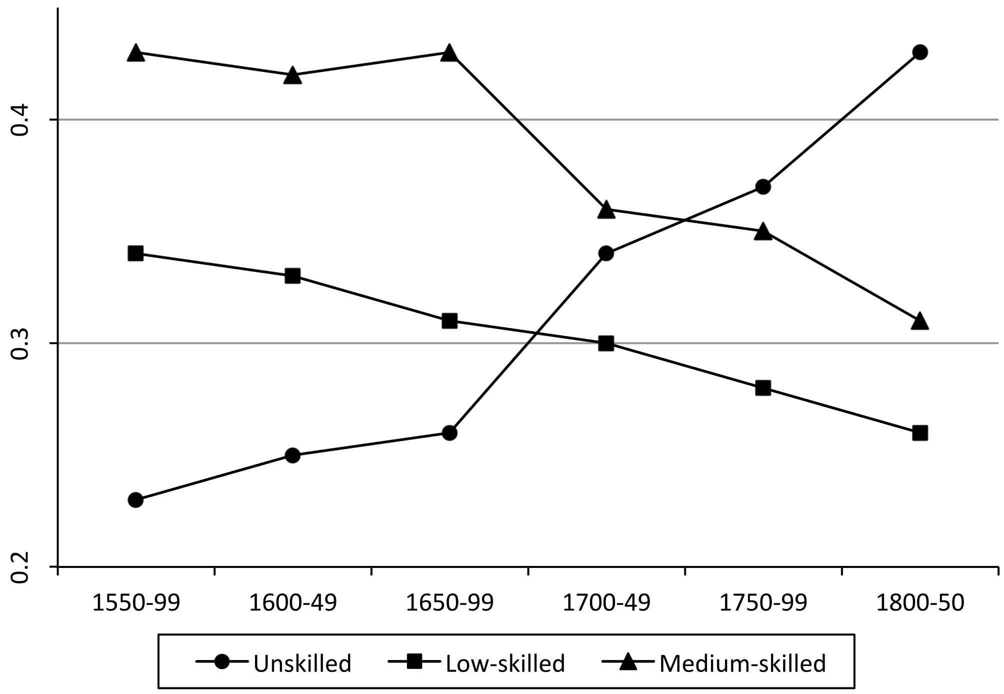

Figure 5.5. The Share of Skills Among Blue-Collar (Manual) Workers, 1550-1850
Source: CAMPOP data (see text).

It is no secret that much of the deskilling observed in our data comes from a growing number of men recorded as 'Labourers' in the registers. These 'Labourers' are likely to have comprised a diverse group of men with a wide range of skill levels, and the mix of the skills may even have changed over time in ways not picked up by occupational data and, hence, by HISCLASS. Also, some would argue that even ordinary labourers were able to accumulate a fair amount of working skills across their life-cycle, and hence that they should eventually be coded as 'lower-skilled' workers rather than 'unskilled'. A simple way in which to deal with this issue is by 'upgrading' all labourers to lower-skilled workers. Figure 5.6 shows the outcome of collapsing lower- and unskilled workers into one group in London and in the provinces, respectively (Table A6 in Appendix VI). The graph largely replicates the patterns from Figure 5.3, with deskilling in London rising until 1750 (from 29% in 1550 to 43%) and in the provinces after 1700 (from 50% to 63% by 1850).

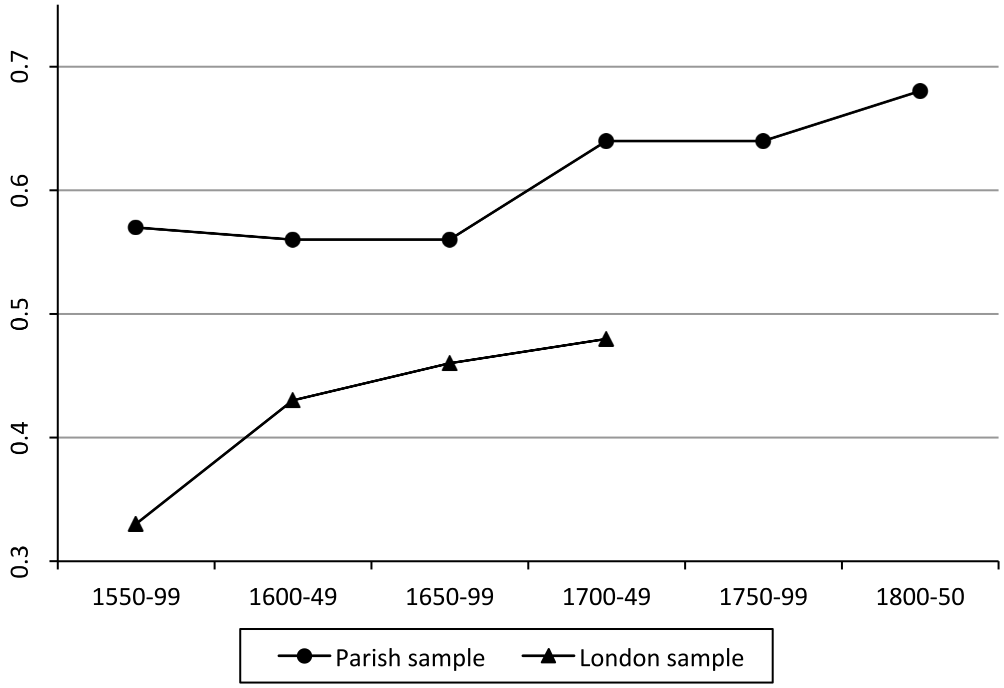

Figure 5.6. The Share of Lower- and Unskilled Workers in London and the Provinces, 1550-1850
Sources: CAMPOP data (see text); London sample: Newton (2007) and Newton and Baker (2007).

Another well-known issue is that the composition of parishes included in the sample change across the period of observation (Wrigley et al. 1997). This could obviously give rise to compositional effects. For example, deskilling could be caused by the sampled parishes shifting from being locations with relatively few unskilled workers to parishes with relatively many. Fortunately, there are several ways in which to control for such compositional effects. We address the issue formally in the regression analysis below in three ways: (i) by using a sub-sample of 11 parishes, identified by Wrigley et al., that cover the years 1600-1789; (ii) by using a sub-sample of the eight most populous parishes that cover the entire period of observation, 1550-1850; and ultimately (iii) by investigating those eight parishes individually. An immediate impression that compositional effects are not a big problem is provided by Figure 5.7. This graph plots the deskilling trend in the full samples against that of the sub-sample containing the 11 parishes that continue during the period 1600-1789, showing that the two samples are reasonably similar (see Table A7 in Appendix VI for exact numbers).[73]

[73] These include Aldenham, Banbury, Bottesford, Colyton, Gainsborough, Gedling, Methley, Odiham, Shepshed, Southill and Terling.

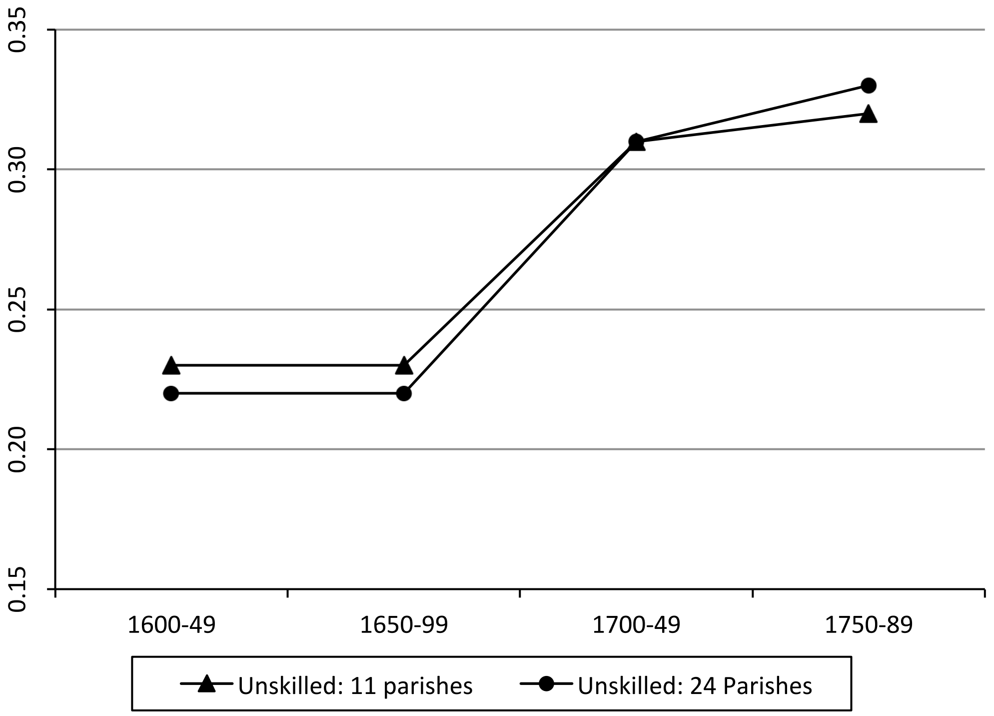

Figure 5.7. Controlling for Compositional Effects, 1600 -1789

Notes: The 24 parishes: Birstall and Shepshed excluded. The 11 parish: see footnote 5. *Source*: CAMPOP data (see text).

5.3 Regression analysis

The most appropriate way to deal with the entire set of issues discussed in the previous section is to run regressions that control for them. This also allows us to use the data at the individual level rather than the aggregated level used in the graphs above. Table 5.3 reports the results of using a standard OLS model to regress the skill-status of the sampled males (i.e. skilled or unskilled in HISCLASS) on a number of explanatory variables that include a mix of individual- and parish-level dummy variables.[74] Column (1) of Table 5.3 shows the results of including the entire 26 parishes in the regression. This analysis clearly confirms the deskilling trend observed in Figure 5.1 above. It shows that the probability of being tagged with an unskilled occupation rises by over 11% between 1550-99 and 1700-50 and by nearly 20% over the entire period. Column (1) also shows that having literacy skills reduces the probability of being unskilled; that migrant workers, i.e. workers not baptised in the parish of observation, were less likely to be skilled; and finally that there is upward occupational mobility over the life-cycle: that is, males were more likely to be unskilled if recorded with an occupation at their marriage rather than later on in life. Many of these conclusions are subject to local variations, which we explore in more detail below.

[74] The OLS model is used for ease of interpretation; the statistical significances remain if we use a Probit model instead.

(1) Full sample	(2) Subsample agricultural	(3) Subsample industrial	(4) Subsample retail	(5) Subsample mixed
REF	REF	REF	REF	REF
0.0349**	-0.105**	0.139***	-0.0513**	0.0325
-2.32	(-2.01)	-2.59	(-1.97)	-1.58
0.0353**	0.0519	0.0807	-0.0212	0.0105
-2.36	-0.97	-1.5	(-0.82)	-0.51
0.112***	0.219***	0.0553	0.0321	0.130***
-7.63	-4.55	-1.08	-1.25	-6.27
0.131***	0.202***	0.0594	0.0788***	0.160***
-9.23	-4.11	-1.19	-3.05	-7.56
0.207***	0.304***	0.054	0.135***	0.261***
-14.65	-6.43	-1.1	-5.13	-12.56
-0.0181**	-0.00827	0.0191	0.012	0.024
(-2.26)	(-0.28)	-1.09	-0.99	-1.28
-0.0554***	-0.0982***	0.00446	0.0288	0.0246
(-5.44)	(-2.62)	-0.2	-1.57	-1.09
-0.0271***	0.00976	-0.0435***	-0.0313***	-0.0494***
(-5.15)	-0.52	(-4.25)	(-3.68)	(-5.51)
-0.299***	-0.429***	-0.0610***	-0.426***	-0.336***
(-31.63)	(-16.25)	(-5.38)	(-20.79)	(-18.98)
REF	.	.	.	.
-0.311***	.	.	.	.
(-29.59)	.	.	.	.
-0.0921***	.	.	.	.
(-9.15)	.	.	.	.
-0.0661***	.	.	.	.
(-6.54)	.	.	.	.
0.478***	0.643***	0.0251	0.458***	0.425***
-25.35	-10.13	-0.47	-12.27	-13.02
NO	YES	YES	YES	YES
0.09	0.15	0.06	0.06	0.13
30516	3083	4512	12278	10643

Table 5.3: Dependent Variable: Unskilled Occupation, by Parish Type

Notes: Columns (2) to (4) split the parishes into sub-groups depending on their main economic activity in 1831 following Schofield (2005). The time reference category is the 1550-99 period. The *t*-values are reported in parentheses. The asteriks *, **, and *** denote significance at the 10%, 5%, and 1% level. *Source:* CAMPOP Data (see text).

By dividing the sampled parishes by their main economic activity following Schofield (2005), Column (1) shows that workers in parishes that were predominantly agricultural (the reference category) were significantly more likely to be unskilled than workers in parishes that had industry or retail and handicrafts as their main activities.[75] Columns (2) to (5) confirm this pattern by splitting the sampled parishes into sub-groups depending on their main economic activity (and controlling for parish-fixed effects). In parishes dominated by agriculture (meaning the most rural parishes of the sample), the time-period estimates in Column (2) show that the probability of holding an unskilled profession rose by over 30% between 1550-99 (the reference period) and 1800-50. Parishes of mixed activities followed closely, showing that the risk of being unskilled increased by 26% over the same period (Column 5). Parishes dominated by retail and handicrafts saw half as much deskilling (13% increase) and industrial parishes comparatively little (5% increase, insignificant). Columns (2) to (5) also establish that the upward life-cycle mobility is chiefly an agricultural phenomenon, while the underperformance of migrants concerns parishes dominated by non-agricultural activities.

The two main issues discussed above – compositional effects and occupational under-recording – also demand attention. The results reported in Table 5.4 speak directly to these concerns. First, Column (1) shows the results of using the full sample of 26 parishes and controlling for parish-fixed effects. The estimates are virtually identical to those reported in Column (1) of Table 5.3, which divided the parishes by their main economic activity. Column (2) of Table 5.4 goes back to the discussion above about Birstall (and Shepshed) in the data section, showing that their exclusion has no critical impact on the deskilling result.[76]

Next, Table 5.4 addresses the compositional effects that occur because the composition of parishes in the pooled sample changes across the period of observation. Later on we treat the issue of compositional effects in the best way possible, namely by studying the most populous parishes individually. For now, Column (3) of Table 5.4 reports the results of running the regression with a sub-sample containing those 11 parishes that, according to Wrigley et al. (1997), consistently remain under observation between 1600 and 1789 (see also Figure 5.7 above).[77] Note that the time reference period (1600-49) in Column (3) is different

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[75] Schofield (2005) divides the 26 parishes into four groups depending on their main economic activity as reported in the 1831 national census. 'Agricultural' parishes include Willingham, Great Oakley, Terling, Aldenham, Ash, Hartland, Morchard Bishop, and Bridford. 'Industrial' parishes include Birstall, Gedling, and Shepshed. 'Retail and handicrafts' parishes include Gainsborough, Lowestoft, Alcester, Banbury, and Dawlish. 'Mixed' parishes include Earsdon, Methley, Bottesford, Austrey, March, Southill, Odiham, Reigate, Colyton, and Ipplepen.

[76] Birstall and Shepshed were the parishes that distorted the occupational structure of the 26 sampled parishes vis-à-vis the national sample (Wrigley et al. 1997). The deskilling result is also robust to entering Birstall and Shepshed in the regression with reduced weights.

[77] These are Aldenham, Banbury, Bottesford, Colyton, Gainsborough, Gedling, Methley, Odiham, Shepshed, Southill and Terling.

from that of the baseline analysis (1550-99) reported in Column (1). That, however, does not deny the fact that the risk of being tagged with an unskilled occupation increased by over 10% between 1600-49 and 1750-89 (Column 3). A broader period coverage can be achieved by narrowing the sample down to the eight most populated parishes that cover the entire period.[78] Column (4) shows that, when we control for compositional effects in this way, the deskilling is both larger and more significant than when we use the full sample (Column 1).

Model: OLS	(1) Full sample	(2) Not Birstall and Shepshed	(3) Subsample 11 parishes	(4) Subsample 8 parishes	(5) Subsample 95%-criteria
1550-99	REF	REF		REF	REF
1600-49	0.0104	-0.00273	REF	0.0826***	0.118**
	-0.69	(-0.18)		-2.87	-2.25
1650-99	0.00758	0.00508	-0.00912	0.0843***	0.167***
	-0.5	-0.33	(-0.71)	-2.96	-2.62
1700-49	0.0897***	0.0952***	0.0655***	0.195***	0.160***
	-6.06	-6.26	-5.3	-7	-3.16
1750-99	0.121***	0.128***	0.105***	0.203***	0.184***
	-8.17	-8.31	-9.15	-7.29	-3.65
1800-50	0.197***	0.210***		0.216***	0.218***
	-13.26	-13.64		-7.71	-4.35
Baptism occupation	0.00504	0.00974	0.00047	-0.0262*	0.00205
	-0.58	-1.04	-0.04	(-1.92)	-0.14
Burial occupation	0.0115	0.00788	0.0246	0.0274	0.0359
	-0.98	-0.61	-1.62	-1.37	-1.18
Born in parish	-0.0346***	-0.0323***	-0.0341***	-0.0443***	-0.0318***
	(-6.60)	(-5.56)	(-4.72)	(-5.10)	(-2.76)
Literate male	-0.292***	-0.385***	-0.189***	-0.125***	-0.266***
	(-31.36)	(-32.54)	(-13.47)	(-6.83)	(-13.35)
Constant	0.295***	0.356***	0.411***	0.285***	0.388***
	-11.83	-13.62	-10.01	-8.12	-8.19
Parish FE	YES	YES	YES	YES	YES
R2	0.12	0.11	0.10	0.07	0.07
Obs	30516	26171	14589	12441	7129

[78] These are Austrey, Banbury, Bottesford, Earsdon, Gainsborough, Great Oakley, Shepshed, and Southill.

Table 5.4. Dependent Variable: Unskilled Occupation, Robustness

Notes: Column (2) includes all parishes except Birstall and Shepshed. Column (3) uses a subsample of those 11 parishes that cover the period 1600-1789. Column (4) includes the eight parishes cover the entire period. Column (5) include the same eight parishes, but only those years in which 95% or more of the males had an occupational discriptor. The time reference category vary by sample. The *t*-values are reported in parentheses. The asteriks *, **, and *** denote significance at the 10%, 5%, and 1% level. *Source:* CAMPOP Data (see text).

However, we are still confronted with perhaps the most critical problem, namely that of occupational under-recording. In addressing this, Column (5) reports the results of using the same eight parishes as used in Column (4). But this time we only include those years where 95% or more of the recorded males had an occupational descriptor. If the deskilling observed in Column (4) was caused entirely by a growing proportion of low-status males being tagged with an occupation over time, then the magnitude of the time-estimates reported in Column (5) after 1500-49 would not be statistically different from that observed in 1500-49 (the reference period). Reassuringly, that counterfactual is incorrect: the deskilling result remains *regardless* of whether we impose the 95% criteria or not. This finding thus establishes that the sub-group of eight parishes do not suffer from any under-recording of lower-status occupations during the early part of the period.

When we adjust for occupational under-recording, the estimates show that most of the deskilling occurred before 1700. That conclusion could, however, be caused by compositional effects created *this time* by imposing the 95% criteria. This is so because the eight parishes may not meet the 95% criteria during the same years. The only way to completely eliminate this potential problem is to run the regression for the eight parishes individually (and of course still uphold the 95% criteria). Glancing over the results of doing this, reported in Table 5.5, confirms that deskilling was the rule rather than the exception: the likelihood of being tagged with an unskilled profession in 1800-50 was always markedly higher (with one exception) than in the (varying) time reference periods. This is true of Austrey (25% increase), Banbury (10% increase), Bottesford (21% increase), Earsdon (12% increase), Gainsborough (14% increase), Great Oakley (23% increase) and Southill (5% increase). Hence, the loss of skills is clearly evident in the data even after dealing with the entire set of issues discussed above.

Two things are worth noting at this point. First, the large rise in the risk of being unskilled in Great Oakley confirms the previous finding (but this time with the 95% threshold) that parishes dominated by agriculture, such as Great Oakley, are especially prone to deskilling (see also Table 5.3, Column 2). Second, the only exception to the rule of deskilling, namely Shepshed, saw the likelihood of being unskilled *decline* by over 15% between 1600-49 (the reference period) and 1800-50. Interestingly, Shepshed is also the only parish in the sub-sample of eight with over 50% of its male workforce employed in manufacturing in 1831 (Wrigley et al. 1997, p. 43). This confirms our previous observation (Table 5.3, Column 3) that parishes dominated by industry were less subjected to a loss of skill than parishes not dominated by industrial activities. Also, and interestingly, most of Shepshed's skill-formation occurred during the seventeenth century rather than during the classical years of the Industrial Revolution.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model:	Austrey	Banbury	Bottesford	Earsdon	Gainsb.	Great Oakley	Shepshed	Southill
OLS	95%-criteria Mixed	95%-criteria Retail	95%-criteria Mixed	95%-criteria Mixed	95%-criteria Retail	95%-criteria Agriculture	95%-criteria Industrial	95%-criteria Mixed
1550-99	REF							
1600-49	-0.0356 (-0.51)		REF		REF	REF	REF	
1650-99	0.179 -1.51		. .		0.103 -1.54	0.145 -1.39	-0.0718 (-0.61)	REF
1700-49	0.126* -1.78	REF	. .	REF	0.169*** -2.74	0.383*** -7.02	-0.170** (-2.43)	0.0579 -0.47
1750-99	0.0892 -0.91	0.0521** -2.06	0.0135 -0.18	0.142** -2.28	0.115*** -3.29	. .	. .	0.0635 -0.46
1800-50	0.272*** -4.16	0.104*** -3.69	0.206*** -3.09	0.120* -1.78	0.144*** -2.71	0.231*** -3.29	-0.154** (-2.57)	0.0529 -0.43
Baptism occupation	-0.128** (-2.13)	0.0688*** -3.06	0.03 -0.53	0.0258 -0.2	-0.0558* (-1.84)	-0.221*** (-2.69)	0.00742 -0.16	0.102 -0.59
Burial occupation	0.244** -2.2	0.0251 -0.28	-0.011 (-0.15)	0.132 -0.93	-0.074 (-1.29)	-0.0299 (-0.21)	-0.0542 (-0.66)	0.0594 -0.31
Born in parish	-0.0291 (-0.58)	-0.000762 (-0.04)	-0.0369 (-0.74)	-0.0829** (-2.39)	-0.0451 (-1.63)	0.083 -1.11	-0.0504 (-1.27)	0.0291 -0.78
Literate male	-0.381*** (-3.36)	-0.401*** (-13.24)	-0.505*** (-5.72)	0.0138 -0.32	. .	-0.497*** (-4.35)	-0.0912** (-2.13)	-0.727*** (-3.85)
Constant	0.543*** -4.93	0.456*** -11.83	0.625*** -5.97	0.178 -1.56	0.302*** -7.89	0.411*** -3.67	0.394*** -4.56	0.739*** -3.73
R2	0.12	0.08	0.12	0.02	0.11	0.12	0.04	0.06
N	406	2605	352	831	1282	225	613	812

Table 5.3. Dependent Variable: Unskilled Occupation, by Parish

Notes: The results concern those years when 95% or more of the males had an occupation descriptor. The fourth row reports the main economic activity of the parish in 1831 following Schofield (2005). The time reference category varies by parish. The *t*-values are reported in parentheses. The asteriks *, **, and *** denote significance at the 10%, 5%, and 1% level. Source: CAMPOP Data (see text).

5.4 A closer look

The deskilling observed above raises important questions about its sectorial origin. Was the loss of skill mainly an agricultural phenomenon, or was it one of industry? And, in either case, can we shed light on the main driving force behind the loss of skill? Our findings above show that workers observed in those parishes that Schofield (2005) has identified as predominantly agricultural were more prone to lose their skills than those recorded in parishes mainly engaged in industry. That conclusion rests, however, on a crucial assumption, implicitly made by Schofield (2005), about how to allocate the unskilled 'labourers' whose work cannot be classified and, hence, identified by sector of employment. Previous studies have struggled, inconclusively, with the same problem (e.g. Broadberry et al. 2015; Shaw-Taylor 2012).

One way forward is to separate out those occupations that we *can* actually categorise by sector. That approach allows us to study the loss of skill within the main sectors of production that is *not* driven by a rising number of 'labourers'. Of course, the more we break down the data, the fewer observations will be available for analysis. Two further complications are that we still wish to uphold the 95% criteria to avoid occupational under-recording, and that we wish to study the parishes individually to avoid compositional effects. These restrictions leave us with a rather scant amount of data. Still, two of the largest parishes in the sample, Banbury and Gainsborough, contain enough occupational information to be made subject to closer inspection.

Although Banbury and Gainsborough are in principle observed across the entire period, 1550-1850, neither provides sufficient information to invoke the 95% criteria over the full 300 years. Gainsborough supplies what seems to be an adequate number of observations for the period 1600-1750 (Table 5.5, Column 5), and the same is true for Banbury for the period 1700-1850 (Table 5.5, Column 2). Conveniently for our analysis, Gainsborough experienced a large shift of labour away from agriculture in the period 1600-1750, which coincided with a large episode of deskilling in this parish. Our analysis below may thus shed light on whether Gainsborough's loss of skill is only linked to its declining primary sector or also to organisational changes within this sector. Similarly, Banbury had a relatively large share of workers employed in its manufacturing sector in the period 1700-1850 (close to 50% not including the 'labourers') and experienced deskilling over the same years. This can help inform us whether or not some of the loss of skill in Banbury is explained by the Goldin-Katz workshop-to-factory hypothesis (Goldin and Katz 1998).

Table 5.6 illustrates the occupational structures for Gainsborough and Banbury during the relevant years mentioned above. For each of the parishes, the occupational titles are divided into four groups: one group for each of the three mains sectors – primary, secondary and tertiary – and one group including the uncategorised 'labourers'. The categorised occupational titles were classified by sector using the PST system developed by Wrigley (2010). Within each sector, the occupational titles were then divided into the four major skill-groups in HISCLASS: high-, medium-, low-, and unskilled workers. Table A1 in appendix VI provides an overview of the most frequent occupations and how they were categorised by skill.

		Gainsborough		Banbury	
		(1)	(2)	(3)	(4)
Sector:	Skill-level:	1600-49	1700-49	1700-49	1800-50
Unknown	Labourer (unskilled)	17.2	33.3	20.8	28.5
	Share of workforce	17.2	33.3	20.8	28.5
Primary	Unskilled	6.6	20.1	25.6	48.3
	Low-skilled	70.1	20.0	28.2	0.0
	Medium-skilled	23.3	59.9	35.9	44.5
	High-skilled	0.0	0.0	10.3	7.2
	Share of workforce	23.1	4.6	9.0	6.7
Secondary	Unskilled	11.5	19.8	1.6	11.6
	Low-skilled	30.0	20.1	38.8	28.2
	Medium-skilled	58.5	60.1	59.6	60.2
	Share of workforce	48.5	49.1	56.4	48.3
Tertiary	Unskilled	16.7	0.0	1.7	3.7
	Low-skilled	3.3	7.2	25.0	29.7
	Medium-skilled	73.4	57.1	60.0	57.9
	High-skilled	6.6	35.7	13.3	8.7
	Share of workforce	11.2	13.0	13.8	16.5

Table 5.6. Skill-structures in Gainsborough (1600-1750) and Banbury (1700-1850)
Source: Cambridge Data (see text)

Looking at the group of unskilled, uncategorised 'labourers' first, it is clear that both parishes saw rising shares: about 7-8 percentage points over the two respective periods (Table 5.6, top row). Our main interest here, however, concerns the skill developments *within* the main sectors of production. In Gainsborough, the share of the workers engaged in primary activities declined between 1600-49 and 1700-49, from 23% to 7% of the sampled workforce (Columns 1 and 2). Note that, even if we allocate the entire group of uncategorised ‘labourers’ to primary activities, Gainsborough’s agricultural sector would still decline, from 40% to 31%, during this period. Indeed, Gainsborough’s shrinking primary sector aligns with recent work on England’s early structural transformation, which documents a considerable shift of labour out of agriculture taking place many years prior to 1750 (Broadberry et al. 2015). The corresponding rise in the size of the non-agricultural sectors in Gainsborough also accords with evidence of GDP per capita growth in England, which is shown to have appeared long before of the classic years of the Industrial Revolution (Broadberry et al. 2015; Nuvolari and Ricci 2013).

Columns (1) and (2) of Table 5.6 also establish that Gainsborough’s agricultural sector was subject to deskilling *even* when we exclude the unskilled, uncategorised ‘labourers’. The share of low-skilled workers employed in agriculture drops from 70% to 20%, while the share of unskilled workers rises from 6% to 20%. Some skill-formation did take place, however, in the form of a rising share of medium-skilled workers, from 33% to 60%. This suggests that organisational changes took place in agriculture, which needed more unskilled workers *and* medium-skilled workers at the cost of lower-skilled ones. Drilling further into the data informs us that much of this change was caused by lower-skilled cottagers and husbandmen virtually disappearing between 1600 and 1750, dropping as a share of the primary workforce from over 12% to less than 1%. This development was counterbalanced by rising shares of unskilled workers (e.g. ‘Farm worker’, ‘Forestry worker’, ‘Gardener’, ‘Groom’, ‘Hostler’, ‘Shepherd’, etc.) and medium-skilled farmers and thus suggests a concentration of land following a change from peasant to large-scale commercial farming.

Gainsborough’s manufacturing sector shows similar trends, with a loss of skills in the shape of fewer lower-skilled workers (30% to 20%) and more unskilled ones (12% to 20%). Note that ‘labourers’ are still excluded from the analysis. The share of medium-skilled workers remains largely constant (59% to 60%). The service sector, contrastingly, shows remarkable evidence of skill *formation*. Contrary to the development of Gainsborough’s primary sector, unskilled tertiary-sector workers effectively disappear (17% to 0%) and medium-skilled workers decline markedly (73% to 57%). This is offset by a modest rise in lower-skilled workers (3% to 7%) and an extraordinary rise in higher-skilled workers (7% to 36%). Deskilling in the tertiary sector could of course in principle have emerged if a sufficiently large number of the uncategorised ‘labourers’ were employed in services (which we would not expect to be the case). What we can be sure of, though, is that the overall deskilling observed in Gainsborough (Column 5 of Table 5.5) was driven by a loss of skills in agriculture *and* industry, and that this is true regardless of how the unskilled, uncategorised ‘labourers’ were *actually* employed by sector.

Turning to Banbury (Columns 3 and 4 of Table 5.6), less than 10% of the sampled workforce was engaged in primary activities by the beginning of the 18th century (still excluding 'labourers'). Even if we allocate the entire group of 'labourers' to the primary sector, the bulk of Banbury workers were still involved in non-agrarian activities during the classical years of the Industrial Revolution. Banbury's manufacturing sector, net of 'labourers', remained largely constant and employed roughly half the workforce, while services kept around 15% of the sampled males busy. The changes in the skill-structures within Banbury's primary and secondary sectors between 1700 and 1850 in many ways looks remarkably similar to those observed in Gainsborough between 1600 and 1750, with the replacement of lower-skilled workers by unskilled ones and with modest growth in the shares of medium-skilled workers. By contrast to Gainsborough, even Banbury's tertiary section saw deskilling in the form of higher- and medium-skilled workers being replaced by lower- and unskilled ones. So the average loss of skill observed in Banbury (Column 2 of Table 5.5) applied to all three main sectors of production, regardless of how the unskilled, uncategorised 'labourers' were actually distributed across the economy.

A closer look at the most common occupations in Banbury's secondary sector shows that craftsmanship declined between 1700 and 1850. A common lower-skilled profession such as 'weaver' dropped from 9.2% to 5.9%, and 'tanners' and 'dyers' jointly fell from 1.6% to 0.5% of the sampled workforce. Medium-skilled artisan professions, such as 'smith', fell in importance, from 4.8% to 2.8%. The halving in the demand for this sort of craftsmanship and artisanal employment fits well both with Goldin and Katz's workshop-to-factory hypothesis and with Allen's idea that highly-paid skilled workers incentivised the mechanisation of Britain (Allen 2009; Goldin and Katz 1998). The declining shares of lower- and medium-skilled manufacturing workers and growing shares of unskilled workers, including 'factory workers', also motivated the rise of resistance groups in the early 19th century, such as the Luddites,[79] underpinning why skilled workers were afraid that factory production would render their skills redundant (Nuvolari 2002). These findings also link to studies on the formation of skills inferred from trends in the skill premium, i.e. the wage rate paid to unskilled workers relative to skilled ones (e.g. Williamson 1985; Clark 2005; Van Zanden 2009; Allen 2009). In a basic supply and demand framework, skill-premia and occupational composition can be seen as reflecting price and quantity dimensions of the overall labour market. Allen's evidence showing that the real wages in the first half of the nineteenth century stagnated while output per worker expanded (Allen 2009) thus aligns with the episode of deskilling we observe.

On the other hand, the replacement of craftsmen and artisans by machines would arguably have increased the demand for 'high-quality workmen', such as instrument makers, joiners, turners, engineers, mechanics, and wrights (i.e. machine erectors and

[79] Ned Ludd, the legendary figurehead of the Luddites, supposedly lived and worked in Anstrey, which is located not far from Banbury (Hammond and Hammond 1919).

installers). According to Mokyr (2009) and Meisenzahl and Mokyr (2012), these professions were necessary to manage the technical innovations that the Industrial Revolution entailed. The Banbury data show that ‘carpenters’, ‘joiners’, ‘turners’, and ‘wrights’ grew modestly, from 11% to 14% of the manufacturing workforce between 1700 and 1850. Similarly, new occupational titles emerging in Banbury in the same period, including ‘engine operators’ and ‘watch-makers’, came to make up nearly 3% of the Banbury manufacturing workers by 1800-50. This lends credence to the notion that industrialisation through mechanisation demanded more high-quality professionals.

5.5 Conclusion

Early modern England underwent significant transformations in terms of structural and technical change. But what happened to the use of working skills in productive activities during these transformations? Previous work has relied on trends in literacy rates or skill-premia to try to quantify the formation of human capital during England’s Industrial Revolution. These measures are, however, either very crude proxies for the acquisition and, even more so, the application of working skills in productive activities (such as literacy rates). Or they provide a rather indirect measure of human capital formation (such as skill-premia).

In this paper, we combine a novel use of the occupational titles recorded in the Cambridge Group’s 26 historical parish registers with a new approach to quantifying human capital used in productive activities. Specifically, we employ the HISCLASS scheme to code the sampled occupational titles according to their skill content and then trace the evolution in the share of unskilled workers across three centuries of English history, from the second half of the sixteenth century to the first half of the nineteenth century.

We find that the risk of being tagged with an unskilled occupation rose considerably across those three centuries, from 20% to almost 40%. This loss of skill finding is robust to dealing with issues arising from compositional effects and from unsystematic recording of occupations. The likelihood of being listed as unskilled varied across the sampled parishes, in time and in extent, depending on the main economic activity of the parish and on the literacy status and migration history of the sampled individuals. Parishes identified by Schofield (2005) to be dominated by industrial activities saw less deskilling on average than those dominated by retail and handicrafts and, especially, agriculture. But, above all, deskilling in the sampled parishes was the rule rather than the exception.

A closer examination of the skill-structures in two of the largest parishes, Banbury and Gainsborough, showed that the loss of skill was not limited to a single sector of production. Rather, it was found in agriculture and industry alike, and sometimes also in the service sector. In Gainsborough, the disappearance of low-skilled husbandmen and cottagers occurred in parallel with a growth in the shares of unskilled farm workers and farmers, and suggests that deskilling in agriculture emerged from organisational changes linked to land concentration. This occurred in combination with a shift of labour out of agriculture.

In Banbury, a parish dominated by retail and handicraft activities during the classic period of the Industrial Revolution, deskilling came in the form of a decline in craftsmanship and artisanal production, as predicted by Goldin and Katz (1998). This motivated the rise of the Luddites, a group of machine-breaking artisans who carried out their activities in the name of their leader Ned Ludd (Nuvolari 2002). While our data supports the workshop-to-factory hypothesis, it is important to note that an additional process of deskilling could have occurred *within* a given profession, which is something that the HISCLASS scheme is unable to detect. For example, a seventeenth-century tailor would have been a highly skilled artisan making bespoke clothes, but in the nineteenth century he may been a sweatshop operative undertaking only a small part of the production process. Similarly, an eighteenth-century weaver was likely to be male and quite often a highly skilled, independent craftsman, but by the mid nineteenth century a weaver was more likely to be a female factory operative with fewer skills.

Some skill formation did emerge in manufacturing captured by the rising shares of 'high-quality workmen' thought necessary to facilitate the Industrial Revolution (Mokyr 2012). This resonates with van der Beek's demonstration that the number of apprenticeships among these professions increased during the eighteenth century (van der Beek 2012) and with the evidence provided by Squicciarini and Voigtländer (2014) that the French Industrial Revolution was not achieved by an accumulation of skills among the average worker, but by the ingenuity and technical ability of a minority. It also squares with the theory proposed by O'Rourke et al. (2013) showing how technical progress during the early stages of industrialisation can be skill saving and skill demanding at the same time.

The sampled workforce makes up a minute (and possibly even biased) fraction of the entire English workforce at the time. Still, if the loss of skill observed in our sample applies more broadly, then it not only highlights the need for a deeper understanding of the impact of early modern England's structural and technical transformations on the demand for skilled workers, but also reinforces the pessimistic interpretation of early modern living standards in England. Indeed, working hours went up (Voth 1998, Allen and Weisdorf 2011); child labour increased (Humphries 2010); heights declined (Cinnirella 2008); and wages stagnated (Clark 2007). The loss of skill would certainly have contributed to a less stimulating work-life among English labourers.

Summary in Dutch

De industriële revolutie is een van de belangrijkste breekpunten in de geschiedenis. Voor het eerst zorgde technologische vooruitgang voor een constante toename van het reëel Bruto Binnenlands Product per hoofd van de bevolking (BBP). Het is dan ook niet verwonderlijk dat er onder economisch historici een debat woedt over de oorzaken van de industriële revolutie. Recentelijk is er veel aandacht gekomen voor de rol van menselijk kapitaal als oorzaak. De economische groei theorie veronderstelt namelijk een positief verband tussen technologische verandering, een toename van menselijk kapitaal en economische vooruitgang (zie Galor 2011 voor een overzicht). Voor de periode na de Tweede Wereld Oorlog is een dergelijk positief verband tussen menselijk kapitaal en economische groei vastgesteld. Voor de periode van de industriële revolutie is er echter geen eenduidig empirisch bewijs gevonden. Onderzoek toont enerzijds aan dat er tussen 1750 en 1850 geen vooruitgang was in scholingsgraad van de Engelse beroepsbevolking (Cressy 1980), anderzijds wordt er gewezen op een toename in de vraag naar hoogopgeleide vakmannen zoals monteurs, technici en werktuigbouwkundigen (Mokyr 2005, Mokyr en Voth 2009).

In mijn thesis heb ik gebruik gemaakt van verschillende historische cijferreeksen van menselijk kapitaal en reëel BBP per hoofd van de bevolking om een bijdrage te kunnen leveren aan het debat omtrent de rol van menselijk kapitaal tijdens de industriële revolutie. De hoofdvraag die hierbij werd gesteld luidt: “In hoeverre heeft menselijk kapitaal bijgedragen aan economische groei op de lange termijn”? Om deze vraag systematisch te kunnen beantwoorden is hij onderverdeeld in deelvragen. Ten eerste is er gekeken naar de toename van menselijk kapitaal in West-Europa waarbij het concept van de ‘Little Divergence’ belangrijk is. Na de Zwarte dood in 1347/48 was economische groei voornamelijk geconcentreerd in het Noordzee gebied. De Hollandse economie kwam tot bloei tijdens de Gouden eeuw, en rond 1670 sloeg de economische groei over naar Engeland. Er is beargumenteerd dat deze fase van ‘pre-industriële economische groei’ cumulatief was, en uitmondde in de Engelse industriële revolutie. Het was dus allereerst belangrijk dit proces van ‘pre-industriële economische groei’ te verklaren – d.w.z. kan de toename in menselijk kapitaal verklaren waarom het Noordzee gebied het economisch zoveel beter deed dan de rest van Europa in de periode voor 1800? Ten tweede is er in deze thesis onderzoek gedaan naar het proces van economische groei in Engeland. Engeland was het eerste land dat succesvol industrialiseerde en is daarom uiterst relevant om de relatie tussen menselijk kapitaal en moderne economische groei te onderzoeken. Om een goed beeld te kunnen schetsen is er data verzameld voor drie verschillende componenten van het ‘menselijk kapitaal’: de formele scholingsgraad (het gemiddelde aantal jaren scholing van de beroepsbevolking tussen 1300 en 1900), de informele scholingsgraad (het aandeel ongeschoolden in de beroepsbevolking tussen 1550 en 1850), en het aandeel hoogopgeleide vakmannen binnen de beroepsbevolking tussen 1550 en 1850 (Mokyr 2005).

In de empirische analyse kwam duidelijk naar voren dat menselijk kapitaal bijdroeg aan de fases van ‘pre-industriële economische groei’. Hoofdstuk 2 heeft aangetoond dat in de periode tussen 1300 en 1800 menselijk kapitaal (gemeten aan de hand van boekconsumptie per hoofd van de bevolking) een groot deel van de toename in het reële BBP per hoofd van de bevolking (maar ook de urbanisatiegraad) van Holland en Engeland kan verklaren. In hoofdstuk 4 is ook gebleken dat er een positieve correlatie is tussen menselijk kapitaal (gemeten als het gemiddelde aantal jaren scholing) en economische groei (reëel BBP) in Engeland in de periode voor de industriële revolutie. Dit is allereerst gebleken uit de gegevens over formele educatie in hoofdstuk 4. In ca. 1700 had een op de zes mannen een middelbare school opleiding genoten. Hoofdstuk 5 heeft verder uiteengezet dat in de periode voor de industriële revolutie slechts een op de vijf mannen ongeschoold werk verrichtte.

In hoofdstuk 2 en 3 is tevens onderzocht wat de oorzaak was van de toename in menselijk kapitaal tijdens de periode van de ‘Little Divergence’. De empirische analyses in hoofdstukken 2 en 3 hebben uitgewezen dat een groot deel van de toename in menselijk kapitaal toegeschreven kon worden aan het Protestantisme en aan ‘female agency’. Hoe kleiner de ongelijkheid tussen mannen en vrouwen was, hoe meer er werd geïnvesteerd in scholing - een hypothese die eerder al werd verondersteld door de Moor en van Zanden (2010). De bevindingen laten zich verder goed verzoenen met het eerdere werk van Becker en Woessmann (2009) die een positieve relatie tussen de Reformatie, menselijk kapitaal en industrialisatie in Pruisen hebben vastgesteld.

In hoofdstukken 4 en 5 lag de focus op Engeland tijdens de periode van de industriële revolutie. Hoofdstuk 4 heeft allereerst aangetoond dat er na circa 1720 een sterke afname was van het gemiddeld aantal jaren schooling. In 1880 ging slechts een op de dertig jongens naar een middelbare school toe (in 1700 was het nog een op de zes). In dit hoofdstuk is ook een tijdreeksanalyse uitgevoerd welke heeft vastgesteld dat formele scholing negatief correleert met reëel BBP-groei tussen 1750 en 1811. Eenzelfde patroon komt naar voren wanneer er gekeken wordt naar informele scholing. In hoofdstuk 5 was uiteengezet dat er een flinke toename was in de vraag naar ongeschoolde arbeid. Waar in 1600 slechts een op de vijf mannen een ongeschoold beroep uitoefende, was dat in 1850 opgelopen tot twee op de vijf.

De conclusie dat menselijk kapitaal de BBP-groei negatief beïnvloedde tijdens de industriële revolutie draagt bij aan eerder onderzoek dat een dergelijk verband had verondersteld aan de hand de ontwikkeling van de geletterdheid tussen 1750 en 1850 (o.a. Nicholas en Nicholas 1992). Er zijn echter ook nieuwe bevindingen aan het licht gekomen. Ten eerste is eerder onderzoek gebaseerd op een stagnatie van de geletterdheid tijdens de industriële revolutie. Hoewel dit een goed beeld schetst van het deel van de populatie dat kan lezen (en wellicht schrijven), is het een magere indicator van de totale scholingsgraad. In hoofdstuk 4 is daarom niet alleen gekeken naar basisscholing, maar ook naar middelbare scholing om een completer beeld te krijgen van het algehele scholingsniveau van de populatie. De trends in de data laten zien dat het scholingsniveau niet stagneerde, maar sterk daalde. Hieruit kan dus worden geconcludeerd dat de afname in de vraag naar formeel geschoolden arbeiders veel sterker is geweest dan eerder werd aangenomen door economisch historici. Ten tweede hebben economisch historici (o.a. Wallis 2008) vaak gewezen op het belang van informele scholing die werd opgedaan door ‘on the job learning’ en/of door in de de leer te gaan bij een ambachtsman. Uit hoofdstuk 5 is echter gebleken dat er ook een afname was in het aandeel geschoolden ambachtsmannen. Ten slotte is er in hoofdstuk 5 getracht een beeld te schetsen van het aandeel hoogopgeleide vakmannen tussen 1550 en 1850. Deze werklieden besloegen slechts 3% tot 5% van de beroepsbevolking, maar zijn volgens Mokyr (2005) onmisbaar voor het proces van industrialisatie. De mechanisatie vergde goed geschoolde monteurs, technici en werktuigkundigen die het proces met hun kennis en ervaring konden ondersteunen. De data in Hoofdstuk 5 laat inderdaad een dergelijk patroon zien: hoewel er een afname is in de vraag naar geschoolde arbeiders en ambachtsmannen, nam het aandeel hoogopgeleide vakmannen toe.

Algeheel kan er geconcludeerd worden dat menselijk kapitaal bijdroeg aan de fases van ‘pre-industriële economische groei’, maar tijdens de industriële revolutie had het slechts een beperkt effect. De algehele scholingsgraad daalde, en er was een toename in het aandeel ongeschoold werk. Dit duidt dus op een proces van ‘deskilling’ (Goldin en Katz 1998): technologische verandering zorgde ervoor dat geschoold werk vervangen kon worden door ongeschoold werk.

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Appendix I: Data construction Chapter 2

Per capita GDP

Observations for Germany, Spain, Italy, Belgium, the Netherlands, England, Sweden, Poland, and Portugal are taken from Bolt and van Zanden (2014). GDP estimates of France, Austria, Switzerland, Ireland, Denmark and Norway are derived from Maddison (2001). The dataset of Maddison gives per capita GDP in 1700 and 1820. The observation for 1750 is interpolated.

Yield ratios

Data is available with intervals of 50 years in Slicher van Bath (1963a, 1963b), supplemented with data for the 18th and early 19th century by Van Zanden (1998). Observations in the sample thus refer to century averages (e.g. the average yield ratios for 1200-49 and 1250-99 gives the observation for 1300). It was required to make several assumptions. Western Europe: There is no evidence for the period 1700-49. Data for the year 1800 is therefore based upon the yield ratio of 1749-99; Southern Europe: Most assumptions were necessary for this sub-set of countries, since data is lacking for periods 1350-99, 1450-99 and 1550-1649. The observation of 1300 refers to the average yield ratio between 1300-49, 1400 to 1400-49, 1500 to 1400-49, 1600 to 1500-49 and 1700 to 1650-99. Yield ratios of these countries do not vary much over time, which makes these assumptions plausible in our view; Central, Northern and Eastern Europe: Evidence for 1500 is based upon average yield between 1500 and 1549.

Merchant fleets

Estimates of the growth of the European merchant fleet between 1500 and 1800 are taken from Van Zanden (2001). The size of the total fleet (in thousand tons) was 200-250 in 1500, 600-700 in 1600, 1.000-1.100 in 1700 and 3.372 in 1800. The estimates of Unger (1992) are slightly higher, as he approximates its total tonnage at 1.000 in 1600 and 1.500 in 1670. It is decided to choose the lower bound estimates of van Zanden and to take averages (i.e. the size of the total fleet was 225 in 1500). Van Zanden gives regional and national shares of the fleet, which can be found in table 7. These shares are used to calculate individual century observations:

Year	c. 1500	c. 1600	c. 1670	1780
Southern Europe	40?	25?	20?	15
Netherlands	16	33	40	12
Great Britain	10-12	10	12	26
France	?	12	8-14	22
Hanseatic towns	20?	15	10	4
Unspecified	-	5	10-4	21

Table 7. Regional and national share of the merchant fleet, 1500-1800

Notes and sources: Van Zanden (2001). Southern Europe: Spain, Portugal and Italy.

1800: Observations are taken from Romano (1962) that was also the original source of van Zanden (2001). It refers to the year 1786-7. There were no individual observations for Norway and Denmark. These countries are assigned to have had the same amount of tonnage per capita; 1700: Estimations for the Netherlands, Great Britain, France, Germany and southern Europe are based upon the shares in table 7. This is compared with the estimates of Vogel (1915) for the year 1670. Vogel estimates the Dutch fleet around 600 tons, which is too high as 420 tons is more likely. To calculate tonnage of the French fleet, the average of Van Zanden's estimate is taken (i.e. 11%). The share of the fleet in Southern Europe is assumed to be 20% (210 ton in absolute terms). The Venetian fleet increased from 20 tons in 1450 to 60 tons in 1780. The observation for 1700 is linearly interpolated. Unger (1992) assigns the Venetian fleet to 32 tons in 1567, which is in line with the interpolation exercise. Unger measures the fleet of Genoa at 30 tons in 1450 and Romano estimates it at 42 tons in 1786-7, which makes it possible to interpolate the years in-between. Combining the fleet of Venice and Genoa gives the observation for Italy for 1700. Subtracting this from the total fleet of southern Europe offers the estimates for Spain and Portugal. Nonetheless, it should be noted that there are no individual estimations, although it is adjusted to their population levels. 7% of the European fleet is unspecified, of which 5% is assigned to Scandinavia (taking a 2% margin of error into account). Taking the ratio of 1800 for division of tonnage between Sweden at the one hand, and Denmark and Norway on the other hand, provides the total tonnage of Sweden. The rest is attributed to Denmark and Norway; 1600: Observations are conducted in a similar way by using the shares given in table 7. Unger gives the observation for Venice, and Genoa is interpolated. Taking these two together, gives the observation for Italy. That what remains (94 tons) is distributed between Spain and Portugal according to their population level. To follow Unger, the Scandinavian fleet increased remarkably after 1670. Since its tonnage was still relatively low at the end of the 17th century, it is assumed that there was no Scandinavian fleet before 1700; 1500: Observations for Germany, southern Europe and Britain are calculated with the help of table 7. In doing so, it is decided to take an average for Britain (11%). Vogel estimates the Dutch fleet around 60 tons by the 1470s, which is too high according to van Zanden. Holland went through a deep recession at the end of the 15th century, and it is therefore likely that the size of the merchant fleet decreased. As this study works with century averages, it is decided to take the average (50 tons) to correct for the depression. Unger provides estimates of the Italian fleet. This is subtracted from the total southern European share and the remaining is assigned to Portugal and Spain. Subtracting all individual observations from the total European tonnage gives the estimate for France (25 tons); 1400 and 1300: Evidence for the Middle Ages is scarce. Unger however gives estimates based on wine and beer trade that provides observations for England, France and Germany.

Appendix II: Overview of data Chapter 2

Table 8 lists the descriptive statistics of the main variables used in the analysis. Table 9 reports on the basic correlation between the variables of interest.

	Mean	Standard deviation
Ln per capita GDP	6.97	0.34
Ln per capita GDP, robustness	7.02	0.33
Urbanization ratio	0.09	0.07
Ln Parliamentary activity	2.52	1.66
Share cities self-government	0.66	0.32
Ln Medieval communes p/c	0.95	0.73
Ln Yield ratio	1.65	0.30
Ln Size of the Merchant fleet p/c	5.68	4.95
Ln Book consumption p/c	9.57	2.22
Years at war	0.59	0.51
Dummy Thirty Years' war	0.01	0.11
Latitude	0.56	0.07
Ln Area	11.9	1.04
Enclosures	0.41	0.32
Colonial realm	1.20	0.46

Table 8. Descriptive statistics

	ln *gdp*	ln *gdp_r*	*urb*	ln *par*	ln *yield*	ln *fleet*	ln *book*
ln *gdp*	1						
ln *gdp_r*	0.88	1					
urb	0.80	0.71	1				
ln *par*	0.31	.30	0.31	1			
ln *yield*	0.47	0.36	0.60	0.35	1		
ln *fleet*	0.47	0.36	0.42	0.11	0.24	1	
ln *book*	0.39	0.38	0.50	0.24	0.40	0.32	1

Table 9. Correlations between main independent variables

Appendix III: Robustness checks Chapter 2

Below, in Tables 10 and 11, the robustness checks with the Allen data of non-specie trade (Table 10) and the volume of Atlantic trade from Acemoglu et al (2005) (Table 11), both showing that the correlation with GDP and urbanization is weak or non-existent.

Estimator Dependent variable	(13) RE Ln GDP	(14) RE Ln GDP_R	(15) RE URB
Ln Non-specie trade p/c	0.02 (0.02)	0.02 (0.03)	0.01* (0.00)
Colonial realm	0.08 (0.15)	0.14 (0.15)	0.04* (0.02)
Ln Area	-0.05 (0.08)	-0.06 (0.07)	-0.02 (0.02)
Latitude	-0.57 (0.92)	-0.39 (0.88)	-0.18 (0.17)
D30	-0.07 (0.05)	-0.12 (0.07)	-0.02** (0.01)
Years at war	-0.02 (0.06)	0.01 (0.05)	0.02 (0.01)
D1300	-0.30 (0.19)	-0.20 (0.17)	-0.09*** (0.03)
D1400	-0.14 (0.15)	-0.04 (0.12)	-0.09*** (0.03)
D1500	-0.20** (0.09)	-0.00 (0.07)	-0.04** (0.02)
D1600	-0.15** (0.07)	-0.11 (0.07)	-0.03* (0.01)
D1700	-0.08 (0.06)	0.03 (0.08)	-0.02 (0.01)
D1750	-0.08* (0.05)	-0.01 (0.05)	-0.02** (0.01)
D1800	Ref	Ref	Ref
Constant	7.80*** (0.94)	7.82*** (0.68)	0.38* (0.19)
R^2	0.15	0.17	0.43
No. of observations	81	79	81

Table 10. Robustness-check international trade and economic development, 1300-1800: Non-specie trade

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively.

Estimator Dependent variable	(16) RE Ln GDP	(17) RE Ln GDP_R	(18) RE URB
Volume Atlantic trade	0.07** (0.03)	0.08*** (0.02)	0.01 (0.01)
Colonial realm	-0.05 (0.12)	-0.01 (0.10)	0.03 (0.02)
Ln Area	-0.08 (0.07)	-0.09 (0.06)	-0.02 (0.02)
Latitude	-0.57 (0.92)	0.20 (1.01)	-0.13 (0.20)
D30	-0.07 (0.05)	-0.12 (0.07)	-0.02*** (0.01)
Years at war	-0.01 (0.06)	0.00 (0.06)	0.02* (0.01)
D1300	-0.14 (0.10)	-0.04 (0.10)	-0.07*** (0.02)
D1400	-0.11 (0.11)	-0.01 (0.10)	-0.09*** (0.03)
D1500	-0.17* (0.10)	0.02 (0.07)	-0.04** (0.02)
D1600	-0.15** (0.07)	-0.11 (0.07)	-0.03* (0.01)
D1700	-0.05 (0.06)	0.06 (0.07)	-0.01 (0.01)
D1750	-0.06 (0.04)	-0.00 (0.04)	-0.01 (0.01)
D1800	Ref	Ref	Ref
Constant	7.89*** (0.83)	7.90*** (0.67)	0.39** (0.17)
R^2	0.25	0.22	0.46
No. of observations	81	79	81

Table 11. Robustness-check international trade and economic development, 1300-1800: Volume of Atlantic trade

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively.

Because there is a very strong time trend in the estimates of book consumption (and in the Protestantism variable), we tested various other specifications of the hypothesis that this proxy for human capital causes economic growth. In the first test we delete the time dummies, which results in a stronger effect of Protestantism on book consumption, and a smaller coefficient for book consumption in the second stage (as may be expected). In the second test we add a time trend, in both stages, which does not really change the results, and in the third test we use the absolute value of book consumption (and not the log), which of course affects the size of the coefficients, but not their significance. Table 12 only reports on the regressions using per capita GDP as outcome variable, the results are similar when using Ln GDP_R or URB as left-hand side variable.

	(19)		(20)		(21)	
Estimator	RE/2sls		RE/2sls		RE/2sls	
Dependent variable	Ln GDP		Ln GDP		Ln GDP	
	(I)	(II)	(I)	(II)	(I)	(II)
Ln Book consumption p/c	-	0.09*** (0.02)	-	0.24** (0.11)	-	-
Book consumption p/c	-	-	-	-	-	0.04*** (0.02)
Protestantism	3.16*** (0.74)	-	1.60*** (0.26)	-	11.25*** (3.06)	-
No of Universities p/c	0.50* (0.30)	0.04 (0.06)	0.32** (0.14)	-0.02 (0.09)	4.92 (3.12)	-0.19 (0.14)
Latitude	-5.33 (5.75)	-0.51 (1.41)	-3.30 (2.73)	-0.55 (1.41)	3.13 (15.10)	-1.77 (1.42)
D30	0.60*** (0.15)	-0.14 (0.21)	0.16** (0.08)	-0.16 (0.28)	-1.30 (1.32)	-0.10 (0.29)
Years at war	0.35 (0.54)	-0.05 (0.06)	0.19 (0.18)	-0.03 (0.08)	1.05 (1.68)	-0.02 (0.08)
Time-trend	-	-	0.01*** (0.00)	-0.01* (0.00)	-	-
D1300	-	-	-	-	-7.71*** (2.13)	0.18 (0.24)
D1400	-	-	-	-	-10.7*** (2.96)	0.45 (0.29)
D1500	-	-	-	-	-8.40*** (2.07)	0.31 (0.22)
D1600	-	-	-	-	-10.1*** (3.42)	0.26 (0.19)
D1700	-	-	-	-	-7.60*** (2.34)	0.24 (0.17)
D1750	-	-	-	-	-4.50*** (1.15)	0.13 (0.13)
D1800	-	-	-	-	Ref	Ref
Constant	10.99** (3.01)	6.39*** (0.77)	-8.49*** (1.40)	9.15*** (1.68)	1.83 (8.95)	7.73*** (0.76)
R^2	0.29	0.14	0.76	0.28	0.60	0.31
F-statistic		18.02		38.35		13.51
No. of observations		69		69		69

Table 12. Robustness-checks: human capital formation and economic development, 1300-1800

Notes: Standard errors are clustered at the country level to control for serial correlation in the unobservables. Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, 1% level respectively. The F-statistics report on the strength of the instrument. The regressions measuring the impact of book consumption on log per capita GDP have no observations for Denmark and Norway.

Appendix IV: Data construction Chapter 4

Literacy rates, 1550-1900:

The study of Cressy (1980) provides evidence on literacy for the years 1500, 1550, 1560, 1580, 1600, 1610, 1640, 1660, 1680, 1710 and 1750. The growth of literacy between 1500 and 1750 was an unstable and noncumulative process. Cressy (1981) distinguishes between eight different phases in the development of literacy in this period. Dates in the interval are interpolated and take the variations in the development of literacy into account. The literacy estimates corresponds well with the estimates provided by Stone (1969, pp. 101). The estimates of Schofield (1981) are used for sub-period 1754-1840. Lord Hardwicke's Marriage Act (1754) prescribed that grooms and bridges should sign their names in the marriage register, which means that after ca. 1750 there exists abundant evidence about literacy rates (of both sexes). The estimates of Schofield are derived from a random sample of 274 English parish registers to estimate the annual percentage of males and females able to sign their marriage contracts. Stephens (1987) gives the percentage of illiterate brides and grooms between 1839 and 1885. The largest part of his statistics concern yearly observations, sometimes with intervals of 5 years. Cressy's (1980) estimates are again used to derive the literacy rates for sub-period 1885-1915.

Literacy rates, 1300-1550:

The reading-literacy rates of Hoeppner Moran (1985) are projected backwards in time by taking the growth in primary schools into account (see discussion in Section 2.1). Multiplying the reading-literacy rates by 0.75 (level of schooling which is based on ratio of reading- to signature-literacy) gives the results of Table 1 in Section 2.1.

Year	1300	1350	1400	1450	1500	**1530**	1548
Elementary schools	12	20	20	36	70	104	124
Male literacy	2.6	4.3	4.3	7.8	15.2	**22.5**	26.9
Female literacy	0.9	1.5	1.5	2.6	5.1	**7.5**	9.0

Table A1. Reading literacy rates, 1300-1548

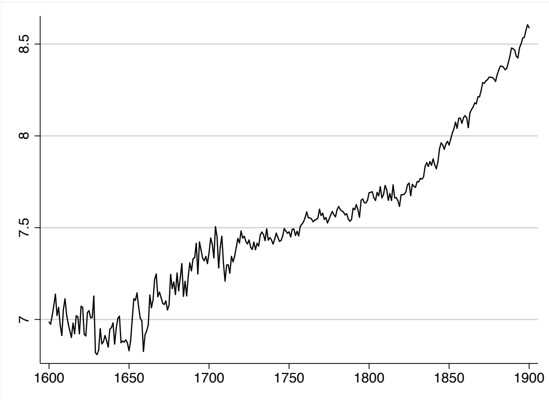
Notes and sources: See Section 2.1. Percentages are rounded up to the nearest digit. Bolt typeface indicates the year from which is projected backwards in time.

Adjustments made to the number of secondary schools, 1500-1720

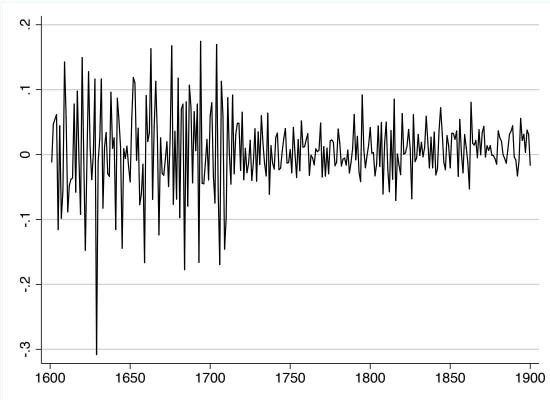
The SIC (1868a) only reported on those schools that were *endowed*, which is very likely to underestimate the number of secondary schools as it does not take into account private fee-paying institutions (see Vincent 1969). Since it only reports on those schools that were still in existence by the 1860s, it is furthermore likely to underestimate the number of school establishments when moving backwards in time. The data on the number of secondary schools is therefore adjusted upwards. For sub-period 1530 - 1600, the ratio of endowed to non-endowed schools of Orme (2006) is used. As discussed in Section 2.2, many of the secondary schools that Orme recorded became endowed between 1480 and 1530 (the ratio decreased from 35/156 to

116/234). It is therefore assumed that the ratio of non-endowed to endowed schools decreased at a similar rate between 1530 and 1600 as it did for the period 1480 to 1530. For sub-periods 1600-1660 and 1660-1720, the ratio of grammar schools to private schools of Vincent (1969) is applied. The number of private tutors is not included as the student numbers are not known.

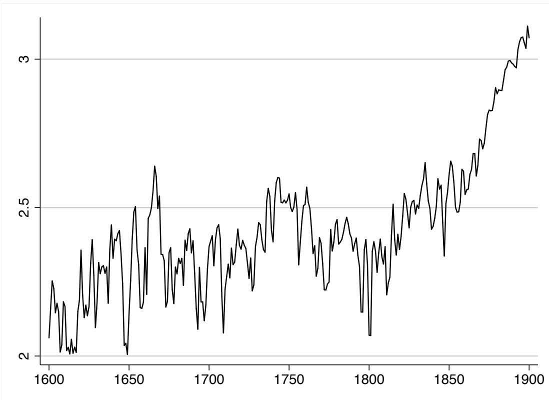
Appendix V: Figures time series Chapter 4



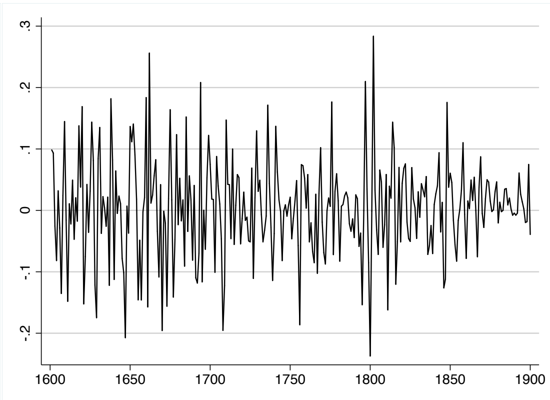
Log of per capita GDP



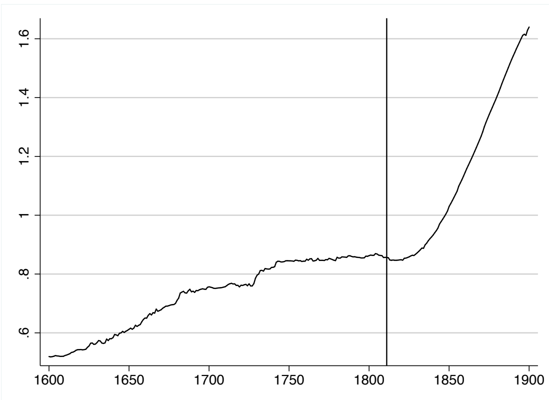
Growth of the log of per capita GDP



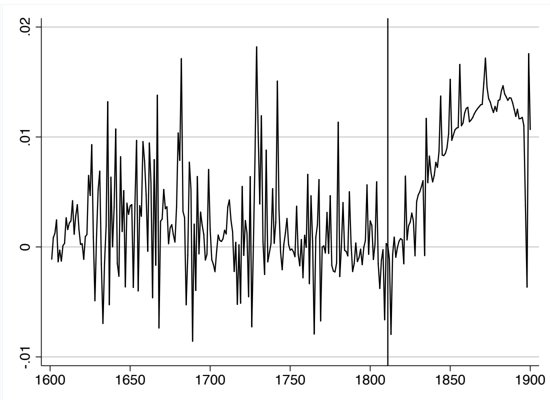
Log of the real wage



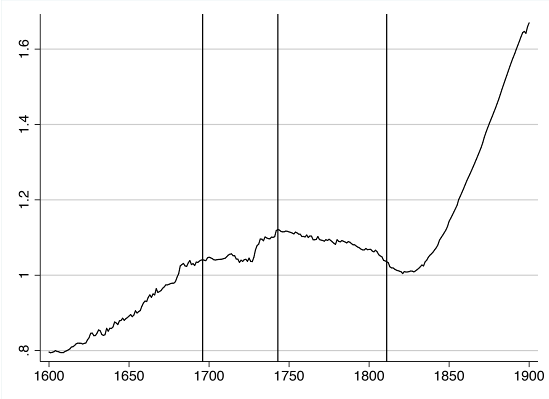
Growth of the log of the real wage

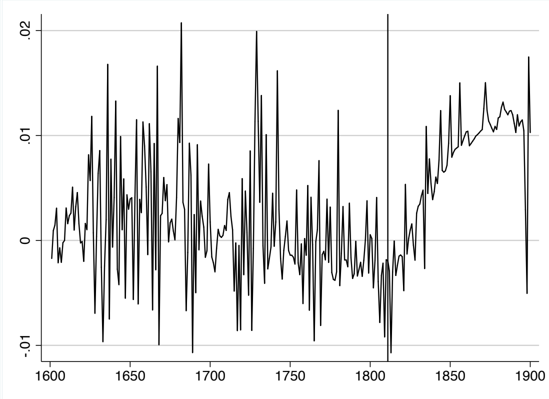


Log of average years of education: Total



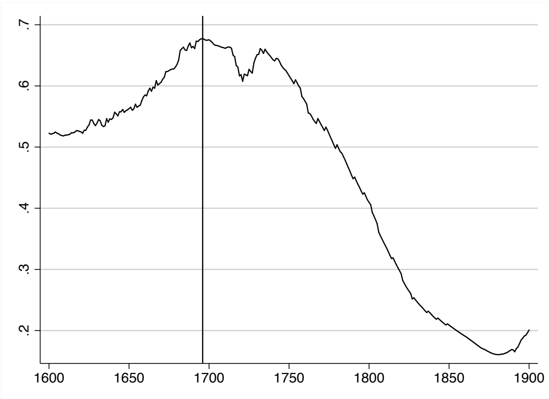
Growth of the log of average years of education: Total

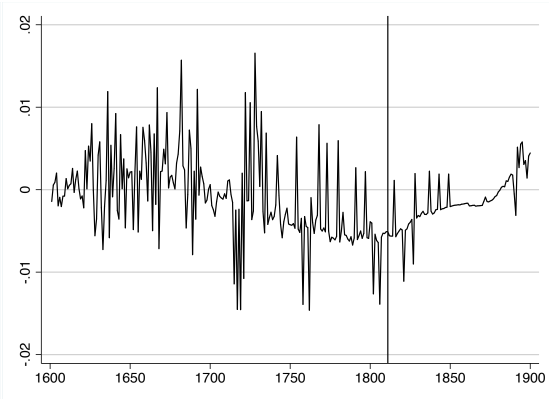




Log of average years of education: Males

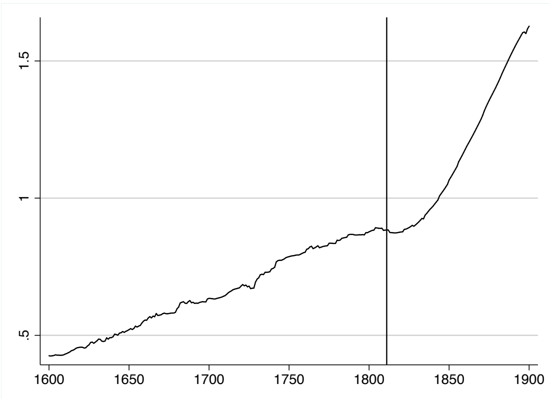
Growth of the log of average years of education: Males

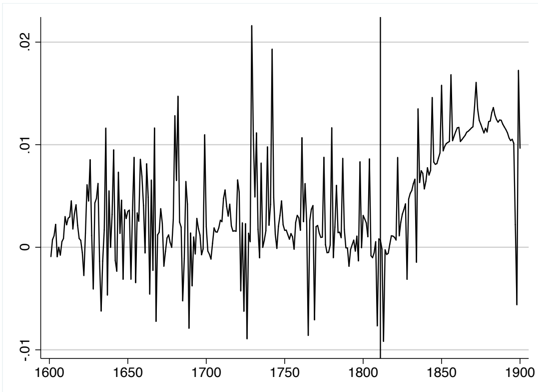




Log of average years of secondary and tertiary education:

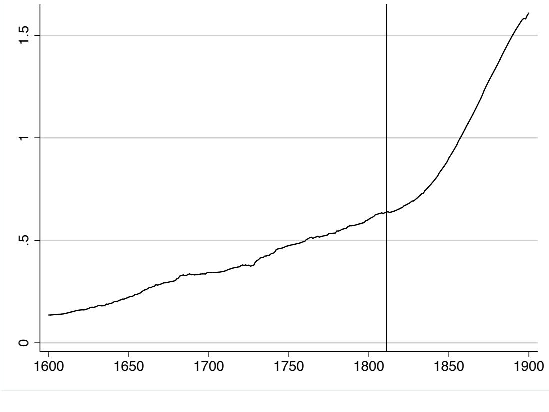
Growth of the log of average years of secondary and tertiary education: Males

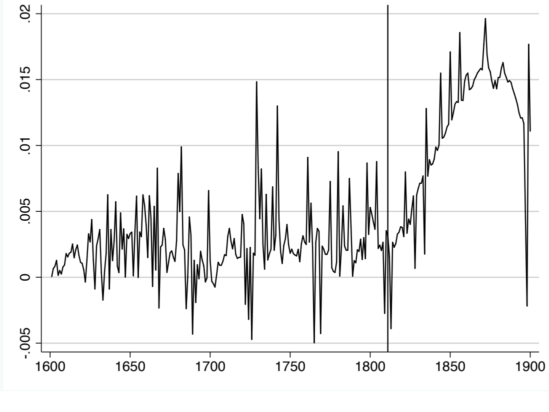




Log of average years of primary education: Males

Growth of the log of average years of primary education: Males





Log of average years of education: Females

Growth of the log of average years of education: Females

Figure A1. *The figures of the time series: levels in left panel, growth rates in right panel*
Notes and sources: Human capital stocks: see Section 4.2; per capita GDP: Broadberry et al 2015; real wages: Allen (2001). The vertical lines refer to the break points as identified by the Quandt-Andrews unknown break-point test (test results upon request from the author).

Appendix VI: Data Chapter 5

Skill-level	**Occupational Titles**
Unskilled:	Boatman, chapman, chimney sweeper, clothier, hostler, porter, suckler, warrener, farm worker, factory worker
Low-skilled:	Barber, basket maker, brick maker, builder, coachman, carder, cottager, shepherd, dairyman, dyer, fisherman, gardener, weaver, glover, needle maker, painter, thatcher, postman, sawyer, servant, soldier, spinner, stonecutter, turner, clerk
Medium-skilled:	Baker, brewer, butcher, carpenter, chandler, cook, clock maker, cutler, dealer, farmer, glazier, innkeeper, maltster, mason, miller, millwright, looker, plumber, printer, saddler, sergeant, shoemaker, smith, tailor, yeoman
High-skilled:	Apothecary, attorney, bailiff, captain, chemist, clergyman, doctor, lieutenant, rector, surgeon

Table A1. Examples of Coding of Occupational Titles in HISCLASS

	Unskilled	Lower- and Unskilled	*N*
1550-99	0.20	0.52	986
1600-49	0.22	0.51	2,879
1650-99	0.22	0.51	3,089
1700-49	0.31	0.59	4,528
1750-99	0.33	0.59	6,708
1800-49	0.39	0.63	9,816
			28,006

Table A2. The Shares of Lower- and Unskilled Workers, Provinces

	Unskilled: CAMPOP	*N*	Unskilled: Social tables	*N*
1675-99	0.23	1,698	0.29	1,390,586
1700-24	0.30	2,372	0.31	1,482,803
1825-50	0.41	4,558	0.42	6,630,700

Table A3. The Share of Unskilled Workers: Social Tables and Census Data

	Low-skilled	Medium-skilled	High-skilled	*N*
1550-99	0.15	0.48	0.37	124
1600-49	0.10	0.74	0.16	371
1650-99	0.11	0.70	0.19	431
1700-49	0.11	0.67	0.22	476
1750-99	0.05	0.74	0.21	644
1800-49	0.06	0.70	0.23	863
				2,909

Table A4. The Share of Workers by Working Skills, White-Collar Workers

	Unskilled	Low-skilled	Medium-skilled	*N*
1550-99	0.24	0.35	0.41	1,052
1600-49	0.24	0.33	0.43	2,402
1650-99	0.27	0.30	0.43	2,773
1700-49	0.33	0.31	0.36	4,139
1750-99	0.36	0.29	0.35	5,954
1800-49	0.43	0.26	0.31	8,742
				25,062

Table A5. The Share of Workers by Working Skills, Blue-Collar Workers

	Unskilled	Lower- and Unskilled	*N*
1550-99	0.01	0.28	151
1600-49	0.08	0.38	181
1650-99	0.11	0.41	398
1700-50	0.16	0.43	985
			1,715

Table A6. The Shares of Lower- and Unskilled Workers, London

	Unskilled: 11 parishes	*N*	Unskilled: 25 parishes	*N*
1600-49	0.23	2,041	0.22	2,879
1650-99	0.23	2,093	0.22	3,089
1700-49	0.31	2,833	0.31	4,528
1750-89	0.32	4,101	0.33	5,306
		11,068		15,802

Table A7. The Shares of Unskilled Workers, 11 and 25 Parishes