Recent Developments In The Theory Of Very Long Run Growth: A Historical Appraisal

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RECENT DEVELOPMENTS IN THE THEORY OF VERY LONG RUN GROWTH: A HISTORICAL APPRAISAL

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Abstract: This paper offers a historical appraisal of recent developments in the theory of very long run growth, focusing on three main areas: (1) linkages between wages, population and human capital (2) interactions between institutions, markets and technology and (3) sustaining the process of economic growth once it has started. Historians as well as economists have recently begun to break away from the traditional practice of using different methods to analyse the world before and after the industrial revolution. However, tensions remain between the theoretical and historical literatures, particularly over the unit of analysis (the world or particular countries) and the role of historical contingency.

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I. INTRODUCTION

There has been a strong revival of interest in very long run growth amongst economists in the last decade or so, including unified growth theory (Galor and Weil, 2000, Galor, 2005), the economics of institutions (North, 1990; Greif, 2006) and general purpose technology (Helpman, 1998, Lipsey et al., 2005). This paper examines these developments in theory, and assesses their significance for economic history. It is argued that economic historians have made parallel discoveries, with both theoretical and historical literatures sharing a refusal to recognise the traditional practice of using different methods to analyse the world before and after the industrial revolution. However, there are also tensions between the two literatures, with theorists often content to work with models where the unit of analysis is the world and an industrial revolution is inevitable. Historians, by contrast, tend to make use of cross-sectional variation, emphasising specific European and even British features of the industrial revolution, and allowing an important role for historical contingency.

The paper begins with an examination of recent developments in the theoretical literature: (1) "unified growth theory" provides a new framework for modelling the transition from a Malthusian regime with a negative relationship between real wages and population to a modern growth regime with a positive relationship between these two variables, with a central role for human capital in bringing about both an industrial revolution and a demographic transition (Galor, 2005). (2) New institutional economics has made progress in modelling the key role of institutions in solving the "fundamental problem of exchange" and creating an environment where economic growth is possible (North, 1990; Greif, 2006). In addition, Schumpeterian endogenous growth models have developed a framework for modelling the link between institutions and technology, via the patent system (Aghion and Howitt, 1998; Carlin and Soskice, 2006). (3) Within the Schumpeterian growth framework, the idea of a general purpose technology (GPT) has also been helpful in understanding how technological progress and economic growth can be sustained (Lipsey et al., 2005).

There have also been important developments in the historical literature on very long run growth in the three areas outlined above: (1) In addition to the "Great Divergence" between Europe and Asia, economic historians have identified a "Little Divergence" within Europe between Britain and Holland on the one hand, and the rest of the continent on the other hand. Britain and Holland managed to maintain the real wage gains of the immediate post-Black Death period while limiting fertility and making a sustained investment in human capital. These countries also experienced growth of real GDP per capita during the late medieval and early modern period despite stagnation in the daily real wage, as a result of the "Industrious Revolution". These developments suggest that it will be necessary to go back to the medieval period to fully understand the transition to modern economic growth (2) Institutions played an important role in the general economic development of late medieval and early modern Europe. Britain and Holland were the only two countries to succeed in overthrowing absolutist government during the early modern period. These two countries also played a leading role in the development of private order institutions, with growing commercialisation showing up in a dramatic decline in the share of the labour force engaged in agriculture and a sharp rise in the level of urbanisation. Interactions between institutions, markets and technology played an important role in the British overtaking of Holland, which marked the final stages of the transition to sustained modern economic growth. Innovation flourished in an environment where a patent system protected intellectual property, there was a large market, and factor prices provided an incentive to use machine-intensive methods. (3) The diminishing returns which had characterised earlier bursts of technological innovation were avoided as a result of the wide range of applications of steam power and the potential for improving the technology. The switch to fossil fuel was also important in sustaining economic growth by freeing the economy from an energy constraint, while interactions between "prescriptive knowledge" and "propositional knowledge" also helped to avoid the onset of diminishing returns (Wrigley, 2004, Mokyr, 2002).

The paper emphasises the common themes in these recent theoretical and historical developments. A concluding section nevertheless considers the difficulties of combining the two literatures. It is difficult to improve upon the perceptive comments of Schumpeter (1954: 815), who noted that "There are such things as historical and theoretical temperaments. That is to say, there are types of minds that take delight in all the colors of historical processes and of individual cultural patterns. There are other types that prefer a neat theorem to everything else. We have use for both. But they were not made to appreciate one another." Schumpeter's words have particular force when applied to very long run growth, where historical narrative without theory can seem to lack direction, but where theory without attention to historical detail can all too easily result in over-simplistic generalisations.

II. RECENT DEVELOPMENTS IN THEORY

1. Wages, population and human capital in unified growth theory

The most influential strand of the recent theoretical literature on very long run growth is unified growth theory, which seeks to explain the transformation from a Malthusian world with a negative relationship between population and per capita income to a Solowian world where population and per capita income can grow together (Hansen and Prescott, 2002). The Galor and Weil (2000) model has become the standard-bearer of unified growth theory, and can be explained with a simple diagrammatic framework (Galor, 2005). The economy moves from a Malthusian regime (with a negative relationship between real wages and population) to a post-Malthusian regime (with a strongly positive relationship between real wages and population) before reaching a modern regime (with a weaker positive relationship between real wages and population). Instead of separate regimes with the transition caused by a large shock, Galor and Weil see the escape from the Malthusian trap as a long dynamic process with long periods of gradual change leading eventually to phase transitions. In this respect, unified growth theory has something in common with historical researchers engaged in crossing the boundaries between medieval, early modern and modern economic history.

In the Galor and Weil model, the development of the economy can be summarised using two key relationships, the education curve and the growth curve. The education curve captures the idea that technological progress (rather than the higher income it creates) raises the rate of return on human capital, so that education *(e)* is an increasing function of the growth rate of technology *(g)*:

$$e_{t+1} = e(g_{t+1}) \tag{1}$$

The growth curve captures the idea that a high level of education in turn generates a high rate of technological progress:

$$g_{t+1} = g(e_t; L_t) \quad (2)$$

Note, however, that the growth curve is also affected by the size of the labour force and hence by the population size *(L)*. This is the familiar scale effect of endogenous growth models.

The development of the economy can be characterised by three regimes, with different population sizes: small, moderate and large. The small population regime is illustrated by Figure 1A. With a small population, the only steady state equilibrium is with zero education and slow technical progress $(\bar{e}, \bar{g}) = (0, g^l)$. In Figure 1B, with a moderate size population (L^m), the growth curve has now shifted up to create the possibility of multiple equilibria. The steady state equilibrium of zero education and a low rate of technological progress $(\bar{e}, \bar{g}) = (o, g^l)$ is locally stable, as is the equilibrium with a high level of education and a high growth rate $(\bar{e}, \bar{g}) = (e^h, g^h)$. There also exists an interior steady state $(\bar{e}, \bar{g}) = (e^u, g^u)$ which is unstable. In Figure 1C, with a large population, the growth curve shifts up further, so that there is now a unique globally stable steady state equilibrium $(\bar{e}, \bar{g}) = (e^h, g^h)$ with high levels of education and technological progress.

The intuition behind the model can be described as follows. The economy starts out in a Malthusian regime with a small population at the subsistence level of per capita income. There is no education and there is only very slow exogenous technological progress. In this world, population expands with technological progress in the standard Malthusian way. This follows from assumptions about preferences, with members of the current generation maximising the utility of their children as well as themselves. Over time, slow growth of the population under the Malthusian regime raises the rate of technological progress, shifting the growth curve upwards. This induces a shift into the moderate population regime, with multiple steady states. One equilibrium is the old Malthusian steady state with slow technological progress and zero education, but there is also a high education, high growth equilibrium. What happens to population growth depends on the balance of two effects. First, there is an income effect. As society gets richer, parents can afford to devote more resources to child rearing, and this increases population growth. But second, there is a substitution effect. Parents wish to give their children more education to cope with the technological progress, leading to a substitution of quality for quantity, because education requires resources. At first, the income effect dominates, as a previously binding subsistence constraint is relaxed. This is the Post-Malthusian regime, characterised by an acceleration of both population and per capita income growth. However, in the long run, this effect from the relaxation of the subsistence constraint disappears and the substitution effect dominates. The economy then passes through a demographic transition and population growth slows down. This is the Modern regime.

Note the importance of the scale effect in the Galor and Weil model, with population growth shifting up the growth curve in Figure 1 and bringing about an industrial revolution via an acceleration of technological progress. However, this makes it hard to understand the technological stagnation of large economies such as Mughal India or Qing Dynasty China. Indeed, in the run up to the British industrial revolution, China’s population expanded from 100 million in 1685 to 300 million in 1790 (Mokyr, 2005: 1148-1149). This issue is addressed by Jones (2001), who asks the question “was the industrial revolution inevitable?” Although he models the demographic transition in much the same way as Galor and Weil (2000), Jones (2001) dampens the feedback from population to technology. With a smaller scale effect, as in Jones (1995), institutional change is then required to bring about an acceleration in the rate of technological progress. The institutional change is modelled by Jones as an exogenous shift in the parameter π, defined as the share of consumption paid to compensate inventive effort. Without such a shock, the industrial revolution, by which Jones (2001: 32-33) means “the onset of rapid population growth and per capita growth culminating in the large increase in standards of living during the 20th century”, does not occur. However, institutions remain a black box in the Jones model, which is unfortunate given the large amount of effort devoted to understanding institutions and institutional change in recent years, to which we now turn.

2. Institutions, markets and technology

There has been much theoretical work on the institutional changes which underpinned the economic development of Europe from the middle ages, with North (1990) establishing the general framework. We will examine here the specific contribution of Greif (2000), who adopts a more formal; approach, using the game of trust or one-sided prisoner’s dilemma to analyse what he calls the fundamental problem of exchange (FPOE): how can you be sure that the other side to a bargain will fulfil their contractual obligations? The game is set out in Figure 2. Player I chooses either to initiate a trade (exchange) or not to initiate the trade (don’t exchange). If he plays “don’t exchange” then no trade occurs and both agents receive pay-off 0, denoted (0, 0). If player I does initiate trade by choosing “exchange”, then player II must decide whether to cooperate (player II plays “exchange-cooperate) or to renege, for example, by running off with the goods that player I has offered, giving nothing in return. Assume that if there is cooperation then gains from trade are given by $\gamma>0$, shared between the two players, so player I gets γ-W and player II gets W. This is the most satisfactory outcome, where both players gain. However, player II can do better by reneging and walking off with the goods; then player II gets $\alpha>W$ and player I faces a loss, with a pay-off $\delta<0$. Note that if player I initiates trade, it is individually rational for player II to renege. But player I can anticipate this response, and so should not initiate trade. This means that the gains from trade (γ) will not be realized, as in Third World countries today and Europe in the Dark Ages. How is it possible to get out of this situation? In theory, player II must be able to credibly commit to not reneging. In practice, medieval Europe developed institutions such as merchant guilds for mitigating the FPOE. Guilds were able to regulate relations between merchants and also to defend merchants against expropriation by the state. It should be noted that Greif (1994) analyses more sophisticated models to deal with games played over more than one period, but the focus remains on how institutions deter opportunistic behaviour.

This work is very helpful in understanding the long build up to modern economic growth emphasised by economic historians such as Britnell and Campbell (1995), with the British industrial revolution having long roots in the commercialisation of the economy from the late middle ages. The emphasis here is on the development of private order institutions. Yet Greif (2006) also recognises the importance of state institutions, since the existence of an effective state can make the enforcement of property rights easier for individuals. Indeed, one strand in the literature which applies new institutional economics to economic development in history emphasises the importance of political developments such as the Dutch Revolt, which led to the de facto independence of the United Provinces from 1579, and the Glorious Revolution of 1688, which established constitutional monarchy in Britain (North and Weingast, 1989). The fact that these two countries led the process of economic development in Europe in the seventeenth and eighteenth centuries, respectively, is at least suggestive of a link between the institutions of government and economic growth.

It is helpful also to apply the approach of institutional economics to the acceleration of technological progress during the industrial revolution. In the context of technological innovation, entrepreneurs can afford to devote resources to the search for new methods only if they can be sure that others will not "run off" with their innovations without paying. The institutional mechanism which solves this fundamental problem of innovation is the patent system. However, it is not simply a question of the introduction of a formal system. In terms of North's (1990) definition of institutions, it is also important that the formal rules are underpinned by informal rules that make the system work. As MacLeod (1988: 1, 10) notes, the formal start of the system may be dated to the 1624 Statute of Monopolies, which was an attempt to end the Crown's abuse of letters patent, or documents by which special privileges were given. The statute specifically exempted patents granted for new inventions from its general proscription. During the seventeenth century, however, only a small minority of inventors filed for patents, preferring other means such as secrecy, to protect their intellectual property. Despite the fact that there were no changes in the formal institutional framework between 1624 and 1835, the system nevertheless developed in the light of the experience of administrators and patentees. By the mideighteenth century, MacLeod (1988: 1) suggests that the system had "developed its own momentum and promoted a first-strike mentality among its users: one neglected to patent at one's peril".

The patent system plays an important role in the Schumpeterian growth model of Aghion and Howitt (1992; 1998), who endogenise the rate of technological progress through spending on research and development (R&D). The model is summarised in Figure 3, taken from Carlin and Soskice (2006). The Solow relation shows a negative steady state relationship between the rate of innovation (x) and the degree of capital intensity measured in efficiency units $(\hat{k})$. However, the Schumpeter relation shows a positive relationship between innovation and capital intensity, which reflects in turn a positive relationship between capital intensity and R&D spending. The initial equilibrium is at A. As well as depending on capital intensity, R&D spending is also affected by the security of property rights in innovation. The introduction of an effective patent system, as in Britain on the eve of the industrial revolution, can thus be seen as shifting the Schumpeter relation upwards, resulting in a new equilibrium at B with a higher rate of innovation. An increase in the savings rate at the same time would shift the Solow relationship upwards, thus offsetting the fall in capital per unit of efficiency labour.

3. Sustaining economic growth

The long history of western economic development contains many cases of short bursts of technological progress, followed by stagnation. Within Europe, economic leadership passed from northern Italy in the first half of the second millennium to Portugal and Spain in the sixteenth century, then to Holland in the seventeenth century and England in the eighteenth century. One of the most important questions to answer about the industrial revolution, then, is why the technological progress continued rather than petering out like earlier growth episodes. This is not a problem in unified growth theory, where the transition to sustained modern economic growth is inevitable, but in the institutional approach, there can be no such presumption.

This issue can be addressed within the Schumpeterian growth model, via the idea of a general purpose technology (GPT). Schumpeter [1912] believed that innovations had clustered in Kondratieff waves since the industrial revolution, and although economists have long since abandoned the idea of a regular periodicity to such clusterings, the fundamental idea has now been revived. Lipsey, Carlaw and Bekar (2005: 98) define a GPT as "a single generic technology recognisable as such over its whole lifetime, that initially has much scope for improvement and eventually comes to be widely used, to have many uses, and to have many spillover effects".

One way of thinking about a GPT is as a major fundamental innovation which raises the productivity of applied research. This can be handled within a Schumpeterian growth framework such as Aghion and Howitt (1998), where production of the consumption good (y) depends on an intermediate good (x) and a productivity parameter (A) reflecting the quality of the intermediate good. Labour (L) can be used in the intermediate goods sector (m) or in research (n). The key relationships in the model are the labour market clearing condition ($\hat{L}$) and the research arbitrage condition ($\hat{A}$). The two relationships are shown in Figure 4, with the productivity adjusted wage ($\omega = w/A$) and the number of research workers (n) on the axes. The labour market clearing condition slopes upwards to the right because an increase in the productivity adjusted wage decreases the demand for labour in the intermediate goods sector, increasing the supply of labour to the research sector. The research arbitrage condition sloped downwards to the right because an increase in the productivity adjusted wage raises the rate of return required to attract workers into the research sector.

The discovery of a GPT raises the return to working in the research sector, hence shifting out the research arbitrage condition from ($\hat{A}_1$) to ($\hat{A}_2$). This increases the number of workers in the research sector and raises the growth rate. This is a very stripped-down version of the model, in which a general purpose technology, by altering the rate of return to research, can produce variations in the long run growth rate. Helpman and Trajtenberg (1998) provide a variant which produces a Schumpeterian cycle. The discovery of a new generation of intermediate goods comes in two stages, with the arrival of a GPT followed by the invention of intermediate goods that implement the GPT. The intermediate goods associated with a particular GPT can only be used profitably in the consumption goods sector after some minimal number have become available. The arrival of a GPT is thus followed by a slump as labour is deployed in research, but the new intermediate goods cannot yet be used in the consumption goods sector. Only after the discovery of sufficient intermediate goods can they be deployed and the economy enter a boom period. The arrival of the next GPT then induces another slump. Within each cycle, research is conducted in the slump (a time to sow) and pays off only in the boom (a time to reap).

III. RECENT DEVELOPMENTS IN HISTORY

1. Wages, population and human capital: northwest European exceptionalism

Recent research has suggested that northwest Europe, particularly Britain and Holland, developed very differently from the rest of Europe from the late middle ages. Since the industrial revolution occurred here, it suggests that a full understanding of the take-off to modern economic growth requires a study cutting across the conventional time periods of economic history. This finding of the Little Divergence within Europe has followed from the recent development of comparing levels rather than simply growth rates of real wages in Europe. Although the necessary data have been available since the pioneering work of the International Scientific Committee on Price History during the 1930s, the early work using the data on wages and prices tended to focus on the path of real wages in an individual country, or where comparisons were made, tended to focus on differences in the rate of change rather than differences in the level (Cole and Crandall, 1964; Braudel and Spooner, 1967; Phelps Brown and Hopkins, 1981). This really only changed with the work of van Zanden (1999) and Allen (2001), who made wage comparisons amongst many European countries for the period after 1500, focusing on levels. Broadberry and Gupta (2006) made wage level comparisons between Europe and Asia, while Pamuk (2005) has looked at the data back to 1300, crossing the period of the Black Death.

Real consumption wages of European unskilled building labourers for the period 1300-1850 are shown in Table 1, taking London in the period 1500-49 as the numeraire. The first point to note is that wages followed a similar pattern across the Black Death in the whole of Europe. Complete time series exist for comparatively few cities before 1500, but there is also scattered evidence for other cities. Taken together, the evidence supports the idea of a substantial rise in the real wage across the whole continent of Europe following the Black Death, which struck in the middle of the fourteenth century, wiping out between a third and a half of the population, when successive waves of the plague are cumulated (Herlihy, 1997). This episode of European economic history is thus clearly consistent with the Malthusian model, with a strong negative relationship between real wages and population. In the first half of the fifteenth century, the real wage was quite uniform across the countries for which we have data, at about twice its pre-Black Death level.

From the second half of the fifteenth century, however, Britain and Holland followed a very different path from the rest of Europe, maintaining real wages at the post-Black Death level and avoiding the collapse of real wages which occurred on the rest of the continent. Although Allen (2001) used the term Great Divergence to describe this process, the term is more usually reserved for the emerging gap in living standards between Europe and Asia (Pomeranz, 2000). As a result, the emerging gap in living standards between Britain and Holland and the rest of Europe has recently become known as the Little Divergence.

Broadberry and Gupta (2006) provide some real wage evidence of the Great Divergence between Europe and Asia, shown here in Table 2. The grain wage, obtained by dividing the silver wage with the silver price of grain, the most important consumption item, is the closest that we can get to the real consumption wage for India and China at this time. Table 2 suggests that real wages in north and south India and the Yangzi delta region of China were falling decisively behind those in Britain from the late seventeenth century, contrary to the revisionist claims of Pomeranz (2000), Parthasarathi (1998) and Frank (1998) that the richest parts of Asia remained at the same level of development as the richest parts of Europe until as late as 1800.

From the late eighteenth century, it becomes possible to calculate the real consumption wage for China, and Allen et al. (2005) are able to show that the comparative Anglo-Chinese real consumption wage at this time was very close to the comparative Anglo-Chinese grain wage. Furthermore, the Anglo-Indian grain wage at this time was around the same magnitude, i.e. about one-third of the English level.

Returning to developments within Europe, Table 1 on its own appears to paint a pessimistic Malthusian picture of the early modern period, with stagnation in Britain and Holland and decline in the rest of the continent. However, it is important to bear in mind that the wage data here are daily wages, rather than weekly or annual earnings. So although daily real wages stagnated in northwestern Europe, annual real earnings and per capita incomes were increasing as the number of days worked per year increased substantially, in what de Vries (1994) labels the "Industrious Revolution". The scale of this effect is quite large, with the loss of approximately fifty holidays per year following the reformation, and a further fifty days through the abolition of "St Monday", the widely accepted pre-industrial practice of not working at the beginning of the week following the excesses of the weekend (Voth, 1998).

Hence the real wage evidence of Table 1 should not be taken as indicative of stagnating real per capita incomes in northwest Europe before the industrial revolution. A number of authors have pointed to a longer period of sustained growth in per capita income in Britain, reaching back into the early modern and medieval periods. An important paper by Campbell and Overton (1996) charted the long run path of output per worker in agriculture, the largest sector of the economy, deriving a growth rate of 0.16 per cent per annum over the period 1300-1800. Making assumptions about non-agricultural output growth and labour supply, van Zanden (2006) charts the path of per capita income in Britain over the period 1300-1800, shown here in Table 3. The growth rate of per capita income between 1300 and 1800, at 0.25 per cent per annum, was somewhat higher than the growth rate of agricultural labour productivity, partly as a result of faster productivity growth in industry and partly as a result of a larger share of the population entering the labour force. Recent estimates by Overton (2006) also point to sustained growth in the median level of personal wealth in England between the 1550s and the 1740s, at a rate of 0.35 per cent per annum, as we would expect with sustained growth of per capita income.

Studies of national income before the industrial revolution have also been made for other European countries, following the pioneering work collected together in Maddison and van der Wee (1994). Table 3, taken from van Zanden (2006), provides estimates for seven countries. Although pre-industrial growth was quite substantial in Britain and the Netherlands, stagnation was the norm in the other countries for which we have data. The national income data thus reinforce the conclusion from the real wage data that Britain and Holland followed a different path from the rest of Europe. But again, it must be stressed that the national income data, based on annual observations, present a more optimistic view of the pre-industrial world than the real wage data, based on daily data.

To what extent can the Little Divergence be explained simply in terms of demographic factors? The simplest Malthusian approach would suggest that the persistence of high real wages in Northwestern Europe was the result of demographic restraint. However, this is far from clear in the population data assembled by Paolo

Malanima, presented here in Table 4. It must be stated at the outset that there is considerable uncertainty about the data particularly in the early years, with estimates of the population of England in 1300 ranging from as low as 4 million to as high as 6 million (Hatcher, 1977). Whatever the pre-Black Death peak population in England, there does nevertheless seem to be agreement that the population was slow to recover. This is much less clear in the rest of northwest Europe, however, with population well above its 1300 level already by 1500 in Belgium (Flanders), and with population nearly twice its pre-Black Death level by this time in the Netherlands (Holland).

De Moor and van Zanden (2005) try to relate the Little Divergence to differences in demographic and labour market behaviour. They argue that what Hajnal (1965) calls the European Marriage Pattern emerged in the North Sea region following the Black Death. The key component was the primacy of mutual agreement over parental authority in the choice of marriage partner. The fact that both partners had to consent to marriage increased the bargaining position of women, and this was underpinned by the system of inheritance and access to the labour market. Although women could inherit in southern Europe as well as in the northwest, the transfer occurred at the point of marriage in the south via the dowry, but upon the death of the woman's parents in the northwest. This made early marriage more attractive in the south, since it enabled a daughter to gain access to the dowry, but it also gave the parents power over the choice of partner because the value of the dowry was uncertain. Increasingly in northwest Europe, but only to a lesser extent in the rest of the continent, growing access to the labour market gave a woman the power to refuse to marry an unsuitable partner chosen by her parents.

There does seem to be some evidence in favour of this idea in the case of England. Wrigley et al. (1997) paint a detailed quantitative picture of England as an economy which was already controlling fertility through late marriage, and which cannot therefore be characterised as being in a high-pressure Malthusian equilibrium. Graph 1 shows clearly that during the seventeenth century, the mean age at first marriage for males varied between 27 and 28, falling below 27 for the first time during the decade 1730-39. By the 1830s, it had fallen below 25. For females, the mean age at first marriage rose as high as 26.3 in the 1710s before falling to 23.1 by the 1830s. It is worth noting that the increase in fertility which accompanied industrialisation in Britain was therefore not a general phenomenon, but rather depended on the earlier limitation of fertility through late marriage. This is also seen by Voigtländer and Voth (2006) as an important factor raising the probability of an industrial revolution in Britain. The case is more difficult to make for Holland, however, given the above-average increase in population over the period 1300-1500.

The sign of the relationship between real wages and population clearly changed from negative to positive between the fourteenth and nineteenth centuries. In the fourteenth century, the increase in the real wage was made possible only by a sharp Malthusian fall in population following the Black Death. By the time of the industrial revolution, by contrast, rapid population growth could be sustained together with a rising real wage. In the intervening period, however, it is not clear that the European economy can really be characterised as in a Malthusian regime. Indeed, recent historical research using VAR analysis suggests that the English economy may have ceased to operate in a Malthusian way much earlier than was once thought. Nicolini (2007) finds that the positive check (a negative relationship between the real wage and the death rate) disappeared during the seventeenth century and the preventive check (a positive relationship between the real wage and the birth rate) disappeared before 1740. Howver, Crafts and Mills (2007) replace the Allen (2001) real wage date used by Nicolini with a new real wage series produced by Clark (2005) and draw even more radical conclusions. Indeed, at no point during the period 1541-1871 were they able to find evidence of positive checks, while evidence of preventive checks could only be detected until 1640.

One important aspect of this new literature on the Little Divergence between Northwest Europe and the rest of the continent is the focus on the linkages between demographic behaviour and the performance of the economy. This is something which had fallen out of favour following the Princeton Project on the Decline of Fertility in Europe of the 1960s and 1970s, which rejected a significant role for economic and social factors in explaining the demographic transition in favour of a process of innovation and diffusion driven by attitudes and networks of communication (Coale and Watkins, 1986; Brown and Guinnane, 2007: 2). There then followed a period when demographic history and economic history pursued almost separate paths. This recent emphasis by economic historians on the links between demographic and economic developments can be seen as mirroring the exploration of the links between the industrial revolution and the demographic transition in unified growth theory. The approach has been strengthened by the findings of Brown and Guinnane (2007) that the Princeton Project's rejection of a role for economic factors rests on an inappropriate statistical methodology. In particular, Brown and Guinnane are able to show for two important regions studied by the Princeton Project that economic factors were indeed statistically significant determinants of fertility if a lower level of aggregation is used, and if appropriate use is made of information on both levels and rates of change of variables.

Economic historians have also recently paid more attention to the role of human capital, a key variable in unified growth theory, but which had previously been neglected in most accounts of the industrial revolution. Again, however, the picture is more complex than suggested by the early unified growth models. The International Scientific Committee on price history collected vast amounts of data on skilled wage rates to complement the unskilled wage rate data presented in Table 1. This data has been used to calculate the skill premium in Table 5, measured as the ratio of the daily wage of skilled craftsmen to the daily wage of unskilled labourers. This provides a measure of the incentive to invest in human capital, which would be expected to rise at the time of the industrial revolution version of unified growth theory. However, there is little evidence to support this. Although the premium did increase in some countries around the time of the industrial revolution, it fell in others, and where the trend was upwards, there were earlier periods when the premium was as high, if not higher. After a more detailed investigation of the British case using a longer run of annual data, Clark (2005) concludes that at the time of the industrial revolution, the skill premium was substantially below its medieval peak of around 2. Galor (2005: 205) acknowledges this point, but counters it with the suggestion that although the demand for human capital was increasing, this was offset by an increase in the supply of human capital, in particular through the introduction of public education.

It is therefore necessary to look directly for evidence of an increase in the quantity of human capital at the time of the industrial revolution. For England, it is possible to track developments in literacy, as measured by the proportion of the population who could sign their names. For the period after 1750, Schofield (1973) presents data on the proportion of males and females who could sign their names at marriage, while for the period before 1750 Houstan (1982) tracks the proportion of those able to sign court depositions in northern England. For males, the big rise in literacy occurred during the seventeenth century, followed by a pause during the industrial revolution period, before the drive to more or less universal literacy during the second half of the nineteenth century. For females, the data suggest a more or less continuous rise in literacy from a very low level in the mid-seventeenth century. The English case thus offers little support for viewing the industrial revolution as uniquely linked to developments in human capital.

Turning to the literacy data for a wider sample of largely west European countries circa 1800 in Table 6, however, notice again the Little Divergence pattern, with high levels of literacy in northwest Europe covering England and Scotland, Belgium and the Netherlands, France north of the Geneva-St. Malo line and Germany west of the Stralsund-Dresden line. In most of these regions, already 60 to 80 per cent of the male population and over 40 per cent of the female population were literate. In more peripheral regions, literacy rates were much lower, between 10 and 45 per cent for males and 10 to 20 per cent for females (Reis, 2005).

The relationship between real wages, population and human capital during the transition to modern economic growth is thus more complex than suggested by unified growth theory. First, there is evidence that the European economy had ceased to behave in a Malthusian fashion long before the industrial revolution. Although the persistence of a high real wage in England is associated with a slow recovery of the population to pre-Black Death levels, Belgium and the Netherlands achieved a high real wage despite a rapid recovery of population. Second, although the incentive to invest in human capital was higher in the medieval period, there was a substantial increase in literacy in northwest Europe during the early modern period. Third, however, the industrial revolution appears to have coincided with a pause in this process of human capital deepening.

2. Institutions, markets and technology

Kindleberger (1996) and Maddison (2001) are the latest in a long line of economic historians to chart the rise to modern economic growth in the west as a series of growth episodes based around success in long distance trade. Economic primacy is seen as passing from the Italian city states before 1500 to Portugal and Spain in the sixteenth century, then to the Low Countries in the seventeenth century before the industrial revolution led to the primacy of Britain from the late eighteenth century. This approach normally goes hand in hand with a stress on institutions. As in the theoretical section, it is useful to begin the survey of historical work in this area with private order institutions.

Many writers have pointed to the importance of financial and commercial innovations in underpinning the success of the leading economies. Many of the key commercial institutions of the western world can be seen as having their origins in the Italian city states of Venice and Florence, which played such an important role in the revival of long distance trade between Europe and the East from the eleventh century. Deposit banking grew out of money changing, while insurance, the legal form of he modern company and double entry book-keeping all grew up around shipping ventures (Lane, 1966; Mueller, 1997). Similarly, early modern Amsterdam is credited by Neal (1990) with a number of commercial innovations including the bill of exchange, transferable shares in the capital stock of corporations traded on secondary markets and perpetual annuities issued annually by government, free of risk of default (consolidated debt or consols).

Any claim to be the originator of any such practices is always open to challenge, however. Hence another important strand in the literature which traces the origins of western economic success to institutional developments is the emphasis on the growing commercialisation of the economy (Britnell and Campbell, 1995). The growing commercialisation of the European economy can most easily be captured quantitatively in the share of the population living in urban areas, since towns were the centres of commerce. Table 7 provides data on the share of the population living in towns of at least 10,000 inhabitants. For Europe as a whole, the trend is unmistakeably upwards from 1400. Looking at regional trends, however, urbanisation is another variable which displays the Little Divergence patter. In the late medieval period there were two main urban centres of commerce in north Italy and in the Low Countries. While urbanisation stalled in north Italy after 1500, there was a brief surge in Portugal and to a lesser extent Spain during the sixteenth century, following the opening up of the new trade routes to Asia and the New World. However, the most dramatic growth of urbanisation in the early modern period occurred in the Netherlands in the sixteenth and seventeenth centuries and in England during the seventeenth and eighteenth centuries as those countries displaced the Iberian powers in long distance trade and commercialised their domestic economies to an unprecedented extent.

The extent of commercialisation and the spread of specialisation which accompanied it can also be captured in Table 8 in the declining share of the labour force engaged in agriculture. In 1500, the release of labour from agriculture had proceeded further in the Netherlands than in the rest of Europe, as the Dutch economy relied increasingly on imports of basic agricultural products such as grain and paid for them with exports of higher value added products (de Vries and van der Woude, 1997). Although Britain remained self-sufficient in grain until the industrial revolution, commercialisation ensured that by the early nineteenth century the value added per worker in agriculture was no lower than in the rest of the economy (Deane and Cole, 1967: 65; Crafts, 1985: 61-63). After 1500, the sharpest decline in the share of the labour force in agriculture occurred in England, so that by 1800 the share of the labour force engaged in agriculture was lower in England than in the Netherlands. Furthermore, in both countries, agriculture's share of the labour force was substantially lower than in the rest of Europe.

Another strand of the literature which seeks to apply the insights of the new institutional economics to history emphasises the role of state institutions. For North and Weingast (1989), the Glorious Revolution is important in creating the climate for the transition to modern economic growth, by limiting the power of the crown to interfere in economic activity, thus solving the "fundamental problem of exchange". A similar argument can be made for the Dutch Revolt of the late sixteenth century, which overthrew the system of Spanish rule and established constraints on the abuse of executive power. The argument has been generalised by Acemoglu, Johnson and Robinson (2005), who emphasise the interaction between access to the Atlantic and constraints on executive power. They point out that the opening up of the new trade routes after 1500 did not benefit all economies with access to the Atlantic equally. In the countries which gained most (Britain and the Netherlands), there were sufficient constraints on the rulers to endure hat they were unable to appropriate the bulk of the gains from trade. By contrast, in the Atlantic economies which failed most obviously to gain from the new opportunities, despite their early role in the discovery of the new trade routes (Spain and Portugal), rulers were sufficiently strong to exploit the opportunities themselves and prevent a strong merchant class from constraining their powers to appropriate.

As Mokyr (2007) notes, the literature on institutions has tended to say very little about the central feature of the industrial revolution, the dramatic technological change which occurred in Britain in the late eighteenth and early nineteenth centuries. One obvious institutional change which could provide such a link is the patent system, which until very recently has received surprisingly little attention in mainstream economic history. The modern literature really began with the study of the English patent system during the industrial revolution by Dutton (1984) and Sullivan (1989), who highlighted the surge in patents from the middle of the eighteenth century, shown here in Graph 3, and saw it as a causal factor. MacLeod (1988) examined the evolution of the system from the mid-seventeenth to the end of the eighteenth century, but emphasised its shortcomings as much as its advantages.

More recently, the importance of the role of the patent system in the acceleration of British economic growth has been emphasised by Broadberry and Gupta (2007) in the context of cotton textiles, where there was a dramatic shift of competitive advantage between Britain and India. Broadberry and Gupta (2007) emphasise the interaction between the large Anglo-Indian wage gap noted earlier and the institutional feature of the British patent system. High money wages in Britain meant that cotton textiles produced domestically with labour-intensive production methods could not compete with Indian goods in third markets, and could only be sold domestically because of protective measures that remained in force between 1701 and 1774 (Inikori, 2002: 428-432; O'Brien, Griffiths and Hunt, 1991). This stimulated a two-stage process of technological change. First, high wages led to the adoption of a more capital intensive technology in Britain, characterised by the use of labour-saving machinery in factories. Second, this resulted in a faster rate of productivity growth in Britain, because of the patent system, which offered better protection of property rights in innovations that were embodied in machinery than it could afford to other innovations. Hence there was a stronger incentive to devote resources to innovation in the machine-intensive industry of Britain, compared with the labour intensive industry of India.

Note, however, that the argument is contingent on particular historical circumstances surrounding economic relations between Britain and India. The process of import substitution was started by the popularity of cotton cloth imported into Britain and the opportunity given to the early British cotton industry by the protective Calico Acts in force between 1701 and 1774 (Berg, 2002; Inikori, 2002: 428-432; O'Brien, Griffiths and Hunt, 1991). As productivity increased in the machine-intensive British cotton textile industry and stagnated in India, a shift in competitive advantage occurred. However, the shift in competitive advantage was delayed in international markets during the late eighteenth and early nineteenth centuries by a temporary rise in raw cotton prices in Britain, as the increase in production put pressure on factor markets. The shift in competitiveness in the Indian market was delayed further by transport costs, which prevented the British from breaking into the Indian market on a large scale until after 1830 (Ellison, 1886: 63; Twomey, 1983).

Now consider the implications of this approach for the question of why the key technological breakthroughs in cotton textiles occurred first in Britain. When Crafts (1977) posed this question, the obvious comparator country was France, which was being portrayed in revisionist work as having similar development potential (O'Brien and Keyder, 1978). However, the revisionism now seems to have been overdone, and in the recent literature on comparative levels of development, France emerges as a relatively low-wage economy in the eighteenth century (Allen, 2001). The other high-wage European economy was the Dutch Republic, and it is therefore interesting now to restate the question posed by Crafts (1977) as "Why Britain, not Holland?" rather than "Why Britain, not France?" The answer offered here is that while Holland had high wages like Britain, it lacked the large market to provide sufficient rewards for innovation. And while France had a large population to provide a large market, it lacked the high wages to stimulate the adoption of machine intensive technology which underpinned the process of technological change that occurred in Britain.

3. Sustaining economic growth

What makes the British industrial revolution different from previous episodes of growth was that technological progress was not a one-off shift, but a sustained process. The recent economic history literature has focused on a number of ways in which the technological progress of the eighteenth century was sustained into the nineteenth century. One strand looks at the role of the steam engine, while a second stand focuses on the way that the use of fossil fuel overcame an energy constraint. A third strand focuses on the interactions between theoretical and practical knowledge.

Some writers have tended to play down the role of the steam engine, since it was not widely used during the early phase of the industrial revolution. Kanefsky (1979) shows that water wheels generated as much power as steam engines as late as 1830. Thus the finding of von Tunzelmann (1978) that the social saving of the stationary steam engine in 1801 was only 0.2 per cent of GDP in 1801 is not too surprising. However, this may understate the importance of the steam engine if what matters is the avoidance of the onset of diminishing returns, and if the steam engine helped to sustain productivity improvements across a wide range of activities. We now know that the early steam engine had great potential for improvement and could be applied across a growing range of activities. The Savery engine began operation pumping water out of mines, but later engines were used to power machinery in the cotton and iron industries and soon spread to most of the manufacturing sector. They were also used to power steam ships and steam locomotives in the service sector, and they were used to drive machinery in agriculture, and later to drive turbines to produce electricity, the next major source of energy. Calculations of the social savings of railways later in the nineteenth century suggest a much larger impact of just this one aspect of steam technology. For 1865, Hawke (1970) estimates the social savings of the railways of England and Wales at 6.4 to 11.4 per cent of the GDP, depending on the treatment of passenger comfort. Leunig (2006), with a more sophisticated treatment of the saving of time, arrives at a similar figure.

Crafts (2004) has recently assessed the contribution of steam technology to labour productivity growth using the accounting framework of Oliner and Sichel (2000), which includes the effects of capital deepening as well as TFP growth. The results are shown in Table 9, with separate calculations for stationary steam engines, railways and steamships. Although the steam engine made very little contribution to economy-wide labour productivity growth in the early phase of the Industrial Revolution, its contribution increased after 1830, and accounted for around a third of economy-wide labour productivity growth after 1850. Furthermore, Crafts (2004: 348) accepts that this ignores important TFP spillovers from steam in the second half of the nineteenth century, following the introduction of the Corliss steam engine and steamships, which permitted increased agglomeration and specialisation along lines of comparative advantage (Rosenberg and Trajtenberg, 2004).

Wrigley (2004) emphasises the importance for sustained growth of breaking free from the energy constraint of the "organic economy". In an organic economy, the supply of energy is limited by the process of photosynthesis, by which plants use sunlight to produce vegetable growth. This organic material can be used to feed the population, provide heat energy (through burning) or mechanical energy (through feeding to draught animals). Since photosynthesis is not a very efficient process, this set limits to the size of the population and living standards that could be supported from a given land area. Land used for growing wheat to feed the population could not be available for forests to fuel blast furnaces or to provide animal fodder for draught animals. The escape from the energy constraint came with the use of coal, the product of photosynthesis accumulated over millions of years, as a source of energy. The coal-fired steam engine provided an abundant additional source of mechanical energy, while heat energy was increasingly obtained from burning coal rather than wood, culminating in the substitution of coke for charcoal in the smelting of iron during the course of the eighteenth century (Hyde, 1977).

Mokyr (2002) has recently argued that what made the British industrial revolution different from previous episodes of growth was the “industrial enlightenment”, which ensured that the original burst of innovations did not peter out. He draws a distinction between prescriptive knowledge (techniques or recipes that people can follow to produce a particular effect) and propositional knowledge (explanations of why the techniques work). The two sets of knowledge together constitute the set of useful knowledge available to a society. If prescriptive knowledge advances but without any change in propositional knowledge, diminishing returns to invention set in. For Mokyr, the breakthrough to sustained economic growth based on continuous innovation was achieved during the industrial revolution because the advances in prescriptive knowledge were matched by developments in propositional knowledge. This occurred as a result of the growth of “open-science” in western Europe during the Enlightenment and the growing contact between theoretically minded scientists and more practical engineers and technologists.

IV. CONCLUDING REMARKS: COMBINING HISTORY AND THEORY

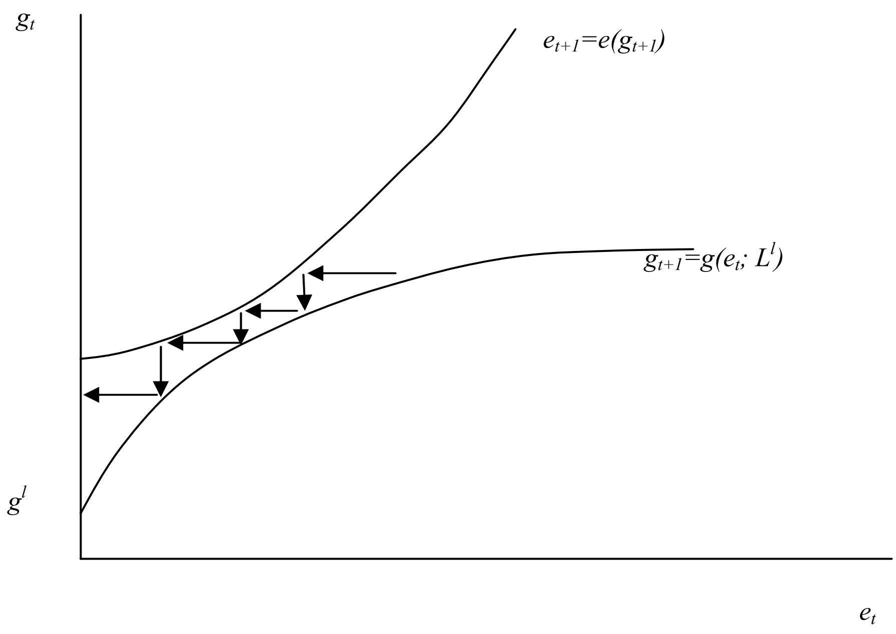
In the introduction, I cited the comments of Schumpeter (1954) on the difficulties created by the existence of historical and theoretical temperaments. In this concluding section, I explore some of the implications of these difficulties, drawing on the examples of the previous sections. First, note that the unit of analysis is often quite different in the theoretical and historical literatures. Unified growth theory, in particular, seems to work best at the level of world development. Indeed, the basic Galor and Weil (2000) model works in terms of a single closed economy. Later work by Galor and Mountford (2007) does explore the Great Divergence within a two-country model, but in a highly stylised way. Where country-specific data are used in Galor (2005), they are typically used for particular episodes and are presented only as suggestive evidence. Historians tend to worry much more systematically about the cross-sectional variation between countries and how it evolves over time, taking delight in those details of the historical process referred to in the quote from Schumpeter (1954: 815) at the beginning of the paper. Historians need to be able to explain the Little Divergence and the differences between Britain and Holland, as well as the Great Divergence. For them, the cross-sectional variation is a crucial part of the story and models must be flexible enough to deal with it in a convincing way and not just as an *ad hoc* afterthought.

A second issue concerns the role of historical contingency. Again, unified growth theorists seem content to treat the industrial revolution as inevitable, with the general framework set up to deliver the transition to modern economic growth and the specifics of the model affecting only the timing. For historians, historical contingency plays a more central role, and things could easily have turned out differently. This point was emphasised by Crafts (1977), who questioned the assumption that because the first industrial revolution occurred first in Britain *ex post*, it must have been more likely there *ex ante*. The importance of historical contingency has since become firmly entrenched in the historical literature via the idea of path dependence, with the sequence of events affecting the final outcome, not just the path taken (David, 1985, Arthur, 1989).

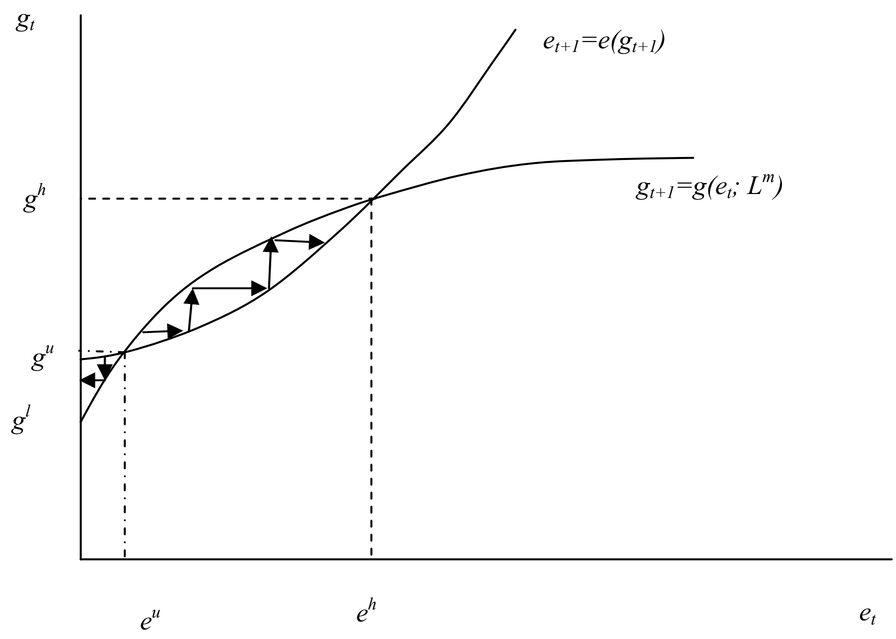
The recent historical and theoretical literatures therefore share a common purpose in breaking away from the traditional practice of using different methods to analyse the world before and after the industrial revolution. However, there remain important differences. From the point of view of an economic historian, it is important that the theoretical framework should remain flexible enough to deal with the cross-sectional variation and leave room for historical contingency.

FIGURE 1: Technological progress and education in the Galor-Weil model

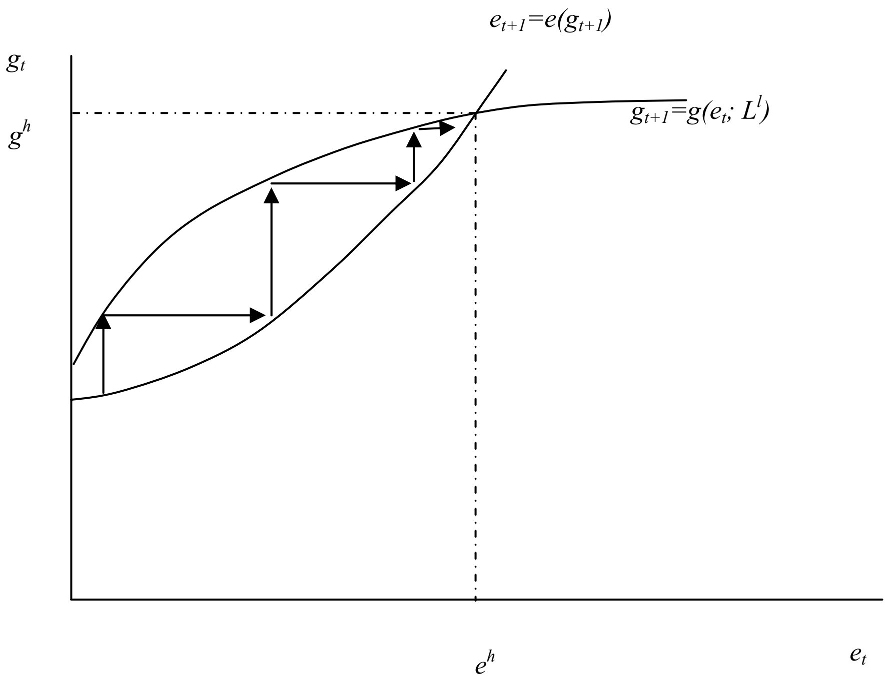
A. Small population



B: Moderate population

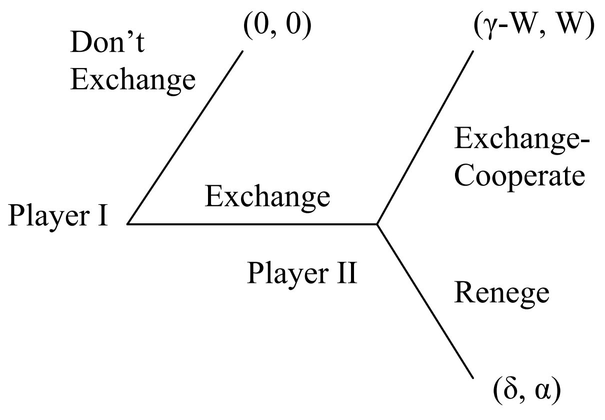


C: Large population



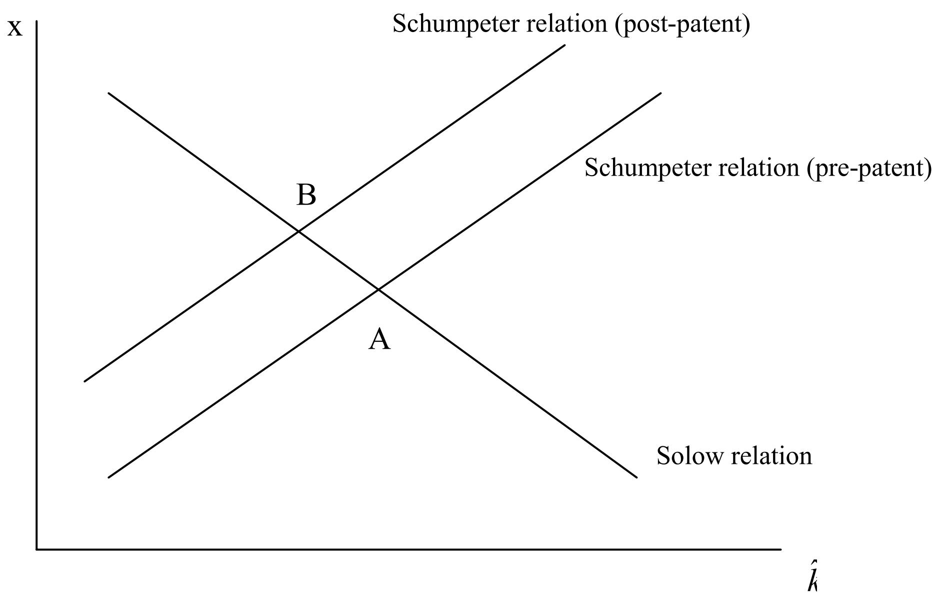
Source: Galor and Weil (2000: 818-820).

FIGURE 2: The one-sided prisoner's dilemma game



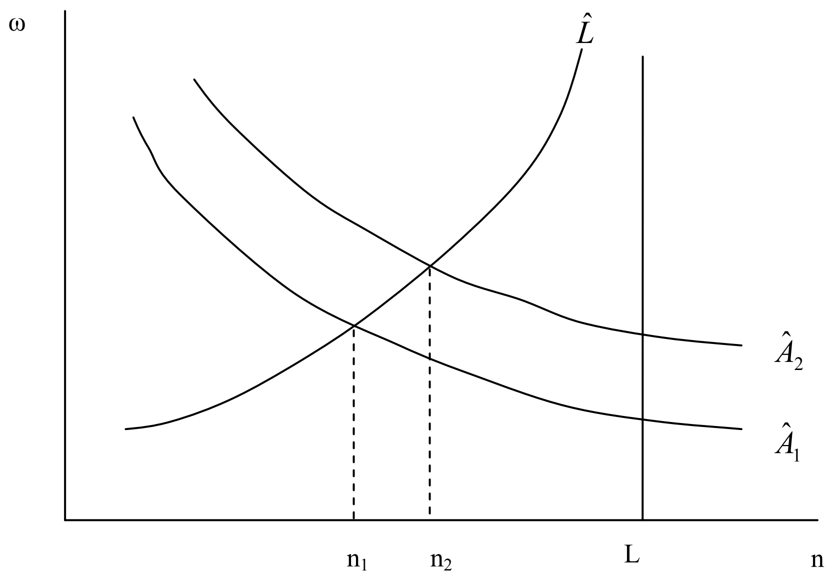
Source: Greif (2000)

FIGURE 3: An increase in returns to innovation



Source: Derived from Carlin and Soskice (2006: 544).

FIGURE 4: Effects of a General Purpose Technology in a Schumpeterian model



Source: Derived from Aghion and Howitt (1998: 58-59)

TABLE 1: Daily real consumption wages of European unskilled building labourers (London 1500-49 = 100)

	1300-49	1350-99	1400-49	1450-99	1500-49	1550-99	1600-49	1650-99	1700-49	1750-99	1800-49
Northwestern Europe											
London	57	75	107	113	100	85	80	96	110	99	98
Amsterdam					97	74	92	98	107	98	79
Antwerp			101	109	98	88	93	88	92	88	82
Paris					62	60	59	60	56	51	65
Southern Europe											
Valencia			108	103	79	63	62	53	51	41	--
Madrid					--	56	51	--	58	42	--
Florence/Milan	44	87	107	77	62	53	57	51	47	35	26
Naples					73	54	69	--	88	50	33
Central & eastern Europe											
Gdansk					78	50	69	72	73	61	40
Warsaw					--	75	66	72	45	64	82
Krakow			92	73	67	74	65	67	58	63	40
Vienna			115	101	88	60	61	63	61	50	27
Leipzig					--	34	35	57	53	44	53
Augsburg					62	50	39	63	55	50	--

Source: Broadberry and Gupta (2006: 7); derived from the database underlying Allen (2001: 429).

TABLE 2: Grain wages of unskilled labourers in England, India and China, 1550-1849

A. Grain wages in England and India (kilograms of grain per day)

Date	England (wheat)	India (wheat)	India (rice, on wheat equivalent basis)	Indian wage as % of English wage
1550-99	6.3	5.2		83
1600-49	4.0	3.8		95
1650-99	5.4	4.3		80
1700-49	8.0		3.2	40
1750-99	7.0		2.3	33
1800-49	8.6	2.5		29

B. Grain wages in England and China (kilograms of grain per day)

Date	England (wheat)	Yangzi delta (rice)	Yangzi delta (rice, on wheat equivalent basis)	Chinese wage as % of English wage
1550-1649	5.2	3.0	4.5	87
1750-1849	7.8	2.0	3.0	38

Source: Broadberry and Gupta (2006: 17, 19).

TABLE 3: Levels of annual GDP per capita in Western Europe (Great Britain in 1820=100)

	1300	1400	1500	1570	1650	1700	1750	1820
Great Britain	29	38	43	44	54	69	84	100
Netherlands			58	58	95	94	94	92
Belgium			46	55	53	55	61	62
Italy	71	71	67	65	60	57	61	53
Spain			46	46	44	42	41	48
Sweden				51				56
Poland			49	45	46	38	32	41
Weighted average			54	54	55	56	56	58

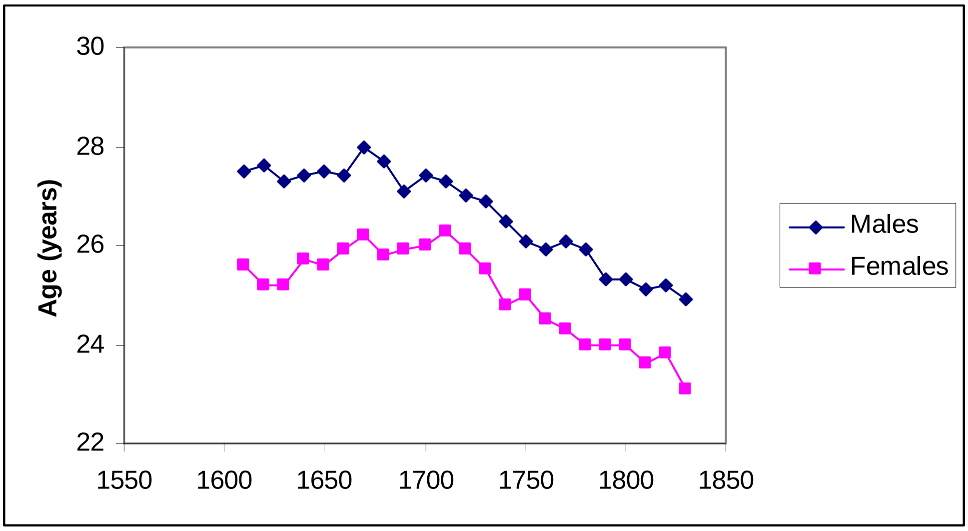
Source: Derived from van Zanden (2006).

TABLE 4: European population by country (millions)

	1300	1400	1500	1600	1700	1750	1800	1870
Scandinavia	1.8	1.4	1.5	2.4	2.9	3.6	5.2	13.3
England (Wales)	4.5	2.7	3.5	4.5	5.5	6.3	9.3	23.0
Scotland	1.0	0.7	0.8	1.0	1.2	1.2	1.6	3.4
Ireland	1.4	0.7	0.8	1.0	1.9	3.1	5.2	5.8
Netherlands	0.8	0.6	1.0	1.5	2.0	2.0	2.1	3.7
Belgium	1.3	1.0	1.4	1.6	2.0	2.2	2.9	4.9
France	16.0	12.0	15.0	18.5	21.5	24.6	29.0	38.0
Italy	12.5	8.0	9.0	13.3	13.5	15.5	18.1	28.0
Spain	5.5	4.5	5.0	6.8	7.4	9.3	10.5	16.2
Portugal	1.3	1.1	1.2	1.3	2.0	2.6	2.9	4.3
Switzerland	0.8	0.5	0.8	1.0	1.2	1.3	1.7	2.7
Austria (Czech, Hung)	10.0	9.0	11.5	12.8	15.5	18.3	24.3	35.7
Germany	13.0	8.0	9.0	16.2	14.1	17.5	24.5	41.0
Poland	2.0	1.5	2.0	2.5	2.8	3.7	4.3	7.4
Balkans	6.0	5.0	5.5	7.0	8.5	9.9	15.1	23.7
Russia (European	15.0	11.0	15.0	16.0	13.0	22.0	35.0	63.0
EUROPE	92.9	67.7	83.0	107.4	115.0	143.1	191.7	314.1
EUROPE (exc Russia)	77.9	56.7	68.0	91.4	102.0	121.1	156.7	251.1

Source: Paolo Malanima (private communication).

GRAPH 1: Mean age at first marriage, England (decennial data)



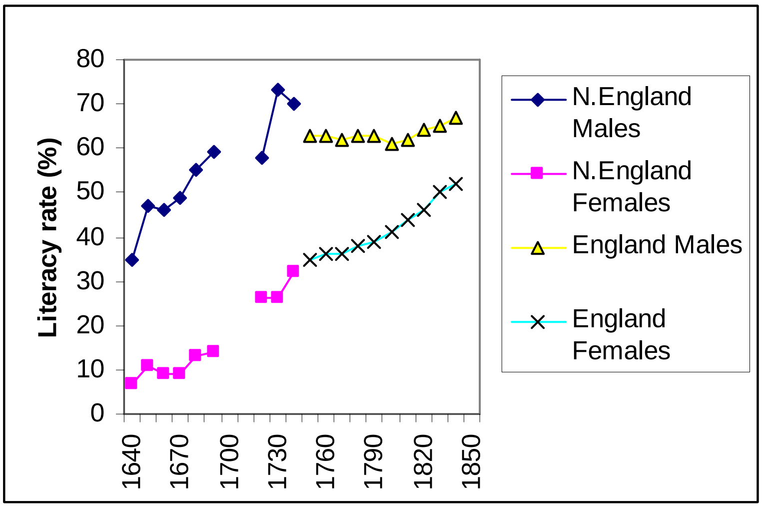
Source: Wrigley et al. (1997: 134).
Note: Each observation refers to the decade beginning in the year indicated. Thus, for example, the 1610 observation refers to 1610-19.

TABLE 5: Skill premium (ratio of skilled wage to unskilled wage)

	1500-49	1550-99	1600-49	1650-99	1700-49	1750-99	1800-49
Northwestern Europe							
London	1.56	1.50	1.59	1.49	1.40	1.55	1.63
Southern England	1.68	1.50	1.49	1.50	1.49	1.52	1.51
Amsterdam	1.45	1.49	1.44	1.40	1.31	1.29	1.32
Antwerp	1.73	1.75	1.66	1.66	1.67	1.67	1.66
Paris	1.57	1.64	1.61	1.59	1.61	1.79	1.66
Southern Europe							
Valencia	1.55	1.29	1.19	1.49	1.51	1.49	--
Madrid	--	1.98	2.51	--	2.27	2.02	2.06
Milan	--	--	1.78	1.95	1.91	1.86	2.00
Florence	1.83	1.97	2.26	--	--	--	--
Naples	2.06	1.57	1.47	--	1.23	1.50	1.73
Central & eastern Europe							
Gdansk	1.33	2.23	1.68	1.79	1.76	1.41	1.67
Warsaw	--	1.44	1.75	1.59	2.79	2.18	2.22
Krakow	2.0	1.79	1.24	1.41	1.50	1.31	2.17
Vienna	1.48	1.50	1.25	1.49	1.50	1.60	1.52
Leipzig	--	1.74	1.94	1.79	1.68	1.61	1.52
Augsburg	1.67	1.35	1.35	1.38	1.43	1.26	--

Source: Derived from Broadberry and Gupta (2006: 5).

GRAPH 2: Literacy rates in England, 1640-1840



Sources: Houstan (1982); Schofield (1973).

TABLE 6: Literacy rates in Europe, circa 1800

	Males	Females	All
England	60	40	
Scotland	65	15	
France	48	27	
Northern France	71	44	
Southern France	44	17	
Belgium	60	37	
Netherlands	73	51	
Germany			
Saxony	80	44	
Hesse	91	43	
Norway			21
Sweden			20-25
Portugal			<20
Italy			
Piemonte			25
Duchy of Parma	45	23	
Marche	17	6	
Hungary			6

Source: Reis (2005).

TABLE 7: European urbanisation rates (%)

	1300	1400	1500	1600	1700	1750	1800	1870
Scandinavia	--	--	0.7	2.1	4.3	4.6	4.6	5.5
England (Wales)	4.0	2.5	2.3	6.0	13.2	16.4	22.1	43.0
Scotland	--	--	2.3	1.5	5.3	11.5	23.9	36.3
Ireland	0.8	2.1	--	1.0	5.1	5.1	7.3	14.2
Netherlands	--	--	17.1	29.5	32.5	29.6	28.6	29.1
Belgium	18.2	21.9	17.6	15.1	20.2	16.5	16.6	25.0
France	5.2	4.7	5.0	6.3	8.7	8.7	8.9	18.1
Italy CN	18.0	12.4	16.4	14.4	13.0	13.6	14.2	13.4
Itali SI	9.4	3.3	12.7	18.6	16.1	19.4	21.0	26.4
Spain	12.1	10.2	11.4	14.5	9.6	9.1	14.7	16.4
Portugal	3.6	4.1	4.8	11.4	9.5	7.5	7.8	10.9
Switzerland	3.0	2.0	2.8	2.7	3.3	4.6	3.7	8.2
Austria (Czech, Hung)	0.6	0.5	0.8	1.6	1.7	2.6	3.1	7.7
Germany	3.4	3.9	5.0	4.4	5.4	5.7	6.1	17.0
Poland	1.0	1.3	5.4	6.6	3.8	3.4	4.1	7.8
Balkans	5.2	4.6	7.7	13.3	14.0	12.3	9.8	10.6
Russia (European	2.1	2.3	2.0	2.2	2.1	2.5	3.6	6.7
EUROPE	5.4	4.3	5.6	7.3	8.2	8.0	8.8	15.0
EUROPE (exc Russia)	5.4	4.4	5.7	7.4	7.9	7.6	8.1	12.8

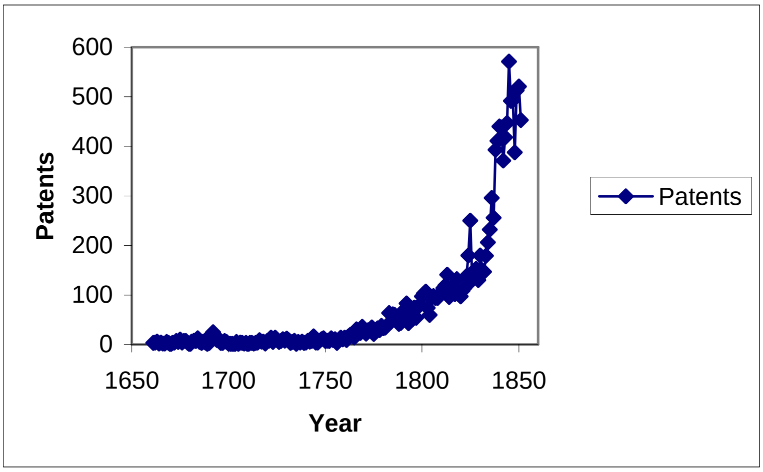
Source: Paolo Malanima (private communication).

TABLE 8: Share of agriculture in the labour force (%)

	England	Netherlands	Italy	France	Poland
1300	76.4	--	63.4	--	--
1400	73.6	--	60.9	71.4	76.4
1500	72.8	56.8	62.3	73.0	75.3
1600	68.9	48.7	60.4	67.8	67.4
1700	55.0	41.6	58.8	63.2	63.2
1750	45.0	42.1	58.9	61.1	59.3
1800	35.5	40.7	57.8	59.2	56.2

Source: Derived from Allen (2000: 8-9).

GRAPH 3: Patents issued in England, 1661-1851



Source: Derived from Sullivan (1989).

TABLE 9: British labour productivity growth and the contribution of steam technology (% per annum)

		Contribution of steam technology:			
	Economy-wide labour productivity growth	Stationary steam engines	Railways	Steam ships	Total
1760-1800	0.2	0.01			0.01
1800-1830	0.5	0.02			0.02
1830-1850	1.1	0.04	0.16		0.20
1850-1870	1.2	0.12	0.26	0.03	0.41
1870-1910	0.9	0.14	0.07	0.10	0.31

Source: Derived from Crafts (2004).

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