Commercialisation, Factor Prices and Technological Progress in the Transition to Modern Economic Growth

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Abstract: We provide a model of the links between commercialisation and technological progress, which is consistent with the historical evidence and places market relations at the heart of the industrial revolution. First, commercialisation raised wages as a growing reliance on impersonal labour market transactions in place of customary relations with a high degree of monitoring led to the adoption of efficiency wages. Second, commercialisation lowered interest rates as a growing reliance on impersonal capital market transactions in place of active investor involvement in investment projects led investors to allow borrowers to keep a larger share of the profits. Third, the resulting rise in the wage/cost of capital ratio led to the adoption of a more capital-intensive technology. Fourth, this led to a faster rate of technological progress through greater learning by doing on the capital intensive production technology. Fifth, the rate of technological progress was raised further by the patent system, which allowed the commercialisation of property rights in innovations embodied in machinery.

JEL classification: N13, O14, O43
Key words: Commercialisation, factor prices, technological progress

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I. INTRODUCTION

A long tradition in economic history links the transition to modern economic growth to the widespread commercialisation of northwest Europe between the late medieval period and the Industrial Revolution (Toynbee, 1884; Polanyi, 1944; Britnell and Campbell, 1995). However the precise nature of the links has remained obscure. We argue in this paper that the growing commercialisation of the late medieval and early modern periods led to the technological progress of the Industrial Revolution via its effects on factor prices.

We begin, therefore, with a definition of commercialisation, which we take to mean more than simply an increase in the proportion of output passing through the market (Britnell and Campbell, 1995: 1). Commercialisation is seen here as encompassing also a growing reliance on anonymity in factor markets as labour markets became more integrated nationally and factor markets more integrated internationally as well as nationally. Finally, we include also in our definition the creation of a market in inventions via the patent system.

The link between commercialisation and technological progress thus proceeds as follows. First, commercialisation raised wages as a growing reliance on impersonal labour market transactions in place of customary relations with a high degree of monitoring led to the adoption of efficiency wages. Second, commercialisation lowered interest rates as a growing reliance on impersonal capital market transactions in place of active investor involvement in investment projects led investors to allow borrowers to keep a larger share of the profits. Third, the resulting rise in the wage/cost of capital ratio led to the adoption of a more capital-intensive technology.

Fourth, this led to a faster rate of technological progress through greater learning by doing on the capital intensive production technology. Fifth, the rate of technological progress was raised further by the patent system, which offered greater protection of property rights in innovations embodied in machinery.

The approach taken here draws on ideas which have been used in the literature on the importance of high wages in stimulating the innovations of the Second Industrial Revolution in late nineteenth century America (Habakkuk, 1962, David, 1975). Until recently, there has been a reluctance to cast Britain in the role of a high wage producer at the time of the Industrial Revolution, since the vast literature on the standard of living debate emphasised the slowness of real wages to rise. However, recent work has emphasised international comparisons of the level of real wages and other factor prices, pointing clearly to Britain's exceptional combination of factor prices (Allen, 2001; 2006; Broadberry and Gupta, 2006; 2008). This is important not only in explaining the adoption of modern technology, but also its non-adoption in other countries with different factor prices, a point emphasised in the theoretical literature by Zeira (1998) and in the historical literature by Broadberry and Gupta (2008), Allen, (2006) and Fremdling (2000). It should be noted that our approach provides a more direct link between commercial development and economic growth than that provided by Acemoglu et al. (2005), who emphasise an interaction between the growth of Atlantic trade and institutions in the form of constraints on the executive. Our approach also maps into variables which are more objectively measurable than institutional quality.

The paper proceeds as follows. In section II, we provide a theoretical model to establish the links between commercialisation and technological progress. Here, we build upon the approach of Greif (1994), who established a link between anonymous market trading relationships and efficiency wages, but without considering explicitly the implications for technology. In section III, we then examine the historical evidence on the links between the commercialisation of the late medieval and early modern period and the technological progress of the Industrial Revolution, focusing on the "Little Divergence" of productivity and living standards within Europe before the "Great Divergence" between Europe and Asia.

II. MODELLING THE TRANSITION TO MODERN ECONOMIC GROWTH

In this section we provide a simple model which links the technological development of the industrial revolution period to the prior commercial development of the late medieval and early modern periods via factor prices. Growing commercialisation leads to an increase in the wage rate, a decline in the rate of interest and hence an increase in the wage/rental price of capital ratio. This leads in turn to the adoption of more capital intensive technology and an acceleration in the rate of technological progress. The commercialisation of invention through the patent system leads to a further increase in the rate of technological progress.

1. The basic framework

There are two technologies to produce a consumption good A with fixed factor proportions, indexed $i \in \{M, T\}$, where the modern technology M is capital intensive, while the traditional technology T is labour intensive. Thus, denoting capital by k_i and labour by l_i, we assume that $k_M > k_T$ and $l_M < l_T$. With a wage rate w and a rate of interest r, entrepreneurial profits are given by:

$$A - l_i\, w - k_i\,(1+r)$$

The user cost of capital is $(1+r)$ in our framework, since the price of capital is normalised to unity, there are no capital gains and the capital depreciates fully after production. There are L individuals in the economy, each endowed with a unit of labour that can be supplied with a utility cost normalised to unity. Shirking workers do not supply their unit of labour and therefore do not suffer this disutility. Among the L individuals there are n entrepreneurs who can organise production using one of the two technologies. For simplicity, we assume that $k_T = 0$, so there is no need to borrow if the traditional technology is adopted. Finally, we assume that $n\, l_T < L$ so there is always excess supply of labour.[1]

2. Production

An entrepreneur willing to produce with the modern technology needs to borrow k_M from a financial sector at interest rate r. Each entrepreneur who uses the M technology will obtain utility:

$$U_M = A - (l_M - 1)\, w - k_M\, r - 1 \qquad (1)$$

while each entrepreneur who uses the T technology will obtain utility:

$$U_T = A - (l_T - 1)\, w - 1 \qquad (2)$$

3. The labour market

[1] This implies that $(\alpha\, n\, l_M + (1-\alpha)\, n\, l_T) < L$, for all α, where α is the share of entrepreneurs using the modern technology

Once hired, individuals decide whether to supply effort or to shirk. If they are caught shirking, they will not receive any wages. Since the probability of getting away with shirking is q_L, the wage w has to satisfy the no-shirking constraint, $q_L\, w < w - 1$, or:

$$w \geq \frac{1}{1 - q_L} \tag{3}$$

Condition (3) is a familiar result from the theory of efficiency wages, and appears also in the work of Greif (1994) as a mechanism for merchants deterring the opportunistic behaviour of agents. The interesting implication here is that a greater reliance on anonymous market forces rather than customary relations will lead to an increase in wage rates. As $q_L \rightarrow 1$, so w rises. This is because workers need to be paid more than their reservation wage, so as to deter opportunistic behaviour in the form of shirking. In a world of personalised labour relations, the employer does not need to pay an efficiency wage, but rather monitors the performance of the workers directly.

Comparing (3) with (1) and (2) and noticing that $l_T > l_M$, we can argue that a labour market equilibrium exists if $A-1 > (l_T - 1)/(1-q_L)$ or

$$q_L < (A - l_T)\,(A-1), \tag{4}$$

which henceforth we will assume to hold. This is necessary, because if q_L is too high, then the entrepreneur cannot make a profit and no labour market equilibrium will exist.

4. The capital market

The demand for capital arises from the desire of entrepreneurs to use the modern technology. Entrepreneurs need capital k_M to invest in the modern technology, but at the same time provide knowledge which is specific to the project. Hence another individual cannot take over the project once the investment has been made, which generates a lock-in effect. Accordingly, on one side of the market, the provider of capital may threaten the entrepreneur to withdraw the finance, while on the other side of the market, the entrepreneur can threaten the provider of capital to withdraw his project specific knowledge, making the investment unprofitable. The interest rate r has an upper bound since the entrepreneur, exactly like the workers before, may cheat by defaulting on his loan and running away with the entire profits without paying the capital owners. Similarly to the earlier case of labour market shirking, q_K is the probability of getting away with this reneging on contractual responsibilities. From the following no-default condition $q_K (A - (l - 1) w) < A - k_M (1+r) - (l - 1) w$, we obtain: $(1+r) \leq \frac{(1-q_K)\left(A-(l_M-1)w\right)}{k_M}$.

Accordingly the equilibrium interest rate is the result of a bargaining process with $(1+r) \in \left(0, \frac{(1-q_K)\left(A-(l_M-1)w\right)}{k_M}\right)$. Moreover, we assume that entrepreneurs and capital owners enter into a Nash bargain, so that in equilibrium:

$$(1+r^*) = \frac{(1-q_K)\left(A-(l_M-1)w^*\right)}{2k_M} \qquad (5)$$

As the probability of escaping without penalty rises ($q_K \rightarrow 1$), the interest rate r declines. The implication here is that placing greater reliance on anonymous market forces rather than customary relations results in lower interest rates. The reason for this is that the entrepreneur has to be allowed to keep a greater proportion of the profits to make opportunistic behaviour less attractive. In a world where the investor takes an active part in the project, there is less need to rely on such incentive mechanisms, since the investor can monitor the project more tightly.

5. Choice of technology

We now characterise equilibrium in the model. It is natural to think that q_L and q_K are correlated, so for notational simplicity we assume $q_L = q_K = q$. Because of the assumption of excess supply of labour, the no-shirking constraint is always binding, so the equilibrium wage is:

$$w^* = \frac{1}{1-q} \tag{6}$$

Moreover, we assume that entrepreneurs and capital owners enter into a Nash bargain, so that in equilibrium:

$$r^* = \frac{(1-q)\big(A-(l_M-1)w^*\big)}{2k_M} \tag{7}$$

Notice that the two equilibria exist only if $1\text{-}q>(l\text{-}1_M)/A$, a condition that we will henceforth assume to be satisfied. Using the modern technology, entrepreneurial utility in equilibrium can be obtained by substituting for w and r in equation (1):

$$U_M = \frac{(1+q)}{2}A - \left(\frac{(l_M-1)(3-q)}{2}\right) - 1 \tag{8}$$

This is inverse u-shaped in Figure 1.

Using the traditional technology, the equilibrium wage is again given by equation (6), with the no-shirking constraints binding. Entrepreneurial utility in equilibrium is then obtained by substituting for w and r in equation (2):

$$U_T = A - \frac{(l_T-1)}{(1-q)} - 1 \tag{9}$$

This is always downward sloping in Figure 1. Comparing the equilibrium utilities, we can derive the following proposition:

Proposition 1: *There is a probability of getting away with shirking or defaulting q^*, such that entrepreneurs choose the modern technology iff $q > q^*$*

Note from Figure 1 that the higher is q, the probability of getting away with shirking or defaulting, the lower the rental cost of capital and the higher the wage. Hence there will be a switch away from the labour intensive to the capital intensive technology as q increases.

6. Technological progress

The use of a capital-intensive technology has a positive spillover generated by learning by doing. More formally, assume that the economy replicates itself once, and that the technology increases according to the following rule.

$$A(t+1) = A(t)(1+ i(K(t))\chi \qquad (10)$$

where $K(t)= n_M(t)\, k_M$ and $n_M(t)$ is the number of entrepreneurs using the capital intensive technology at time t, $i(.)$ is the number of innovations and χ the value of each innovation. As more entrepreneurs adopt the capital intensive technology, there will thus be an acceleration in the rate of technological progress.

We now provide micro-foundations for this process of technological progress, to illustrate the importance of an efficient system for protecting intellectual property. We assume that all individuals can have an idea, with probability μ, for improving the technology when working in a capital intensive firm. The process of thinking requires a fixed cost c in terms of effort. If the innovator can appropriate an amount γ from the innovation, the expected profit from an innovation is $\gamma\mu\chi - c$. Accordingly, there will only be innovations if $\gamma > c/\mu\chi$. If patent protection is sufficiently poor, γ will be too low to generate technological progress.

III. COMMERCIALISATION AND TECHNOLOGY IN HISTORY, 1300-1850

1. Patterns of commercialisation

Recent research suggests that northwest Europe, particularly Britain and Holland, developed very differently from the rest of Europe from the late middle ages. 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 from the time of the Industrial Revolution (Pomeranz, 2000). To avoid confusion, we prefer to use the term "Little Divergence" to describe this Anglo-Dutch development. Since the Industrial Revolution occurred in northwest Europe at the end of the Little Divergence, a full understanding of the take-off to modern economic growth requires a study cutting across the conventional time periods of economic history. This section argues that the key aspects of the Little Divergence all reflect different aspects of a single process, the growing commercialisation of the region.

One way in which the growing commercialisation of the economy can be captured quantitatively is in the share of the population living in urban areas, since towns were the centres of commerce. Table 1 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 displays the Little Divergence pattern. 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 2 in the declining share of the labour force engaged in agriculture. The link between commercialisation and the share of the labour force in agriculture is at least implicit in the historical literature on proto-industrialisation following the work of Mendels (1972), who saw commercialisation leading to the development of industry in the countryside before the Industrial Revolution. It is also implicit in the work of Brenner (1982), who emphasises the contrast between England, where the peasantry was replaced by tenants and labourers who had to compete in the market, and the continent where peasants were able to cling to the land and preserve feudal property rights. 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.

2. Wages

The Little Divergence was first identified from the comparison of levels rather than simply growth rates of 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 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 (2007) has looked at the European data back to 1300, crossing the period of the Black Death.

Table 3 sets out the pattern of silver wages in Europe. The silver wage is the silver content of the money wage in the local currency, and is useful for comparing wages across countries on a silver standard. Note first that Northwestern Europe saw substantial silver wage growth in the century after the Black Death of the mid-fourteenth century and again during the early modern period after 1500, as well as during the Industrial Revolution period from the mid-eighteenth century, when Britain finally overtook the Netherlands decisively. Second, note that although southern Europe shared in the rise in the silver wage following the Black Death, from the mid fifteenth century the region was characterised more by fluctuations than by trend growth in the silver wage. Third, central and eastern Europe were also characterised more by fluctuations than by trend growth in the silver wage from the mid-fourteenth century. If commercialisation leads to rising wages, this is the pattern that we would expect, with southern Europe playing an important part in the commercialisation of the continent during the first half of the millennium, but with northwest Europe playing the leading role after 1500.

3. Interest rates and the cost of capital

We are interested in the incentives to adopt capital intensive technology. Hence we need also to examine the cost of capital, an important element of which is the rate of interest. The path of the risk-free rate of interest in Britain over the period between the mid-twelfth and mid-nineteenth centuries has been measured by Clark (1988) in two ways. First, perpetual rent charges were perpetuities which gave the purchaser a specified payment each year, with the payment secured on buildings or land. The ratio of the rent to the purchase price can be used to calculate the rate of interest in nominal terms. Second, an estimate of the rate of interest in real terms can be obtained by comparing the ratio of land rents to land prices. The real rate of return on holding land (r) is given by:

$$r = R / P_L + \hat{P}_L / P_L - \hat{P} / P$$

where R is the nominal land rent, P_L is the price of land, P is the general price level and a hat over a variable indicates the rate of change. Since the real price of land did not appreciate rapidly over this period, the ratio of the land rent to the price of land can be taken as an indicator of the real rate of interest.

Since the annual inflation rate was generally low during this period, nominal and real rates are not very different, as can be seen in Table 4. Both the rent charges and the land rent data suggest a rate of interest around 10% in the late medieval period, falling to 5-6% in the aftermath of the Black Death, 1350-1400. There was a further reduction in the rate of interest during the first half of the eighteenth century, to around 3-4%.

The evidence for a number of other European countries is shown in Table 5, indicating a similar decline in interest rates in all countries for which we have data. This is consistent with the convergence of interest rates within an integrated capital market, and can be seen also in Epstein's (2000: 19) data on interest rates on public debt and in Neal's (1990: 141-165) data on stocks that were traded internationally. This pattern can be attributed to the greater international mobility of capital than labour. The downward trend of interest rates in Europe, combined with the increase in wages, translates into an increase in the wage/cost of capital ratio.

4. Factor prices and technology

Although interest rates had converged by the eighteenth century, wages had not, which means that the wage/cost of capital ratio was higher in northwest Europe than in the rest of the continent, providing a greater incentive for the substitution of capital for labour in Britain and Holland. And yet until very recently, there has been surprisingly little work on the role of factor prices in the adoption of capital intensive technology before or during the Industrial Revolution. The omission is all the more surprising given the central role accorded to factor prices in most accounts of Anglo-American differences in technology and productivity during the nineteenth century (Rothbarth, 1946; Habakkuk, 1962; David, 1975; Broadberry, 1997).

Recent work by Broadberry and Gupta (2006; 2008) and by Allen (2006) emphasises the important role of factor prices in explaining the key technological choices of the Industrial Revolution period. Broadberry and Gupta (2008) point to the much higher wages in Britain than in India already in the late seventeenth century, when Indian cotton textiles were imported into Britain by the East India Company. This can be seen in the first column of Table 6. Combined with the smaller differences in the cost of raw cotton and the cost of capital, this presented British producers with a severe total factor input (TFI) price disadvantage. To get to a point where the free on board price was cheaper in Britain, required a shift to more capital intensive technology and a sustained period of technological progress to increase total factor productivity (TFP). For much of the eighteenth century, the fledgling British cotton industry required protection, although the point at which the shift in competitive advantage from India to Britain occurred varied by product (as a result of different input costs) and by market (as a result of transport costs).

As Allen (2006) notes, another feature of Britain's unusual factor price development was the high price of wood and low price of coal, which encouraged a shift to coal-using technology. In the case of the cotton industry, this became a major factor only after the period of the major macro inventions, since water power was the main source of energy before the 1820s. Allen (2006) also sees Britain's high wages as important in explaining why the innovations of the Industrial Revolution period were not immediately applicable to other European economies, where wages were lower than in Britain.

Once the shift to capital-intensive technology had occurred, technological progress accelerated. In Table 6, TFP growth shifted in Britain's favour at an annual rate of 0.3 per cent before 1770, rising to 1.5 per cent during the period 1770-1820. This would be quite consistent with the 1.9 per cent per annum TFP growth rate estimated by Harley (1993: 200) for the British cotton industry between 1780 and 1860, together with slowly rising or stagnating productivity in India.

One reason for expecting an increase in TFP growth following the shift to capital intensive technology is the greater potential for learning on capital intensive technology, as emphasised by Arrow (1962). However, modern Schumpeterian models of economic growth also emphasise the role of the patent system, which gave better protection of intellectual property rights to innovations embodies in machinery (Aghion and Howitt, 1998). Until very recently, the patent system during the Industrial Revolution 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 Figure 2, 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, Broadberry and Gupta (2008) emphasise the role of the British patent system, or other incentives to innovate such as prizes, in the acceleration of technological progress in cotton textiles.

5. The upshot for economic development

In Table 3, we examined the path of silver wages. However, an analysis of the transition to modern economic growth would not be complete without considering the path of real consumption wages and GDP per capita. The real consumption wage is obtained by dividing the silver wage with the silver price of basic consumption goods. Real consumption wages of European unskilled building labourers for the period 1300-1850 are shown in Table 7, taking London in the period 1500-49 as the numeraire. The first point to note is that real 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 broadly 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.

Table 7 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 7 should not be taken as indicative of stagnating real per capita incomes in northwest Europe before the Industrial Revolution. Table 8, taken from van Zanden (2006), provides estimates of per capita GDP 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.

The historical data thus point to the emergence of modern economic growth as along drawn out affair, reaching back to the rise of real wages in the late medieval period, following the Black Death, and the subsequent divergent path of relative factor prices in northwest Europe and the rest of the continent. This divergence in relative factor prices led to the adoption of a more capital intensive production process in northwest Europe, culminating in the acceleration of techno logical progress in Britain during the Industrial Revolution.

IV. CONCLUDING COMMENTS

We have argued that commercialisation played a pivotal role in the transition to modern economic growth. We see the growing commercialisation of the late medieval and early modern periods as leading to the acceleration of technological progress during the Industrial Revolution period via its effects on factor prices. The argument can be summarised as follows: (1) Commercialisation raised wages as a growing reliance on impersonal labour market relations in place of customary relations with a high degree of monitoring led to the adoption of efficiency wages. (2) Commercialisation lowered interest rates as a growing reliance on impersonal capital market transactions in place of active investor involvement in investment projects led investors to allow borrowers to keep a larger share of the profits. (3) The resulting rise in the wage/cost of capital ratio led to the adoption of a more capital-intensive production technology. (4) This led to a faster rate of technological progress through greater learning by doing on the capital intensive technology (5) The rate of technological progress was also raised by the patent system, which offered greater protection of property rights in innovations embodied in machinery. The patent system can itself be seen as another reflection of the spread of commercialisation to the process of invention.

We have used the term “commercialisation” to describe the process of evolution of the institutional system, noting that the growing reliance on market forces proceeded more rapidly in northwest Europe than in the rest of the continent following the Black Death in the mid-fourteenth century. We do not have a simple answer to why the northwestern and southern parts of Europe responded so differently in terms of commercial development to the shock of the Black Death. However, by mapping into directly measurable variables such as factor prices, we hold out the possibility of a more empirical approach to the role of institutions in very long run growth.

FIGURE 1: Effects of q on choice of technology

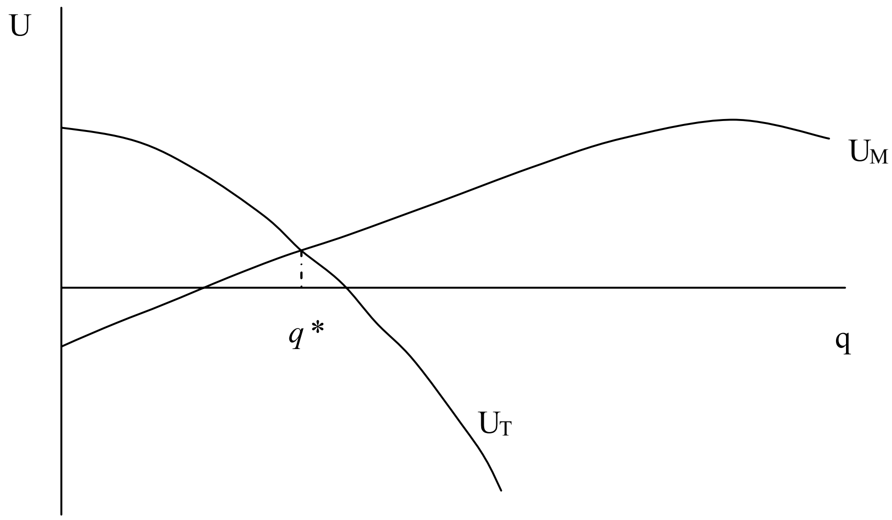


TABLE 1: European urbanisation rates (%)

	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
Italy 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

Source: Paolo Malanima (private communication).

TABLE 2: 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).

TABLE 3: Daily silver wages of European unskilled building labourers (grams of silver per day)

	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	2.9	3.4	4.5	3.8	3.2	4.6	7.1	9.7	10.5	11.5	17.7
Amsterdam					3.1	4.7	7.2	8.5	8.9	9.2	9.2
Antwerp			3.5	3.1	3.0	5.9	7.6	7.1	6.9	6.9	7.7
Paris					2.8	5.5	6.6	6.9	5.1	5.2	9.9
Southern Europe											
Valencia			5.6	5.2	4.2	6.6	8.8	6.9	5.7	5.1	--
Madrid					--	6.3	8.0	--	5.1	5.3	8.0
Florence/Milan	2.2	4.5	3.8	3.5	2.9	3.8	4.7	4.1	3.2	2.9	3.1
Naples					3.3	3.5	5.3	4.8	4.8	3.8	3.8
Central & eastern Europe											
Gdansk					2.1	2.1	3.8	4.3	3.8	3.7	4.8
Warsaw					--	2.5	3.2	2.7	1.9	3.4	4.9
Krakow			2.7	2.1	1.9	2.9	3.4	2.9	2.2	2.9	2.4
Vienna			4.0	3.2	2.7	2.6	4.4	3.5	3.2	3.0	2.1
Leipzig					--	1.9	3.5	3.9	3.7	3.1	4.4
Augsburg					2.1	3.1	4.0	4.7	4.2	4.3	--

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

TABLE 4: Interest rates in Britain (% per annum)

	Perpetual rent charges (nominal)	Rent/price ratio on land (real)	Annual inflation rate
1151-1200	9.5		
1201-1250	10.3	7.3	+0.5
1251-1300	10.2	10.3	+0.5
1301-1350	11.2	10.2	+0.3
1351-1400	4.5	9.4	0.0
1401-1450	--	5.6	0.0
1451-1500	4.0	5.0	+0.2
1501-1550	4.6	5.5	+1.2
1551-1600	6.0	5.8	+1.8
1601-1650	6.0	5.4	+0.7
1651-1700	5.3	5.4	-0.2
1701-1750	4.3	4.3	-0.3
1751-1800	4.0	3.6	+1.4
1801-1850		3.6	-0.8

Source: Clark (1988: 273)

TABLE 5: Interest rates in other European countries (% per annum)

	Flanders (land)	France (rent charges)	Italy (land)	Italy (rent charges, wheat)	Italy (rent charges, money)	Germany (rent charges)
1201-1250		10.8	8.6	9.5		
1251-1300	10.0	11.1	10.6	10.9		10.8
1301-1350			12.9	14.0	7.3	10.1
1351-1400			8.1	10.3	6.0	9.7
1401-1450			9.6	10.4	8.4	8.5
1451-1500	6.4	9.2	7.6	11.6		6.5
1501-1550		8.2				5.3
1551-1600	4.3	8.3				
1601-1650	3.9	6.6				
1651-1700	4.4					
1701-1750	3.8	4.2				
1751-1800	2.7	4.8	4.7			

Source: Clark (1988: 274)

TABLE 6: Comparative GB/India costs and prices (India =100)

A. Costs

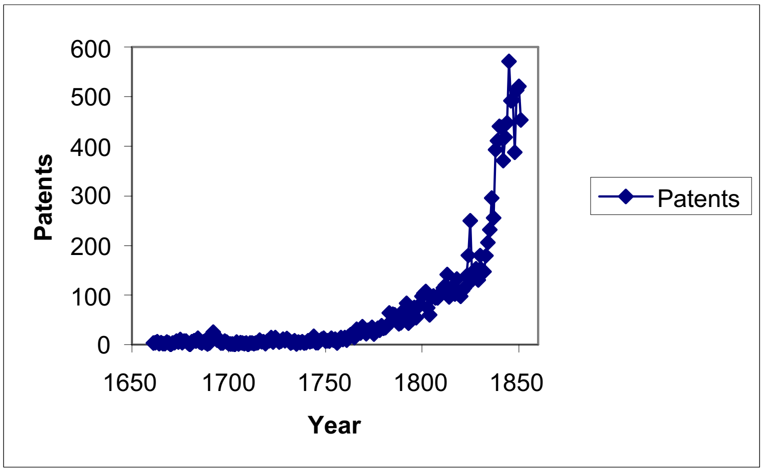
	Wage *(W/W*)*	Raw cotton price *(C/C*)*	Cost of capital (R/R*)	TFI price
c.1680	400	182	137	206
c.1770	460	320	113	270
c.1790	663	480	106	357
c.1820	517	127	61	150

B. Prices and TFP

	TFI price	FOB price (P/P*)	TFP (A/A*)
c.1680	206	200	103
c.1770	270	200	135
c.1790	357	147	243
c.1820	150	53	283

Source: Broadberry and Gupta (2008).

FIGURE 2: Patents issued in England, 1661-1851



Source: Derived from Sullivan (1989).

TABLE 7: 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 8: 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).

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