A Farewell to Alms:

A Brief Economic History of the World

Draft, 1 October 2006

Forthcoming, Princeton University Press, 2007

He is a benefactor of mankind who contracts the great rules of life into short sentences, that may be easily impressed on the memory, and so recur habitually to the mind

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1 Introduction

The basic outline of world economic history is surprisingly simple. Indeed it can be summarized in one diagram: figure 1.1. Before 1800 income per person – the food, clothing, heat, light, housing, and furnishings available per head - varied across societies and epochs. But there was no upward trend. A simple but powerful mechanism explained in this book, *the Malthusian Trap*, kept incomes within a range narrow by modern standards.

Thus the average inhabitant in the world of 1800 was no better off than the average person of 100,000 BC. Indeed, most likely, consumption per person declined as we approached 1800. The lucky denizens of wealthy societies such as eighteenth century England or the Netherlands managed a material life style equivalent to the Neolithic. But the vast swath of humanity in East and South Asia, particularly in Japan and in China, eked out a living in conditions that seem to have been significantly poorer than those of cavemen.

The quality of life quality also failed to improve on any other observable dimension. Life expectancy was the same in 1800 as for the original foragers of the African savannah, 30-35 years at birth. Stature, a measure both of the quality of the diet, and of children's exposure to disease, was higher in the Neolithic than in 1800. And while foragers likely satisfied their material wants with small amounts of work, the modest comforts of the English in 1800 were purchased only through a life of unrelenting drudgery. Nor did the variety of their material consumption improve. The average forager had a diet, and a work life, much more varied than the typical English worker of 1800 even though the English table by them included such exotics as tea, pepper, and sugar.

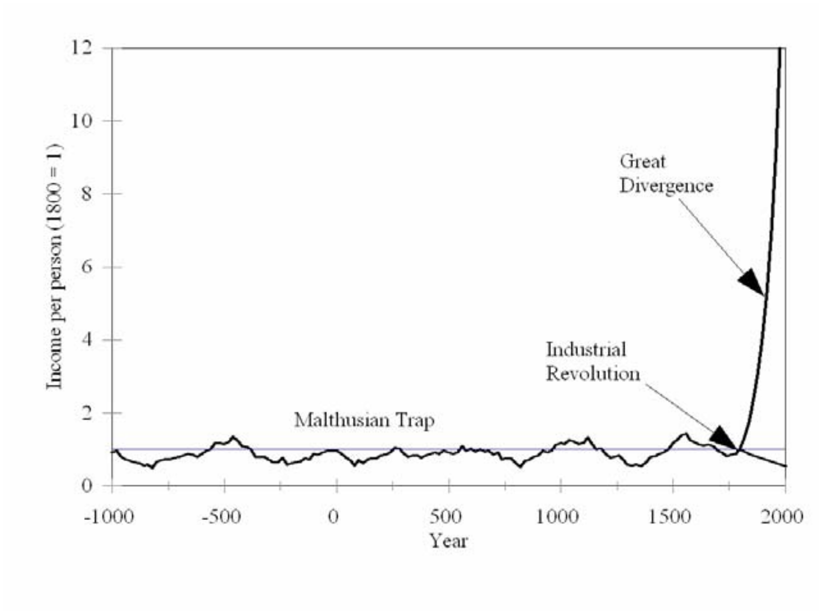

Figure 1.1 World Economic History in One Picture

Finally hunter-gatherer societies are egalitarian. Material consumption varies little across the members. In contrast great inequality was a pervasive feature of the agrarian economies that dominated the world of 1800. The riches of a few dwarfed the pinched allocation of the masses.

Considering even the broadest definition of material life, the trend, if anything, was downward from the Stone Age to 1800. And for the poor of 1800, those who lived on unskilled wages alone, the hunter-gatherer life would have been a clear improvement.

Some will object that material living conditions, even including life expectancy and work efforts, give little impression of the other dimensions by which life changed between the Neolithic and 1800: dimensions such as security, stability, and personal safety. But we shall see below that however broadly we picture living conditions, things do not improve before 1800.

Thus the great span of human history - from the arrival of anatomically modern man through Confucius, Plato, Aristotle, Michelangelo, Shakespeare, Beethoven, and all the way to Jane Austen indeed - was lived in societies caught in the *Malthusian Trap*. Jane Austen may have written about refined conversations over tea served in China cups. But for the mass of the English population as late as 1813 material conditions were no better than their naked ancestors of the African savannah. The Darcys were few, the poor plentiful.

The Industrial Revolution, a mere 200 years ago, changed forever the possibilities for material comfort. Incomes per person began a sustained growth in a favored group of countries around 1820. Now in the richest of the modern economies living standards are 10-20 times better than was average in the world of 1800. Further the biggest beneficiary of the Industrial Revolution has so far been the poor and the unskilled, not the typically wealthy owners of land or capital, or the educated. Within the rich economies of our world there is not only more for everyone, but lots more for the bottom strata.

But prosperity has not come to all societies. Material consumption standards in some countries, mainly those of sub-Saharan Africa, are now well below the average pre-industrial society. These countries, such as Malawi or Tanzania, might be better off had they never had contact with the industrialized world, and instead continued in their pre-industrial state. Modern medicine, airplanes, gasoline, computers, the whole technological cornucopia of the last 200 years, have succeeded mainly in producing material living standards that are likely the lowest ever experienced by any people in world history. Just as the Industrial

Revolution has reduced income inequalities within societies, it has increased them between societies. There lives now both the richest people who ever walked the earth, and the poorest. This divergence in regional and national fortunes since the Industrial Revolution has recently been labeled the *Great Divergence*.

Thus world economic history poses three interconnected problems: the long persistence of the *Malthusian trap*, the escape from that trap in the *Industrial Revolution*, and the consequent *Great Divergence*.

The Malthusian Trap – Economic Life to 1800

The first third of the book is devoted to a simple model of the economic logic of all societies before 1800, and to showing how this accords with a wide variety of historical evidence. This model requires only three basic assumptions, can be explained graphically, and explains why technological advance improved material living conditions only after 1800.

The crucial factor was the rate of technological advance. As long as technology improved slowly material conditions could not permanently improve, even while there was cumulatively significant gain in the technologies. In this model the economy of humans in the years before 1800 turns out to be just the *natural* economy of all animal species, with the same kinds of factors determining the living conditions of animals and humans.

This is called the *Malthusian Trap* because the vital insight underlying the Malthusian model was that of the Reverend Thomas Robert Malthus, who in 1798 in *An Essay on a Principle of Population* took the initial steps towards understanding the logic of this economy.

In the Malthusian Economy before 1800 the world of economic policy was upside down: vice now was virtue then, and virtue vice. Those scourges of failed modern states - war, violence, disorder, harvest failures, collapsed public infrastructures, bad sanitation – were the friends of mankind before 1800. In contrast policies beloved of the World Bank and the U.N. now – peace, stability, order, public health, transfers to the poor – were the enemies of prosperity.

At first sight the claim of no material advance before 1800 seems absurd. Figure 1.2 shows a Nukak hunter gatherer family of the modern Amazonian rain forest, naked, with a simplicity of possessions. Figure 1.3 in contrast shows an upper class English family, the Braddylls, painted in all their finery by Sir Joshua Reynolds in 1789. How is it possible to claim that material living conditions were on average the same across all these societies? But the logic of the Malthusian model matches by the empirical evidence for the pre-industrial world. While even long before the *Industrial Revolution* small elites had an opulent life style, the average person in 1800 was no better off than their ancestors of the Paleolithic or Neolithic.

The Malthusian logic developed below also reveals the crucial importance of fertility control to material conditions before 1800. All pre-industrial societies for which we have sufficient records to reveal fertility levels had some limitation on fertility, though the mechanisms varied widely. Most societies before 1800 consequently lived well above the bare subsistence limit. That is why there was room for living standards in much of Africa to fall since the Industrial Revolution.

Mortality conditions also mattered, and here Europeans were lucky to be a filthy people who squatted happily above their own feces stored in their basement cesspits in cities such as London.

Figure 1.2 The Nukak, a surviving hunter gatherer society in the Colombian rain forest. ©Gustavo Pollitis/Survival International

Poor hygiene combined with high urbanization rates kept incomes high in eighteenth century England and the Netherlands. The Japanese, with a developed sense of cleanliness, were able to subsist accordingly on a much more limited income.

Since the economic laws governing human society were those that govern all animal societies, mankind was subject to natural selection throughout the Malthusian Era, even after the arrival of settled agrarian societies with the Neolithic Revolution. The Darwinian struggle that shaped human nature did not end with the Neolithic Revolution that transformation of hunter-gatherers into settled agriculturalists, but continued indeed right up till the Industrial Revolution.

For England we will see compelling evidence of differential survival of types in the years 1250-1800. In particular economic

Figure 1.3 The Braddyll family. Sir Joshua Reynolds, 1789.[1]

[1]Wilson Gale-Braddyll, Member of Parliament and Groom to the Bedchamber of the Prince of Wales.

success translated powerfully into reproductive success. The richest men had twice as many surviving children at death as the poorest. The poorest individuals in Malthusian England had so few surviving children that their families were dying out. Pre-industrial England was thus a world of constant downward mobility. Given the static nature of the Malthusian economy, the superabundant children of the rich had to, on average, move down the social hierarchy. The craftsmen's sons became laborers, merchant's sons petty traders, large landowner's sons small-holders.

Just as people were shaping economies, the economy of the pre-industrial era was shaping people, at the least culturally, perhaps even genetically. The arrival of an institutionally stable capital-intensive pre-industrial economic system in England set in motion an economic process that rewarded middle class values with reproductive success, generation after generation. This selection process was accompanied by changes in characteristics of the pre-industrial economy that seem to owe largely to the population displaying more "middle class" preferences. Interest rates fell, murder rates declined, work hours increased, and numeracy and literacy spread even to the lower reaches of the society.

This counter-intuitive pre-industrial world was created by just one thing, the persistently slow rate of technological advance before 1800. The rate of technological advance in Malthusian economies can be inferred from the rate of population growth. The typical rate of technological advance before 1800 was well below 0.1% per year.

The Industrial Revolution

After millennia trapped in the Malthusian economy two unprecedented events seemingly occurred in Europe between 1760 and 1900. The first was the *Industrial Revolution*, the appearance for the first time of rapid economic growth fueled by increasing production efficiency from advances in knowledge. The second was the *Demographic Revolution,* an unprecedented decline in fertility which started with the upper classes and gradually encompassed all of society. The *Demographic Revolution* allowed the efficiency advance of the *Industrial Revolution* to get translated, through the physical capital accumulation it induced, not into an endless supply of impoverished people, but into the astonishing rise of incomes per person since 1800.

This leads naturally to the great questions of economic history. Why was the rate of technological change so slow in all pre-industrial societies? Why did this rate increase so greatly after 1800? Why was one bi-product of this technological advance a decline in fertility? And, finally, why have all societies not been able to share in the ample fruits of the *Industrial Revolution*?

There are only three known approaches to these puzzles. The first locates the *Industrial Revolution* in events outside the economic system, such as changes in political institutions, as with the introduction of modern democracies. The second argues that pre-industrial society was caught in a stable, but stagnant, economic equilibrium. Some shock set forces in motion that moved society to a new dynamic equilibrium. The last approach argues the *Industrial Revolution* was the product of a gradual evolution of social conditions in the Malthusian era: growth was endogenous. On the first two types of account the *Industrial Revolution* might never have occurred, or could have been delayed thousands of years. Only on the third account was there any inevitability to the *Industrial Revolution*.

The classic account of the Industrial Revolution has suggested it was an abrupt transition between economic regimes as portrayed in figure 1.1, with a change within 30 years from pre-industrial productivity growth rates to modern rates. If this is correct then only theories that emphasize an exogenous shock or a switch between equilibria could possibly explain the *Industrial Revolution*.

The classic account has also suggested that there were significant technological advances across quite disparate sectors of the economy contributing to *Industrial Revolution* growth, again suggesting that there had to be some economy-wide institutional change or equilibrium shift to explain the events. This suggests that we should be able to find the preconditions for an *Industrial Revolution* by looking at changes in the institutional and economic conditions in England in the years just before 1800. And waves of economists and economic historians have thrown themselves at the problem of explaining the *Industrial Revolution* with just such an explanation in mind, with spectacular lack of success.

But this conventional picture of the *Industrial Revolution* as a sudden fissure in economic life turns out to be unsustainable. There is good evidence that the productivity growth rate did not make such a clean upward movement, but instead fluctuated irregularly between periods in England all the way back to 1200, so that arguments can be made for 1600, for 1800 or even for 1860 as the true break between the Malthusian and the modern economy.

Also when we try and connect efficiency advance to the underlying rate of accumulation of knowledge in England the link turns out to depend on many accidental factors of demand, trade, and resources. In crucial ways the classic Industrial Revolution in Britain in 1760-1860 was a blip, an accident, superimposed on a longer running upward sweep in the rate of knowledge accumulation that had its origins in the Middle Ages or earlier.

Thus though an *Industrial Revolution* of some kind certainly occurred between 1200 and 1860 in Europe, though there is a divide which mankind crossed, a materialist's Jordan at the gates of the Promised Land, there is still plenty of room for debate about its precise time and place, and hence debate about the conditions which led to it. In particular an evolutionary account of gradual changes is a much more plausible explanation than has been realized.

The book proposes a variant of these evolutionary ideas, along the lines suggested by Oded Galor and Omar Moav.[2] The Neolithic Revolution which established a settled agrarian society with massive stocks of capital changed the nature of selective pressures operating on human culture and genes. Ancient Babylonia in 2,000 BC may have seemed superficially to be an economy not dissimilar from that of England in 1800. But the intervening years had profoundly shaped the culture, and maybe even the genes, of the members of English society. These changes were what created the possibility of an Industrial Revolution only in 1,800 AD not in 2,000 BC.

Other scholars have recently posed the challenge of "Why an Industrial Revolution in England as opposed to China, Japan or India?" The speculation here, and it is just a speculation, is that England's island position and its highly stable institutions, which resulted in a surprisingly orderly and internally peaceable society all the way from 1066 to the present, advanced the process of

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[2] Galor and Moav, 2002.

preference evolution more rapidly than in the more turbulent agrarian economies.

Whatever its cause, the *Industrial Revolution* has had profound social effects. As a result of two forces – the nature of the technological advance, and the *Demographic Revolution* – growth in capitalist economies since the *Industrial Revolution* has had strongly equalizing effects within societies. Despite fears that machines would swallow up men the greatest beneficiaries of the Industrial Revolution so far have been unskilled workers.

Thus while in pre-industrial agrarian societies typically 50% or more of income went to the owners of land and capital, in modern industrialized societies the share of land and capital is normally less than 25%. Technological advance might have been expected to dramatically reduce unskilled wages. After all, there was a class of workers who, offering only brute strength, were quickly swept aside by machinery. About one million horses were employed in Britain in the early nineteenth century. One hundred years later most of these had disappeared from the economy – swept aside by steam and internal combustion engines. Their value in production having fallen below their feed costs they were hauled off to the knackers yard. Similarly there was no reason why capital or land need not have increased their shares of income. This redistribution of income towards unskilled labor has had profound social consequences. But there is nothing in the happy developments so far that ensures that modern economic growth will continue to be so benign in its effects.

The Great Divergence

The last third of the book considers why the *Industrial Revolution*, while tending to equalize incomes within successful economies, has at the same time led to a *Great Divergence* in national economic fortunes. How did we end up in a world where a minority of countries have unprecedented riches, yet a large group of countries have seen declining incomes since the *Industrial Revolution*?

The technological, organizational and political changes spawned by the Industrial Revolution in the nineteenth century all seemed to predict that it would soon transform most of the world in the way it was changing Britain, the U.S.A. and northwest Europe. By 1900, for example, cities such as Alexandria in Egypt, Bombay in India, and Shanghai in China were all, in terms of transport costs, capital markets, and institutional structures fully integrated into the British economy. Yet the growth of a favored few nations was followed very haltingly in many societies, leading to the ever widening income gap between societies.

This divergence in incomes is another great intellectual puzzle on a par with that of the *Industrial Revolution* itself. And it provides a further severe test of theories of the *Industrial Revolution* itself. Can these theories be reconciled with the increasing divergence within the world economy? A detailed examination of the cotton industry, one of the few found from the earliest years in both rich and poor countries, shows that the anatomy of the great divergence is complex and unexpected, and again hard to reconcile with economists favorite modes of explanation – bad institutions, bad equilibria, and bad development paths.

The new technologies of the *Industrial Revolution* could be exported mechanically relatively easily to most of the world, and the inputs for production obtained cheaply. But the one thing that could not be replicated in many locations was the social environment which underpinned the cooperation of people in production in the countries where these techniques were developed. The last chapter considers how the same swings in the relative economic energy of somnolence of economies as were seen in the pre-industrial world led to much greater swings in income per person because of the escape from Malthusian constraints, and because technologies developed since the Industrial Revolution magnified the economic effects of differences in economic performance by workers.

Thus there is a great irony in economic history. In most areas of enquiry – astronomy, archeology, paleontology, biology, history for example – knowledge declines as we move away from our time, our planet, our society. In the distant mists lurk the strange objects: quasars, dwarf human species, hydrogen sulfide fuelled bacteria. But in economic history the distant world of the Malthusian era, however odd it may appear, is the known world. In pre-industrial societies living standards are predictable from disease and other environmental conditions. Differences in social energy across societies also were muted by the Malthusian constraints, so that they had minimal impacts on living conditions. But since the *Industrial Revolution* we have entered a strange new world where economic theory is of little or no use in understanding differences in income across societies, or the future path of income in any society. Wealth and poverty is a matter of differences in local social interactions that get magnified, not dampened, by the economic system to produce feast or famine.

2 The Logic of the Malthusian Economy

No arts; no letters; no society; and which is worst of all, continual fear, and danger of violent death: and the life of man, solitary, poor, nasty, brutish and short. (Hobbes, 1651, Book I, ch. 13).

The vast majority of human societies, from the original foragers of the African savannah, through settled agrarian societies until about 1800, had an economic life that was shaped and governed by one simple fact: in the long run births had to equal deaths. Since this same logic governs all animal species, until 1800, in this "natural" economy, the economic laws for humans were the same as for all animal species.

It is common to assume that the huge changes in the technology available to people, and in the organizational complexity of societies, between our ancestors of the savannah and Industrial Revolution England, must have improved material life even before modern economic growth began. But in this chapter I show that the logic of the natural economy implies that the material living standards of the *average* person in the agrarian economies of 1800 was, if anything, worse than for our remote ancestors. Hobbes, in the quote above, was profoundly wrong to believe that in the state of nature man was any worse off than in the England of 1651.

This chapter develops a model of the pre-industrial economy, the Malthusian model, from three simple and seemingly innocuous assumptions. This model has profound implications about how the economy functioned before 1800, that are then tested and explored in the following three chapters.

The Malthusian Equilibrium

Women, over the course of their reproductive lives, can give birth to 12 or more children. Still in some current societies the average women gives birth to more than 6 children. Yet for the world before 1800 the number of children per woman that survived to adulthood was always just a little above 2. World population grew from perhaps 0.1 m. in 100,000 BC to 770 m. by 1800. But this still represents an average of 2.005 surviving children per woman before 1800. Even within successful pre-industrial economies, such as those in Western Europe, long run rates of population growth were very small. Table 2.1 shows for a number of European countries population in 1300 and 1800, and the implied numbers of surviving children per woman. None of these societies deviated far from two surviving children per woman. Some force must be keeping population growth rates within rather strict limits over the long run.

The Malthusian model supplies a mechanism to explain this long run population stability. In the simplest version there are just three assumptions:

1. Each society and epoch has a **BIRTH RATE,** determined by customs regulating fertility, and independent of material living standards.[3]

2. The **DEATH RATE** in each society declined as living standards increased.

3. **MATERIAL LIVING STANDARDS** declined as population increased.

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[3] It is often assumed that in the pre-industrial world the birth rate rose with income, since people would delay fertility in times of economic hardship. Chapter 4, however, shows that such an assumption does not change the essential character of the Malthusian model, as is also not supported empirically.

Table 2.1 Populations in Western Europe, 1300-1800[4]

Year	c. 1300	c. 1800	Surviving Children per woman
Norway[a]	0.400	0.883	2.095
S. Italy[c]	4.75	7.9	2.061
England[b]	5.8	8.7	2.049
France[d]	20	27.2	2.037
N. Italy[c]	7.75	10.2	2.033
Iceland[a]	0.084	0.047	1.930

The birth rate is just the number of births per year per person, for convenience normally quoted as births per thousand people. Maximum observed fertility levels have been 50-60. But the birth rate varies significantly even across pre-industrial societies. Pre-industrial England sometimes had birth rates of less than 30. Recently in the area of highest birth rates, Central Africa, some countries had birth rates which exceed 50 per thousand: Niger 55, Somalia 52, Uganda 51.

The death rate is again just deaths per head of the population, also typically quoted per thousand people. In a *stable* population life expectancy at birth is the inverse of the death rate.[5] Thus if death rates are 33 per thousand, life expectancy at birth is 30 years. At a death rate of 20 per thousand, life expectancy would rise to 50.

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4 [a]Tomasson, 1977, 406. [b]Clark, 2006a. [c]Federico and Malanima, 2002, table 2. [d]Le Roy Ladurie, 1981, ---.

5 Formally, if e_0 is life expectancy at birth, and D is the death rate, $e_0 = 1/D$.

In a stable population birth rates equal death rates. So equivalently in stable populations, characteristic of the pre-industrial world, life expectancy at birth is also the inverse of the birth rate. Thus in pre-industrial society the only way to achieve high life expectancies was by limiting births. If pre-industrial populations had displayed the fertility levels of the modern Niger, life expectancy at birth would have been less than 20.

Material living standards are the average amount of goods (food, alcohol, shelter, clothing, heat, and light) and services (religious ceremonies, barbers, servants) that people in a society consume. Where new goods are introduced over time, such as newspapers, Wedgwood fine porcelain, and vacations at the seaside, it can be tricky to compare societies in terms of the purchasing power of their real wages. But for most of human history, and for all societies before 1800, the bulk of material consumption has been food, shelter, and clothing, so that material living standards can be measured with more accurately. In societies economically sophisticated enough to have a labor market, material living standards for the bulk of the population will be determined by the purchasing power of unskilled wages.

Figure 2.1 shows graphically the three assumptions of the simple Malthusian model. The horizontal axis for both panels is material living conditions, indicated as y. In the top panel birth, B, and death, D, rates are plotted on the vertical axis. The material income at which birth rates equal death rates is called the *subsistence income* denoted in the figure as y^*. This is the income that just allows the population to reproduce itself. At material incomes above this the birth rate exceeds the death rate and population is growing. At material incomes below this the death rate exceeds the birth rate and population declines. Notice that this subsistence income is determined without any reference to the produc

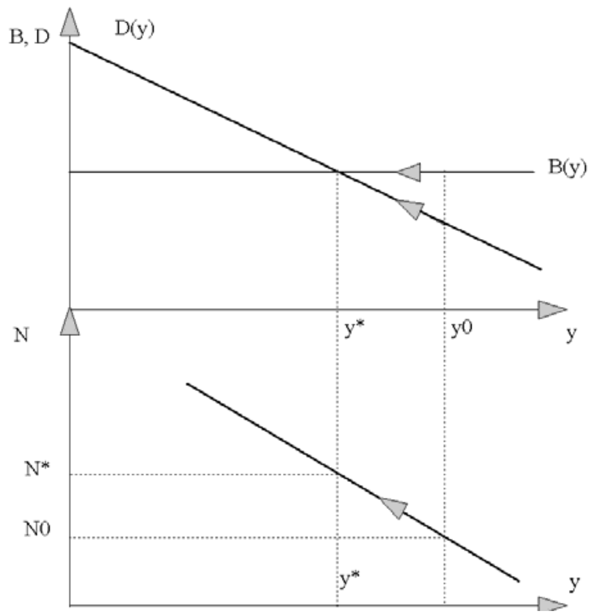

Figure 2.1: Long Run Equilibrium in the Malthusian Economy

tion technology of the society. It depends only on the factors which determine the birth rate and those that determine the death rate. Once we know these we can determine the subsistence income, and life expectancy at birth.

In the bottom panel population, N, is shown on the vertical axis. Once we know N, that determines y, and in turn the birth rate and death rates.

With just these assumptions it is easy to show that the economy will always move in the long run to the level of real incomes where birth rates equal death rates. Suppose population starts at an arbitrary initial population: N_0 in the diagram. This will imply an initial income: y_0. Since y_0 exceeds the subsistence income, births exceed deaths and population grows. As it grows, income declines. As long as the income exceeds the subsistence level population growth will continue, and income continue to fall. Only when income has fallen to the subsistence level will population growth cease, and the population stabilize.

Suppose that instead the initial population had been so large that the income was below subsitence. Then deaths would exceed births and population would fall. This would push up incomes. The process would continue until again income is at the subsistence level. Thus wherever population starts from in this society it always ends up at N^*, with income at the subsistence level.

The terminology "subsistence income" can lead to the confused notion that in a Malthusian economy people are all living on the brink of starvation, like the inmates of some particularly nasty Soviet Era Gulag. In fact in almost all Malthusian economies the subsistence income considerably exceeded the income required to allow the population to feed itself from day to day.

Differences in the location of the mortality and fertility schedules across societies also generated very different subsistence incomes. What was subsistence for one society was extinction for others. Both 1400 and 1650, for example, were periods of population stability in England, and hence periods where by definition the income was at subsistence. But the wage of the poorest workers, unskilled agricultural laborers, was equivalent to about nine pounds of wheat per day in 1650, compared to eighteen pounds in 1400. Even the lower 1650 subsistence wage was well above the biological minimum of about 1,500 calories a day. A diet of a mere two pounds of wheat per day, supplying 2,400 calories per day, would keep a laborer alive and fit for work. Thus pre-industrial societies, while they were subsistence economies, were not typically starvation economies. Indeed, with favorable conditions, they were at times wealthy, even by the standards of many modern societies.

The assumption that is key to the income always returning to the subsistence level is the third one, of a fixed trade off between population and material income per person. For reasons given below, this tradeoff is called the *technology schedule*.

The justification for the decline in material incomes with higher population is the famous the *Law of Diminishing Returns* introduced to economics by David Ricardo. Any production system employs a variety of inputs, the principle ones being land, labor, and capital. The *Law of Diminishing Returns* holds that if one of the inputs to production is fixed, then employing more of other inputs will increase output, but by progressively smaller increments. That is, the output per unit of the other factors will decline as their use in production is expanded, as long as one factor remains fixed.

Land was the key factor of production in the pre-industrial era that was inherently in fixed supply, and it was with reference to land that Ricardo (and independently Malthus) formulated *The Law of Diminishing Returns*. This limited supply implied that average output per worker fell as the labor supply increased in any society, as long as the techology was static. Consequently the average amount of material consumption available per person fell with population increases.

Figure 2.2 shows assumed relationship between labor input and the value of output for pre-industrial societies that underlies the third assumption of the Malthusian model. The increase in the value of output from adding each person is the marginal product of that person, which equals the wage in market economies.[6] As can be seen the marginal product declines as more

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[6] This is just the slope of the curve at any labor input.

people are added (and thus wages also fall in market economies). Average output per person falls also as the population rises, since the additional output from each person at the margin is less than the output per person from existing workers.[7]

To appreciate concretely why this will happen consider a peasant farmer with fifty acres of land. If he alone cultivates the land then he will maximize output by using low intensity cultivation methods - keeping cattle or sheep which left to fend for themselves and periodically culled for meat and skins, as with the Argentinian pampas in the early nineteenth century. With the labor of an additional person milk cows could be kept also, increasing total output. With yet more labor the land could be cultivated as arable. Arable requires much more labor input per acre than pasture for plowing, sowing, harvesting, threshing and manuring. But arable also yields a greater value of output per acre. With even more people the land could be cultivated more intensively as garden, growing vegetables and roots as well, increasing output yet further. Yields are increased by ever more careful shepherding of supplies of manure, and by suppression of competing weeds by hand hoeing. With enough labor input the output of any acre of land can be very high, as in the agricultural systems of coastal China and Japan around 1800, when one acre of land was enough to support a family. In contrast in the same period there was in England in 1800 nearly twenty acres of land per worker.

We can also see in figure 2.1 that the sole determinants of the subsistence income are the birth and death schedules. Knowing just these we can determine the subsistence income. The connection shown in the lower panel between income and population

7 Average output per person is the slope of the straight line drawn from the origin to the output curve at any given level of labor input.

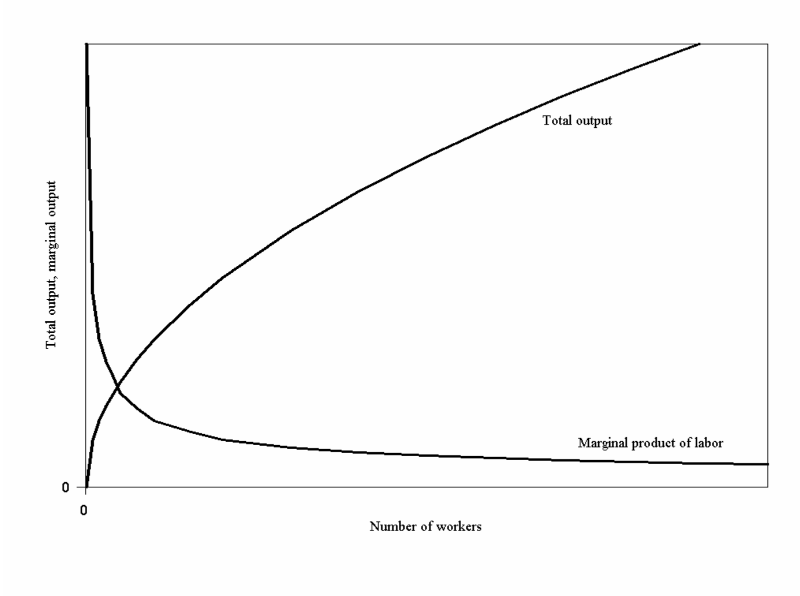

Figure 2.2: Labor Input and Output on a Given Area of Land

serves only to determine what population corresponds to the subsistence income.

Because I want to show that the same economic model applies to all human societies before 1800, even those which had no labor market, and also to animal societies, I have developed the model in terms of income per person. Classical Economists, however, writing about conditions in England circa 1800, developed their thinking in terms of the wages of unskilled workers. Thus in 1817, David Ricardo, using similar logic argued that real wages (as opposed to income per person which includes land rents and returns on capital) must always eventually return to the subsistence level.[8] Ricardo's proposition later became known as the *Iron Law of Wages*. Classical Economics thus denied the

[8] McCulloch, 1881, 50-58.

possibility for other than transitory improvements in the living standards of unskilled labor.

Changes in the Birth Rate, and Death Rate Schedules

Different societies will have different locations for the birth rate and death rate schedules, and these can change over time. Suppose, for example, that the birth rate schedule increased as in figure 2.3. It is then simple to see what happens to the death rate, material incomes, and the population. In the short run births exceed deaths. Population thus grows, driving down real income, and so increasing the death rate until deaths again equal births. At the new equilibrium real income is lower, and population is greater. Any increase in birth rates in the Malthusian world drives down real incomes. Conversely anything which limits birth rates drives up real income. Since life expectancy at birth in a stable population is also just the inverse of the birth rate another important component of material living standards is solely determined by the birth rate. As long as this remained high, life expectancy at birth had to be low. Pre-industrial society could thus raise both material living standards and life expectancy by limiting births.

Again if the death rate schedule moves up, as in figure 2.4, so that at each income there is a higher death rate, then at the current income deaths exceed births so that population falls. This drives up the real income until the death rate is driven down to the old birth rate. At the new equilibrium the death rate has fallen to the fixed birth rate, the income is higher, and population is lower. An increase in the death rate schedule, given a fixed birth rate, increases real incomes but in the long run has no effect on the annual death rate, or on life expectancy at birth.

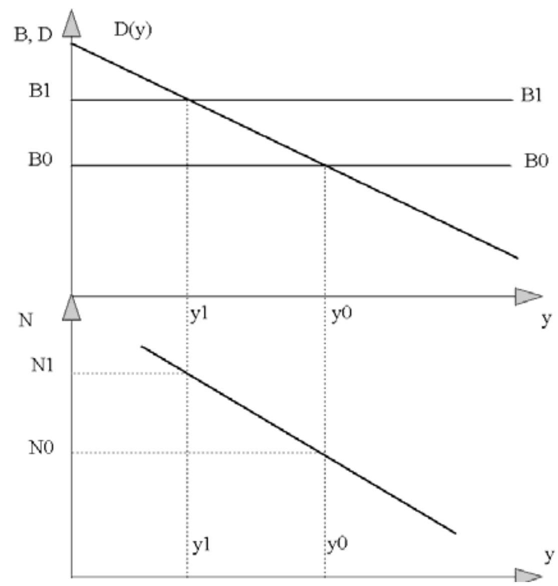

Figure 2.3   Changes in the Birth Schedule

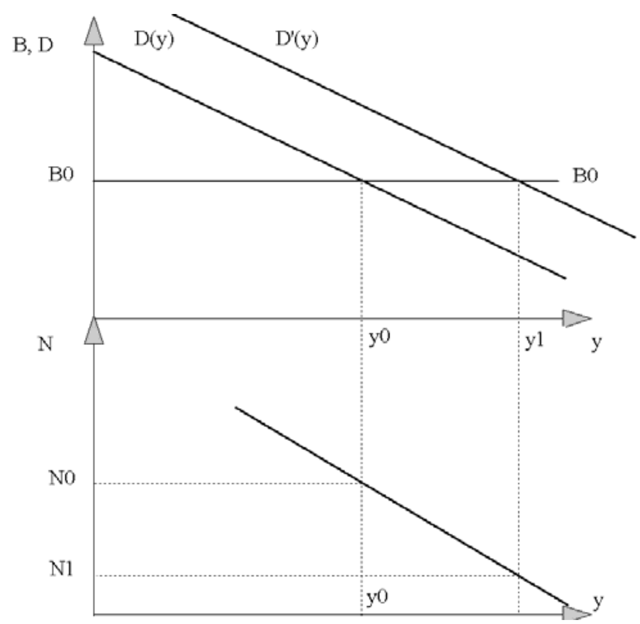

Figure 2.4   Changes in the Death Schedule

This simplest Malthusian world thus exhibits an counterintuitive logic. Anything that raised the death rate schedule, that is the death rate at a given income - war, disorder, disease, poor sanitary practices, or abandoning breast feeding - increased material living standards without changing life expectancy at birth. Anything that reduced the death rate schedule - advances in medical technology, better personal hygiene, improved public sanitation, public provision for harvest failures, peace and order - reduced material living standards without any gain in life expectancy at birth.

Changes in Technology

While the real income was determined from the birth and death schedules, the population size depended on the connection between population and real incomes. Above this was labelled the *technology* schedule, because the major cause of changes in this schedule have been technological advances. But other things could shift this schedule: a larger capital stock, improvements in the terms of trade, climate changes, or more productive economic institutions.

Figure 2.5 shows a switch from an inferior technology, represented by curve T_0, to a superior technology, represented by curve T_1. Since population can only change slowly, the short run effect of a technological improvement was an increase in real incomes. But the increased income reduced the death rate, births exceeded deaths, and population grew. The growth of population only ended when income returned to subsistence. At the new equilibrium the only effect of the technological change was to increase the population. There was no lasting gain in living

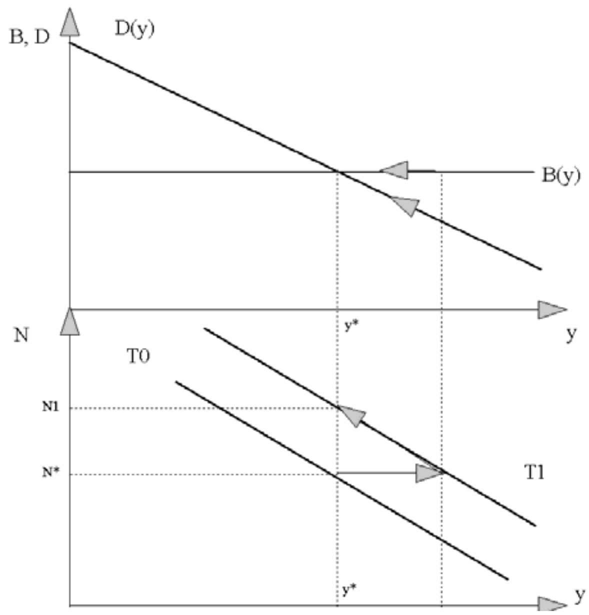

Figure 2.5 The Effects of Technological Advance

standards. The path of adjustment from an isolated improvement in technology is shown in the figure.

The Malthusian Model and Economic Growth

In the millennia leading up to 1800 there were significant improvements in production technologies, though these improvements happened slowly and sporadically. The technology of England in 1800, which included cheap iron and steel, cheap coal for energy, canals to transport goods, firearms, and sophisticated sailing ships, was hugely advanced on the technology of hunter gatherers in the Paleolithic before the development of settled agriculture. The degree of advance of technology was revealed in the encounters between Europeans and isolated Polynesian islanders in the 1760s. The English sailors who arrived in the previously isolated Tahiti in 1767 on the *Dolphin*, for example, found a society with no metals. The iron of the Europeans was so valuable to the Tahitians that a single nail initially could be bartered for either a pig or a sexual encounter. Captain Wallis had to post guards, and institute severe punishments, to stop the sailors from removing nails from every part of the ship they had access to. The local inhabitants on a number of occasions stole ship's boats to burn them to retrieve the nails.[9]

But though technology was advancing before 1800 the rate of advance was always slow relative to the world after 1800. Figure 2.6, for example, shows for England, the actual location of the technology curve of Malthusian model from 1200 to 1800. From 1200 to 1650 there is seemingly complete stagnation of the production technology of the English economy. After 1650 the technology curve does shift upwards, but not at a rate fast enough to cause any sustained increase in output per person beyond what was seen in earlier years in the decades before 1800. Instead technological advance, as predicted, resulted mainly in a larger and larger English population. In particular in the later eighteenth century all technological advance was absorbed immediately into higher population. Before 1800 the rate of technological advance in any economy was so low that incomes were condemmed to return to the Malthusian Equilibrium.

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9 Robertson, 1955, ---. The price of pigs rose rapidly as the sailors depleted the local stock, so that when Captain Cook arrived in 1769 a pig cost an axe. Banks, 1962, ---.

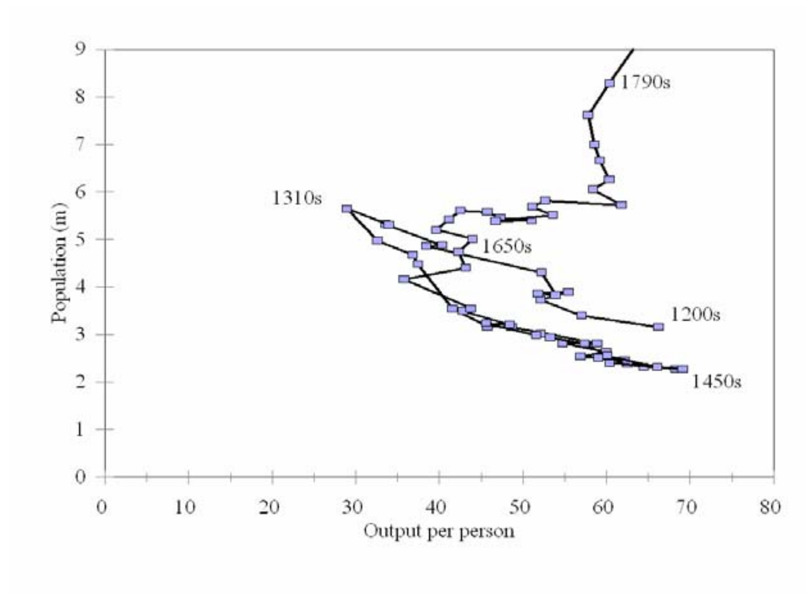

Figure 2.6 Revealed Technological Progress in England, 1200-1800

This was the historical context in England in the years 1798-1817 when Thomas Malthus (1766-1834) and David Ricardo (1772-1823) developed what became known as *Classical Economics,* with its key doctrine of the subsistence wage. They did not assume, as modern people do, that technical progress is inevitable and continuous, but instead regarded it as sporadic and accidental.

Even in the circumstances of England in 1798-1817, when the economy was well into the period we now dub the Industrial Revolution, this assumption was not just reasonable, but indeed compelling in the light of history. The new technologies associated with the Industrial Revolution begun appearing in the 1760s, but from 1770 to 1817 real wages did not rise, and for some groups such as agricultural laborers in the south of England actually fell. Sustained real wage gains started only in the 1820s. And much of these initial wage gains were a product not of English technological advance, but of political events such as the victory over Napoleon, which reduced the tax burden, and of the development of cheap supplies of foreign food and raw materials. Indeed one of the great social concerns of the years 1780-1834 in England was the problem of the rising tax burden on rural property owners created by payments to support the poor under the Poor Law.

Thus Malthus and Ricardo predicted that as long as fertility behavior was unchanged, economic growth could not in the long run improve the human condition. All that growth would produce would be a larger population living at the subsistence income. China, for Malthus, was the embodiment of the Malthusian economy. Though the Chinese had made great advances in draining and flood control, and had achieved high levels of output per acre from their agriculture, they still had very low material living standards because of the dense population. Thus he writes of China,

> *If the accounts we have of it are to be trusted, the lower classes of people are in the habit of living almost upon the smallest possible quantity of food and are glad to get any putrid offals that European labourers would rather starve than eat.*[10]

In the preindustrial world sporadic technological advance produced people, not wealth.

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[10] Malthus, 1798, 115.

Human and Animal Economies

The economic laws we have derived above for the pre-industrial human economy are precisely those that apply to all animal, and indeed plant populations. Before 1800 there was no fundamental distinction between the economies of humans and those of other animal and plant species. This was also a point Malthus appreciated.

> *Elavated as man is above all other animals by his ntellectual faculties, it is not to be supposed that the physical laws to which he is subjected should be essentially different from those which are observed to prevail in other parts of the animated nature.*[11]

Thus in evolutionary ecology, the Malthusian model dominates as well. For animal and plant species population equilibrium is similarly attained where birth rates equal death rates. Birth and death rates are both assumed to be dependant on the quality of the habitat, the analog of the human level of technology, and population density. In practice variations in death rate with population density seem most important in regulating population sizes, as we have assumed for human society. Ecological studies typically consider just the direct link between birth and death rates and population density, without considering the intermediate links, such as material consumption, as I have done above. But the Malthusian model for humans could also be constructed in this more reductionist way.

At least some ecological studies find that population density affects mortality in ways that are analogous to those we have posited for human population, through the supply of food available per animal. Thus one recent study showed that over forty years Wildebeest mortality rates depended largely on the

[11] Malthus, 1830, 225.

available food supply per animal: "the main cause of mortality (75% of cases) was undernutrition".[12] Hence the Industrial Revolution after 1800 represented the first break of human society from the constraints of nature, the first break of the human economy from the natural economy.

Political Economy in the Mathusian Era

Malthus's *Essay* was written in part as a response to the views of his father, who was a follower of the eighteenth century Utopian writers William Godwin and the Marquis de Condorcet. Godwin and de Condorcet argued that the misery, unhappiness, and vice so common in the world was not the result of an unalterable human nature, but was the product of bad government.[13] Malthus wanted to establish that poverty was not the product of institutions, and that consequently changes in political institutions could not improve the human lot. As we see, in a world of only episodic technological advance, such as England in 1798, his case was compelling.

Certainly one implication of the Malthusian model, which helped give Classical economics its seemingly harsh cast, was that any move to redistribute income to the poor (who then in England were mainly unskilled farm laborers) would result only in more poor in the long run, perhaps employed at even lower wages. As Ricardo noted in 1817,

> *The clear and direct tendency of the poor laws is in direct opposition to these obvious principles: it is not, as the legislature benevolently intended, to amend the condition of the*

[12]Mduma et al., 1999, 1101.
[13]Godwin, 1793. Condorcet, 1795.

Figure 2.9 The church in Okewood, where Malthus earned his living as a curate while working on his *Essay*.[14]

> *poor, but to deteriorate the condition of both poor and rich (McCulloch, 1881, 58).* [15]

The reason the poor laws would lower wages was that they aided in particular those with children, so reducing the costs of fertility and driving up the birth rate.

But Malthus and his fellow Classical Economists did not see that their arguments not only suggested the inability of government to improve the human lot through traditional methods, they

[14]Malthus probably lived at his father's house in nearby Albury. Albury's population of 510 in 1801 had grown to 929 by 1831.

[15]Thus Classical Economics was very influential in creating the draconian reforms of poor relief in England in 1834. The most influential member of the Poor Law Commission set up to examine the workings of the old poor law was Nassau Senior, Professor of Political Economy at Oxford University.

also implied that many of the government policies that his fellow Classical economists attacked – taxation, monopolies, trade barriers such as the Corn Laws, wasteful spending – would similarly have no effect on human welfare in the long run.

Indeed if we follow the logic laid out here good government in the modern sense – stable institutions, well defined property rights, low inflation rates, low marginal tax rates, free markets, free trade, avoidance of armed conflict – would all either make no difference to living standards in the Malthusian Era, or would indeed lower living standards.

To take one example, suppose that the pre-industrial king or emperor levied a poll tax on every person in the economy, equivalent to ten percent of average income. Suppose also that, as was the wont of such sovereigns, the proceeds of the tax were simply frittered away: on palaces, cathedrals, mosques, or temples, on armies, or to stock a large harim. Despite the waste, in the long run this would have no effect on the welfare of the average person.

To understand why, refer back to figure 2.1. The tax would act like a shock to the technology of the economy, shifting the lower curve left by ten percent uniformly. In the first instance, with the existing stock of people, the tax reduces incomes per person by ten percent, thus driving up death rates above birth rates. But in the long run after tax incomes must return to their previous level to stabilize population again. At this point population is sufficiently smaller so that everyone earns a high enough wage that after paying the tax they have sufficient left over to equal their old pre-tax earnings. In the long run exactions by the state have no effect in the Malthusian economy on welfare or life expectancy. Luxury, waste, extravagance by the sovereign all had no cost to the average citizen in the long run! Similarly restrictions on trade and obstructive guild rules were again costless.

Thus at the time the *Wealth of Nations* was issued in 1776, when the Malthusian economy still governed human welfare in England, the calls of Adam Smith for restraint in government taxation and unproductive expenditure were largely pointless. Good government could not make countries rich, except in the short run before population growth restored the equilibrium.[16]

So far we have just considered actions by government that shift the effective consumption possibilities for a society. Governments could also through their policies directly affect birth rates and death rates. War, banditry, and disorder all increased death rates at given levels of income (though war often killed more through the spread of disease than from the direct violence). But all increases in death rates make societies better off in material terms. Here "bad" government not only does not hurt people, it makes them better off. Good governments, those that, for example, as in some periods in Imperial Rome and Imperial China, stored grains in public granaries against harvest failures, just make life more miserable by reducing the periodic death rate from famines at any given average material living standard.[17]

It is thus ironic that while the Classical Economists, and in particular Adam Smith, are taken by modern proponents of limited government as their intellectual fathers, their views made little sense in the world they were composed in.

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16 It is explained below that high incomes in eighteenth century England probably owed more to bad personal hygiene than to advances in Political Economy.

17 In China state granaries in the eighteenth and nineteenth centuries typically redistributed up to 5 percent of all grain output. See Will and Wong, 1991.

Income Inequality and Living Standards

Pre-industrial societies differed in the their degree of income inequality. Forager societies, on modern evidence, seem to have been egalitarian in consumption. In such communities there was no land or capital to own, while in settled agrarian societies as much as half of all income could derive from ownership of assets. Further forager societies were typically characterized by a social ethic that mandated significant sharing. Thus even the labor income of successful hunters was taxed by the less successful.

Agrarian societies from the earliest times were much more unequal. The richest members of these societies commanded thousands of times the average income of the average adult male. Thus aristocrats, such as the Duke of Bedford in England in 1798, resided in a luxury that the farm laborers on his extensive estates could hardly comprehend.

The Malthusian model developed above takes no account of income distribution. But by analogy with the discussion of the previous section on taxation and living standards we can see that greater inequality will have little or no effect on the living standards of the landless workers, the mass of the population. The more equally land rents and capital income is distributed across the general population the more will these rents be simply dissapated in larger population sizes. If these rents were instead appropriated by an aristocratic elite, as they were in many pre-industrial societies, then they could be enjoyed with little or no cost to the rest of the population. Thus while inequality could not make the median person better off in the Malthusian world, it could raise average incomes per person, through the higher incomes of the propertied elite.

Table 2.2 Malthusian "virtues" and "vices"

"Virtues"	"Vices"
Fertility Limitation	Fecundity
Bad Sanitation	Cleanliness
Violence	Peace
Harvest Failures	Public Granaries
Infanticide	Parental solicitude
Income inequality	Income equality
Selfishness	Charity
Indolence	Hard Work

Thus it was possible that England, France or Italy in 1800 could have a higher income per person that the original foragers. But perversely only through their achievement of greater inequality than earlier societies. And the boost to incomes per person from inequality was limited. Land rents and capital income made up perhaps half of all income settled agrarian societies. The expropriation of all these incomes by an elite would double income per person compared to a state of complete inequality.

In summary table 2.2 shows Malthusian "virtues" and "vices." But virtue and vice here is measured with reference only to whether actions raised or lowered material income per person.[18]

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18 It is explained in chapter 3 why indolence is a virtue in Malthusian economies.

Material Conditions: Paleolithic to Jane Austen

This chapter explained the first claim made in the introduction, that living standards in 1800, even in England, were likely no higher than for our ancestors of the African Savanna. Since pre-industrial living standards were determined by fertility and mortality the only way living standards could be higher in 1800 would be because either mortality rates were greater at a given real income, or fertility was lower.

This conclusion may seem too powerful in the light of figures 1.1 and 1.2. But the upper class that author's such as Jane Austen wrote about were a small group within English society. The circulation of *The Times* in London in 1795, in the richest city in the world with a population of nearly one million people, was still only 4,800.[19] In *Sense and Sensibility* Austen has one of her characters note of a young man that £300 a year is "Comfortable as a bachelor" but "it cannot enable him to marry."[20]

In contrast the mass of farm laborers in England in 1810 had an annual income of £36 or less per year. Even though England was one of the richest economies in the world, they lived by modern standards a pinched and straightened existence. If employed they labored 300 days a year, with just Sundays and the occasional other day off. The work day in the winter was all the daylight hours. Their diet consisted of bread, a little cheese, bacon fat and weak tea, supplemented for adult males by beer. The diet was low in calories given the heavy manual labor, and they must often have been hungry. The monotony was relieved to some degree by the harvest period where work days were long, but the farmers typically supplied plenty of food. Hot meals were few

[19]See Craik, 1969, 28-32.

[20]Austen, 1811, ---.

since fuel for cooking was expensive. They generally slept once it got dark since candles for lighting were again beyond their means. They would hope to get a new set of clothes once a year. Whole families of 5 or 6 people would live in two room cottages, heated by wood or coal fires.[21] There was almost nothing that they consumed – food, clothing, heat, light or shelter - that would have been unfamiliar to the inhabitants of ancient Mesopotamia. If consumers in 8,000 BC were able to get plentiful food, including meat, and more floor space, they could easily have enjoyed a life style that English workers in 1800 would have preferred to their own.

[21] Eden, 1797. Clark, 2001.

3 Malthusian Era Living Standards

(Tierra del Fuegians in 1832) These poor wretches were stunted in their growth….. If a seal is killed, or the floating carcass of a putrid whale is discovered, it is a feast; and such miserable food is assisted by a few tasteless berries and fungi (Darwin, 1839, ---).

(Tahitians in 1769) These happy people may almost be said to be exempt from the curse of our forefather; scarcely can it be said that they earn their bread with the sweat of their brow when their cheifest sustenance Bread fruit is procurd with no more trouble than that of climbing a tree and pulling it down (Banks, 1962, 341).

The logic of the Malthusian economy is clear. There should be no systematic gain in living standards on average across societies between earliest man and the world of 1800 on the eve of the Industrial Revolution. Disease, war, infanticide and customs regulating marriage and sex could elevate material living standards. But on balance the happy circumstances that made for Tahiti in 1769, or the unhappy ones that made for Tierra del Fuego in 1832, were no more likely in 1800 as in 100,000 BC. In this chapter I consider the empirical evidence for this first crucial contention of the Malthusian model of society. Were material living standards truly no better on average in 1800 AD than in 10,000 BC or even 100,000 BC?

Real Wages before 1800

Since the poorest half of any society typically lives on their wage alone, without any property income, measures of real wages provide a good index of living standards in any society. However comprehensive measures of wages are available for only a few societies before 1800, and only in a few rare cases can we get good measures as early as 1200.

Pre-industrial England, however, has a uniquely well documented wage and price history. The relative stability of English institutions after the Norman Conquest of 1066, and the early development of markets, allowed a large number of documents with wages and prices to survive. Using these we can estimate of nominal wages, the prices of consumption goods, and thus real wages, for England back to 1209. To set the context here, 1209 was in the reign of the famously "bad" King John, just six years before he was forced by the barons to codify their rights in the Magna Carta of 1215.

Figure 3.1 shows the real day wage of building laborers and farm workers in England by decade from 1200 to 1809 as an index with 1800-9, at the end of the Malthusian Era, set at 100 for farm workers. The real wage is just a measure of how many units of a standard basket of goods these laborers could buy with one day's earnings through these 60 decades.[22]

The composition of that basket of goods is shown in table 3.1. It was determined by expenditure studies done for farm workers and others in the 1790s, a decade in which the poverty of farm workers had become an issue of some concern because in part of the growing burden of the Poor Laws.[23] These studies revealed that even around 1800 English farm workers spent three

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22 These real wages are drawn from the series derived in Clark, 2005 and Clark, 2006a. These series are the most comprehensive measures available for living standards in any pre-industrial economy, including goods whose prices are typically not measurable such as housing.

23 Clark, Huberman and Lindert, 1995. Clark, 2001.

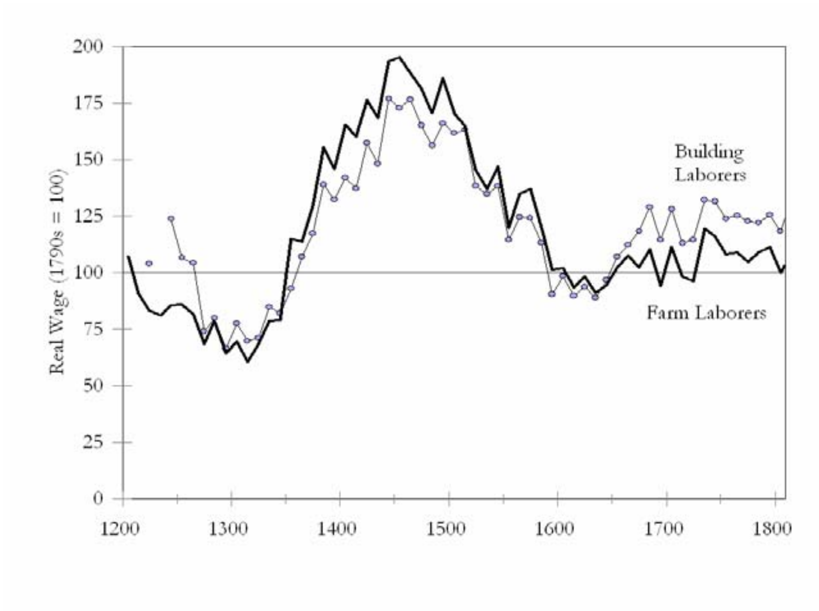

Figure 3.1 English Laborer's Real Wages 1209-1809.

Table 3.1 Expenditure Shares of Laborers before 1800

Category of Expenditure	Share (%)
Food and Drink:	**75**
Grains/Starches	44
Meat	9
Dairy	10
Sugar and Honey	3
Drink	8
Salt and Pepper	1
Housing	**6**
Heating	**5**
Light and Soap	**4**
Clothing, Bedding	**10**

quarters of their income on food, with starches such as bread accounting for the bulk of that expenditure at 44 percent of the entire budget. The other quarter of their expenditures was devoted to the basics of shelter, heating, light, soap and clothing and bedding. This despite the fact that by the 1790s English workers earned more than workers in most other European economies, and also significantly more, as we shall see, than workers in India, China or Japan.

Real wages in England showed remarkably little gain in the 600 years from 1200 to 1800. The fluctuations within the six hundred years are much more dramatic than any long run upward trend. Thus in 39 of the 60 decades between 1200 and 1800 real wages for farm workers are estimated to be above their level in 1800. The highest real wages are found in the interval 1400-1549, long before 1800. The years around 1300, before the onset of the plague years in England in 1349, do show lower wages than in 1800. But wages in the early thirteenth century, are close to their level of 1800.

The English experience also shows that while the Malthusian economy displayed stagnating material living standards, these were not necessarily low standards of living, even by the measure of many modern economies. Though the consumption pattern of the pre-industrial English worker around 1800 may seem fairly primitive, it actually implies, by its shares devoted to different goods, a reasonably high living standard. Over 40 percent of the food consumption, for example, was for luxury goods like meats, milk, cheese, butter, beer, sugar and tea (see table 3.1). All of these are very expensive ways to derive the calories and proteins necessary to work and to maintaining the body. Very poor people do not buy such goods.

The comparative affluence of the pre-industrial worker in England can be illustrated in two ways. First we can compare the day wages of English farm workers and construction laborers before 1800 to those of some of the poorer countries of the current world.[24] Table 3.2 shows the wages of construction laborers in Malawi in 2001 and 2002, compared to the prices of some major items of consumption, along with to the comparative data for construction laborers in England in 1800.

Only food prices are available for Malawi, but since these were 75 percent of English farm workers' expenditures they provide a fair approximation of living standards. The second column shows the day wage in England as well as prices in England. The fourth column the same data for Malawi in 2001-2. Columns 3 and 5 show how much of each item could be purchased with the day wage in each country. Thus the day wage in England in 1800 would purchase 3.2 kg. of wheat flour, while the day wage in Malawi would purchase only 2.1 kg. of (inferior) maize flour.

English workers of 1800 could purchase much more of most goods than their Malawian counterparts. The last row shows the cost of the English basket of foods in d. (assuming that all income was spent on food) and the equivalent cost in Malawi (in Kwacha). If a Malawian tried to purchase the consumption of the English worker in 1800 he could afford only 40 percent as much. Thus living standards in England in 1800 were 2.5 times greater than those of current day Malawi. Figure 3.2 shows a rural village in Malawi now. Yet the wage in Malawi is still above the subsistence level for that economy, since the Malawian population continues to grow rapidly.

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[24] This data is not so easy to obtain as might be assumed, since modern poor countries tend to have very poor statistic gathering bureaucracies.

Table 3.2 Wages and Prices in Malawi, 2001-2, and England, 1800[25]

	England, 1800 (d.)	England, 1800 Units per day	Malawi 2001-2 (Kwacha)	Malawi 2001-2 Units per day
Wage	23.9	-	69	-
Prices				
Flour (kg)	7.5	3.2	33	2.1
Bread (kg)	5.9	4.0	46	1.5
Potato (kg)	1.2	20.4	16	4.2
Beef (kg)	17.4	1.4	123	0.6
Eggs (doz)	11.1	2.1	84	0.8
Milk (l)	2.4	9.9	48	1.4
Sugar (kg)	26.3	0.9	42	1.7
Beer (l)	4.1	5.8	93	0.7
Tea (kg)	219.5	0.1	248	0.3
Salt (kg)	9.1	2.6	24	2.8
Cost of English Basket	23.9	1.0	178	0.4

For a much wider range of countries we have estimates of real national income per person in 2000. It is also possible for England to estimate national income per person back to 1200, so we can compare average income per person in pre-industrial England with the range in the modern world. Table 3.3 shows the results of that comparison. England in 1200-1800 had as high, or

[25]Source: Malawi, ILO.

Figure 3.2 A rural village in Malawi.[26]

higher, an income per person as large areas of the modern world. Countries with more than 700 million people in the year 2000 had incomes below the average of pre-industrial England. Another billion people in India had average incomes only 10 percent above England before the Industrial Revolution. Some modern countries are dramatically poorer. Hundreds of millions of African now live on less than 40 percent of the income of pre-industrial England.

The reductions in mortality from modern vaccines, antibiotics, and public health measures in these poor countries since 1950 have been rightly celebrated as a significant triumph of international aid efforts. Life expectancy was 40 in developing countries in 1950, but 65 by 2000.[27] One side effect of this, however, has

[26] Hans-Peter Kohler, University of Pennsylvania.
[27] Levine et al., 2004, 9.

Table 3.3 Comparative Incomes per Person, 2000[28]

Country	Population 2000 (m.)	Income per person (2005 $)	Relative Income (%)	Population Growth Rate (%)
Tanzania	34	569	20	2.1
Burundi	7	717	25	2.9
Ethiopia	64	832	29	2.3
Sierra Leone	5	849	30	2.3
Malawi	10	935	33	2.4
Nigeria	127	956	34	2.4
Zambia	10	972	34	2.1
Madagascar	16	1,014	36	3.0
Rwanda	9	1,129	40	2.4
Burkina Fasa	11	1,141	40	3.0
Mali	11	1,150	41	2.3
Benin	6	1,417	50	2.7
Kenya	30	1,525	54	2.6
Ghana	19	1,590	56	2.1
Nepal	23	1,809	64	2.2
Senegal	10	1,945	69	2.3
Bangladesh	131	2,052	73	2.2
Nicaragua	5	2,254	80	2.0
Cote D'Ivoire	16	2,345	83	2.0
Pakistan	138	2,497	88	2.2
Honduras	6	2,505	89	2.3
Moldova	4	2,559	90	0.3
Cameroon	15	2,662	94	2.0
England pre 1800	-	**2,828**	**100**	**0.1**
Zimbabwe	13	3,016	107	0.6
India	1,016	3,103	110	1.4
Bolivia	8	3,391	120	1.6
China	1,259	4,446	157	0.6

28 Income, Penn World Tables. Population, UN.

been that even at wages well below those of pre-industrial England, population in these countries is still growing with a rapidity never seen in the pre-industrial world, as table 3.3 shows. The subsistence wage, at which population growth would cease, is many times lower in the modern world than in the pre-industrial period. This is one factor leading to the Great Divergence in incomes discussed in the last section of the book. Given the heavy dependence of many sub-Saharan African countries on farming still, health care improvements are not an unmitigated blessing, but exact a cost in terms of lower material incomes.

This information on English living standards before 1800 illustrates that within any society under the Malthusian constraints wages and living standards can fluctuate by large amounts. Societies subject to Malthusian constraints were not necessarily particularly poor, even by the standard of today.

Figure 3.2 shows long run real English builders' day wages in comparison to those in North and Central Italy, and those of the Netherlands. Wages in both Italy and the Netherlands were significantly higher in the years before 1800 than they were in 1800 itself. They were also typically even higher than wages in England. Again there is no secular increase in real wages.

Information on real wages for societies earlier than 1200 is more fragmentary. But table 3.4 shows a very simple measure of wages, the equivalent of the wage in pounds of wheat, for unskilled laborers in a variety of earlier societies all the way back to Ancient Babylonia in the second millennium before Christ. Also in comparison are shown wheat wages around the world in 1780-1800. In the case of Japan the wheat wage is calculated by calculating the wheat equivalent of a pound of rice

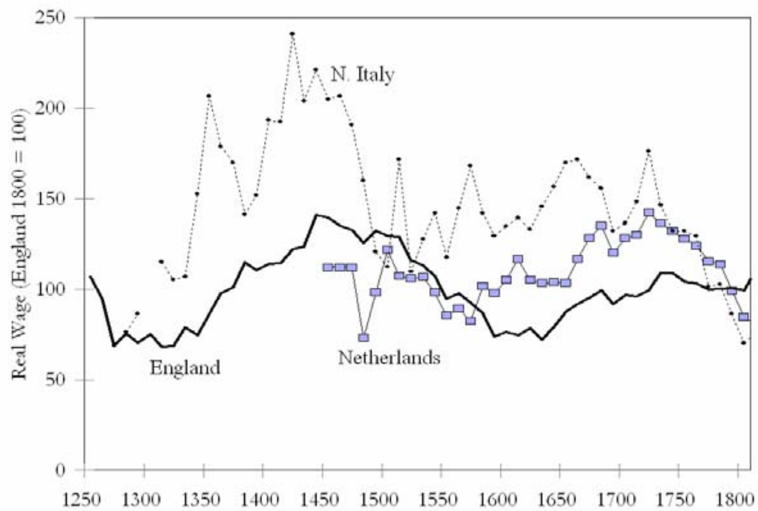

Figure 3.2 Comparative European Real Wages, 1250-1809[29]

Two things stand out. First the great range of wage levels, in the order or 7 to 1, even in the pre-industrial era. These variations in the Malthusian framework should have no relation to the technological sophistication of the society, and instead be explained by differences in fertility and mortality conditions across societies. The wage quotes from 1780-1800 do seem to confirm that the technological sophistication of the society is not the determinant of wages. English wages, for example, are on the high side, but not any higher than for such technological backwaters then as Istanbul, Cairo and Poland.[30] English wages on

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[29] North and Central Italian wages are from Federico and Malanima, 2002. Dutch wages are from de Vries and van der Woude, 1997, 609-628. The relative level of these wages to English in 1800 was fixed by assuming wages were proportionate to real GDP in each country relative to England in 1910 and 1810 respectively.

[30]The limitations of the grain wages as a measure are revealed in the comparison to Poland, however. Grain was the great export crop of eastern Europe

Table 3.4 Unskilled Laborers' Wage in Wheat Equivalents[31]

*farm wage

Location	Period	Day Wage lbs of wheat
Old Babyloniaa	1800-1600 BC	15*
Assyriab	1500-1350 BC	10*
Neo Babyloniaa	900-400 BC	9*
Classical Athensc	408 BC	30
Classical Athensc	328 BC	24
Roman Egyptd	c. 250 AD	8*
Amsterdame	1780-1800	21
Istanbulf	1780-1800	18
Londong	1780-1800	16
Antwerpe	1780-1800	16
Cairof	1780-1800	15
Englandg	**1780-1800**	**13**
Warsawe	1780-96	13
Leipsige	1780-1800	13
Danzig (Gdansk) e	1780-1800	11
Englandh	**1780-1800**	**11***
Viennae	1780-1800	10
Parise	1780-1800	10
Madride	1780-99	9.0
Naplese	1780-1800	7.6
Valenciae	1780-5	6.8
Milane	1780-1800	5.6
Japan (Kyoto) i	1791-1800	4.5

and was relatively much cheaper there than elsewhere in Europe. A more comprehensive wage measure would show lower eastern European wages.

[31] [a]Powell, 1990, 98, Farber, 1978, 50-1. [b]Zaccagnini, 1988, 48. [c]Jevons, 1895, 1896. [d]Rathbone, 1991, 156-8, 464-5. [e]Van Zanden,1999, 181-185. Allen, 2001. Allen-Unger data set of wheat prices. [f]Pamuk, 2005, 224. [g]Clark, 2005. [h]Clark, 2001. [i]Bassino and Ma, 2005, Appendix table 1 (assuming 45 lbs of wheat flour per 60 pounds of wheat).

average were about the same for ancient Babylon and Assyria, despite the great technological gains of the intervening thousands of years. In the next two chapters we will ask whether fertility and mortality conditions are consistent with these wage variations. In particular why were Asian societies such as Japan so poor compared to England in 1800?

Second that there is no sign of any improvement in material conditions for settled agrarian societies as we approach 1800. There was no gain between 1800 BC and 1800 AD, 3,600 years of history. Indeed the wages for Japan and southern Europe for 1800 stand out by their low level compared to Ancient Babylonia, Ancient Greece, or Roman Egypt. The evidence on pre-industrial wages is consistent with the Malthusian interpretation of the previous chapter.

Calories, Proteins and Living Standards

A proxy for living standards in the distant past is the living standard of surviving forager and simple agrarian societies. However, since these societies do not have labor markets with wages we need another metric to compare their material conditions to those of pre-industrial societies around 1800.

One such index of living standards is food consumption per person, measured as calories or grams of protein per person per day, shown in table 3.5. As income rises in poor societies, characteristically calorie consumption per person also increases. How did calorie consumption in England in 1800 compare to earlier societies?

Table 3.5 Calories and Protein per Capita[32]

Group	Years	Kcal.	Grams Protein
England, farm laborers[a]	1787-96	1,508	27.9
Britain, farm laborers[a]	1863	2,395	37.7
Ache, Paraguay[b]	1980s	3,827	-
Hadza, Tanzania[g]	-	3,300	-
Alyware, Australia[g]	1970s	3,000	-
Onge, Andaman Islands[g]	1970s	2,620	-
Aruni, New Guinea[d]	1966	2,390	-
!Kung, Botswana[b]	1960s	2,355	-
Bayano Cuna, Panama[f]	1960-1	2,325	49.7
Mbuti, Congo[g]	1970s	2,280	-
Anbarra, Australia[g]	1970s	2,050	-
Hiwi, Venezuela[b]	1980s	1,705	64.4
Shipibo, Peru[e]	1971	1,665	65.5
Yanomamo, Brazil[c]	1974	1,452	58.1

The evidence we have for England is from surveys of poorer families, mainly those of farm laborers who only constituted about 40 percent of the population, made in 1787-96 as part of a debate on the rising costs of the Poor Law.[33] Members of these families consumed an average of only 1,500 kilocalories per day.

The information we have for the likely consumption of earlier societies comes from modern forager and shifting cultivation societies. These reveal considerable variation in calorie consump-

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32 [a] Clark, Huberman and Lindert, 1995, 223. [b]Hurtado and Hill, 1987, 183. Hurtado and Hill, 1990, 316. [c]Lizot, 1977, 508-512. [d]Waddell, 1972, 126. [e]Bergman, 1981, 205. [f]Bennett, 1962, 46. [g]Jenike, 2001, 212.

33 Eden, 1797.

tion across the groups surveyed, ranging from a modest 1,452 kilocalories per person per day for the Yanomamo, to a kingly 3,827 kilocalories per day for the Ache. But the median is 2,340, and all these estimates are at or above those for England in the 1790s. Primitive man ate well compared to one of the richest societies in the world in 1800. Indeed British farm laborers by 1863 had just reached the median consumption of these forager and subsistence societies.

Further the English diet of the 1790s typically had a lower composition of protein than these more primitive societies. Indeed when we compare these foraging societies' calories and protein consumptions with those of British farm workers at the end of the Industrial Revolution we find that the median forager was just as well off in terms of food consumption.

Variety of diet is another important component of human material welfare. On this dimension again hunter gatherers were significantly better situated. The English agricultural laborer did have by 1800 a limited access to the new goods of sugar and tea. But the overwhelming bulk of his diet was the traditional daily monotony of bread, leavened by modest amounts of beef, mutton, cheese and beer. In contrast hunter gatherer diets were widely varied. The diet of the Yanomamo, for example, included monkey, wild pig, tapir, armadillos, anteaters, alligators, jaguar, deer, rodents, a large variety of birds, many types of insects, caterpillars, various fish, larvae, freshwater crabs, snakes, toads, frogs, various palm fruits, palm hearts, hardwood fruits, brazil nuts, tubers, mushrooms, plantains, manioc, maize, bananas, and honey.[34]

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[34] Chagnon, 1983, 57-8. In addition Yanomamo men were daily consumers of tobacco and a hallucinogenic snuff.

Engel's Law and Living Standards

When the Prussian statistician Ernst Engel (1821-96), not to be confused with his rabble rousing contemporary Friederich Engels (1820-95), undertook studies of German working class budgets in the he found a simple but powerful empirical relationship, now called Engel's Law. The poorer a family, the larger the share of its income was spent on food. This relationship has been confirmed by numerous subsequent studies. For the poorest societies food can represent more than 80 percent or more of all expenditures, while for the richest spending on the actual food content of meals is a mere 5-10 percent of income.

Even within the food category of expenditures, there are further variants of the original Engel's Law. When people are very poor, so that hunger is ever present, they consume the cheapest forms of calories available – grains such as wheat, rice, rye, barley, oats, maize and beans or potatoes – consumed in the cheapest possible way as porridge, mush, or bread. Their diet is also extremely monotonous, with little spent on flavorings. Thus Irish farm laborers in the years before the famine lived on a diet that was composed almost entirely of potatoes. At the lowest incomes the share of the cheapest calorie sources in income is very large. But as incomes increase a larger and larger share of food consumption is for more expensive calories - milk, cheese, butter, eggs, meat, fish, beer and wine – or for spices of no calorific value such as pepper, tea, and coffee.

For the ordinary people of the poorest societies meat seems to have been the pre-eminent luxury item. It was reported, for example, that the Sharanahua foragers of Eastern Peru

> *…are continually preoccupied with the topic of meat, and men, women and children spend an inordinate amount of time talking*

about meat, planning visits to households that have meat, and lying about the meat they have in their households (Siskind, 1973, 84).

In this and a number of other forager societies meat would be traded by hunters for sexual favors from women. "The successful hunter is usually the winner in the competition for women."[35]

These consumption patterns can be portrayed using the device of the Engel curve, as in figure 3.3. An Engel curve shows how consumption of any good changes with income, with the implicit assumption that relative prices are kept constant. Goods such as food, called necessities, are a much larger share of the consumption of poor people than of rich people. Indeed for many of these goods, such as basic starches, as income increases the absolute amount spent on the good will decline. Other goods are luxuries. Their share in consumption expenditure rises with income, at least for some range of incomes.

Differences in relative prices can induce deviations from the Engel's Law regularity, but a good general index of living standards is thus either the share of income spent on food, or the share of the food budget spent on basic starches as opposed to meats, alcohol, and refined sugars.

Table 3.6 shows the shares of food expenditures devoted to these categories for farm laborers in England in the 1790s. With only 61 percent of their food expenditures devoted to basic starches these workers reveal themselves to be living well, even compared to Indian farm laborers circa 1950. They also seem to have been much better off than Japanese laborers in the eighteenth century. For England we get evidence on the consumption patterns of agricultural workers back to the thirteenth century because of the custom of feeding harvest workers. The diets of harvest workers from 1250 to 1450 imply an even higher standard

[35]Siskind, 1973, 95-6.

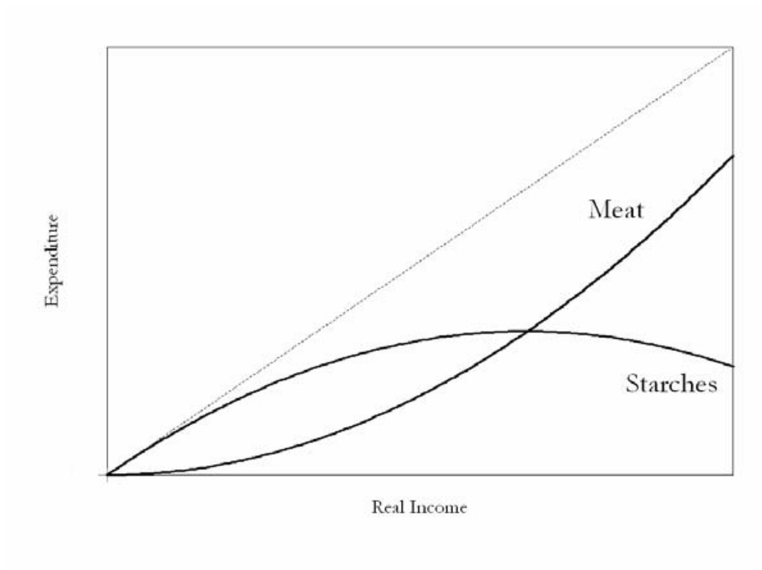

Figure 3.3 Engel Curves

Table 3.6 Share of Different Products in Food Consumption of Farm Workers[36]

Location	Years	Cereals and Pulses (%)	Sugar (%)	Animal products, fats (%)	Alcohol (%)
Englandd	1250-99	48.0	0.0	40.2	11.8
Englandd	1300-49	39.7	0.0	43.0	17.0
Englandd	1350-99	20.8	0.0	55.3	24.0
Englandd	1400-49	18.3	0.0	46.4	34.3
England[a]	**1787-96**	**60.6**	**4.7**	**28.4**	**1.3**
Japan[c]	c. 1750	95.4	0.0	4.6	0.0
India[b]	1950	83.3	1.6	5.4	0.8

36 [a]Clark, Huberman and Lindert, 1995, [b]-----, [c]Bassino and Ma, 2005, [d]Dyer, 1988.

of living for earlier centuries than for England in the 1790s. After the onset of the Black Death in 1348-9 harvest workers were fed a diet that was composed only about 20 percent in cost of basic grains, the rest being dairy products, fish and beer.

Engel's Law, though a simple empirical relationship, has profound importance in explaining world history. In the Malthusian era incomes were bound to remain low, and so food dominated expenditures. Apart from the effect this may have had on conversation, the high share of food expenditures before 1800 ensured that these early societies were largely dispersed and agrarian. If 80 percent of income in the pre-industrial world was spent on food, then 80 percent of the population was employed in agriculture, fishing, or hunting.[37] Agricultural production also demanded a population that lived close to the fields, so pre-industrial societies were predominantly rural, with small urban populations. Around 1450 in England, for example, the average parish would have had 230 residents. Unlike modern high income economies people would encounter strangers rarely.

If the great majority of income was spent on food then there was also little surplus for producing "culture" in terms of buildings, clothing, objects, entertainments, and spectacles. As long as the Malthusian Trap dominated the great priority of all societies was food production.

But the link between consumption and production implies that another index of living standards, at least for societies where trade possibilities were limited, was the proportion of the population engaged in agriculture. Again the comparative prosperity of early England shows up in the high shares of the population, even at early dates, occupied outside of the agricultural sector in areas

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[37] This would not necessarily hold once countries traded substantial quantities of foodstuffs. But such substantial trade was rare before 1800.

such as clothing production or building. Thus in the county of Suffolk in England in 1620-35 only 63 percent of male testators were engaged in farming or fishing.[38] In comparison in Tanzania in 2000 83 percent of males were occupied in farming and fishing.[39]

Human Stature and Material Living Standards

Information on real day wages, food consumption, or occupations is available for only a small share of pre-industrial societies. Wage labor was absent from very early societies, and later ones with labor markets have often left no records. To measure living standards for most of the pre-industrial era we must resort to more indirect measures. One such is average heights. The most obvious effect of better material living standards is to make people taller. If you travel even now to a poor country, such as India, it is immediately striking how short people are. The current average height of Dutch and Norwegian males is 178 cm (70 in), with British and American males slightly smaller at 175 cm (69 in). In contrast males in southern India in 1988-90 had an average height of only 164 cm (64.4 in.), a full 14 cm shorter than the Dutch.[40] Figure 3.4 shows the height gap between rich and poor societies in the form of an anthropologist and the people he studies.

There is little sign in modern populations of any genetically determined differences in potential statute, except for some rare

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[38] Allen, 1989, Evans, 1987.

[39] ILO statistics.

[40] Brennan, McDonald and Shlomowitz, 1997, 220. The states were Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. Males aged 25-39.

Figure 3.4 E. Hagen with a Yanomamo family in 200?. Hagen is 175 cm, the average height for US males.

groups such as the pygmies of Central Africa. And the positive correlation between health measures and height is well documented.[41] Stature is determined by both childhood nutrition and the incidence of childhood illness. Episodes of ill health at growth phases can stop growth, and there is only partial catch up later. But both nutrition and the incidence of illness depend on material living conditions.

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41 Steckel, 1995.

There is evidence on the stature of the living from only a few pre-industrial societies, and then typically not for long before 1800. But through measurement of the long bones in skeletal remains we can get evidence on the stature of a much earlier set of pre-industrial societies.

Table 3.7 shows a summary of this evidence on the stature of living males for the years around 1800 for a range of countries, given in order of average heights. The heights were drawn from a variety of sources: military recruits, convicts, freed slaves, and indentured servants. Indian heights in 1843, for example, are those of indentured servants recruited for labor in Mauritius. But since these Indian workers were being selected for heavy manual labor abroad, there is no reason to expect they were smaller than the general population. These Indian indentured servants were significantly smaller than indentured servants recruited in England for service in North America in the eighteenth century. Similarly the Chinese heights are for immigrants to Australia who were later imprisoned. But their heights were significantly less than those of eighteenth century English convicts transported to America or Australia. The African heights are those of slaves freed on route to the Americas by British ships.

Clearly at the onset of the Industrial Revolution heights of European males were intermediate between those of the modern US and Europe, and those of modern India. Malthus himself, from his time as a country parson, knew that living conditions for the laboring classes in England were poor enough around 1800 that they resulted in stunting. Thus,

> *It cannot fail to be remarked by those who live much in the country, that the sons of labourers are very apt to be stunted in their growth, and are a long while arriving at maturity (Malthus, 1798, 94)*

Table 3.7 Estimated Average Height of Adult Males in pre-Industrial Societies[42] (* birth years).

Period	Location	Type	Ages	Height (cm)
1830s	Sweden[a]	Soldiers	Adult	172
1710-59*	England[f]	Convicts	23-60	171
1710-59*	England[f]	Indentured	23-60	171
1830s	England[a]	Soldiers	Adult	169
1830s	N. Italy[a]	Soldiers	25-40	167
1830s	Bavaria[a]	Soldiers	Adult	167
1830s	France[a]	Soldiers	Adult	167
1830s	Netherlands[a]	Soldiers	Adult	167
1770-1815	England[b]	Convicts	23-49	166
1830s	Hungary[a]	Soldiers	Adult	166
1830s	Austria[a]	Soldiers	Adult	164
1819-39	W. Africa (Yoruba) [d]	Slaves	25-40	167
1819-39	Mozambique[d]	Slaves	25-40	165
1819-39	W. Africa (Igbo) [d]	Slaves	25-40	163
1800-29*	S. China[e]	Convicts	23-59	164
1843	S. India[c]	Indentured	24-40	163
1842-4	N. India (Bihar) [c]	Indentured	24-40	161
1883-92	Japan[g]	Soldiers	20	159

Heights in Asia seem to have been generally much lower than in Europe: 162 as opposed to 167 cm. Thus again the evidence is

42 [a]A'Hearn, 2003, table 3. Adjusted to adult heights. [b]Nicholas and Steckel, 1991, 946. [c]Indentured Servants, Brennan, McDonald and Shlomowitz, 1997, 220. [d]Slaves freed from ships transporting them. Eltis, 1982, 459-60. [e]Morgan, 2006, table 4a. [f]Komlos, 1993, 775. [g]Yasuba, 1986, 223. Adjusted from age 20 to adult heights.

of inferior living conditions in Asia as compared to Europe around 1800. However heights for Africa, despite the presumably much inferior technology there, were at 165 cm not much below the European average. A world average for heights around 1800 would thus be about 164 cm.

In tropical Africa, nature itself supplied high material living societies through high death rates from disease. For Europeans, and indeed almost as much for the native Africans, tropical Africa was deadly. Half of British troops stationed on the coast of West Africa in the eighteenth century died in their first year in station.[43] When the journalist Stanley made his famous journeys across Equatorial Africa in the late nineteenth century, the special ability that allowed him to make his discoveries was not any particular ability with guns or languages, but his ability to withstand the many illnesses that killed all of his white companions.

How do these heights at the end of the pre-Industrial Era compare with earlier societies? As a guide to likely living conditions before the arrival of settled agriculture we have average heights for modern foraging societies. Franz Boas in particular collected height observations from hundreds of native American tribes in the late nineteenth century. As table 3.8 shows, there is a range of variation that is similar to that in agrarian societies around 1800. Some hunter-gatherers were were significantly taller than the nineteenth century Chinese, Indians, Japanese and many Europeans. The median of the heights for these forager societies is 165 cm, very little less than in Europe in 1800, and significantly above Asia circa 1800.

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43 Black Americans who colonized Liberia after 1823 also had extraordinarily high death rates, suggesting that Africans had little genetic protection against the disease environment. McDaniel, 1992.

Table 3.8 Heights of Adult Males in Modern Foraging and Subsistence Societies[44] * = heights adjusted to ages 21-40.

Period	Group	Location	Ages	Height (cm)
1892	Plains Indians[e]	USA	23-49	172
1970s	Anbarra[c]	Australia	Adults	*172
1970s	Rembarranga[i]	Australia	Adults	*171
1910	Alaskan Inuit[d]	USA	Adults	*170
1891	Shoshona[g]	USA	20-59	166
1890	N. Pacific Indians[f]	USA	Adults	*167
1944	Sandawe[j]	Tanzania	Adults	*167
1970s	Fox Basin Inuit[i]	Canada	Adults	*166
1880s	Solomon Islanders[h]	Solomon Is.	Adults	*165
1906	Canadian Inuit[d]	Canada	Adults	*164
1969	!Kung[a]	Bostwana	21-40	163
1980s	Ache[b]	Paraguay	Adults	*163
1970s	Hadza[i]	Tanzania	Adults	*163
1985	Hiwi[b]	Venezuela	Adults	*156
1980s	Batak[i]	Phillipines	Adults	*155
1980s	Agta[i]	Phillipines	Adults	*155
1980s	Aka[i]	C.African R.	Adults	*155

The Tahitians of the 1760s, with their stone-age technology, seem to have been as tall, or taller, than their English visitors with all their marvelous European technology. The explorers certainly thought them tall, remarkably enough that Joseph Banks, a scientists on the Endeavour expedition of 1769, measured the

[44]The heights of all !Kung males averaged 2 cm less than those 21-40 (Lee and deVore, 1976, 172). [a]Lee and DeVore, 1976, 172, [b]Hurtado and Hill, 1987, 180-182, [c]Kelly, 1995, 102, [d]Hawkes, 1916, 207, [e]Steckel and Prince, 2001, [f]Boaz, 1891, 27. [g]Boaz, 1899, 751. [h]Guppy, 1886, 267. [i]Jenike, 2001, 223. [j]Trevor, 1947, 69.

height of a particularly tall Tahitian at 75.5 inches (192 cm).[45] In England in 1800 only one adult male in 2,500 would be 192 cm or more.[46] Since on his short visit he likely saw only a few hundred adult males, given the length of his stay and the low population densities of Tahiti, average heights in Tahiti were with strong probability greater than in eighteenth century England.

Thus the thousands of years of advance representing the difference between forager technology and that of agrarian societies around 1800 did not lead to any signs of a systematic improvement in human material living conditions.

To look at living conditions in the actual historical past, as opposed to equivalent societies now, we have inferred male heights from skeletal remains. Figure 3.4 summarizes the published evidence available on average heights from skeletal remains in Europe from 1 AD to 1800, where the average height estimate has been controlled for gender, for regional effects, and in a limited way for age at death. The century long averages summarize data from 9,477 sets of remains. There is no trend in this series. Also shown are the heights of male conscripts by birth year for Sweden from 1820 on, and the heights of native born US males, from 1710 on. The gains in income after 1800 show up clearly in the heights of the living.

Table 3.9 shows measures of the average male stature from skeletal collections from locations outside Europe in 1 AD to 1800 AD. The small size of many of these collections, their potentially unrepresentative economic status, and the errors in inferring stature from the lengths of long bones, all imply large potential errors in inferring specific population heights from these

[45]Banks, 1962, 334.

[46]Assuming the standard deviation of heights was the same as in modern Britain.

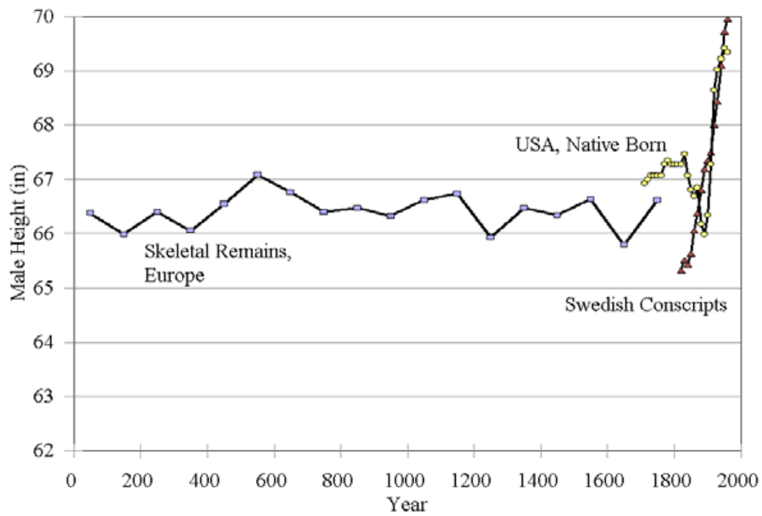

Figure 3.4 Male heights from skeletons in Europe, 1 AD to 2000[47]

samples. But the overall pattern is clear. Average heights in the skeletal record before 1 AD were just as great as those for

England and the Netherlands, the most advanced Malthusian economies in the world in the eighteenth century. The simple average of the heights in the collections dating before the birth of Christ in table 3.7 is 168 cm (66 inches) for males. This is greater than for skeletons in 18th century England and the Netherlands. This was about three inches less than for the richest modern economies, but exceeds heights for the poorer modern economies, such as India in the nineteenth and twentieth century, and Japan in the nineteenth century. Heights, and hence by implication living standards, did fluctuate somewhat

[47] Koepke and Baten, 2003, Steckel, 2001, figures 3 and 4.

Table 3.9 Heights from Skeletal Remains by Period[48]

Period	Location	Observations	Height (cm)
Mesolithic[a]	Europe	82	168
Neolithic[a]	Europe	190	167
Neolithic[b]	Denmark	103	173
1600-1800[h]	Holland	143	167
1700-1800[h]	Norway	1,956	165
1700-1850[h]	London	211	170
Pre-Dynastic[c]	Egypt	60	165
Dynastic[c]	Egypt	126	166
2500 BC[d]	Turkey	72	166
1700 BC[e]	Lerna, Greece	42	166
2000-1000 BC[f]	Harappa, India	-	169
300 BC – 250 AD[i]	Japan – Yayoi	151	161
1200-1600[i]	Japan – Medieval	20	159
1603-1867[i]	Japan – Edo	36	158
1450[g]	Marianas, Taumako	70	174
1650[g]	Easter Island	14	173
1500-1750[g]	New Zealand	124	174
1400-1800[g]	Hawaii	-	173

before 1800. But the variations, as predicted in the Malthusian model, have no connection with technological advances.

48 [a]Meiklejohn and Zvelebil, 1991, 133, [b]Bennike, 1985, 51-2, [c]Masali, 1972, [d]Mellink and Angel, 1970, [e]Angel, 1971, [f]Dutta, 1984, [g]Houghton, 1996, 43-45, [h]Steckel, 2001, [i]Boix and Rosenbluth, 2004, table 6.

Thus Europeans in parts of the medieval period seem to have been taller than those in the classical period, or in the eighteenth and early nineteenth centuries. Polynesians in the period before contact with the outside world were also tall by pre-industrial standards, according well with the inference drawn above from Banks' report. Yet there is no doubt that the technology of the Polynesians was far behind that of the Europeans. Polynesia still was a Neolithic economy without metals. Fish hooks were laboriously fashioned from bone or coral. The preferred weapon of war was a wooden club. Canoes had to be fashioned from tree trunks using fire and stone axes. The canoes were sometimes mounted with sails, but not rigged in such a way that they could sail into the wind. Thus long ocean voyages were hazardous. There was little or no earthenware. There was no system of writing. Cloth was made from tree bark, but little clothing was required in the equatorial climate.

The natural environment of Polynesia was benign. The scourge of the tropics, malaria, did not exist on the islands until imported along with the mosquito by white mariners. Thus the British and French crews spent months ashore in Polynesia with few if any deaths from local diseases. But where nature failed them, the Polynesians seem to have supplied their own mortality.[49]

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[49]The reason for the very high living standards, as we shall see in chapter 5, seems to have been high death rates from infanticide, internal warfare, and human sacrifice. Polynesia was paradise for the living, but a paradise with a cost.

The Industrious Revolution

Consideration of early forager societies, through skeletons, and of remnant forager societies now, suggests that material living conditions were if anything better for these societies than for the settled agrarian societies on the eve of the Industrial Revolution.

But another dimension of living conditions was how long people had to labor to get their daily bread, and the types of labor they performed. Here the arrived of settled agrarian societies probably reduced human welfare. A world of leisure for the original foragers gave way to a world of continuous labor by the eve of the Industrial Revolution. Not only was this labor continuous, it was also much more monotonous than the tasks of the foragers. But this change in the quantity and quality of work long preceded the arrival of modern technology.

Anthropologists have long debated how much work people had to do to achieve subsistence in pre-industrial societies.[50] The earlier anthropological tradition assumed that hunter gatherers lead hard lives of constant struggle to eke out a living. The Neolithic agricultural revolution, by increasing labor productivity in food production, reduced the time needed to attain subsistence, and allowed leisure, craft production, religious ceremonies and other cultural expressions.

However, the innovation of systematic time allocation studies of hunter-gatherer and subsistence cultivation groups in the 1960s, showed labor inputs in these societies to be surprisingly small. For example, the Hiwi, a foraging group from Venezuela, consumed a modest 1,705 kilocalories per day and often complained of hunger. Yet men would generally forage for less than 2 hours

[50] See, for example, Gross, 1984.

per day, even with high returns from each hour of work.[51] Indeed work time in these societies is considerably less than in settled agrarian societies. Table 3.10 shows estimates of the total work input of males per day in modern societies where foraging or hunting were still significant activities. For these societies median hours of work per day by males, including food preparation and child care, were just 5.9, or 2,150 hours per year. Such low work inputs need not be maladaptive for foragers. Ecologists have calculated how many hours a day various bird and mammal species engage in "work" - foraging, moving, defending territory or even socializing – as opposed to resting. If we just take the species closest to man – apes and monkeys – work hours per day averaged only 4.4.[52]

To put forager work efforts in context, time studies that include study, housework, child care, personal care, shopping and commuting suggest that modern adult males (16-64) in the UK engage in 3,200 hours of labor per year (8.8 hours per day). Thus males in these subsistence societies consume at least 1,000 hours more leisure per year than in affluent modern Europe.

Despite popular images of the Industrial Revolution herding formerly happy peasants into a life of unrelenting labor in gloomy factories, this transition seems to have occurred before the Industrial Revolution rather than as a result of it.

In England on the eve of the Industrial Revolution the typical male worked 10 or more hours per day for 300 or more days per year, for a total annual labor input in excess of 3,000 hours. For building workers we know the length of the typical work day from

[51] Hurtado and Hill, 1987, 1990.

[52] Winterhalter, 1993, 334. Chimpanzees, the hardest working of the ape and monkey families, did work as much as modern man at 9 hours a day.

Table 3.10 Male Labor Inputs per Day[53]

Group	Group or Activity	Hours
Tatuyo[k]	Shifting cultivation, hunting	7.6
Mikea[i]	Shifting cultivation, foraging	7.4
Ache[b]	Hunting	6.9
Abelam[a]	Subsistence agriculture, hunting	6.5
!Kung[g]	Foraging	6.4
Machiguenga[h]	Shifting cultivation, foraging, hunting	6.0
Xavante[f]	Shifting cultivation, hunting	5.9
Aruni[c]	Subsistence agriculture	5.2
Mekranoti[f]	Shifting cultivation, hunting, foraging	3.9
Shipibo[j]	Subsistence agriculture, fishing	3.4
Bemba[d]	Shifting cultivation, hunting	3.4
Hiwi[e]	Hunting	3.0
Yanomamo[k]	Shifting cultivation, hunting, foraging	2.8
Median		**5.9**
Britain, 1800[n]	Farm laborers, paid labor	8.2
England, 1800[o]	Building Workers, paid labor	9.0
London, 1800[p]	All Workers	9.1
UK, 2000[q]	**All, 16-64**	**8.8**

the fact that employers charged for their services both by the hour and by the day. The ratio of daily to hourly wages suggests the typical hours per day. Table 3.11 shows this evidence. Average

53 [a]Scaglion, 1986, 541. [b]Kaplan and Hill, 1992. [c]Waddell, 1972, 101. [d]Minge-Klevana, 1980. [e]Hurtado and Hill, 1987, 178-9. [f]Werner et al., 1979, 311 (food only). [g]-----. [h]Johnson, 1975. [i]Tucker, 2001, 183. [j]Bergman, 1980, 209. [k]Lizot, 1977, 514 (food only). [n]Clark and van der Werf, 1998. [o]Clark, 2005, 1322. [p]Voth, 2001. [q]UK, Office of National Statistics, Time Use Survey, 2000.

daily hours of paid labor for these workers over the whole year would be nearly 9 per day. There is also no sign of increasing hours for builders as the Industrial Revolution proceeds, and if anything, a decrease. Agricultural workers seem to have had similarly long numbers of hours per year. Comparing the wages paid to day workers with those paid to annual workers suggests that annual workers were putting in a full 300 day year.[54] Workers were kept in employment throughout the winter with such tasks as hand threshing of grains, ditching, hedging, and mixing and spreading manure.

Joachim Voth in an interesting study of time use in Industrial Revolution England used summaries of witness statements in criminal trials which often contain statements of what the witness was doing to estimate annual work hours in 1760, 1800 and 1830. His results for London, where the information is most complete, are shown in table 3.10. They suggest men in London in 1800 worked 9.1 hours per day.[55] Thus a labor input of 9 hours per day of the year, for paid labor alone, seems to have been the norm in England by 1800. The transition to the intense labor of the modern world occurred before the Industrial Revolution.

This helps explain why Polynesia appeared such an idyll to European sailors, and why Captain Blyth had trouble getting his sailors on board again after their stay in Tahiti. The main food supplies in Polynesia were from breadfruit trees and coconut palms, supplemented by pig meat and fish. But all the labor that was required for the breadfruit trees and the palms was to plant the tree, tend it till it grew to sufficient height, and then harvest

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[54] Clark and van der Werf, 1998.

[55] Voth, 2001, 1074. Voth finds evidence of a significant increase in work hours from 1760 to 1830, but the evidence of building workers suggests if anything a decline of the length of the work day as the Industrial Revolution proceeds.

Table 3.11 The Work Day of English Builders[56]

Decade	Towns	Hours
1720	1	10.4
1730	-	-
1740	1	8.3
1750	1	-
1760	1	11.9
1770	1	10.1
1780	2	11.3
1790	2	10.9
1800	4	10.5
1810	5	10.3
1820	7	10.3
1830	9	9.9
1840	10	9.9
1850	9	10.0
1860	8	10.0

the fruits when ripe. Like the subsistence societies of table 3:10 the Polynesians apparently labored little.

The Industrious Revolution and Welfare

Suppose a Malthusian economy where workers work 2,100 hours per year experiences an "industrious revolution" which increases labor inputs to the 3,200 hours per year typical of English workers in the Industrial Revolution period. What is the

[56]Clark, 2005.

long run effect of this on living standards? Figure 2.7, showing the effects of a technological advance in the Malthusian era actually covers this situation also. Higher labor inputs would generate higher annual material output, and thus a short run situation where births exceeded deaths, and hence population growth. Eventually with enough population growth the economy would again attain equilibrium, with the same annual real income as before, but workers now laboring 3,200 hours per year for this annual wage as opposed to the previous 2,100 hours.

Indeed a community which had cultural norms which prevented people from working more than 1,900 hours per year would be better off than one where people were allowed to work 3,200 hours. The prohibitions of work on Sundays and Holy Days by the Catholic Church, or of work on the Sabbath in Judaism, improved welfare in the pre-industrial era. More enforced holidays would have made living conditions even better.

In comparing forager living standards with those on the eve of the Industrial Revolution we need to make some correction for this difference in hours. Another way to measure the real living standards of people in 1800 relative to those of the pre-documentary past is to consider the number of kilocalories such societies produced per hour of labor when producing their major food staples. This is a measure of their consumption possibilities as opposed to their realized consumption, which depends also on hours of work.

The surprise here is that while there is wild variation across forager and shifting cultivation societies, many of them had food production systems which yielded much larger numbers of calories per labor-hour than the English agriculture in 1800, at a time when labor productivity in English agriculture was probably the highest in Europe. In 1800 the total value of output per man-hour in English agriculture was 6.6 d., which would buy 3,600 kilocalories of flour, but only 1,800 kilocalories of fats and 1,300 kilocalories of meat. Assuming English farm output was then half grains, one quarter fats and one quarter meat this implies 2,600 calories output per worker-hour on average. Since the average person eats 2,000 kilocalories per day, this means each farm worker could feed 13 people, so labor productivity was very high in England.

Table 3.12 shows in comparison the energy yields of foraging and shifting cultivation societies per worker-hour. The range in labor productivities is huge, but the minimum average labor productivity, that for the Ache in Paraguay is about 2,000 kilocalories per hour, not much below England in 1800. And the median yield per labor hour is 4,500 kilocalories, nearly double English labor productivity.

Some of the reported labor productivities are astonishing, such as for shifting cultivation of maize by the Mikea of Madagascar. These societies, many of them engaging in the most primitive of cultivation techniques, thus typically had greater potential material outputs, at least in food production, than England on the eve of the Industrial Revolution. For example, the Peruvian Shipibo's staple crop, providing 80 percent of their calorie intake, was bananas cultivated in shifting patches of forest land. The technique of cultivation was extremely simple. The land was burned, and the larger trees felled. Banana seedlings were planted among the fallen trees and stumps. The land was periodically weeded to prevent weeds choking out the banana trees. Yet in these tropical conditions the yield was more than 60 lbs of bananas (15,000 kilocalories) per labor-hour. This is just an illustration once more of the Law of Diminishing Returns. With a

Table 3.12 Calories produced per worker-hour, Forager and Subsistence Societies versus England, 1800.[57]

Group	Location	Staple Foods	Kcal. per hour
Mikea[f]	Madagascar	Maize	110,000
Mikea[f]	Madagascar	Tuber foraging	1,770
Mekranoti[d]	Brazil	Manioc, Sweet Potato, Banana, Maize	17,600
Shipibo[g]	Peru	Banana, Maize, Beans, Manioc	7,680
Xavante[d]	Brazil	Rice/Manioc	7,100
Machiguenga[e]	Peru	Manioc	4,984
Kantu[c]	Indonesia	Dry Rice	4,500
Hiwi[b]	Venezuela	Game (men)	3,735
Hiwi[b]	Venezuela	Roots (women)	1,125
Ache[a]	Paraguay	Palm fiber, shoots (women)	2,630
Ache[a]	Paraguay	Game (men)	1,340
Foragers, median			**4,740**
England, 1800		Wheat, milk, meats	2,600

vast land area at their disposal even foragers with a very primitive agricultural technology can have very high outputs per worker. These foraging and shifting cultivation societies were typically not materially more wealthy simply because their labor input was on

57 [a]Kaplan and Hill, 1992. [b]Hurtado and Hill, 1987, 178. [c]Dove, 1984, 99. [d]Werner et al., 1979, 307. [e]Johnson, 1975. [f]Tucker, 2001, 183. [g]Bergman, 1980, 133.

average only about 60 percent of that of England in 1800. Whatever material prosperity the English had in 1800 was wrested from the soil by hard work and long hours. The evidence seems to be that Marshall Sahlins was substantially correct when he controversially claimed that foraging and swidden societies had a form of "primitive affluence," which was measured in the abundance of leisure as opposed to goods.[58]

Thus if anthropologists are correct about the low labor inputs of hunter-gatherer societies then while we would expect material living standards to be the same between 10,000 BC and 1800 AD, real living conditions probably declined with the arrival of settled agriculture because of the longer work hours of these societies. The Neolithic agricultural revolution did not bring more leisure, it brought more work for no greater material reward.

That still leaves a puzzling question to address. Why as the Industrial Revolution approached had labor inputs in some societies increased so much? This is addressed in chapter 8.

Conclusion

There is ample evidence in the historical and skeletal record to support the key contention of the Malthusian model. Living conditions before 1800 were independent of the level of technology of a society. But living standards did vary substantially across societies before 1800. Medieval Western Europe, for example, in the period between the onset of the Black Death in 1348 and renewed population growth in 1550, was extraordinarily rich, rich even by the standards of the poorest economies of the world today. Polynesia before European contact also seems to have

[58]Sahlins, 1972.

been prosperous. In contrast China, India and Japan in the eighteenth and nineteenth centuries appear to have been very poor. Chapters 4 and 5 consider the causes of these variations, which lay in the determinants of fertility and mortality.

4 Fertility in the Malthusian Era

In almost all the more improved countries of modern Europe, the principle check which keeps the population down to the level of the actual means of subsistence is the prudential restraint on marriage (Malthus, 1830, 254)

Given that societies before 1800 were Malthusian, the only ways human agency could improve living standards was by reducing fertility or increasing mortality. Reducing fertility had two effects in a Malthusian economy. First it would increase living standards. Second it would increase life expectancy. Indeed if the birth rate was unresponsive to living conditions, the birth rate alone would determine life expectancy at birth. If the birth rate was at the biological maximum of 60 per thousand, life expectancy at birth would be a mere 17 years. If the birth rate could be reduced to 25 per thousand life expectancy would rise to 40.

The historical demography of western Europe before 1800 has been intensively researched. This research established years ago that fertility limitation was in place already by the sixteenth century when the data to establish fertility become available. In England in the 1650s, for example, when English fertility was at its pre-industrial minimum, the birth rate was 28 per 1000, less than half the biological possibilities. A women at age 50 would have given birth on average to only 3.6 children.

It used to be thought that fertility limitation of this magnitude was unique to western Europe, and helped explain the prosperity of these European areas compared to other pre-industrial economies in the seventeenth and eighteenth centuries. For Europe had a unique marriage pattern for pre-industrial societies where women married late, and large fractions never married.[59] Indeed Malthus himself in the second and subsequent editions of his *Principle of Population* argued that the prosperity of western Europe was based on its exercise of the *preventive check* through marriage choices. It was also thought that the fertility limitation of western Europe reflected also a more individualistic, rational society where men and women realized the costs of high fertility and took steps to avoid it. Europe's eventual experiencing of the Industrial Revolution was thus foreshadowed hundreds of years earlier by its adoption of a modern marital pattern and family structure which emphasized individual choice. [60]

More recent research, however, suggests most societies before 1800 limited fertility by as much as in western Europe, though in very different ways. It also suggests that the reasons for fertility limitation in Europe had little to do with rational individual calculation, and much more to do with European social customs.

European Fertility

Western European fertility was kept well below the biological possibilities through a curious mechanism. There is no sign in these countries before 1800 that contraceptive practices were consciously employed.[61] Marital fertility levels were high. Table 4.1, for example, shows marital fertility for a variety of countries

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[59]Hajnal, 1965.

[60]Macfarlane, 1976.

[61]France just before the French Revolution is a possible exception, though any fertility limitation there in the late eighteenth century was very limited.

Table 4.1 Annual birth rate, married women, Europe before 1790[62]

Country or Group	20-4	25-9	30-4	35-9	40-4	All Births (20-44)
Hutterites	.55	.50	.45	.41	.22	10.6
Belgium	.48	.45	.38	.32	.20	9.1
France	.48	.45	.40	.32	.16	9.1
Germany	.45	.43	.37	.30	.16	8.6
Switzerland	.45	.38	.34	.22	.16	7.8
Scandinavia	.43	.39	.32	.26	.14	7.7
England	.43	.39	.32	.24	.15	7.6

in Western Europe before 1790 compared to the Hutterite standard.[63]

Birth rates within marriage were lower than for Hutterites, but by different amounts across countries. English fertility was the lowest, French the highest. A woman married from ages 20 to 44 had 7.6 children in England in the years before 1790, but 9.1 in Belgium or France. In comparison Hutterite women would have 10.6 children in these 25 years. But these European differences from Hutterite levels mostly stemmed from adherence to social practices without individual targeting of fertility.

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[62]Flinn, 1981, 86.

[63]The Hutterites are communal Anabaptists of German origin, now mainly located in Canada, with good health, but early marriage and no fertility limitation within marriage. They thus provide a reference on the possibilities of unrestricted fertility.

Part of the evidence against conscious contraceptive practices is the lack of patterns in fertility that might be found where there was conscious control of fertility. With such control older married women would be more likely to have achieved their target fertility, and be avoiding further births. In this case, absent confounding factors, European marital fertility should have fallen further below the Hutterite standard for older women. As table 4.2 shows the relative birth rate in early Europe compared to Hutterite rates is instead independent of age.

Similarly if there was a target number of children, then we might observe that women with many children by a given age would show lower fertility at that age.[64] Or with targets, the death of a child would increase the chances of a birth in the following years, since now the family was falling further behind its target. There is no sign of any of these fertility patterns within European marriages before 1800.

The other source of evidence about fertility control comes from diaries, letters, and literature. Samuel Pepys' diaries, for example, give an extraordinarily insight into the habits and mores of the upper classes in London in 1660-9. Pepys was having extramarital sexual relationships, even abusing his stewardship of the Navy office to obtain sexual favors from the spouses of Navy contractors. Yet though he feared getting his companions pregnant, he made no use of contraception. Instead he preferred relationships with married women where the pregnancy could be

[64]Both these tests unfortunately run into the problem that people would have different targets for family sizes. The ones who want lots of children may then marry earlier and so still have high fertility levels at later ages.

attributed to the husband, or, to his intense frustration, he refrained from penetration in his amorous encounters.[65]

Yet despite the apparent absence of contraceptive practices, the birth rate in most pre industrial western European populations was low, at only 30-40 births per thousand, because of the *European Marriage Pattern*. This had four features.

1. *A late average age of first marriage for women: typically 24-26.*
2. *High fertility within marriage.*
3. *Large numbers of women never marrying: typically 10-25 percent.*
4. *Low illegitimacy rates: typically 3-4 percent of births.*

Low illegitimacy rates imply large scale abstenance from sex outside marriage, since the majority of women of reproductive age were unmarried.

These features avoided more than half of possible births simply from marriage patterns, as is illustrated in figure 4.1. The horizontal measure is the number of women, the vertical their ages. The area of the rectangle gives the total number of reproductive years per 100 women, assuming women are fertile from 16 till 45.

Delayed marriage avoided nearly a third of possible births. Eschewing marrying avoided 10 to 25 percent of the remaining births. Thus fertility was reduced by a third to a half by the marriage pattern. Also since the years 16 to 25 are those of higher fertility for women, the proportion of births avoided is even higher than this exercise would suggest.

Table 4.2 shows the mean age at first marriage of women in various European countries before 1790. Also shown is the number of children a women married at the average age of first

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[65]Once when he feared he had impregnated the wife of a naval officer at sea he frantically used his official position in the Navy to recall the husband in time for the pregnancy to be attributable to him. Pepys, 1953.

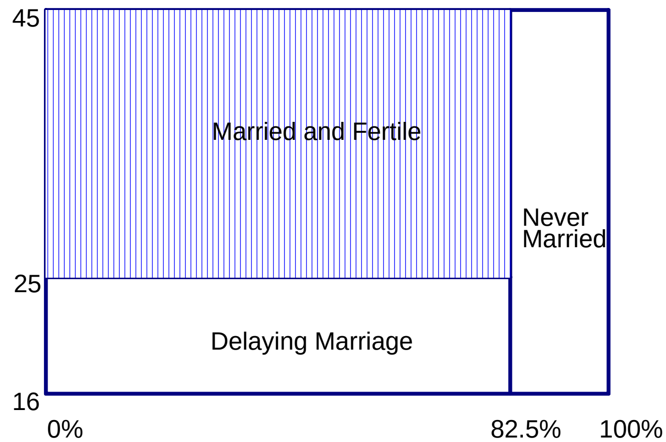

Figure 4.1 The European Marriage Pattern and Fertility

Table 4.2 Age of marriage of women and Marital Fertility in Europe before 1790[66] * = inferred assuming missing values at European average.

Country or Group	Mean Age at First Marriage	Births per married women	% never married	Total Fertility Rate
Belgium	24.9	6.8	-	6.2*
France	25.3	6.5	10	5.8
Germany	26.6	5.6	-	5.1*
England	25.2	5.4	12	4.9
Netherlands[a]	26.5	5.4*	-	4.9*
Scandinavia	26.1	5.1	14	4.5

[66]Flinn, 1981, 84. [a]de Vries, 1985, 665. Weir, 1984.

marriage would have if she lived to age 45. Finally the total fertility rate, the number of children born to the average woman, is roughly calculated taking into account the illegitimacy rate and the likely fraction of women never marrying. Before 1790 women in the different countries of northwest Europe thus gave birth to between 4.5 and 6.2 children each, with a median of 4.9. This corresponds to a crude birth rate of about 32 per thousand. By implication birth rates in Belgium and France were about 40 per thousand.

East Asian Fertility

When Malthus wrote his various editions of the *Principle of Population* he assumed that China represented the full misery of the Malthusian trap, and that life was miserable there as a result of high fertility. Research in the last thirty years, however, suggest that like pre-industrial Western Europe, and like many forager societies, both China and Japan avoided many potential births. Indeed Asian restrictions on fertility, though coming through completely different mechanisms, were likely nearly as severe as in Western Europe.

In Asia, as Malthus knew, early and almost universal marriage for women was the norm. Recent studies of family lineages, and local population registers, suggest an average age of first marriage by women in China around 1800 of 19. The percentage of women never marrying was also low, at probably only 1 percent for the general population.[67] Men also married early, at a mean age for first marriage of 21, but the percentage of men never marrying was much higher, perhaps even as high as 16 percent.

[67] Lee and Wang, 1999, 67-8.

Chinese males were no more likely to marry than their western European counterparts. This was because female infanticide created a surplus of males, and also remarriage after the death of a spouse was more common for men than for women.[68] There is similarly evidence that in nineteenth century Japan marriage was earlier than in pre-industrial western Europe and nearly universal for women.

But in both Japan and China fertility rates within marriage were much lower than in western Europe. Table 4.3 shows the estimated age-specific fertility rates for married women averaged across various Chinese groups, and in Japan, compared to pre-industrial western Europe. At all ages within marriage Chinese and Japanese women had fewer children per year. As a result a Chinese or Japanese woman married from age 20 to 45 would give birth to only about 5 children, as opposed to 8 in western Europe. Across both upper and lower classes the mean age of last birth was about 34 in China, compared to nearly 40 in Europe.[69]

It is not known why marital fertility in East Asia was so low. As in pre-industrial western Europe there is no sign of an early curtailment of fertility that would clearly indicate family planning. Fertility rates within China and Japan were uniformly about half those of the Hutterites at all ages. Thus the likely source is again not conscious fertility control by individuals, but instead adherence to social customs that resulted in lower fertility.[70]

These patterns implied that despite early and nearly universal marriage the average woman in China or Japan around 1800 gave

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68 Lee and Wang, 1999, 70-3, 89.

69 Because of female infanticide some of these birth rates are estimated from male births alone appropriately inflated. Lee and Wang, 1999, 87.

70 Lee and Wang, 1999, 90-1, cite as contributors to low Chinese fertility extended breastfeeding, and cultural beliefs that sexual activity was damamging to health.

Table 4.3 Age-Specific Marital Fertility Rates outside Europe[71]

Country or Group	20-4	25-9	30-4	35-9	40-4	All Births (20-44)
Hutterite	.55	.50	.45	.41	.22	10.6
W. Europe	.45	.42	.35	.28	.16	8.3
China	.24	.25	.22	.18	.10	5.0
Japan	.29	.25	.22	.15	.12	5.2
Roman Egypt	.38	.35	-	-	-	7.4

birth to less than 5 children, less than half the biological possibilities, and similar to the birth rates for eighteenth century Europe.

A further factor driving down birth rates (and also of course driving up death rates) was the Chinese practice of female infantide. Based on the imbalance between recorded male and female births an estimated 20-25 percent of girls died from infanticide in Liaoning, for example. Evidence that it was conscious female infanticide comes from the association between the gender imbalance of births and other factors. When grain prices were high more girls are missing. First children were more likely to be female than later children in a family. The chance of a female birth being recorded for later children also declined with the

[71] Hutterite and W. European, Table 4.1. China and Japan, Lee and Wang, 1999, 87. Roman Egypt, Bagnall and Frier, 1994, 143-6.

numbers of female births already recorded for the family. All this suggests conscious female infanticide.[72]

Female infanticide contributed to limiting the overall birth rate in later generations by changing the adult sex ratio. Female infanticide meant that while nearly all women married, nearly 20 percent of men never found brides. Thus the overall birth rate per person, which determines life expectancy, was reduced. The overall birth rate for the eighteenth century is unclear from the data given in this study, but by the 1860s when the population was stable it was around 35 per 1000, about the same as in pre-industrial Europe, and less than many poor countries now. Earlier and more frequent marriage than western Europe was counter-acted by lower marital fertility and by female infanticide to produce equivalent overall fertility rates.

There is evidence in Japan of a very similar pattern of fertility control. Measured birth rates are as low as in Western Europe. One source of demographic information is Buddhist temple death records. These records, documenting the memorial services for persons affiliated with the temple, have been used to estimate that circa 1800 villages in the Hida region of Central Japan had a birth rate of only 36 per thousand, little higher than the rates in England in the seventeenth and eighteenth centuries.[73] These low rates were achieved by a marriage and fertility pattern very similar to Liaoning. Female marriage was early and nearly universal, but marital fertility was low.

Roman Egyptian Fertility

[72] Lee and Campbell, 1997, 64-75.
[73] Jannetta and Preston, 1991, 426.

The one early society for which we have demographic information is Roman Egypt in the first three centuries AD. As in pre-industrial China and Japan female marriage was early and universal. The estimated mean age at first marriage for Egyptian women was only 17.5.[74] As in China and Japan in the eighteenth and nineteenth centuries, however, fertility was restricted to some degree within marriage. Marital fertility rates were only about two thirds the Hutterite level.

This early and universal marriage, and relatively high fertility rates within marriage would seem to imply high overall fertility rates compared to westen Europe. After all an Egyptian woman married from the average age of 17.5 until age 50 would give birth to 8 or more children at these rates. But in fact birth rates were 40-44 per thousand, implying a life expectancy at birth of 23-25 years. In comparison French birth rates in 1750 were about 40 per thousand. So Roman Egypt, despite early marriage, had fertility levels only slightly higher than eighteenth century France.[75]

The intervening factor that again kept Egyptian birth rates lower than we would expect was again social customs. In western Europe widows commonly remarried, but not in Roman Egypt. Also divorce was possible in Egypt. But while divorced husbands commonly remarried younger women, divorced women typically did not remarry. Thus while in Egypt almost all the women got married, the proportion still married fell steadily after age 20. Consequently women surviving to age 50 typically gave birth to only 6 children, rather than 8.[76] Thus for all the settled agrarian

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[74]Bagnall and Frier, 1994, 114.

[75] Weir, 1984, 32-33.

[76] Average births per adult woman would be lower than this because not all women would live to age 50.

societies where we have good demographic data for the years before 1800 fertility rates tended to be well below the biological possibilities.

Forager Fertilities

Forager societies seem to have also typically restrained their fertility, though in a pattern more reminiscent of Asia than of western Europe. Table 4.5 shows some measures of fertility for modern forager groups. First is the average number of births per woman per year, second the average age of women at first birth, third the average age at the last birth, and lastly the total fertility rate, the number of births per woman who lived to the end of her reproductive life. For the groups in table 4.5, the total fertility rate averaged 4.9 The numbers of births per year in these hunter gatherer societies are thus also far below the biological possibilities. These birth rates are also as low or lower than those of pre-industrial western Europe. In England before 1790, for example, the average women similarly gave birth to 4.9 children across her entire reproductive life. Thus fertility rates in England on the eve of the Industrial Revolution were likely no lower than for the earliest forager groups. This is one reason why living standards did not show any upward tendency before the Industrial Revolution. In Malthusian societies some kind of fertility control was the norm rather than the exception. Only the sources of these controls varied widely.

Table 4.5 Fertility in Modern Forager Societies[77] * = estimated from columns 2-4.

Group	Births per year per woman	Mean age - first birth	Mean age - last birth	Total Fertility Rate
Ache[c]	0.32	20	42	8.0
Yanomamo[c]	0.34	18	38	6.9
James Bay Cree[a]	0.37	22	39	6.3*
Cuiva (Hiwi)[b]	-	-	-	5.1
!Kung[a]	0.35	21	37	4.7
Arnham Land, monogamous[a]	0.30	19	34	4.5*
Kutchin (pre 1900)[a]	0.30	23	35	4.4
!Kung[a]	0.27	19	34	4.1
Batak[a]	0.44	18	26	3.8
Arnham Land, polygamous[a]	0.18	19	34	2.8*
Median	**0.32**	**19**	**36**	**4.6**

The Birth Rate and Income

An issue that has exercised historical demographers since the time of Malthus is whether the birth rate in pre-industrial Europe was "self-regulating." What they mean by this is shown in figure 4.2. This shows the birth and death schedules of a simplified

[77] [a]Kelly, 1995, 246. [b]Hurtado and Hill, 1987, 180. [c]Hill and Hurtado, 1996, 262.

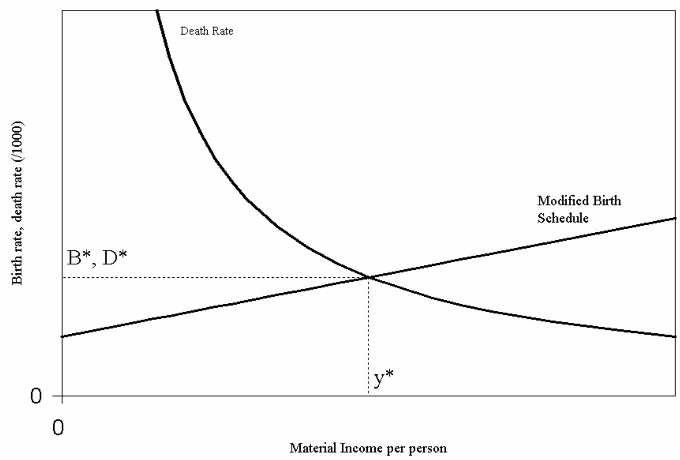

Figure 4.2 A Malthusian Model where Births Increase with Income

Malthusian model, as well as a modified birth schedule, which slopes upwards with material incomes. In the more complicated Malthusian model it is assumed that in good times people marry earlier, and more marry, so that fertility increases. In bad times fewer marry, and they marry later, so that fertility declines.

It should be clear that it does not change the basic equilibrium of the model, as long as births increase with income. What does change is the mechanism and the speed with which the society gets back to equilibrium if some event pushes it away. In the simple Malthusian model, all the adjustment is done through changes in mortality. In the modified model changes in fertility play a role. If the population gets so high that material income is below subsistence in the simple Malthusian model, people must die to get the population back to equilibrium. In the modified model population can decline in part simply through the mechanism of reduced births.

Further the empirical evidence for the pre-industrial period suggests that gross fertility did not rise significantly with income. When information about wealth from wills was linked to information about likely gross fertility for male testators in England around 1600, the suggestion is that richer testators would have only modestly higher gross fertilities than poorer ones. Table 4.6 shows the characteristics of poorer testators, those with less than £100 in bequests, and richer testators, those with £100 or more in bequests. The richer testators on average had about ten times the assets of the poorer.

Probabilities of ever marrying were possibly, but only possibly, higher for richer men. For 12.7% of poorer testators there was no evidence of any marriage at their time of death, while this was true for only 7.8% of richer testators. Correcting for potential underreporting of widowers among the poor, the true difference in marriage rates may be only 2%.[78] But the age at marriage was the same for both groups. Also marriages lasted almost as long for the poorer as for the richer testators. This implies that just from the difference in marital behavior, there would be only 2-5% higher gross fertility for richer testators.

Once married the median time till the first identified birth from parish registers was again very similar for the poorer and richer testators. Thus despite the huge income differences between the poor and the rich in this sample, the overall gross fertility of the rich was likely only very modestly higher than for the poor.

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78 Clark and Hamilton, 2006, explains why poorer men are less likely to be identified as widowers from their wills. 3 percent fewer poorer men were identified as widowers than were richer men.

Table 4.6 Measures of Likely Gross Fertility and Wealth, England, 1620-38[79]

Variable	Obs.	Poor	Rich
Average wealth	2,145	£32	£361
Percent unmarried	2,145	12.7%	7.8%
Average age at death	251	52.3	55.2
Age at first marriage	83	27.1	27.2
Years married	180	27.8	29.1
Median time, marriage to first birth (years)	70	1.22	1.17

Wealthier families in Nuits in France in 1744-92 had more births per year of marriage. But the size of this effect was again small.[80] Similarly in China there is little sign of higher gross fertility among high status lineage groups in the Beijing nobility than there was among peasants in Liaoning.[81] Total marital fertility was higher in the lower status community, and the percentage of women marrying somewhat higher. Thus it does not do too much violence to reality to simply assume a given birth rate for any pre-industrial society, independent of income per person.

79 Clark and Hamilton, 2006.
80 Hadeishi, 2003.
81 Lee and Wang, 1999, 68, 85.

Explaining Pre-Industrial Fertility

Fertility was limited in almost all pre-industrial societies. But, with rare exceptions such as France on the eve of the French Revolution, there is no clear evidence that this was a conscious individual decision. Nor is there much sign that this was control exercised at the community level. People exhibited individual behaviors that limited fertility, but with little sign of any conscious objective. This stark conclusion will be controversial among demographic historians, but it can be amply supported by consideration of the details of peoples' behavior.[82]

There was no control of fertility within marriage in pre-industrial western Europe. But was the delay and avoidance of marriage aimed, at the individual or the community level, at reducing fertility? Malthus in the *Principles* seems to assume that postponing or eschewing marriage was the only way to limit fertility. (He himself did not get married till age 38, and then to a woman of 27, who gave birth to only 3 children).[83]

The case for marriage behavior as a planned limitation of fertility is strengthened by the fact that the European marriage pattern prevailed to different degrees in different epochs. In England, for example, it was most marked in the seventeenth century, where fertility limitations were so severe that population sometimes declined. In the eighteenth century the average age of first marriage declined, so that by 1800-50 it was 23.4 compared to nearly 26 in the seventeenth century. The percentage of women never marrying declined also to 7 percent by these years. Did

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82 Thus MacFarlane, 1987, argues that marriage decisions in pre-industrial England were individualistic, prudential and calculating.

83 Ironically only two of Malthus's children survived to marry, and neither of them had children. So Malthus has no descendants.

fertility increase at the time of the Industrial Revolution because of the enhanced job opportunities?

However, the notion that fertility was adapting to living standards in pre-industrial England can be quickly dispelled. The increase in fertility in the eighteenth century occurred in all settings across England: rural parishes, industrial parishes, urban parishes. Further if delayed marriage was a conscious attempt by individuals to reduce the numbers of children they had then it has some inexplicable features. The first is that not marrying seems to have involved, at least for the women, a lifetime of sexual abstinence, since illegitimacy rates were so low. Given that large numbers of women were prepared to eschew for life sexual pleasures, or delay them for a decade or more, it is mysterious that once they married abstinence became an utterly forgotten option.[84]

Once married no control was exercised, no matter how many children had already been born and were still alive. The randomness of births and deaths in the pre-industrial world meant that the numbers of surviving children varied enormously across families. A sample of 2,000 English married men's wills from the early seventeenth century shows, for example, that while 15 percent died with no surviving children, 4 percent died with eight or more surviving children. If delaying marriage was about controlling fertility then why did those with the abundance of children show no signs of abstenance within marriage compared to their less lucky compatriots?

Another difficulty emerges if we consider the "marriage market." In looking for a spouse people were looking not just for

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[84]Selective abstinence is practiced in many foraging societies through, for example, social customs that forbid sexual relations between a married couple for a period after the birth of each child.

affection, but also for a partner who would be an economic asset. Both wives and husbands in the poorer classes had to work, for example, and a good worker would add substantially to the comfort of the partner. Surviving descriptions of courting in the seventeenth and eighteenth centuries have a fairly unromantic caste, where the focus of the parties is as much or more on the character and energy of the prospective spouse as on their physical attractiveness. Younger women would be less desirable as marriage partners, it is argued, because they have more potential childbearing capacity. That is why they tended to get married later.

But this would imply that the age of marriage for women would be pushed up in this society more than the age of marriage for men. The age at which men marry has no effect on the number of children they would have to support. But the age of marriage of men was always about 2 years higher than for women, as it is in modern western countries. When the age of first marriage fell in England in the eighteenth century it fell equally for men and women.

Finally once a woman has delayed marriage until age 30 or 35 the expected number of children she would bear falls to quite small numbers under pre-industrial conditions. In England the average woman marrying at 35 would give birth to less than 1.9 children, and even one marrying at 30 would give birth to less than 3.5 children.[85] So by age 30 the numbers of children who would survive to adulthood that a woman would expect to have would still be close to two. Thus there was no reason to delay marriage beyond 30 if fertility limitation was the issue. Yet many

[85]Based on the fertility rates in table 4.2 the numbers would be 1.9 and 3.5 *if the woman survived to age 45*, which not all would, so that these numbers are upper bounds.

women remained celebate their entire lives, and many did not marry till their mid thirtys or later.

Nor is there any sign that the marital pattern in western Europe was created by community controls. For communities had very limited means to prevent marriages. In pre-industrial England, for example, by age 21 children could marry without parental consent. The authorities in England did attempt to raise the age of marriage in many places by requiring apprentices to trades not to marry, and by making them complete long apprenticeships (such as seven years). But since apprenticeships began at age 14, this would not explain the much higher average age of marriage for men of 26-28. Ministers and parishioners also sometimes explicitly tried to stop marriages by refusing to read the bans (the required announcement of the intention to marry to be read for three weeks prior to the marriage date) or to allow a ceremony.[86]

But such tactics, which were anyway of dubious legality under both canon and common law, were likely to prevent or delay relatively few marriages, and only in the more rural parishes. In a large city such as London, which by the seventeenth century had swelled to over half a million people, a tenth of the population of England, such tactics would be futile. For even if the local parish refused to marry the couple, there was a cheap and easy alternative. Pre-industrial England before 1753 had its own equivalents of Las Vegas wedding chapels.

Because of the arcane and involved nature of ecclesiastical authority, at a number of places in London free-lance chaplains, who made their livings from the fees paid by couples, were able to legally marry couples without the formal posting of bans and the public marriage ceremony. These marriages were valid if the did

[86]Ingram, 1985, 145.

not violate other church rules concerning marriages. The most popular place was the Fleet Prison and its "rules."[87] Between 1694 and 1754 an average of perhaps 4,000 such marriages were performed yearly.[88] Since in these same years there were only 6,000 marriages per year in London, the Fleet prison was a huge purveyor of weddings. The marriage registers suggest that people also travelled from counties near London for a Fleet wedding. There were other lesser London marriage emporiums such as the Southwark Mint and the King's Bench prison rules. Thus in London there was no effective control over marriage by local parishes. Yet the average age of marriage and the percent not marrying does not seem to have any lower in London and its environs than in remote rural areas where communities might exert more informal controls.

Consequently social controls do not seem plausible as an explanation for the late age of marriage, and low frequency of marriage before 1700. Individual choice does seem to have been the crucial element, but as noted these were choices that seemed to be centered on factors other than conscious control of fertility.

Summary

Living standards stayed well above the physical subsistence minimum in the pre-industrial world, because most societies had customs and social mores that kept fertility well below the biologi-

[87] The "rules" of a prison were the area around a prison house in which prisoners imprisoned for debt were allowed, after giving enough security to clear their debts if they fled, to live and continue in their normal work where possible.

[88] The prison was surrounded by public houses where chaplains had established wedding chapels, and where the newly wed couple could celebrate their union. See Brown, 1981.

cal possibilities. The way these customs operated, however, varied greatly across societies. If modern foragers are any guide to the distant passed our ancestors of the Savanna probably limited fertility as much as did settled agrarian societies around 1800.

Thus the empirical finding of the previous chapter of the absence of any sign of improving living conditions before 1800, even for technologically advanced societies, is explained in part by the probably absence of any fertility decline before 1800. Given that fertility levels were likely the same in Asia as in western Europe around 1800 a puzzle that remains, however, is why countries such as Japan and China seem to have been so poor in the Malthusian era? And why were countries such as the Netherlands and England relatively wealthy among the European countries. In the next chapter on mortality I address that puzzle.

5 Mortality in the Malthusian Era

> *When has any such thing been even heard or seen; in what annals has it ever been read that houses were left vacant, cities deserted, the country neglected, the fields too small for the dead and a fearful and universal solitude over the whole earth?... (letter from Petrarch to his brother at the onset of the Black Death in Italy 1348)*

In this chapter we consider two main questions. The first is whether, as assumed in the Malthusian model, pre-industrial mortality was a declining function of income? In England, for example, in the years 1540-1800 there is no sign of any association between national mortality rates and national income levels, as expected in the Malthusian model.[89] Did England, and perhaps also the Netherlands, escape the Malthusian constraints long before 1800?

The second question is the role of differences in mortality rates (at a given income level) in explaining income differences across societies before 1800. There were substantial variations in incomes across pre-industrial societies. England and the Netherlands, for example, had comparatively high incomes in the eighteenth century, Japan had a very low income. But fertility rates do not seem to have varied dramatically in the pre-industrial world. So if these societies were still Malthusian, high income economies must have been mainly the product of higher mortality rates at a given level of income.

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[89] Wrigley et al., 1997, 614-5 gives mortality rates. Clark, 2005 and Clark, 2006a gives real wage rates.

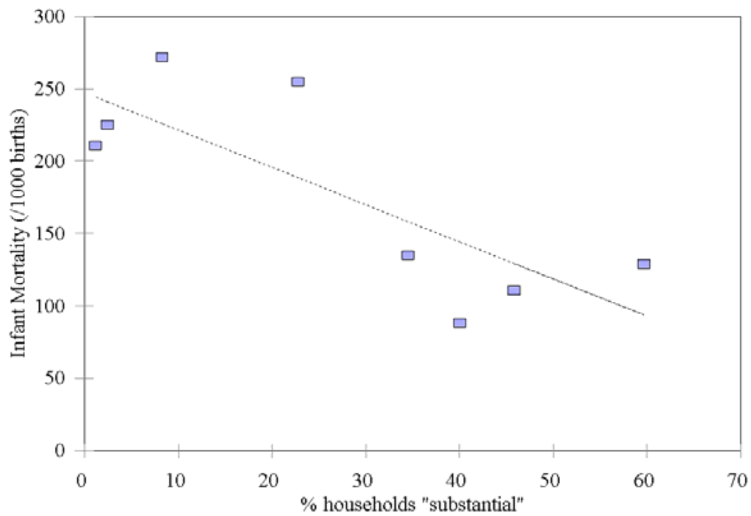

Figure 5.1 Household Wealth and Infant Mortality, England, 1538-1653[90]

Income and Mortality

Though over time in England after 1540 there was no sign of a link between national income or wage levels and the national mortality rate, there is strong evidence in from the experience of the rich and the poor that income had a powerful effect on mortality rates, even in England.

Infant mortality rates, for example, in eight London parishes in the years 1538-1653 can be compared with the percentage of the households in each parish which were 'substantial' in the tax listings of 1638. Figure 5.1 shows that infants had much better

[90]Landers, 1993, pp. 186-88.

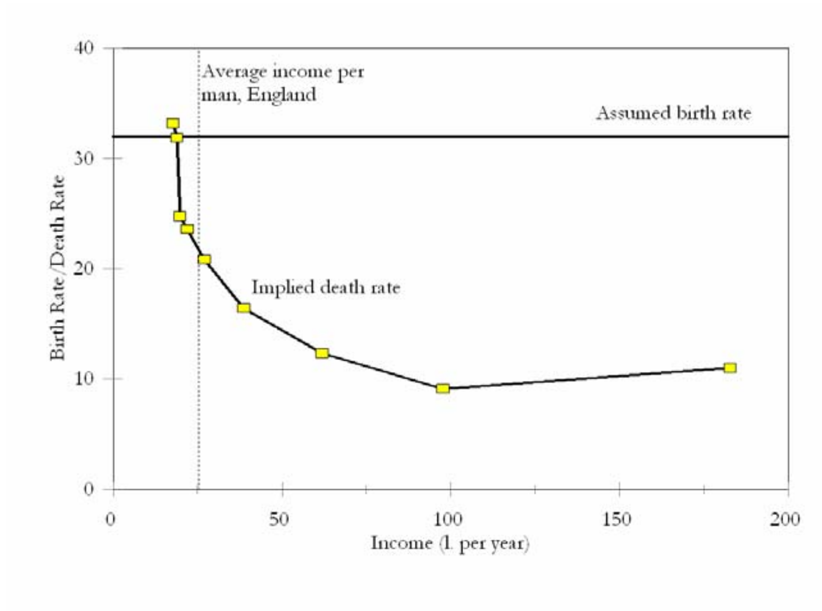

Figure 5.2 Household Income and Implied Birth and Death Rates, England, 1585-1638

survival chances in richer parishes. Indeed the crude measure of household income used here explains 62 percent of the variation in infant mortality rates in London. Further though London had notoriously high mortality rates, with the population only maintaining itself from constant immigration from the countryside, the infant mortality rates of the richer parishes were better than for England as a whole in these years.[91]

Similarly, as will be shown in the next chapter, using wills made by English men in the years 1685-1638, we can also infer the overall mortality rate by household income. Figure 5.2 shows this estimate. The curve shows exactly the downward slope we would expect under the Malthusian model, with the implied household

[91] The overall infant mortality rate for England in 1580-1649 was 169. Wrigley et al., 1997, 219.

income a powerful predictor of death rates. For the poorest groups leaving wills death rates exceeded birth rates. For the richest households death rates were well below birth rates.

The failure of the aggregate data for England to show any relationship between income or wages and the death rate thus seems to be just the product of shifts of the death rate schedule over time caused by changes in the disease environment, changes in the degree of urbanization (which drove up mortality rates) and improvements in sanitation and medical practices. Figure 5.3, for example, shows the infant mortality rate by decade in England versus real income per person. As can be seen the infant mortality rate shows no decline with income. But this must be because the decline in mortality with income revealed across households at any one time, as in figures 5.1 and 5.2 is being obscured by shifts in the mortality schedule, portrayed by the dotted lines, from period to period.

So, overall, it seems safe to assume that even up till 1800 there was in all societies an inherent, but shifting, tradeoff between income and mortality rates that tied long run incomes to the level which balanced fertility with mortality.

Life Expectancy

Since in the pre-industrial world, even with various mechanisms for limiting births, fertility levels were high by modern standards, mortality rates had to be high also. In a stable population, typical of the pre-industrial world, life expectancy at birth was just the inverse of the birth rate. Life expectancy at birth in England averaged only 37 years between 1540 and 1800. Life expectancy at birth, at 28 in the latter half of the eighteenth

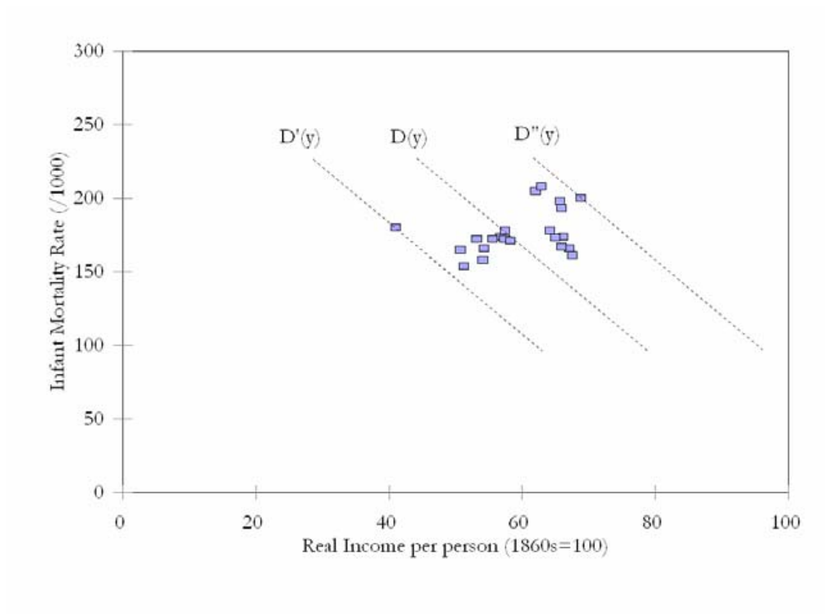

Figure 5.3 English Infant Mortality Rates and Real Incomes by Decade, 1580-1800[92]

century, was even lower in pre-industrial France (which also had a higher birth rate).[93]

These low life expectancies are often misinterpreted in popular writings to mean that few people survived into their forties. But though the chances of living to the biblical three score and ten was much less than now, there were plenty of quite elderly people in the pre-Industrial world, as a perusal of the biographies of kings, writers, scientists, statesmen and other notables from the Malthusian era reveals. A random sample of ages at death of notables born between 1600 and 1750, for example, shows Berkeley, 67, Goethe, 83, Hume, 65, Kant, 80, Leibniz, 70, Locke, 72, Molière, 51, Newton, 85, Adam Smith, 68, Voltaire, 83. These

92 Infant mortality rates from Wrigley et al., 1997, 224.
93 Weir, 1984, 32.

considerable ages reflect the fact that life expectancy at age 20 was as high, or even higher, than life expectancy at birth. Thus those who lived long enough to become famous had reasonable prospects of getting to their biblical entitlement.

Life expectancy at birth was so low because infant and child mortality were so high. In England from 1580 to 1800 18 percent of infants died within the first year of life. Only 69 percent of newborns made it to their fifteenth birthday. But those lucky enough to celebrate a fifteenth birthday could then expect to celebrate 37 more birthdays.

Tables 5.1 to 5.3 show indicators of mortality and life expectancy for a variety of societies: life expectancy at birth and at 20 years of age, as well as the fraction of people dying within one year and 15 years of birth. Table 5.1 shows these measures for modern forager societies. Since these are small populations of innumerate people individual estimates of life expectancy for these groups are subject to a lot of error. Life expectancy at birth in these forager groups ranged from 24 to 37, with a median of 32.5 years: less than eighteenth century England, but as good or better than all the other agrarian societies listed in table 5.2.

Table 5.2 shows life expectancy for settled agrarian societies in the Malthusian era. England after 1540 stands out as having relatively good life expectancies. There was, however, no trend towards improved life expectancy in England from 1550 to 1800. The other settled agrarian societies before 1800 – Egypt, Italy, France, China and Japan – generally had lower life expectancies. Thus on average life expectancy in settled agrarian societies was no higher, and possible a bit lower, than for modern foragers.

Death rates were typically much higher in towns and cities than in the countryside. Urban mortality was indeed so high that,

Table 5.1: Life Expectancy for Modern Foragers[94]
*=estimated from shares dying by 15.

Group	e_0	e_{20}	Infant Mortality (%)	Deaths 0-15 (%)
Ache, Paraguay [a]	37	37	12	34
Kutchin, Yukon [b]	*35	-	17	35
Hadza, Tanzania [b]	33	39	21	46
!Kung–Ngamiland, Botswana [b]	*32	-	12	42
!Kung – Dobe, Botswana [b]	30	40	26	44
Agta, Philippines [b]	24	47	37	49

were it not for continual migration from the countryside, the cities would have faded from the earth. In London from 1580 to 1650, for example, there were only 0.87 births for every death. Without migration the city would have lost about a half percent of its population every year. Early towns were generally crowded and unsanitary, so that infectious diseases such as plague, typhus, dysentery, and smallpox spread quickly. Life expectancy at birth in London in the late eighteenth century, a mere 23 years, was thus lower than for most pre-industrial societies, even though London then was perhaps the richest city in the world. As late as 1800 Londoners were not able to reproduce themselves: 30 percent of all infants died in the first year of life. Indeed urban

94 [a]Hill and Hurtado, 1996, 196; [b]Pennington, 2001, 192.

Table 5.2 Life Expectancy in Agrarian Economies[95]

Group	e_0	e_{20}	Infant Mortality (%)	Deaths 0-15 (%)
W. Europe				
Italy, Medieval Pistoia[b]	29	25	21	56
England, 1550-99 [c]	38	33	18	30
England, 1650-99 [c]	35	31	18	32
France, 1750-89 [e]	28	-	21	-
England, 1750-99 [c]	38	34	17	30
East Asia and Africa				
Egypt, 11-257 – rural[a]	28	21	-	45
China (Anhui), 1300-1880[f]	28	33	-	-
China (Beijing), 1644-1739[f]	26	30	-	-
China (Liaoning), 1792-1867[f]	26	35	-	-
Rural Japan, 1776-1815 [g]	33	37	25	50
Urban				
Egypt, 11-257 – urban[a]	24	17	-	48
London, 1750-99 [d]	23	-	30	-

dwellers in Roman Egypt had a better life expectancy than eighteenth century Londoners.

For the years before 1540 it is generally only possible to estimate adult life expectancy. Table 5.3 shows these estimates.

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95 [a]Bagnall and Frier, 1994, 334-6, [b]Herlihy, 1967, 283-8, [c]Wrigley at al., 1997, 224, 256, 614, [d]Landers, 1993, 136, 158, 170-1, [e]Weir, 1984, Flinn, 1981, 92, [f]Lee and Fang, 1997, 54-5. Life expectancy at age 0 assumed three years less than life expectancy at age 6 months. One quarter of girls assumed to have died at birth from infanticide. [g]Jannetta and Preston, 1991, 427-8. Life expectancy at 20 estimated from life expectancy at 15.

The Roman Empire outside Egypt provides just two reliable pieces of evidence. The first is a list of the hundred town councilors at Canusium, in southern Italy, in AD 223. From the regular succession of office holding it is possible to estimate that life expectancy for town councilors at age 25 was 32-34. This is upper class male life expectancy. The second piece of evidence is a table constructed by a jurist, Ulpian. This was a guide to the length of time bequests of life annuities, typically to freed slaves, would be a burden on testators' estates. Life expectancy at age 22 was 28 in Ulpian's table. This, if correct, shows lower class life expectancies.

In England life expectancies in the medieval period can be estimated for male tenants of land and cottages on medieval manors, and for members of monastic communities. Zvi Razi used the court records of Halesowen to determine the interval between male tenants' first acquiring property and their death. Since the minimum legal age was 20 the average age at first property holding must be 20+. The estimated life expectancy of males in their early twenties was 28 years before the onset of the Black Death, and 32 years in the 50 years after the first outbreak. This is close enough to life expectancy in England at age 20 in the years 1580-1800 that we cannot be sure, absent also evidence on infant and child mortality, that life expectancy was in fact any lower in 1300 in England than in 1800.

In both China and Japan life expectancies at age 20 were as high or higher than those in England in 1800. These societies had a different pattern of mortality, with infant mortality relatively greater than in Europe, probably as a result of infanticide, and adult mortality consequently lower.

It would be nice to compare the life expectancies for Europe in the years after 1300 with those of communities before 1300, to

Table 5.3 Pre-Industrial Life Expectancy at age 20.[96]

Group	Age	Life expectancy
Magistrates, Canusium, Italy, AD 223 [a]	25	33
Ex-slaves, Italy, c. AD 200 [a]	22.5	28
England, 1300-48 (tenants) [b]	20+	28
England, 1350-1400 (tenants) [b]	20+	32
England, 1440-1540 (monks) [c]	20	27
England, 1750-99	**20**	**34**
Rural Japan, 1776-1815	20	37
Rural China (Liaoning), 1792-1867	20	35
Modern Foragers	20	40

test further the claim made above that living conditions did not improve between the Neolithic and 1800. Unfortunately while it is possible to estimate the age at death for skeletal remains, no reliable way has been found to translate these estimates into estimates of life expectancy at a given age. Skeletal material from the very young and very old does not survive so well in the ground as that of prime aged adults, so that the surviving remains are unrepresentative.

But the impression remains that, as with material living conditions and fertility, there was little change in life expectancy in the pre-industrial world all the way from the original foragers to

[96] Tables 5.1 and 5.2. [a]Duncan-Jones, 1990, 94-7. [b]Razi, 1980. [c]Harvey, 1993, 128.

1800. Since fertility was likely similar between forager and settled agrarian societies, the mortality rate must also have been similar.

Sources of Mortality

Studies of modern forager and non-market societies suggest that deaths from accidents and homicide – to use the old legal terminology, deaths from *misadventure* - formed a surprisingly high proportion of all deaths compared to settled agrarian societies, and to modern societies.

Part of this stemmed from the way of life of these societies. In the mobile societies of foragers there were heightened risks of death from encounters with dangerous animals, drowning, thirst, and falls. But homicide was a still greater killer than these accidental causes. Despite romantic notions of *the noble savage*, violent conflict within groups and between bands of foragers seems to be frequent.

Table 5.4 shows for some modern hunter gatherer societies the deaths per 1000 males per year overall and from accidents and homicide. Forager societies where we have a complete breakdown of causes of death are few. And the small size of these groups implied a lot of random variation in the causes of death in the observation periods. But these observations suggest that homicide, including intergroup conficts, was the source of death of 7-55 percent of people in such communities, averaging 21 percent of deaths. The reason for these high rates of violent deaths in forager societies is not clear. In part it may stem from the absence of supervening legal authorities which could settle disputes without resort to violence.

Table 5.4 Causes of Male Deaths in Forager and Subsistence Societies[97] * = male and female deaths. ( ) = very rough estimate.

<table>
<tr><th>Group</th><th>Death Rate/ 1000</th><th>Accident /1000</th><th>Homicide /1000</th></tr>
<tr><td>Neolithic France (5500 BC – 2200 BC) [c]</td><td>-</td><td>-</td><td>(1.4)</td></tr>
<tr><td>Ache, Forest period[a]</td><td>27</td><td>3.5</td><td>15.0</td></tr>
<tr><td>Yanomamo, 1970-4[a]</td><td>-</td><td>2.1</td><td>3.6</td></tr>
<tr><td>!Kung before 1973[a]</td><td>32</td><td colspan="2">4.4</td></tr>
<tr><td>New Guinea - Gebusi[b]</td><td>-</td><td>0.6</td><td>6.9</td></tr>
<tr><td>New Guinea – Goilala, Hewa[b]</td><td>-</td><td>-</td><td>*6.6</td></tr>
<tr><td>Agta[b]</td><td>42</td><td>-</td><td>*3.3</td></tr>
<tr><td>United Kingdom, 1999[d]</td><td>12</td><td>-</td><td>0.01</td></tr>
<tr><td>USA, 1999[d]</td><td>12</td><td>0.5</td><td>0.10</td></tr>
</table>

Jean Guilaine and Jean Zammit have tried to estimate the numbers of people who died violently in Neolithic France from skeletal evidence. Figure 5.5. shows the kind of graphic evidence of violence that can be found in skeletal remains. Though there must be many caveats about their estimate, they conclude that 3 percent of the dead were killed or injured by violence. Assuming based on their appendix tables that the ratio of killed to injured

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97 [a]Hill and Hurtado, 1996, 174. [b]Knauft, 1987. [c]Guilaine and Zammit, 2005, 133, 241-9. [d]World Health Organization, 2002, table A.8.

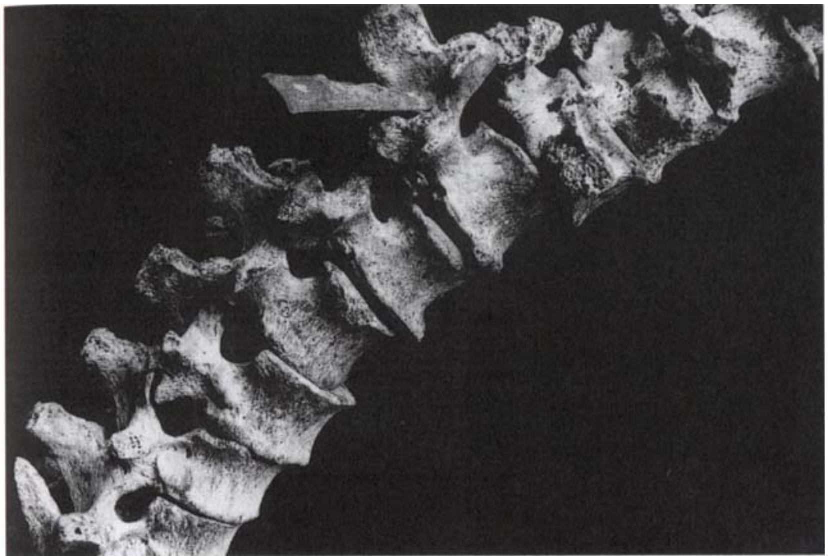

Figure 5.5 Copper dagger blade lodged in a vertebra, third millennium BC[98]

was 2:1, that these were all male, and that life expectancy was 35 gives the estimate in the table. This suggests much lower rates than for modern foragers, but much higher than modern high income societies.

For in most modern societies deaths from violence occur at a low rate. In typical modern western European societies, such as the UK, male deaths from violence are only 0.01-0.02 per thousand per year. There seemingly was a transition from early societies where interpersonal violence was a major contributor to death rates, to modern ones where violence is not an important source of mortality. When did that transition occur?

In England we can trace back sources of mortality all the way to the late twelfth century. Since in medieval England the property of anyone who killed unlawfully reverted to the king, the king

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[98] Guilaine and Zammit, 2005, 137.

had an incentive to discover all murders. English kings thus early established a system of coroners' inquests on all accidental and violent deaths. These inquests establish the numbers of homicides and accidental deaths per year for various counties in England back to the late twelfth century.[99]

Figure 5.4 shows the trend in these various local estimates as well as later national homicide rates for males, per 100,000 of the population. Though there was a steady decline in homicide rates between 1200 and 1800, Medieval England was already very peaceable compared to modern forager societies. Male death rates per year from unorganized violence in England even circa 1200 averaged 0.2-0.25 per 1,000 males. This shows the toll from unorganized violence. War deaths, the results of organized violence, have to be added to get the overall losses from homicide.

Figure 5.5 shows estimated English male death rates from the various external and internal wars by decade from the 1170s to the 1900s.[100] Here the average losses were surprisingly small, in the order of .12-.15 per 1,000 males for most of the period 1150-1800. Thus even in medieval England before 1350 the average annual death rates from all violence for males were 0.32 per 1,000. This is an order of magnitude less than forager societies observed currently. It is also less than the estimated Neolithic rate.

Early European wars produced few casualties because the size of armies before 1700 was typically small. In the 1290s, when Edward I assembled the largest armies of his long reign, before he

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99 Cockburn, 1977, 1991. Given 1977. Hair, 1971. Hanawalt, 1976, 1979.

100 There is a good historical record of all the battles and campaigns of the English, many with casualty estimates. For the earlier battles casualty numbers were estimated from those conflicts where a count was available.

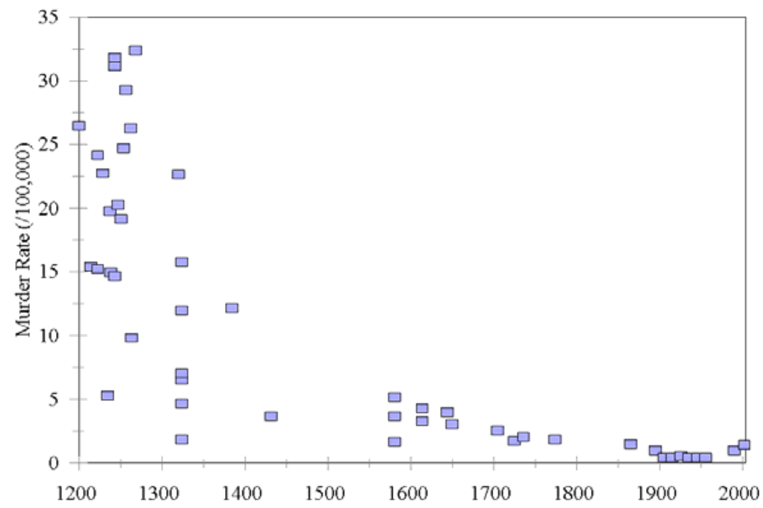

Figure 5.4 Homicide rates for males, England 1190s-2000

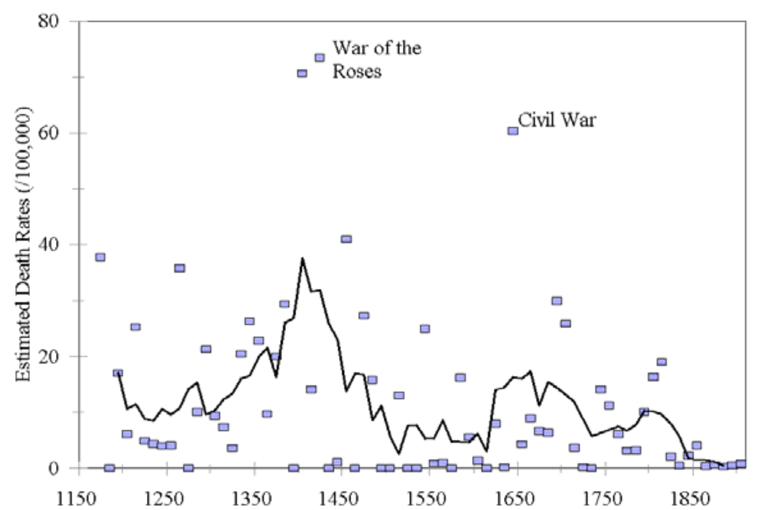

Figure 5.5 Death Rates from Military Conflicts, England 1170s-1900s. The line shows a 50 year moving average of combat death rates in England.

was severely constrained by financial problems, his army to suppress the Welsh rebellion of 1294-5 was 31,000 at its maximum. This was about 0.6 percent of the English population. When the locus of the fighting switched to France in the Hundred Years War, the size of armies was even smaller because of development of smaller, more professional and better equipped armies, and the costs of moving troops to France. When Henry V invaded France in 1415 he had only about 10,000 men.[101] And casualties in war from violence were limited, because battles were infrequent, and the battles themselves did not always produce large casualties. Edward I, who reigned for 35 years from 1272 to 1307, and who led armies in Wales, Scotland, Flanders and the Holy Land, took part in only one full battle, at Falkirk in Scotland in 1298.[102] Thus one reason that forager living standards were probably as high even as those in Europe by the eighteenth century was the relatively low rates of death from violence in these settled agrarian economies (though England was a particularly stable and peaceable pre-industrial society).

Mortality and Living Standards

Fertility rates seeming did not vary much across the pre-industrial world, at least where we can observe fertilities. Fertility rates in England in 1800 were no lower than in eighteenth century Japan, or in forager societies. Living standards did vary quite considerably across pre-industrial societies, however. Referring, for example, to figure 3.1 living standards of English laborers in 1450 were three times as high as in 1300, and nearly double the

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[101] Prestwich, 1996, pp. 116-8.
[102] Prestwich, 1996, pp. 305-11.

levels of 1800. The bulk of the explanation for this variation in living standards would seem to be variation in mortality rates at a given level of income.

Thus the explanation for the very high living standards of Europeans in the years 1350 to 1600 was undoubtedly the arrival of Bubonic plague in 1347 (the Black Death).[103] Its first onslaught in the years 1347-1349 carried away 30 to 50 percent of the population of Europe. But the plague continued to strike periodically thereafter for the next 300 years. In England between 1351 and 1485 there were 30 plague outbreaks. As late as 1604, for example, the city of York lost at least a quarter of its population in one year to a Bubonic plague outbreak. Paris had 22 plague epidemics from 1348 to 1596.[104]

Plague outbreaks mysteriously diminished in frequency and severity in western Europe from the late seventeenth century on. The last great European plague epidemics were in 1665 in London, in 1657 in Italy, in the 1660s in France, in 1663 in Holland, and in the 1670s in Austria and Germany. Yet the plague did not disappear elsewhere in the world, but remained endemic in many parts of Asia. Plague had been present in Hunan in China since at least 1792, but spread to other parts of China and from there to Bombay in the late nineteenth century, where it killed 6 million, in the 1890s.[105]

The bacterium that causes plague seemed to remain just as virulent as it had been earlier. In the nineteenth century Indian outbreak from 60 to 90 percent of the infected died. 78 percent

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[103]The term "Black Death" for the plague was only introduced hundreds of years after 1349 in England.

[104]Cipolla, 1993, 132. Galley, 1995, 452.

[105]Benedict, 1988. The plague spread from Bombay to England through rats on grain ships, but was contained there with the loss of only 6 people. There was an even more recent outbreak in India in 1994 that infected at least 700 people.

of the infected in a late outbreak in Marseilles in 1721 died, as did 80 percent of the infected in Noja, Italy, in a small outbreak in 1815. Thus the London outbreak of 1665 killed perhaps 16 percent of the city's population. The 1657 outbreak in Italy killed 44 percent of the population of the afflicted cities.[106]

The continued virulence of the disease in these later outbreaks is one of the reasons its disappearance from Europe remains a medical mystery.

We know a considerable amount about pre-industrial plagues because of the later Asian outbreak of the late nineteenth century. In the course of this outbreak the plague bacteria was discovered independently by French and Japanese investigators, as well as the means of transmission. If the medieval plague was similar to this later outbreak it was transmitted not from person to person, but through the bites of infected fleas. The fleas preferred host is rats, but when rats die from the disease the fleas move on to people, spreading the plague bacteria.[107]

Bubonic plague was so called because of the "buboes" or boils which appear in the groin and armpits of the afflicted.[108] The plague was particularly loathsome because of the appearance of the sick, the diseased apparently exuding an unbearable stench. Agonizing pain accompanies the boils, and sufferers normally died 4 to 7 days after symptoms appeared.

In line with modern beliefs on how the disease was transmitted the epidemic was reported sometimes to be preceded by the appearance of large numbers of dying rats. Since rats do not

[106] Cipolla, 1993, 133.

[107] The British did experiments such as suspending guinea pigs at different heights above plague infested fleas to see how high the fleas could jump.

[108] Caused by swelling of the lymph nodes.

move great distances the plague would thus spread at a slow pace from one district of a town to another.

Yet in pre-industrial Europe no-one made the connection between rats and the plague. Instead all kinds of absurd theories as to the cause and transmission of the disease had currency, even as late as the London outbreak of 1665. It was widely believed both that people were infectious, and that the plague came from a poisonous cloud called a "miasma" being exuded from the earth in certain localities.[109] Thus a further horror of the disease was that the afflicted were often abandoned to their fate. Sometimes the city or commune would order that their houses be sealed with the sick inside. In the 1665 London outbreak attempts to control the disease thus included such useless measures as killing large numbers of cats and dogs, shutting up the infected into their houses, sniffing herbs to ward off bad air, and burning fires in the streets again to dispel the supposedly poisonous air.

The plague years from 1347 to the 1660s are often taken by historians as a period when Europe was sadly afflicted. If we understand the Malthusian model we see that this was not the harsh judgement of a vengeful Old-Testament God on a sinful Europe, but a blessing visited by a beneficent Deity. We saw that the plague, by increasing death rates at any given material living standard, raised living standards all across Europe in these years. But given that European fertility rates, at least in the years after 1540, show no sign of increasing with income levels, the plague probably did this at no cost in terms of life expectancy. Plague deaths just substituted for deaths that would have occurred anyway from economic causes.

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[109] Special tight fitting garments were made for those who administered to the sick and dying to protect them from the miasma.

Thus in table 5.3 we see that the life expectancies of tenants and monks at age 20 in the plague years were no worse than for those of tenants before the onset of the plague. After the initial onset the plague offered Europeans a greatly enhanced material life style at no cost in terms of the average length of life. In the Malthusian world, gifts from the God's took surprising forms!

Dutch and English Mortality

The plague explains the high incomes of many European societies in the medieval period. The eventual disappearance of the plague from Europe, because of the disease's dependence on a sufficient rat population in close proximity to people, is probably a sign of improvements in standards of cleanliness in Europe in the seventeenth century. The result, of course, for many European societies was lower incomes. But incomes in both England and the Netherlands remained high compared to most pre-industrial societies, particularly those of South and East Asia. Why were England and the Netherlands comparatively wealthy in the eighteenth century?

Some see this as the first breaking of the Malthusian trap, a break that occurred first in the Netherlands around 1600.[110] But even though both the Netherlands and England witnessed efficiency advances in the seventeenth century that were unusually rapid by pre-industrial standards, these rates of productivity advance were too low to raise incomes much above subsistence given the continued link of population with income.

Figure 5.6, for example, shows real wages in the Netherlands versus the population by decade from the 1500s to the 1810s. In

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[110] See, for example, de Vries and van der Woude, 1997, 687-9.

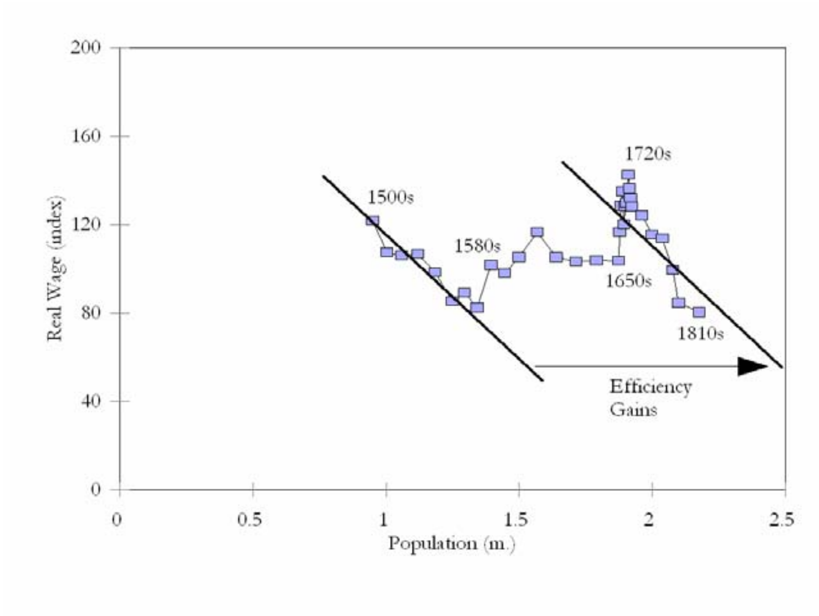

Figure 5.6 Real wages versus Population in the Netherlands, 1500s to 1810s

the early sixteenth century the Dutch experienced the same real wage declines as the rest of Europe as populations everywhere grew. But from the 1570s to the 1670s the Dutch were able to expand the production possibilities and experience both rising population and wages. The efficiency advance that appears between the 1570s and 1670s in the Dutch Golden Age was, however, followed by a period of technological stagnation, characteristic of Malthusian economies, from then till the 1810s. In that 140 year period of stasis, when population had plenty of time to adjust to the subsistence level, real wages remained high by pre-industrial standards in the Netherlands.[111] So high Dutch real wages, given that the Netherlands did not have particularly

[111] See figure 3.2 and table 3.4

low fertility by European, or indeed even by Asian, standards must stem from unusually high mortality rates in the Netherlands.

In England also, where efficiency gains were modest or non-existent between the 1700s and 1790s, again the ability to sustain relatively high real wages must stem from unusually high mortality.

One factor that helped keep eighteenth century incomes high in the Netherlands and England was the increasingly urban character of these societies. Figure 5.7 shows the percent of the population in towns in N. Italy, England and the Netherlands at 50 year intervals from 1500-1800 (and at 100 year intervals before that) compared to real wages. The figure shows two things. The first is that in Europe before 1800 real wages and urbanization were poorly linked, even at the national level. In N. Italy urbanization was always about 20 percent, even while real wages varied by a factor of 2:1. In England in 1400 urbanization rates were less than 5 percent, even though wages were significantly higher than in 1800 when urbanization rates were more than 25 percent. Factors other than real wages were driving urbanization.

The second feature revealed by the figure is that by 1800 the Netherlands and England were the most urbanized parts of Europe. Given the high death rates of European cities in 1800 and before, this high level of urbanization helped drive up overall death rates, and hence incomes. For example, in late eighteenth century England, death rates were about 23 per thousand in the countryside compared to 43 per thousand in London. The existence of London alone pushed up the death rate schedule in England by about 10 percent.

In the Dutch case another factor driving up mortality was colonial adventures. From 1602 to 1795 the VOC (the Dutch East Indies Company) recruited about 1 million men, of whom

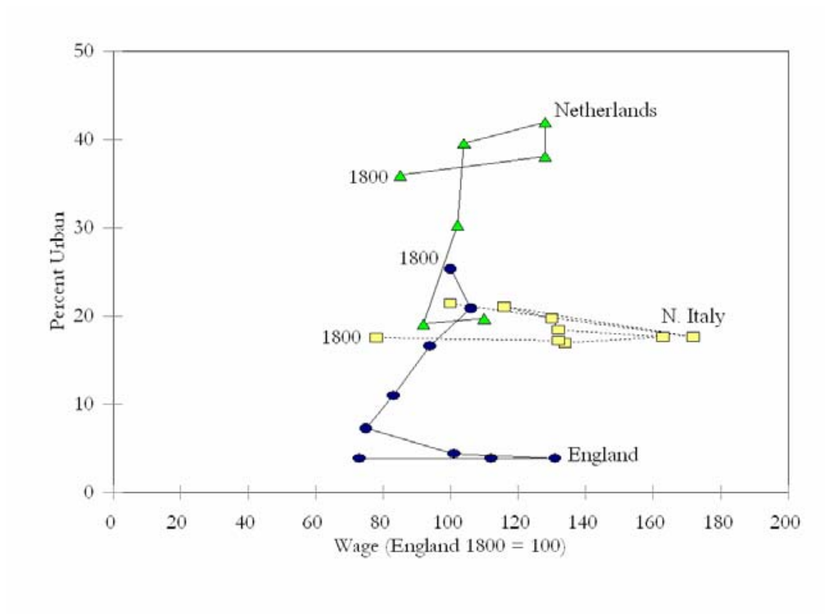

Figure 5.7 Urbanization Rates 1300-1800[112]

perhaps half died in service. The annual losses from this service counterbalanced the half million immigrants drawn to the Netherlands from elsewhere in Europe in the same years by high Dutch wages. But since these losses were almost all men, it also skewed the sex ration in the Netherlands. In a society with about the equivalent of 35,000 male births per year, counting immigrants, the VOC was consuming annually the equivalent of about 5,000 of these! This skewed the gender ratio. In Amsterdam in 1795 there were 1.32 adult women per adult male. In Delft in 1749 the ratio of adult women to men was 1.5. The skewed gender ratio drove down the percentage of women marrying in Dutch cities.

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[112] Urbanization rates - N. Italy, Federico and Malanima, 2002, table 1. Netherlands and England, de Vries, 1984, 39 (adjusted upwards to be comparable to N. Italy).

Thus the 1829 census revealed that 24 percent of Amsterdam women aged 40-55 had never married. [113]

If we ask why Europeans were so rich compared to Asians the most likely answer appears to be that Europeans throughout the pre-industrial era were by modern standards, and those of pre-industrial China and Japan, a filthy people, living in dirt and squalor. The low standards of personal and community hygiene are everywhere apparent in pre-industrial Europe.

One crucial economic problem for hygiene in pre-industrial Europe was that human waste had little or no market value, because it was not socially acceptable to use it as the valuable fertilizer it was for farm and garden purposes. As Alan Macfarlane notes, "where in Japan, night soil could be used in lieu of rent, in England one had to pay to have it taken away."[114] Its disposal was thus a major social problem in Europe. Samuel Pepys, for example, complains in his diary in October 1660 that "Going down to my cellar...I put my feet into a great heap of turds, by which I find that Mr. Turner's house of office is full and comes into my cellar." Neighbors' overflowing turds were apparently just an everyday nuisance in seventeenth century London![115]

In contrast in China and Japan human waste, urine as well as feces, was a valuable property which householders sold to farmers, and which various groups competed for the right to collect. Waste in Japan and China was thus not dumped into cesspits, sewers and streams, contaminating water supplies. Instead in cities such as Osaka in the eighteenth century contractors found it

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[113] de Vries and van der Woude, 1997, 72-75.

[114] MacFarlane, 2003, 173.

[115] It took five days after this complaint for the neighbor to clean out the overflowing privy.

profitable even to provide public containers on street corners in order to profit from the waste deposits.[116] In Japan and China the waste also seems to have been carried away daily, as opposed to being stored in cesspits below houses which were only periodically emptied.

Human waste has dangers as a fertilizer, but the Japanese at least, aware of this, stored the waste in pits and tubs for months before use, allowing fermentation which destroyed many of the infectious organisms.

The Japanese and Chinese also had a much more developed sense of personal hygiene. While bathing was not popular in England, and indeed regarded as an indulgence in the early modern period, in Japan bathing in hot water was popular and frequent.[117] The Chinese also bathed whenever possible, and employed plenty of soap.[118] The Japanese washed their hands after urinating or defecating, and kept privies clean. In the nine years Pepys kept his diary for the 1660s, only once does he mention his wife having a bath.

> *My wife busy in going with her woman to the hot house to bathe herself….she now pretends to a resolution of being hereafter clean. How long it will hold I can guess*[119]

Pepys also makes it very clear that he is not about to follow her example: "me thinks it cannot be clean to go so many bodies with the same water."

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[116]Hanley, 1987, 10.

[117]Dr Robert Willan, the famous London dermatologist, writing in 1801 noted that "most men resident in London and many ladies though accustomed to wash their hands and face daily, neglect washing their bodies from year to year" (quoted in Razzell, 1994, ---).

[118] Lee and Fang, 1999, 45.

[119]Quoted in Wright, 1960, 76.

Data for soap production in eighteenth century England support the idea that washing of people and clothing was not a frequent activity. In the 1710s when England's population was 5.7 million, taxed soap output was 25 million pounds, less than one fifth of an ounce per person per day for all uses of soap.[120] To show how meager a use of soap this is, note that the Southern Africa Food Security Operation currently aims to supply to their destitute clients two fifths of an ounce of soap per day, that transported convicts in Australia in the mid-nineteenth century got a ration of half an ounce of soap per day, and that the ration of soap for the both the Union and Confederate Army at the beginning of the US Civil War was 0.64 ounce per day.

The low attention paid by the English to personal hygiene was expressed in their primitive toilet arrangements. While in Japan toilets were built at some distance from living quarters, the English upper classes seemed to prefer the convenience of adjacent toilets, even with the problems of odors that created.[121]

Further in Japan the living spaces were kept much cleaner. Houses had raised wooden floors, and outside shoes were taken off at the entrance. They watered the streets outside their houses to keep dust down. In contrast in England the majority of people, until quite close to 1800, lived in dwellings with beaten earth floors covered by rushes that were only infrequently renewed. Into these rushes went deposits of waste food, urine and spit. Indeed the effluvium deposited on floors from the ordinary business of the household was so rich that allegedly when saltpeter men were empowered in the late sixteenth and early seventeenth centuries to dig out earth floors as rich sources of saltpeter (potassium nitrate), they dug not just barn floors but also the

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120 Deane and Cole, 1967, 72.

121 Hanley, 1987, 19.

floors of houses. The English also lived with a much more extensive domestic menagerie of dogs and cats which made their contributions of fecal material to dwelling spaces and streets.

Thus the comparative wealth of the English, expressed also in their greater physical stature, when we compare them to the Chinese or Japanese in 1800 probably stemmed mostly from the comparative filth that they lived in. For in the Malthusian economy the traditional virtues of cleanliness and hard work gave no reward to a society at large, and indeed just made life harder and incomes lower.

Infanticide

Polynesia was a healthy place before Europeans arrived. The climate was mild, there were no mosquitoes to carry malaria, and the isolation of the islands protected them from many diseases such as the plague. The healthiness of island living shows in the fates of the wives and children of the Bounty Mutineers. After the 1789 mutiny Fletcher Christian, eight other mutineers, and six Tahitian men settled in 1790 with twelve Tahitian women (some probably kidnapped) on the tiny mischarted island of Pitcairn: two miles long and one mile wide. By 1800 14 of the 15 men were dead, 12 murdered by their companions (and one committing suicide).[122] But the women had borne 23 children by 1808, all of whom survived. So that despite the murderous violence among the men, the population of 27 in 1790 had grown to 34. By 1823 there were 66 people on Pitcairn. Thus in one generation the

[122]Once conflict broke out, there was no retreat for any of the participants, and no-one could sleep soundly at night until they had dispatched their enemies. Nordhoff, 1934.

population doubled. By 1856 there were 196 people on Pitcairn, an island with 88 acres of flat land, and a serious population problem.

The healthiness of the Pacific Islands is confirmed by the death rates of European troops stationed abroad in the early nineteenth century, which are given in table 5.5. British and French troops in the Pacific had lower death rates than when they were stationed in their own countries. Notice also that the death rates for European troops stationed in tropical Africa or the Caribbean were extremely high in comparison. Nearly half of British troops stationed in Sierra Leone died each year.

Fertility was also probably high among the pre-contact Polynesians. Sexual activity among women was early and universal. Why then was Tahiti such an apparent paradise to the visiting English sailors, rather than a society driven to the very subsistence margin of material income as in Japan. The answer seems to be that infanticide was widely practiced before European Christian missionaries, who first arrived in 1797, changed local practices.[123] Unfortunately since our sources on this are the missionaries who had ever incentive to portray pre-Christian practices as abhorrent, we will never be certain of these reports.[124]

But the estimates from the early nineteenth century are that between two thirds and three quarters of all children born were killed immediately.[125] The alleged methods used included suffocation, strangulation and neck breaking. All the observers agree that the act was performed immediately after birth. If the

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[123] Oliver, 1974, 424-6.

[124] The first Christian mission was not a success, and the missionaries had limited influence until after 1809 when the social disruption caused by contact with Europeans led many to turn to Christianity.

[125] This seems extraordinary, but it is what the missionary accounts record. The journals of Cook, Bligh, Banks and others contain little information on infanticide.

Table 5.5 Healthy and Unhealthy locations c 1800 as evidenced by troop mortality[126]

Location	Troops	Dates	Death Rate /1000
New Zealand	British	1846-55	9
Tahiti	French	1845-49	10
Cape Colony	British	1818-36	16
Malta	British	1817-36	16
Canada	British	1817-36	16
Gibraltar	British	1817-36	21
Bombay	British	1830-38	37
Madras	British	1829-38	49
Bengal	British	1830-38	71
Martinique	French	1819-36	112
Jamaica	British	1817-36	130
Senegal	French	1819-38	165
East Indies	Dutch	1819-28	170
Sierra Leone	British	1819-36	483

child lived for any length of time it would then be treated with great care and affection. One sign of infanticide was the agreement by most visitors that there were more men than women on the islands. The reasons for this Tahitian practice are surprisingly unclear. The paradise of the *noble savage* seemingly had its savage underside.[127]

126 Curtin, 1989, table 1.1.

127 I thought I was transported into the garden of Eden…A numerous people there enjoy the blessings which nature showers liberally down upon

The Europeans may have been a dirty people, but they did have a horror of infanticide, and there is no evidence of this practice in pre-industrial Europe either as a deliberate strategy, or through differential care of girls and boys.

But infanticide was common enough in other Malthusian economies that European abstinence from this may indeed be regarded as an aberration. In both Roman Italy and in Roman Egypt parents exposed unwanted children in the market places and the streets, though at least some of these unfortunates were rescued and raised as slaves. In pre-industrial China and Japan the gender ratio of the population shows that there was significant female infanticide. In these Malthusian economies infanticide did raise living standards.

The White Death

In 1347 Europe was invaded by a bacterium from the East, *Yersinia Pestis*, the Black Death, that by raising mortality rates increased living standards in Europe for the next 300 years. In 1492 when Columbus, perhaps the luckiest man in history, stumbled upon a continent whose existence he had no right to expect, the local peoples were visited by death from the West in the form of numerous new diseases. The four major ones constituting the White Death were cholera, measles, smallpox, and typhus. All these had developed relatively recently in the crowded conditions of the Eurasian landmass, and were novel to the Americas which had been cut off from contact with Eurasia for millennia. Similarly the inhabitants of Australia, New Zealand,

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them….Every where we found hospitality, ease, innocent joy, and every appearance of happiness amongst them. (of Tahiti, 1768. Bougainville, 1772, 228-9).

and the Pacific Islands made acquaintance with these four diseases and others only with the arrival of Europeans.[128]

By analogy with the earlier experience of Europeans with the Black Death, the spread of the White Plague to the New World in the years 1492 and later should have both reduced the native population of the Americas, but also substantially improved living standards for Native Americans. There are some indications of groups in the New World for whom exposure to European diseases may have had the expected beneficial effects on living standards. Thus Boas's studies in 1892 of Great Plains Indians, who were mainly born between the 1830s and 1860s, reveals that despite substantial suffering from exposure to European diseases such as smallpox, the Plains Indians were very tall by the standards of the pre-industrial world.[129] But the bulk of the native populations seemingly got no material benefits. This would be a challenge for the Malthusian model, except that the White Plague was typically accompanied by Europeans expropriating native lands and resources, preventing higher mortality rates from having their normal Malthusian effects.

The Neolithic Revolution and Livings Standards

The great economic transformation of the pre-industrial era was the Neolithic Revolution: the move from hunter-gatherer societies to those that employed cultivated crops and domesticated animals. Anthropologists and archeologists have long debated what the effect of this transformation was on living

[128] McNeill, 1976.
[129] Steckel and Prince, 2001.

standards, but in ways that in the light of the Malthusian model seem confused.

Given that fertility rates of forager and settled agrarian societies were likely the same, material living standards would be higher in the society with the *higher* mortality rate at a given level of income. Thus the ability to store food in settled agrarian societies, which would allow people to survive better lean periods of the year, would reduce living standards. The increase in disease mortality from greater population densities would increase material living standards. The balance of these effects could go either way. Thus the effect of settled agriculture on living standards in a Malthusian world is inherently ambiguous. The evidence from heights seems to suggest that on balance settled agriculture probably reduced living standards by modest amounts.

6 Malthus and Darwin: Survival of the Richest

> *Man tends to increase at a greater rate than his means of subsistence; consequently he is occasionally subjected to a severe struggle for existence, and natural selection will have effected whatever lies within its scope. (Darwin, 1871, 386-7).*

Introduction

As has been emphasized, in the Malthusian Era the economic laws that governed human society were the same as those that govern all animal societies. Indeed Charles Darwin proclaimed his inspiration for *On the Origin of Species* was Malthus's *On a Principle of Population*. Darwin then employed his theory of natural selection in *The Descent of Man* to explain how humans evolved from earlier progenitors. Darwin even went so far, in the conclusion of that work, to endorse social Darwinism.

> *Man, like every other animal, has no doubt advanced to his present high condition through a struggle for existence consequent on his rapid multiplication; and if he is to advance still higher, it is to be feared that he must remain subject to a severe struggle (Darwin, 1871, 403).*

While this affirmation of Social Darwinism was misguided, Darwin's insight that, as long as population was regulated by Malthusian mechanisms, mankind would be subject to natural selection was profoundly correct.

In the Malthusian era on average every woman could have only two surviving offspring. But these two had to be selected by some mechanism from the average of 5 children each women had in the pre-industrial era. And as long as mothers and fathers varied in their characteristics this survival process favored some types of individuals over others. The Darwinian struggle that has shaped human nature did not end with the Neolithic Revolution, but continued indeed right up to 1800.

In this chapter we will see that there is very good evidence of differential survival of types for pre-industrial England in the years 1250-1800. In particular we shall see that economic success translated very powerfully into reproductive success, with the richest individuals having at least twice the numbers of surviving children at death as the poorest.

Indeed the evidence is that the poorest individuals in the Malthusian era would typically not reproduce themselves. Instead pre-industrial England at least was a world of constant downward mobility. Given the static nature of the economy, and the economic opportunities it afforded, the abundant children of the rich had to, on average, move down the social hierarchy. The craftsmen of one generation supplied many of the laborers of the next, merchants sons became the petty traders, large landowners sons provided the smallholders.

The downward nature of social mobility in the Malthusian era is in stark contrast to the modern world, where the lower fertility of the rich for most of the years since 1870, and the expansion of upper level economic opportunities, has created instead a world of constant upward mobility, where parents on average see their children move up the social hierarchy.

Survival of the Richest

The first two basic Malthusian propositions, shown again in figure 6.1, imply that reproductive success, the number of

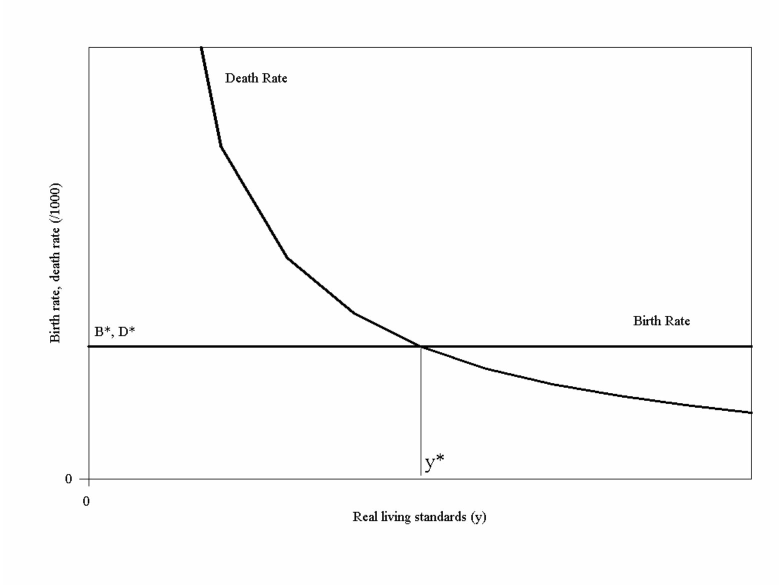

Figure 6.1 Birth and Death Schedules

offspring a person leaves on their death, increased with income. This curve was drawn for society as a whole. But within any settled agrarian society there are huge variations in income per person at any time. The existence of land and capital as assets that generate rents allows some individuals to command much greater shares of output than others. The same Malthusian logic thus implies that those who are successful in economic competition in settled agrarian societies, those who acquire and hold more property, or develop skills that allow for higher wages, would also be more successful reproductively.

We can demonstrate the deep truth of this reasoning using an unusual source. This is the wills of a large sample of men in England around 1600, mainly drawn from Suffolk. Most of these wills were made very close to the death of the testator. 77 percent were entered into probate within a year of composition, implying that more than 77 percent of testators died within a year of composing the will. These wills record both the numbers of living children the testator had at the time of their will, and the likely economic position of the testator, as revealed by how much they bequeathed. Below is a will typical except for its brevity.

JOHN WISEMAN of Thorington, Carpenter (signed with X), 31 January 1623.

> *To youngest son Thomas Wiseman, £15 paid by executrix when 22. Wife Joan to be executrix, and she to bring up said Thomas well and honestly in good order and education till he be 14, and then she is to bind him as apprentice. To eldest son John Wiseman, £5. To son Robert Wiseman, £5 when 22. To daughter Margery, £2, and to daughter Elizabeth, £2. To son Matthew Wiseman, £0.25. Rest of goods, ready money, bonds, and lease of house where testator dwells and lands belonging to go to wife Joan. Probate, 15 May 1623.* (Allen, 1989, 266.)

Wills could bequeath very small amounts, such as the following.

WILLIAM STURTENE of Tolleshunt Major, Husbandman, 14 November 1598.

> *To Francis my son 10s. To Thomas Stonard my son-in-law 1 cow in consideration of money which I owe him. To William and Henry his sons and Mary his daughter each a pewter platter. To Elizabeth my wife the rest of my goods. Probate, 3 February 1599. (Emmison, 2000, 171)*

Wills were not made by a random sample of the population, but were instead made by those who had property to bequeath. But the custom of making wills seems to have extended well down the social hierarchy in pre-industrial England. In Suffolk in the 1620s 39 percent of males who lived past age 16 made a will that was probated.[130] Higher income individuals were more likely to leave a will, but there are plenty of wills available for those at the bottom of the hierarchy such as laborers, sailors, shepherds, and husbandmen.

Wills by 1600 mention nearly all surviving children. Potentially some children were omitted from wills because they received no bequest. But the numbers of omitted children must have been small.

One way this can be demonstrated is through the ratio of sons to daughters. Daughters were much more likely than sons to be excluded from wills: because they had married and were given their share of the inheritance in dowry, or because they were given no bequest. John Hynson of Fordham, Cambridge left to his two unmarried daughters Margaret and Mary £30 each. His three married daughters, whose names were not even given, were described thus "To my 3 daughters who are married 10s (£0.5) each."[131] Even bequests to unmarried daughters were generally smaller than for sons. For example, John Pratt of Cheveley, Cambridge left each son £5, but each daughter only £2.[132]

Hence the ratio of boys to girls named in wills can be used as a measure of how many daughters were omitted. The ratio of boys to girls would be 1.05 at birth in England circa 1600, falling to 1.03 for ages 1-25 because of higher infant mortality for boys.[133] Thus the expected ratio will be 1.03 if boys and girls had

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[130]Probated means registered in the appropriate court. Since probate had a cost others would have made wills that were never probated.

[131]Evans, 1993, p. 217.

[132]Evans, 1993, p. 108.

[133]Based on estimated relative male and female mortality rates by age in 1580-1649 (Wrigley et al. , 1997, 296, 303).

equal chances of being mentioned in wills. The actual ratio, as table 6.1 shows, averaged 1.05. Probably only 2 percent more girls than boys are omitted from these wills. But given that girls were so much more likely to be excluded if anyone was, the overall omission rate for children must have been very low.

Since we are interested in the reproductive success of testators, dead children were counted as surviving offspring if they themselves had produced living offspring. Thus William Cooke of Great Livermere in Suffolk, who died at about age 74, left four living children, but also two dead sons who both had two surviving children.[134] He was counted as having 6 children.

As can be seen in table 6.1 the average numbers of children per testator were modest. For a population to be just reproducing itself the numbers of children surviving each male at time of death would have to exceed two. It has to exceed two since some of these children are minors who would die before they would reach the age (sixteen or more) where they would be potentially writing wills. For the average testator in our sample to get 2 children who survived to age 16 at least they would need to have left 2.07 children when they died. Thus London testators circa 1620 were definitely not reproducing themselves. Those outside London in smaller towns, with 2.43 surviving children per testator, were experiencing a population growth of less than 20 percent per generation. Country testators, however, were growing by 40 percent per generation.

It might be still possible that poor families, having little to leave, more often omitted both boys and girls equally, which our

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[134] Evans, 1987, p. 359.

Table 6.1 Surviving Children per Male Testator, England, 1585-1638

Location	Number of wills with information on children	Children per testator	Sons per testator	Ratio Sons/ Daughters
London	177	1.96	0.83	0.77
Town	267	2.43	1.22	1.04
Rural	1,806	2.92	1.51	1.08
ALL	2,250	2.79	1.42	1.05

gender ratio test will not discover. We can control for this kind of gender neutral omission by also examining the relationship between wealth and the frequency of either no child being named as an heir, or of no male heir being named.

The reasoning is as follows. Even if poorer testators omit some children from their wills because they have few assets, or chose to leave everything to one child, they will certainly not omit all their children for this reason. Further given the preference for males as heirs, while they might leave assets only to the oldest son, they would not omit all their surviving sons from a will. Thus if we take as an index of fertility either just the frequency of at least one child being named, or the frequency of at least one son being mentioned in the will, this should be proof against the type of omission of children possibly to be found in poorer families. We shall see below that when our analysis of fertility is carried out using these as alternative measures the results remain as strong as when using all children.

The estimated assets of testators were constructed from the information in wills by adding together the cash payments directed by the testator, with the estimated value of houses, land, animals, grain bequeathed by the testator. The average value of assets equaled £235 in 1630s prices.[135] But the median value was only £100. This would generate an annual income of about £6 at the return on capital typical of this period. The yearly earnings of a carpenter in this period would be about £18, and of a laborer £12. This reinforces the idea that the wills covered a large part of the income range.

These measures of assets correlate well with literacy, as measured by whether the person signed the will, and with the occupation or social status of the person. Table 6.2 shows this by dividing testators into seven broad occupational categories. *Gentlemen* at the top of the scale were mostly literate, and had average bequests of more than £1,000. Laborers at the bottom were mostly illiterate, and had average bequests of £42. But within each social rank there were huge variations in the wealth of the testator. There were laborers with more assets than some of the gentry. Indeed knowing someone's occupation explains only about one fifth of the variation in assets across testators.

Figure 6.2 shows the estimated numbers of children per male of each of eight bequest classes - £0-9, £10-24, £25-49, £50-99, £100-199, £200-499, £500-999, £1000+ - revealed by the wills. The bottom four income groups cover the bottom 50 percent of testators. The numbers of children are shown both for all men, and for married or widowed men only. In both cases there is a very powerful connection between assets and surviving children.

[135] 1.1 houses, £44, 9.9 acres of land, £99, goods, £4, and £88 in cash.

Table 6.2 Testators by Social Rank, 1585-1638

Social Group	Numbers of wills	Fraction of testators literate	Average value of bequests (£)	Maximum value of bequests (£)
Gentry	59	0.94	1,084	10,935
Merchants/ Professionals	87	0.84	268	1,739
Farmers	659	0.50	406	7,946
Unknown	345	0.44	154	1,360
Traders	84	0.47	112	1,390
Craftsmen	267	0.40	85	525
Husbandmen	333	0.24	87	1,898
Laborers	100	0.14	42	210

For all men someone with less than £10 in bequests would typically have fewer than two children, while someone with £1000 or more, nearly four children. The link between assets and surviving children was thus extremely strong.[136]

The link shown here between assets and surviving children cannot be an artifact created by poorer testators omitting some children because they had nothing to bequeath them. This is evident in a number of ways. We know, for example, from the work of Wrigley and his associates that the typical male testator in England in these years would leave 2.58 surviving children.[137] So

136 Given that we have a very noisy measure of assets bequeathed, the true relationship between assets and children is most likely even stronger than shown in the figure.

137 Wrigley et al., 1997, 614.

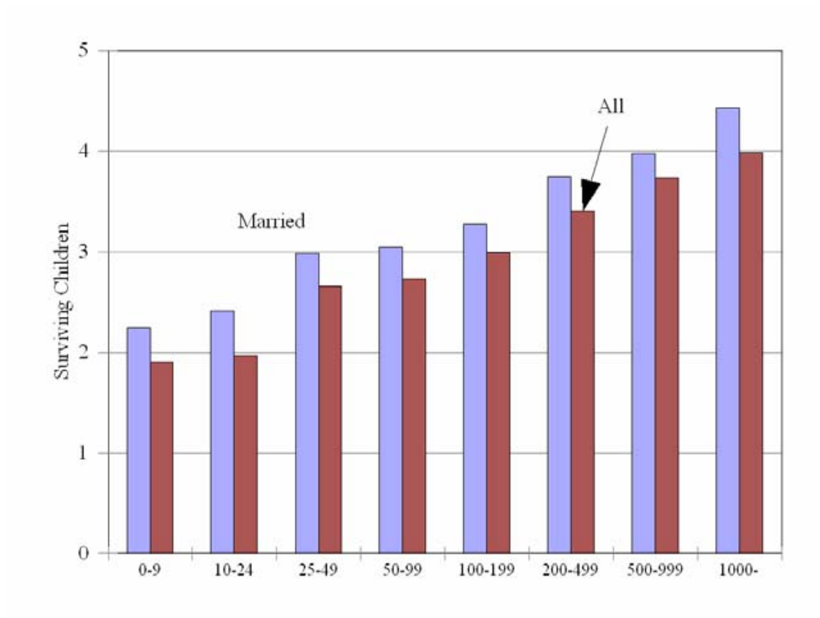

Figure 6.2 Surviving Children by the Assets of the Testator in £

testators with assets with four children per family must be producing substantially more surviving children than the general population, and by inference than the poorest testators also.

Interestingly assets predict reproductive success much better than social status or literacy. Economic status rather than social class is what mattered for reproductive success in England in these years. Presumably this was because the occupational labels used to form people into status classes were imprecise. There were husbandmen who were literate and wealthier than yeomen who were illiterate. There were carpenters who worked for others and owned no assets, and there were carpenters who were employers and engaged in building and leasing property.

Since the results presented above concern only the surviving children of the first generation, without any measure of their reproductive success, they are suggestive rather than conclusive that the pre-industrial economy was selecting for individuals of greater economic success.[138]

The reproductive success of the rich was probably greater because their children survived better. For a sub-group of testators we can link the wills to parish records that give the age and marriage date of the testator. These records suggest that the birth rate of the rich was thus likely only a few percent higher than for the poor. In line with the evidence on infant mortality shown in figure 5.1 for London parishes, the reproductive advantage of the rich lay with the better survival rates of their children.

Using this data on reproductive success, and the assumption that the birth rate was the same for all income classes, it is possible to infer the implied deaths rates in England around 1600 as a function of income. This was shown in figure 5.2. Death rates decline substantially with income.

There is evidence that the pattern uncovered here of much higher net fertility by richer groups existed in England at least by 1250. Medieval kings had a financial interest in the deaths of their tenants in chief, those who held land directly from the crown in the feudal system. These individuals were mostly an economically privileged group, and included the highest nobility of the land. Thus from 1250 on the king's officials conducted *Inquisitiones Post Mortem* on the deaths of these tenants, which are preserved in the Public Record Office. These inquisitions record only the following information, however, about surviving children: the oldest

[138]If the rich males of the first generation got rich only as a result of accident, or non-heritable traits, then their children might not have any greater reproductive success than those of the poor.

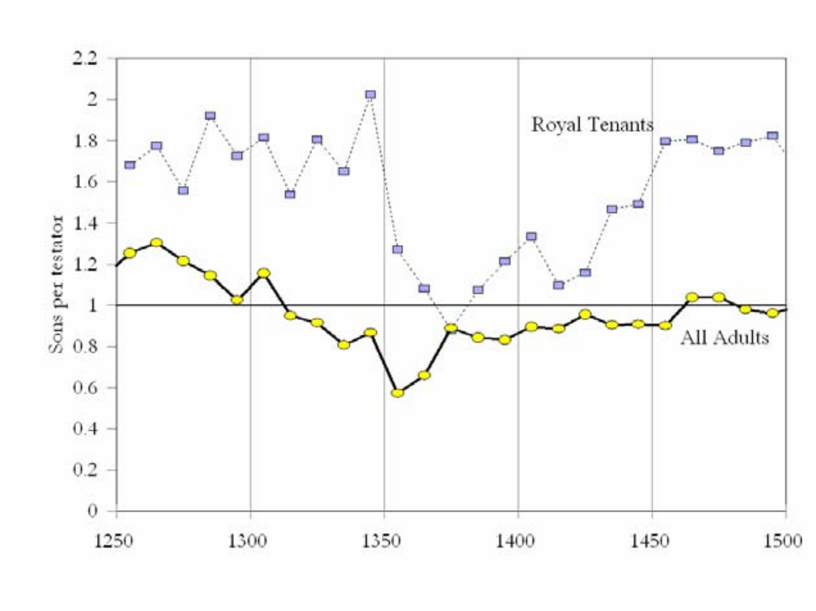

Figure 6.3 Sons per Testator, 1250-1500

surviving son or his descendants; failing a male heir all daughters or their descendants.

The evidence of the wills in 1585-1638 provides a way to infer total numbers of surviving children from measures such as the fraction of times there was an heir, or the fraction of times there was a male heir, for wealthy groups such as royal tenants before 1500. Figure 6.3 shows two series by decade. The first is the average number of males per adult inferred for the whole population of England by decade from data on the aggregate movement of population. As can be seen, except for the phase of population growth up to 1315, this number was one or below one. The second is the implied average number of adult male children produced by royal tenants. This was calculated by using the proportions revealed for 1585-1638 between total male surviving children and the fraction of testators leaving a son or leaving some child.

In the two periods in medieval England where the population was stable or growing, 1250-1349, and 1450-1500 tenants in chief were producing on average about 1.8 surviving sons, nearly double the population average. Even in the years of population decline from 1350 to 1450, though implied surviving sons per tenant in chief declined, it remained at above the replacement rate of in most decades. Thus, as later, in medieval England the rich seem to have been out-reproducing the poor.

Note that in England the reproductive success of the class that engaged in warfare on a large scale in the pre-industrial era, the aristocracy, was much poorer than for economically successful commoners, and was probably less good than that of the average person. Table 6.3 shows for the English aristocracy - kings, queens, dukes and duchesses - the Net Reproduction Rate, as well as life expectancy at birth for males by period from 1330 (when Dukes were first created) Medieval manorial tenants, for example, had a life expectancy at age 20 of about 30, compared to 22 for the aristocracy.[139]

These excess deaths at relatively young ages contributed to the low net fertility of aristocrats. Thus in the earliest period we observe fertility, 1480-1679, the aristocracy, despite its privileged social position was barely reproducing itself. Only after 1730 when death rates from violence declined to levels little above the general population, did aristocratic life expectancy come to exceed the general population. In this period also did aristocrats finally enjoy more reproductive success than the average person.

Thus from the earliest times we can observe in the pre-industrial era reproductive success in a settled agrarian economy

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[139] Razi, 1980, 130.

Table 6.3 The Demography of English Aristocrats, 1330-1829[140]

Period	Net Re-placement Rate	Male Life Expectancy at Birth	Male Life Expectancy at 20	Fraction of Deaths Violent
1330-1479	-	24.0	21.7	26
1480-1679	1.04	27.0	26.3	11
1680-1729	0.80	33.0	30.0	7
1730-1779	1.51	44.8	39.9	3
1780-1829	1.52	47.8	42.7	4

like England seemingly went to those who succeeded in the economic sphere, and avoided occupations where violent death was a hazard. It is plausible that ever since the arrival of institutionally stable agrarian societies with private ownership of land and capital, and secure transmission of assets between generations, those who were economically successful, and in particular those who accumulated assets, were also reproductively successful.

[140]Hollingsworth, 1965, 8-11. Hollingsworth considers only legitimate children, but argues that illegitimate children were few, less than 10 percent of these totals.

Reproductive Success in Earlier Societies

The Malthusian assumptions imply that in all societies, those who command more income will have more reproductive success. This probably held even more strongly with other pre-industrial societies that, unlike Europe, were polygamous. For in these environments men could more effectively translate income into reproductive advantage.

Thus anthropologists have demonstrated that among pastoralists in modern Kenya, ownership of cattle correlates strongly with reproductive success through marrying more and younger wifes.[141] The Ache of Paraguay, hunter-gatherers, moved every day in search of game, so property ownership was minimal in this society, limited to what a person could carry. Reproductive success in this group was still correlated with economic success. But it was the success of males in bringing in meat to camp each day. All the adult males hunted, and Ache hunters who brought home more meat had higher fertilities. The most successful hunters at the mean age of 32 had .31 children per year compared to 0.20 for the least successful. Survival rates were about the same for children of successful and unsuccessful hunters.[142]

But the mechanisms by which people commanded more income seem to have been very different in hunter gatherer societies than in the settled agrarian economies that preceded the Industrial Revolution.

As we saw for the case of the upper classes in England, violence was not a successful reproductive strategy. Rates of violent death were very low. This contrasts with conditions in modern hunter gatherer or shifting cultivation societies where

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[141] Borgerhoff-Mulder, 1987. Cronk, 1991.

[142] Hill and Hurtado, 1996, 316-7.

Table 6.4 Reproductive Success of Male Yanomamo, 1987[143]

Age	Killers n	Killers Average Offspring	Non-killers N	Non-Killers Average Offspring
20-24	5	1.00	78	0.18
25-30	14	1.57	58	0.86
31-40	43	2.83	61	2.02
41+	75	6.99	46	4.19

accidents and violence are a much more important source of mortality. There mortality death rates from accidents and violence for males were typically 3-18 per 1000 males per year. At the extreme, among the Ache violence was the cause of most male deaths.

In these societies violence was a way of gaining more resources and hence more reproductive success. Thus Napoleon Chagnon in a famous study of the warlike Yanomamo society found that a major predictor of reproductive success was having killed someone. Male Yanomamo sired more children at a given age if they had murdered someone than if they had not.[144] Table 6.4 shows the numbers of children male Yanomamo had fathered as a function of age, and of their status as a "killer" or "non-killer."

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[143]Chagnon, 1988.

[144]Of course, this raises the question of whether murder is a successful reproductive strategy for males, since some of those who fail in the attempt will die themselves, and not be reported upon here.

Social Mobility with Survival of the Richest

England in the years 1585-1638 was still a relatively static society, with little change in income per person. It was, as noted, a society still in the Malthusian grip where economic change was slow or non-existent. Consequently the relative numbers of occupations, the wage rates for different occupations, and the stock of housing per person changed little. Land per person fell, but land values were increasing with the growth of population, so the value of land per person also changed little. The great reproductive success of richer testators thus meant that their children had to be on average moving down the social ladder in terms of assets and occupations, and moving down reasonably rapidly.

Table 6.5 illustrates this for Suffolk in 1620-1638. The second column of the table shows the sample of male will makers from Suffolk arranged by asset class. Added to the observed wills are the appropriately sized group of males who made no will, assumed to have 0 assets, as well an appropriately sized group of testators whose wills were approved in higher courts, and whose assets are assumed to all exceed £1000. The next column shows the share of each class of males in the population in the first generation. The next column gives the observed numbers of male children from each asset class who reach at least age 16. We assume the non-mill makers had the same numbers of children as those making wills whose assets were £0-9. For those whose wills were proved in higher courts we assume they had the same numbers of children as those of the highest observed asset class. This implies that of a population of 3,613 wills in the first generation we end up with 4,266 adult male successors in the next generation, an increase of 18 percent per generation. This is close

Table 6.5 Inter-generational Mobility in Suffolk, 1620-38[145]
*higher courts

Assets	Males in First Generation	Share of first generation (%)	Male Adult Children	Share of second generation (%)
0 (no will)	2,204	61.0	(2,125)	49.8
0-10	140	3.9	135	3.2
10-24	101	2.8	107	2.5
25-49	125	3.5	158	3.7
50-99	211	5.8	294	6.9
100-199	260	7.2	398	9.3
200-499	288	8.0	491	11.5
500-999	116	3.2	220	5.2
1000-	68	1.9	137	3.2
1000- *	100	2.8	(201)	4.7
All	3,613	100	4,266	100

to the 21 percent gain per generation found by Wrigley et al's. for England in this period.

The last column of the table shows the shares of the children of each asset class in the next generation. Testators with less than £10 in assets and those who left no will were 65 percent of the first generation. But their sons constituted only 53 percent of the next generation. Testators with more than £500 in assets were 7.9 percent of the initial generation. Their sons were 13.1 percent of

[145]The numbers in brackets in column 4 are estimates from the observed reproductive success of he highest and lowest group of will makers in the archdeaconry courts.

the next generation. Given that assets per person in the population probably stayed constant over this interval, there thus must have been considerable net downward mobility in the population. Nearly half of the sons of higher class testators would end up in a lower asset class at death. Indeed net mobility would be downward for testators in all the groups with £25 or more in assets.

Zvi Razi's evidence from the court rolls of Halesowen 1270-1430 is consistent with the suggestion of the *Inquisitiones Post-Mortem* that the rich were much more successful in reproducing themselves in medieval England. Table 6.6 shows the percentage of families showing up in the court rolls of 1270-82 who had direct descendants holding land in the manor 70 years later in 1348. All the families with the largest holdings in 1270-82 still had direct descendants holding land. But only 25 of the 70 families holding the smallest amounts of land had a descendant holding land.

However the distribution of holding sizes had not become more unequal because though families with larger holdings in 1270-82 on net acquired land, they also often divided up their holdings between multiple heirs, keeping the size distribution in balance. Since Ravi's data does not allow us to know whether the small landholders were in fact suffering demographic collapse, or simply either disappeared from the court rolls, or leaving the manor, the data does not demonstrate that medieval England was experiencing the same population dynamics as later.[146] But it is consistent with that interpretation.

This story of the reproductive advantage of the rich is also found in a collection of surveys of communicants in villages in Austria and southern Germany for the seventeenth to nineteenth

[146] Inhabitants without land were less likely to appear in court rolls since they do not show up in land transactions or as pledges.

Table 6.6 Survival of Landowners, Halesowen, 1270-1348[147]

Family Type in 1270-82	Numbers of Families	Number with descendants holding land 1348	Percentage with descendant land holders
Rich	40	40	100
Middling	64	58	91
Poor	70	25	36
ALL	174	123	-

centuries assembled by Joerg Baten. Villagers of higher social status, and those revealed to be more likely literate had at the time of the surveys more surviving children.[148]

Thus economic orientation had a dynamic of its own in the static Malthusian economy. Middle class values, and economic orientation, were most likely being spread through reproductive advantage across all sections of stable agrarian societies. Chapter 8 explores the implications of these Darwinian selection processes.

[147]Razi, 1981, 5.

[148]Joerg Baten, personal communication.

7. Technological Change in the Malthusian Era

"Same as it ever was…….same as it ever was…" (Talking Heads, Once in a Lifetime, 1984).

Introduction

There was significant technological advance in the Malthusian era. Pre-industrial economies were not completely static. In the period before 1800 in Europe, for example, there were significant improvements in many technologies (though some of these same innovations were made earlier and independently in China). Thus the list of basic technologies which were unknown or unused in the ancient world is a surprisingly long one. These include, for example, the nailed horseshoe, which protected hooves from soil moisture which wore hooves out quickly and caused them to splinter.

The Greeks and Romans also did not use stirrups which allowed cavalry with lances to be used as shock troops in warfare. In antiquity war was mainly conducted on foot, or horses pulled chariots. The Greeks and Romans also used horse harnesses which wound around the belly and neck of the horse. Experiments earlier this century by a retired French cavalry officer suggest that harnessed in this way horses lose up to 80 percent of their traction power, since the neck strap presses on the windpipe and the jugular. In the medieval period horse collars which sat on the horses shoulders were introduced. The Greeks and Romans also lacked windmills (first documented in Yorkshire, England, in 1185), buttons on clothing (first found in Germany in the 1230s), spectacles (1285, Italy), mechanical clocks and firearms (fourteenth century), and movable type printing (1453, Gutenberg).[149] A Swedish windmill, the successor of a medieval innovation, is shown in figure 7.1

What was the rate of improvement of technology, however, compared to the modern world? And how did it vary over time? Can we reduce all the complex changes in technology to a single number, the rate of advance of technology per year? How do we compare the invention of the bow for hunting, for example, with the introduction of the personal computer? How much technological progress is represented by the introduction of the mechanical clock in Europe in 1285, compared to the knitting frame of 1589?

Economists measure the rate of technological advance in a particular way. The lower curve in figure 7.2 shows the typical pre-industrial connection between land per person and output per person. This shows the *production function* of the society. Technological change in this measure is an upward shift in the production possibilities at any level of land per person, again shown in figure 7.2. If A is the measure of the level of technology, the rate of technological advance, g_A, is the percentage upward movement per year of the production function at any level of land per person. For example, if g_A is one percent per year, at a given land labor ratio the society is able to produce 1 percent more output per year.

This measure of the rate of technological advance has the property that

$$g_A = \theta_1 g_{A_1} + \theta_2 g_{A_2} + ... + \theta_n g_{A_n}$$

[149]See Mokyr, 1990.

Figure 7.1 A windmill, unknown in the world of Plato, Aristotle, and Euclid, but introduced in the middle ages (Faro, northern Gotland, Sweden)

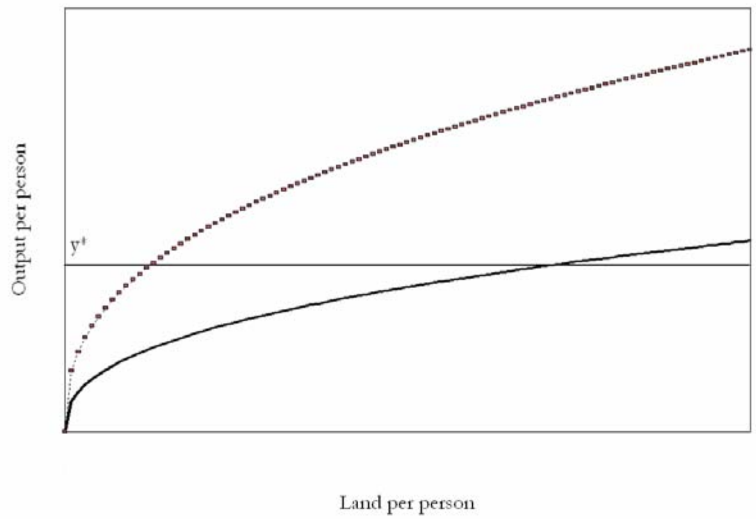

Figure 7.2 The Effects of Technological Advance before 1800

where the θ's are the values of the output of each industry of the economy divided by total value of final outputs, and the g_{Ai}s are the efficiency growth rates within each industry.

Economists use this weighting because it measures how much technical changes mattered to the average consumer. It measures efficiency by looking at the changes in efficiency of production of each good within the economy weighted by how much of each good is consumed. This productivity measures effectively takes a poll of consumers and asks "How much are things being done more efficiently for *you* this year as opposed to the last?"

Measuring Technological Advance from Population

In figure 7.2 the Malthusian mechanism stabilizes population at the level where the land per person produces just the subsistence income *y**. Technological change in this world showed up as an upward shift in the production possibilities.[150] But as long as income was constrained to return to the subsistence level, *y**, population would grow after technological advance until land per person fell sufficiently so that output per person was again *y**.

For one pre-industrial society we can actually plot out this curve over a wide range of acres per person. That is England in the three hundred and sixty years 1240-1600 where the production technology seems to have been static, but population varied by nearly 3 to 1 because of the plague losses after 1348. Figure 7.3 shows output per person by decade from the 1240s to the 1590s. Also shown is the single production function that best fits this data. The static nature of the technology over these years is well illustrated by how well this single curve fits all these observations.

If we can represent aggregate technological advance in this way as the shift upwards in the production function, then measuring technological advance over long periods using population becomes easy.

Let N be population, and g_N the population growth rate. If *c* is the share of land rents in income in pre-industrial society, then

$$g_N = \left(\frac{1}{c}\right) g_A \qquad .$$ [151]

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[150]Here "technology" is used in the broadest possible way to include any element of invention or social organization that affects output per acre. Thus legal innovations that increase output through better defining property rights will be included in the technology.

[151] This result is derived in the technical appendix.

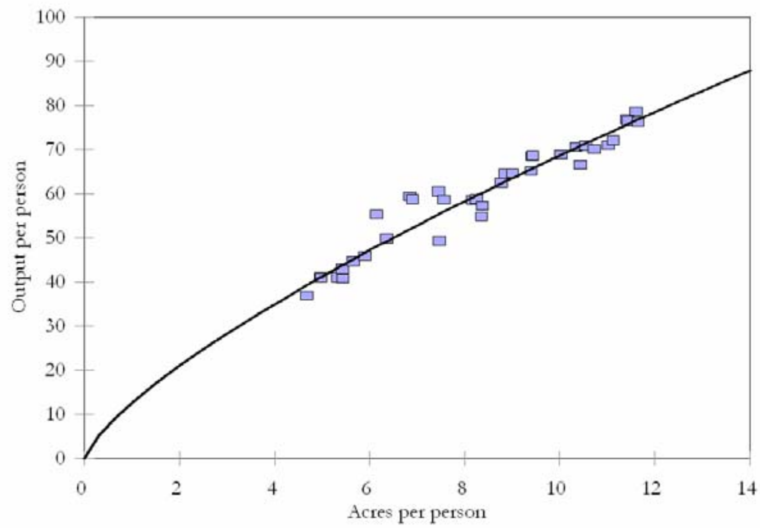

Figure 7.2 Ouput per person versus land per person, England 1240s-1590s

This simple formula says, for example, that if the share of land rents in income was one fifth, then a one percent improvement in the technology will increase population by five percent. Note that to implement this formula to measure the rate of pre-industrial technological advance all we need is some estimate of the share of land rents in all sources of income, and of the rate of population growth.

Pre-industrial England again supplies estimates of the share of land rents in income all the way from 1200 to 1800. Figure 7.4 shows this share by decade. Though the share moved up and down somewhat it was remarkably stable over time at 24 percent of income. The relative constancy of the rent share in all income

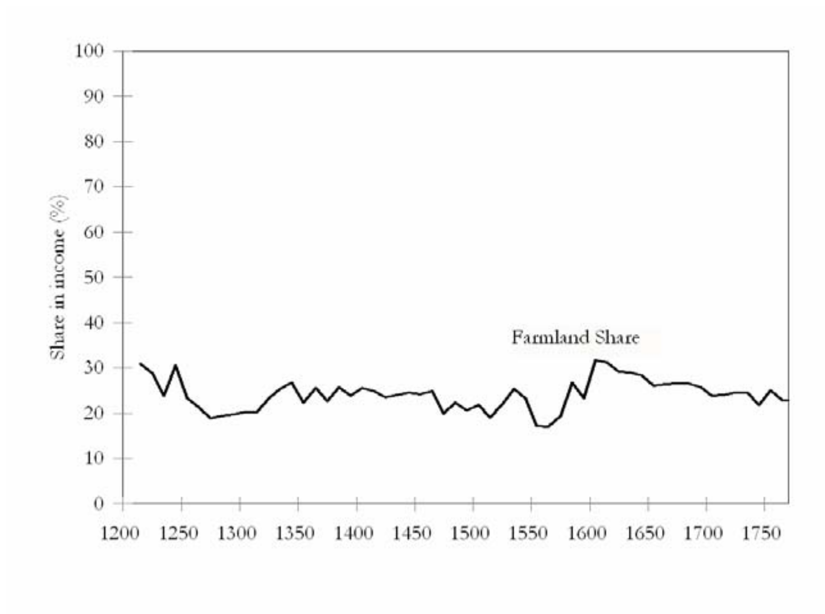

Figure 7.4 Land Rents as a Share of All Income, England

allows us to infer simply how much technological progress would change population.[152]

In 1500-49 in England at the farm level the rent share was probably about 40 percent.[153] In comparison in Sichuan, China in the eighteenth century the rent share at the farm level for sharecropping averaged 50 percent.[154] Evidence from Babylonia in the time of Hammurapi (1792-1750 BC), suggests a share of one third for land rent.[155] So the national rent share could vary between 0.2-0.3. But for our purposes the exact number hazarded makes little difference.

What is the history of world population up until 1800? The second column of table 7.1 shows rough estimates of world

[152] To be precise, the production function is Cobb-Douglass.
[153] Clark, 2006a, table 6.
[154] Zelin, 1986, 518.
[155] Harris, 1968, 728.

Table 7.1 Population and Technological Advance, 130,000 B.C. to 1800[156]

Year	Population (millions)	Population Growth Rate (%)	Technology Growth Rate (%)
130,000 BC	0.1	-	-
10,000 BC	7	0.004	0.001
1 AD	300	0.038	0.009
1000 AD	310	0.003	0.001
1250 AD	400	0.102	0.025
1500 AD	490	0.081	0.020
1750 AD	770	0.181	0.045

population from 130,000 B.C., when anatomically modern humans first appeared, to 1750. There is huge error in these estimates. Thus the population in 10,000 BC before the onset of the Neolithic Revolution is estimated using the observed densities of modern foraging populations. We know from archeological evidence that in the years leading up to the Neolithic Revolution humans were steadily expanding the range of foods they consumed from hunting and foraging, allowing for greater population densities.[157] In the table I guess at a population of 100,000 people in 130,000 BC, but the time scale is so long here that the exact number hazarded makes little difference.

[156]Durand, 1977, 285. The estimate for 130,000 BC was made based on the idea that the range of animals man could hunt expanded greatly in this era. See Stiner, 2001, 2005.

[157] See Stiner, 2001, 2005.

The last two columns of table 7.1 show the implied rate of population growth, and the implied rate of technological advance according to the formula above with a rent share of 0.25.[158] The low rate of technological advance before 1750 is immediately apparent. Since the Industrial Revolution rates of technological progress for successful economies have typically been 1 percent or greater. For the pre-industrial era, at the world scale, rates of technological advance over long periods never exceeded even 0.05 percent per year. At a rate of 0.05 percent the production possibilities curve shown in figure 7.1 shifts upwards by 5 percent in every 100 years. Thus the Industrial Revolution represented an abrupt shift in the character of the economy, represented in the first instance by the rate of technological advance seemingly shifting abruptly upward.

Another suggestion that emerges from the table is that within the Malthusian era the rate of technological advance increased over time. The Malthusian era was not completely static, and indeed showed signs of greater dynamism as it approached its end. But even at these higher rates of technological change, things happened very slowly. In the 1,750 years between the birth of Christ and the eve of the Industrial Revolution the technology improved in total by 24 percent, based on these population estimates. That is, on aggregate economies in 1750 produced only 24 percent more output per acre of land, at a given level of people per acre, than in 1 A.D. That was why the world for so long was trapped in the Malthusian era.

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[158] The crudeness of these estimates is illustrated by the fact that there is tremendous uncertainty about even the population of Italy in 14 A.D. Estimates of 7 million and 17 million both have supporters. See Brunt, 1971.

In the long run in the Malthusian era all technological advance should show up in the form of increased land rents. Indeed land rents should rise at the same rate as population in order to keep constant the share of land rents in income as population grows. Thus

$$g_A = cg_N = cg_s$$

where s is real land rents. Again for England 1200-1800 we can measure land rents and see that their growth rate is consistent with the absence of productivity growth before 1600, and modest rates of growth in the interval 1600-1800.

Table 7.2 shows the rate of growth of real land rents in England from 1200 on by century, calculated as the difference between the rate of growth of nominal land rents and the rate of growth of prices. On balance from 1200 to 1600 there is no growth in real land rents, and in fact a slight decline. Implied productivity growth rates are slightly negative. From 1600 to 1800 there is sign in land rents of some efficiency gains, but based on land rent increases alone the implied rate of productivity advance would only be 0.06% per year.

The Locus of Technological Advance

Just as we can use population densities to roughly measure the rate of technological advance before 1800, we can also use them to measure which societies had the most advanced production technologies. Figure 7.5 gives the numbers of people per square mile of farmland in the various regions of the world circa 1500. Four regions show up as having high populations per acre:

Table 7.2 Inflation and Real Rent Growth

Period	Inflation Rate %	Nominal Rent Growth Rate %	Growth rate real land rents %
1200-1300	0.49	0.11	-0.39
1300-1400	0.08	0.05	-0.03
1400-1500	-0.06	-0.25	-0.19
1500-1600	1.32	1.77	0.45
1600-1700	0.36	0.60	0.24
1700-1800	0.50	0.84	0.34
1800-1900	-0.40	0.27	0.67
1900-1950	2.3	2.0	-0.30
1950-2000	5.9	7.7	1.80

central Europe, the Middle East, India, and East Asia, particularly Korea and Japan. Though population densities had increased everywhere by 1800, the result of technological advance, the world shows a very similar pattern of densities. As in the modern era a very large share of world population is found in Europe, India and East Asia.

In particular, there is little sign of any great difference in the implied technological sophistication of Europe and either the Indian subcontinent, or of East Asia, on the eve of the Industrial Revolution. If living standards were the same across these societies than there is nothing that would pick out Europe in 1800 as having a more advanced technology than a number of eastern societies, including both China, India, Korea and Japan.

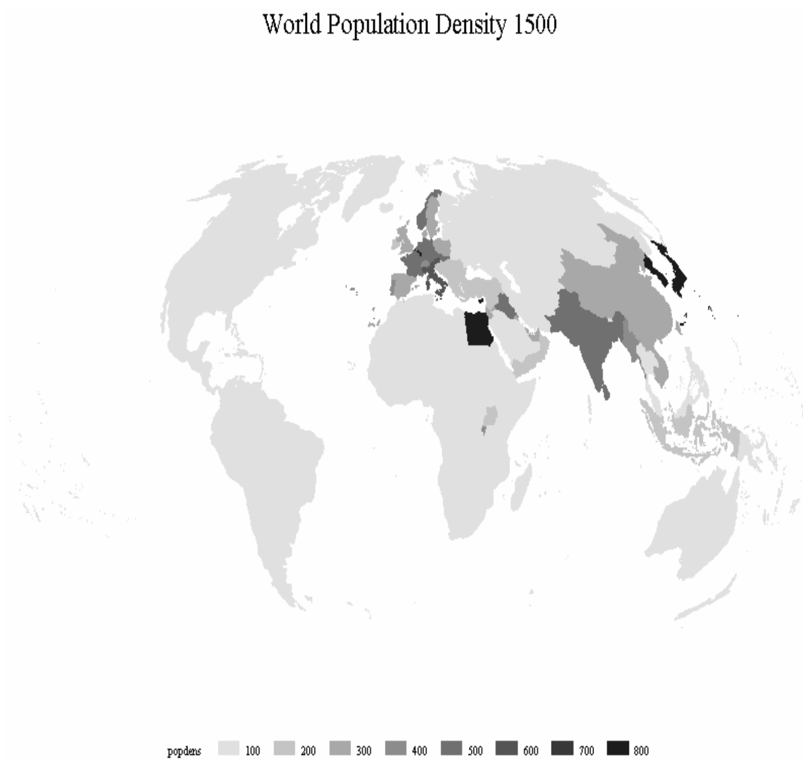

Figure 7.5 World Population Densities, circa 1500[159]

Indeed figures 7.5 and 7.6 show aggregate population densities for large areas. If we concentrate on smaller regions and sub-regions, such as the Yangtze Delta in China, population densities circa 1800 were dramatic by European standards. In1801 England, then just moderately densely populated by European standards had 166 people per square mile. In contrast

[159]The figure is drawn using the admittedly very speculative numbers of McEvedy and Jones, 1978 for population. Farmland areas are those for modern times as reported by the FAO.

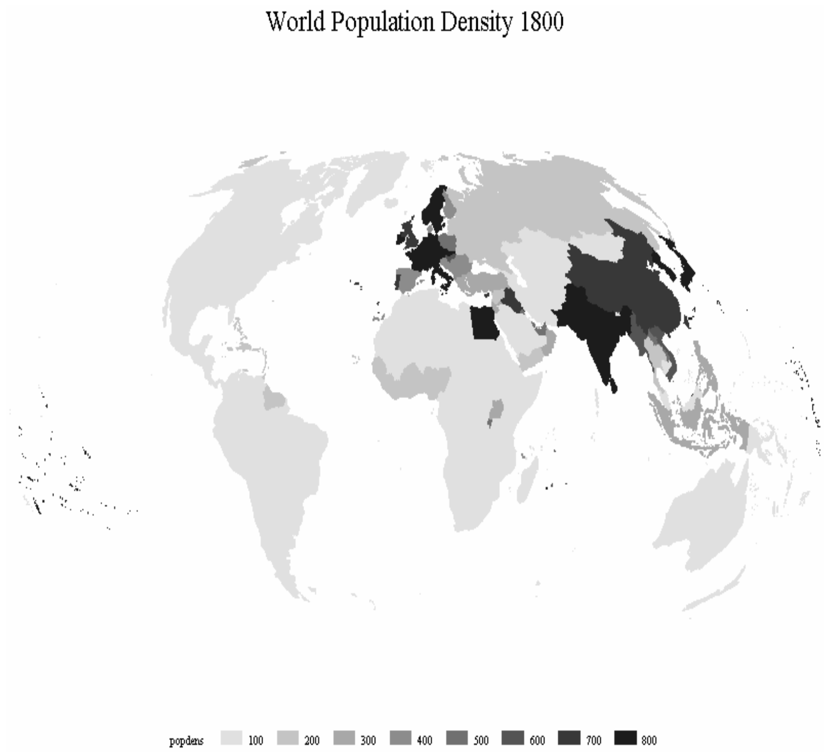

Figure 7.6 World Population Densities, circa 1800

Japan as a whole was supporting about 226 people per square mile from 1721 to 1846, and the coastal regions of China attained even higher population densities: Jiangsu in 1787 had an incredible 875 people per square mile. It may be objected that these densities were based on paddy rice cultivation, an option not open to most of Europe. But even in the wheat regions of Shantung and Hopei Chinese population densities in 1787 were more than double those of England and France. Thus in terms of the major production activity of these societies, agriculture, if there was any technological advantage in 1800 it likely lay with the coastal regions of East Asia.

However, as we saw in chapter 3, at least in the cases of India and Japan there are indications that material living standards were far behind those in England, and indeed were likely lower than those of most Malthusian economies.

Technological Regression

Before 1800 there were also long periods where technology either showed no advance at all, or even regressed. Australian Aboriginals, for example, are believed to have arrived in Australia between 40,000 and 60,000 years ago: long before people first arrived in the Americas. But technology seemingly remained frozen on the Australian continent in all the long period up to the arrival of British colonizers in 1788, judging by the technology of Aborigines at first contact.

Further there are signs of actual technological regression. The Australian Aboriginals who seemingly reached Australia by sea, no longer had sea-worthy craft in most of Australia by 1788. In Tasmania, where a community of about 5,000 Aboriginals was cut off from the mainland by rising sea levels for about 12,000 years, the technological regression was even more dramatic. When encountered by Europeans in the late eighteenth century, the Tasmanians had a material culture at the level of the Paleolithic, more primitive than that they had been endowed with by their ancestors. Despite the cold they had no clothing, not even animal skins. They had no bone tools, and no ability to catch the fish abounding in the sea around them. Yet archeological evidence shows that they had once had bone tools, and once fish was an important part of their diet. The gap between their technology and the English in 1800 was as illustrated above reflected in the respective population densities of the societies. Tasmania, about half the area of England, had an estimated 5,000 inhabitants at a time when England had 8 million.[160]

The statues of Easter Island similarly pay mute testimony to a technological and organizational ability that the inhabitants had once had, but no longer possessed by the time of European contact. The inhabitants of Hawaii had arrived there by sea voyages they were no longer capable of undertaking. Allegedly they had lost the knowledge of where they had come from, so that they were surprised to find that any other people existed.

In Artic Canada the Inuit on contact in the nineteenth century had a material culture that was considerably less complex than their ancestors the Thule people of five centuries before. The Thule people were able to hunt large sea mammals in open-water, and wintered in permanent houses that were stocked with ingenious and elegant artifacts including games and children's toys, harpoons, boats and dogsleds. Sometime between the sixteenth and the eighteenth century the Inuit lost much of their material culture. Hunting of sea-mammals in the open water was or restricted to smaller species. Winter was now spent in transient snow-houses, since they were unable to procure sufficient food supplies to winter in one location. Artifacts were simpler, and decorated or ornamental objects produced only in a few areas. So marked was this difference that it took archaeologists a long time to accept that the Inuit were indeed the descendents of the Thule.[161]

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160 Jones, 1977, 1978.

161 McGhee, 1994.

It is even claimed that China, the leading area of the world in technological sophistication as late as 1400, also went into a technological decline. When Marco Polo visited China in the 1290s he found they were far ahead of the Europeans in technical prowess. Their ocean-going junks, for example, were larger and stronger than European ships. In them the Chinese sailed as far as Africa. The Portuguese, after a century of struggle, reached Calicut, India in the person of da Gama in 1798 with four ships of 70-300 tons, and perhaps 170 men. There they found they had been preceded 80 years before by Zheng He, whose fleet may have had as many as 300 ships and 28,000 men.[162]

Yet by the time the Portuguese reached China in 1514, the Chinese had lost the ability to build large ocean going ships. Similarly Marco Polo had been impressed and surprised by the deep coalmines of China. Yet by the nineteenth century Chinese coalmines were primitive shallow affairs which relied completely on manual power. By 11th century AD the Chinese measured time accurately using water clocks, yet when the Jesuits arrived in China in the 1580s they found only the most primitive methods of time measurement used, and amazed the Chinese by showing them mechanical clocks. The decline in technological abilities in China was not caused by any catastrophic social turmoil. Indeed in the period after 1400 China continued to expand by colonizing in the south, the population grew, and there was increased commercialization.[163]

162 Finlay, 1992, 225-6.
163 Mokyr, 1990.

Why Was Technological Advance so Slow pre 1800?

This is one of the great puzzles of world history, in the light of what came after 1800. What makes it so puzzling in part is that pre-industrial societies differed from each other in every conceivable way socially and institutionally. In Christian Europe there was a horror of incest, in Roman Egypt the preferred marriage partner was a sibling. Christian Europe embraced alcohol with fervor and relish, and in good times consumed enormous quantities, while the Muslim world abhorred it. In Europe animal flesh was eaten with gusto, in Hindu India it was avoided by all but the sinful. The Europeans in turn were horrified by the Aztec practice of eating the flesh of dead enemies. Yet despite the bewildering variety of cultures and institutions, all these societies had one thing in common: the production technology improved very slowly.

We shall not address this puzzle fully until we discuss the Industrial Revolution itself. But there is a common misapprehension that must be corrected first. That is that before 1800 the institutional framework of all societies removed all incentive for people to invest in better technique.

The popular misconception of the pre-industrial world is of a cowering mass of peasants ruled over by a small, violent and very stupid upper class that extracted all surplus from them beyond subsistence, and so gave no incentives for trade, investment, or improvement in technique. The exclusive and moronic ruling classes were aided in their suppression of all enterprise and innovation by organized religions of stultifying orthodoxy, which punished all deviation from established practices as heretical. The trial and condemnation of Galileo Galilei by the Holy Inquisition in 1633, for defending the Copernican view that the earth re

Figure 7.7 The Trial of Galileo, 1633

volved around the sun, seems to be the exemplar of the reign of superstition and prejudice in the Malthusian era.

There may have been societies before 1800 that fit this popular stereotype. There were frequent attempts by religious authorities to impose fallacious dogmas about the natural world. But as an explanation of the slow technological advance of the world as a whole before 1800 the prevailing view makes no sense, and is maintained only by a modern species of superstitious dogmatism, which is that of modern economics and its priestly cast.

For while all societies before 1800 displayed slow rates of technological advance, some had institutions as favorable to economic growth as any the current World Bank could wish for. Medieval England in the years 1200-1500, for example, is a society that we know, from figure 7.2 above, experienced little or no overall technological advance. Yet medieval England through almost all of this period was a society of extraordinary institutional stability, where most individuals enjoyed great security both of their persons and their property. This can be demonstrated in a number of ways.

First consider the fraction of income in the society that was seized by the government or the church in the form of taxes, tariffs, tithes and levies of all kinds. Were enterprise and innovation in pre-industrial societies discouraged because the fruits of effort were seized by a rapacious states and religious bodies?

In medieval England, as in most of Europe, tax collection by the central government at less than 1 percent of national income was miniscule in comparison to modern states, and attempts to increase the take by the king were vigorously resisted. Thus the Poll Tax of 1381, which triggered a brief but widespread rebellion in which the rebels captured London and killed the Archbishop of Canterbury and the king's Chancellor, was a temporary war tax on all adult males in England, levied at 1 percent of a laborer's annual wages. After this reaction no English sovereign attempted a Poll Tax again, until the similarly ill-fated venture of Prime Minister Margaret Thatcher in the 1980s.

In medieval Europe the church was a much more important levier of taxes, most of which went to support high living by the priestly class, in the form of the tithe. But though the tithe was supposed to be a tenth of gross output, the effective rate of collection on all but grain crops was much lower than this. Thus the overall tax burden on medieval cultivators was 8-12 percent. For artisans and tradesmen the burden was even lighter. As table 7.3 shows, estimates for Imperial China suggest a similarly low rate of taxation.

The onset of the Industrial Revolution in England was associated with a much larger collection of taxation by state and church. Tithe collections fell sharply as a share of income, but national and local tax assessments rose more.

One reason why taxes were so light in pre-industrial agrarian societies was that the ruling class had a rich source of income without resorting to taxation, which was from land ownership. As figure 7.4 showed for England land rents were about 20 percent of income. In England by 1300 most of the land owned by this ruling class was either leased out to tenants on a commercial basis, or was held by tenants on fixed rent leases with hereditary right.

In contrast in the richest modern societies governments typically seize, under threat of force, 30 to 50 percent of all output. It may be objected that much of that income seized is returned to taxpayers in the forms of pensions, schools, hospitals, unemployment payments, and income support. But a system of high taxes on economic activity, combined with generous provision of income and services independent of effort, is precisely what the World Bank consensus among economists would fear as a barrier to effort and initiative.[164]

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[164]One mitigating factor is the switch of economic activity illegally outside the tax system to the "shadow economy." A recent survey estimated that such economic activity now constitutes as much as 18 percent of the output of high tax European economies. In Italy, for example, 24-30 percent of GDP was estimated to be produced in this way in 1990-3. Schneider and Enste, 2000, 80.

Table 7.3 The Share of Income Collected in Taxes[165]

Country	Period	All taxes (including church) %
England[a]	1200-1349	8-10
England[a]	1760-1859	14-16
Ming China[b]	c. 1550	6-8
Quing China[b]	c. 1650	4-8
Quing China[b]	c. 1750	8
Ottoman Empire[d]	1500-99	3.5
Ottoman Empire[d]	1600-99	3.5
Ottoman Empire[d]	1700-99	4.5
USA[c]	2000	30
England[c]	2000	37
France[c]	2000	45
Sweden[c]	2000	54

So the taxing systems of economies like medieval England, that returned none of the income collected to consumers in the form of social services or transfers would actually do much less damage to individual initiative than modern tax and transfer schemes.

A second aspect of the security and stability of medieval England was the comparatively low threat from physical violence,

165 [a]Author's calculations. [b] Feuerwerker, 1984. [c]OECD. [d]Pamuk, 2005, graph 1 (central government only).

which was illustrated in chapter 5. From the thirteenth century on the typical Englishman died in his bed (with, of course, typically two children in solicitous attendance). This was no Hobbesian world of plundered, burning villages strewn with the unburied dead.

In day to day life violence rates in the medieval period were high by later standards, but were still not such as we would think would interfere with the operation of economic incentives. Murder rates were substantially higher in the thirteenth century than in the modern world. But most of their decline towards modern levels occurred long before the onset of modern economic growth. And even at their worst in the thirteenth century homicide rates at 0.21 per 1,000 in England still implied that the average male over their lifetime had only about a 0.7 percent chance of being murdered. These rates are at the high end for the modern world, but most travelers would not fear to hesitate to visit many societies with similar or higher rates now: Thailand (0.13), Latvia (0.17), Trinidad and Tobago (0.17), Estonia (0.23), Bahamas (0.26), Philippines (0.26), Puerto Rico (0.38), Brazil (0.42).[166]

Another sign of the security of property in medieval England, and the general stability of institutions, is the modest fluctuations in property values over time. Figure 7.8 shows the average price of farmland per acre in England by decade from 1200 to 1349, inferred from 796 property transactions, relative to the price of farm output.[167] It is thus the real price of farmland. Overall there is remarkably little variation in the real price by decade. Someone investing in farm land would find it an investment

166 World Health Organization, 2002, table A.8.

167 The property sales are recorded in the chartularies of religious foundations and private families.

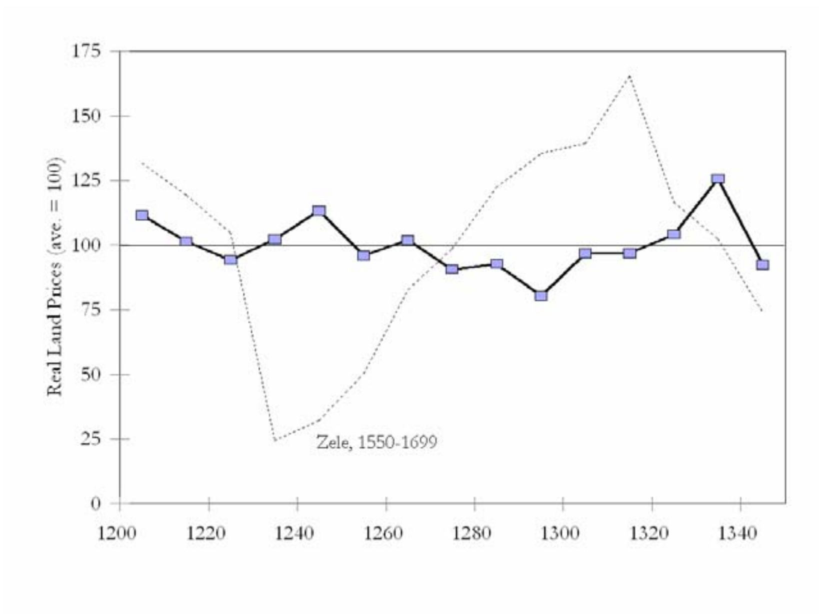

Figure 7.8 Real Land Prices, England 1200-1349[168]

involving very little risk. This must imply very few periods of disruption and uncertainty within the economy. Any such disruption typically leaves its mark on the prices of assets such as land and housing.

In comparison the figure shows also the decadal average of the real price of arable land in the district of Zele, near Ghent, in Flanders from the 1550s to the 1690s, which should dramatically greater variation. The reason for this is easy to learn from the narrative history of Flanders. In 1581-92 Flanders was the setting for the fight over Dutch independence. Ghent was recaptured from the rebels in 1584 after fierce fighting. After 1585 Flanders was mostly Spanish but the Dutch continued to raid the countyside until 1607. This shows in the huge depreciation in land values in Zele: they were less than 20 percent of there level in the

[168]Zele, Clark, 1996.

1550s by the 1580s. There was also warfare in Flanders in the period 1672-97 during the wars of the Dutch and the Habsburgs against Louis XIV. Land values in these years also declined sharply relative to their level in the peaceful years of the 1660s.

Thus the sometimes turbulent nature of high politics in England in the medieval period - there were armed conflicts between the King and the Barons in the periods 1215-19, 1233, 1258-65 and much of 1312-1326 - had no impact on the average person. At the local level property rights were stable and secure.

Another measure of the institutional stability of England in the medieval period was the absence of inflation. Inflation has social costs since it drives up the costs of using the monetary system for exchange and to store value. Yet weak governments frequently have currencies that inflate rapidly, since such inflation provides a revenue source for governments. Long run inflation was largely absent in the pre-industrial English monetary system, as table 7.2, which shows inflation rates by century, revealed. Only with the influx of south American silver to Europe in the sixteenth century was there any appreciable inflation, and this from external sources. But this period, known amongst some historians as that of the *Price Revolution*, witnessed inflation rates that were so low by modern standards that any Central Bank chief would be boasting of them. Indeed inflation shows up as a major economic problem in England only in the twentieth century.

Property and person might be secure, the objection will be voiced, but in a society where there was a strict division between the noble class at the top and a mass of undifferentiated servile peasantry at the bottom, this stability and security was that of a stultified social order, not that of a economy pregnant with the possibilities of progress. However, this is another caricature of the pre-industrial world. Case after case, study after study, shows that even medieval England was a highly fluid society where people lived at every type of economic condition, from landless wage laborers to wealthy, and where movement between conditions was frequent.

Taxation records and manorial court rolls reveal from the earliest years a society of enormous income and wealth disparities, even from the earliest years. Records of the 1297 Subsidy (a tax on movables), for example, suggest that even above the minimum value of possessions, about a quarter of the annual wage of a laborer, that made households liable to the tax there were huge variations, both in town and countryside, in the value of possessions.[169]

Even at the lowest level, the laborers and peasants, there was an active land market from early in the thirteenth century at least that transferred even land notionally was held by unfree tenants to unrelated individuals. Thus peasants, or even laborers, who were energetic and frugal could accumulate land and move up the rural social hierarchy. This shows up, even from the earliest years, in great inequalities in land holdings. A survey of the royal manor of Havering in 1251, for example, reveals that while 4 tenants held more than 200 acres of land each, 41 held less than an acre, and 46 between 1 and 3 acres.[170]

Another factor causing great social mobility and fluidity in Malthusian societies like medieval England was the accidents of demography. Figure 7.9 shows the distribution of the numbers of surviving children for male testators in England both outside London, and in London itself, from the wills discussed above. But the distributions shown here would have been characteristic for the whole Malthusian era. Outside London one third of males

[169]Biddick, 1987.
[170]MacIntosh, 1980.

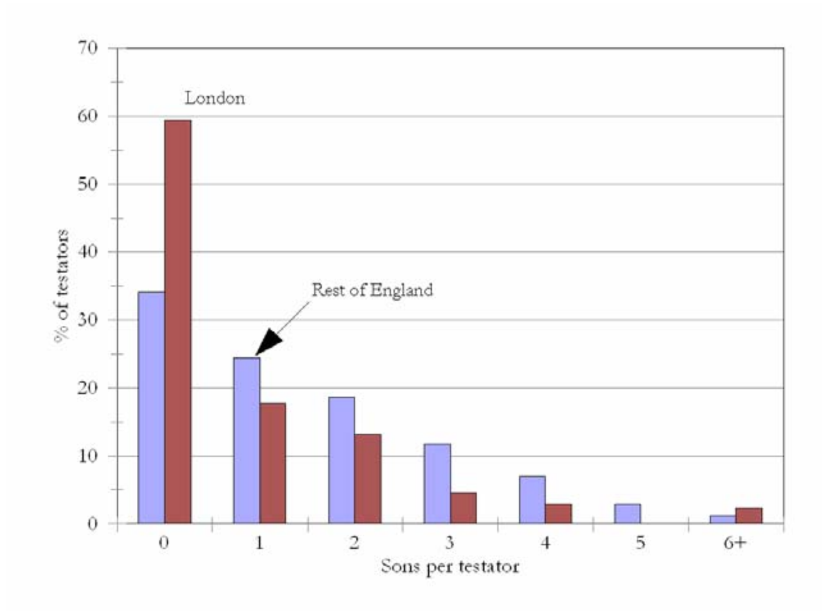

Figure 7.9 Sons per Male Testator, England c. 1620

leaving wills had no surviving son, while 11 percent had four or more sons. Very few fathers had one son to which all their property and position devolved. Instead collateral inheritance was frequent, as were cases where to retain their social position sons of larger families would have to accumulate property on their own. This meant that accidents of birth and inheritance were constantly moving people up and down the social ladder.

The data also illustrates the well known fact that in the pre-industrial era cities such as London were deadly places where the population could not reproduce itself and had to be constantly replenished by migration from the countryside. Nearly 60 percent of London testators left no son. Thus the craft, merchant, legal and administrative classes of London had to be constantly re-stocked by socially mobile youths from the countryside.

Medieval England may have been a static society economically. But the overall stasis should not blind us to the churning dynamism of the social fabric, with individuals headed up and down the social scale, sometimes by extraordinary amounts. Thus a substantial fraction of the landed aristocracy of England, even in the medieval period, actually had its foundation not in longaristocratic lineage or in military success, but from successful merchants and lawyers who from the twelfth century on were using their profits to buy land and enter the aristocracy.[171] High church positions were even more open to the lower orders. In the medieval period only 27 percent of English bishops, the clerical aristocracy, came from the nobility. The rest were the sons of lesser gentry, or farmers, or of merchants and tradesmen.[172]

The social fluidity of medieval England was probably the norm, rather than an exception, for the Malthusian era. Thus in Ming and Ching China, all the way from 1371 to 1904 commoners were typically 40 percent or more of those recruited by way of examination into the highest levels of the Imperial bureaucracy. But also in China those with money, at least from the 1450s on, could alternatively buy official ranks and titles.[173] In *ancien Regime* France the ranks of the nobility were similarly stocked from financially successful merchants and government officers from earlier generations.

This vertical mobility was echoed in a surprising degree of geographic mobility across these early societies in a society where travel was costly and slow. Thus the records of a 1292 tax levied by Philip the Fair on the households of Paris (except for nobility, clergy and students) show 6.1% were from outside France: 2.1%

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[171]Wasson, 1998.
[172]Chibi, 1998, Table 1.
[173]Ho, 1959.

English, 1.4% Italian, 0.8% German, 0.7% Flemish, 0.6% Jewish, and 0.4% Scottish.[174] A poll tax levied on aliens in England in 1440 revealed about 1,400-1,500 unnaturalized alien males in London at a time when the total adult male population of the city would be only about 15,000: nearly 10% of the population.[175]

As long as we can find examples of Malthusian societies, like medieval England, which were fully *incentivized* yet witnessed only the glacial slow pre-industrial pace of technological advance, then formal institutions cannot be the cause of the long Malthusian era in the simple way that most economists routinely imagine. If formal institutions are the key it must be because somehow Malthusian economies provided little or no incentive specifically for technological advance. But we shall see below when we come to study the Industrial Revolution itself that while innovation lay at its core, the transition to higher rates of efficiency advance was accomplished before there was any significant improvement in incentives to innovate. Alternatively there must have been informal, self-reinforcing social norms in all pre-industrial societies that discouraged innovation.

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174 Sussman, 2005, 18, 20.

175 Thrupp, 1957, 271. This assumes a total population for London of 50,000. The tax lists show few merchants, suggesting it was designed for artisans and laborers only.

8 Preference Changes

> *We see, therefore, how the modern bourgeoisie is itself the product of a long course of development, of a series of revolutions in the modes of production and of exchange (Marx and Engels, 1848).*

The Malthusian era was one of astonishing stasis, in terms of living standards and of the rate of technological change. It was thus an economy where we would expect that only one thing, land rents, would change across the ages. Wages, returns on capital, the capital stock per person, hours of work per person, skill premiums, should all have remained the same on average from the dawn of market economies to the end of the Malthusian era. This reinforces the puzzle of how the economy ever escaped the Malthusian Trap. How did stasis before 1800 transform itself into dynamism thereafter?

Static living standards have been amply shown by empirical evidence above, as has the slow aggregate rate of efficiency advance. Yet there were, despite this, profound changes in basic features of the economy within the Malthusian era. Four in particular stand out. Interest rates fell from astonishingly high rates in the earliest societies to close to low modern levels by 1800. Literacy and numeracy increased from being a rarity to being the norm. Work hours rose between the hunter gatherer era to modern levels by 1800. Finally there was a decline in interpersonal violence. As a whole these changes show societies becoming increasingly *middle class* in their orientation. Thrift, prudence, negotiation and hard work were imbuing themselves into communities that had been spendthrift, violent, impulsive and leisure loving.

A plausible source of this seeming evolution of human preferences is the survival of the richest that is evident in pre-industrial England. The arrival of institutionally stable agrarian economies with the Neolithic Agricultural Revolution of as early as 6,000-7,000 BC, gradually molded human behavior, probably mostly culturally, but also potentially genetically.[176] The people of the settled agrarian economies who launched the Industrial Revolution around 1800, though they lived no better than their grandfathers of the Paleolithic, were systematically different in attitudes and abilities. The exact date and trigger of the Industrial Revolution may remain a mystery, but its probability was increasing over time in the environment of institutionally stable Malthusian economies. Technology, institutions and people were interacting in an elaborate dance in the long pre-industrial agrarian era of 8,000-10,000 years.

Interest Rates

One of the most profound prices in any economy, along with the land rents and the wage rates, is the *interest rate* for the use of capital. Capital, the stored up output that is used to aid current production, exists in all economies. Its principal form in the settled agrarian economies that preceded the Industrial Revolution was housing and land improvements. But another important element in temperate regions was the stored up fertility of the land, which constituted a bank that farmers could make deposits

[176]The insight into the potentially Darwinian nature of the Malthusian era owes to Galor and Moav, 2002, though the argument here employs different specifics. Recent experiments in domesticating foxes and rats suggest that with sufficiently strong selection, powerful changes can be made in the behavior of animals within as few as 8 generations. Trut, 1999.

in and withdrawals from depending on the urgency of their needs. There was thus as much capital per unit of output in medieval Europe, India or China as there is in modern economies.

Because capital allows for production of more output when combined with labor and land, it commands a rent just like land, and that rent when we measure it as percentage return on the value of the capital we call the *interest rate*, or the *return on capital*. The real interest rate is simply the number of dollars of rent the lender of a $100 worth of capital will receive each year, net of allowances for the depreciation of the value of the capital from physical decay, or from losses of value through inflation in the case of financial capital. Such implicit interest rates can be measured in any society where land or housing is both sold and rented.

Measuring real interest rates is not easy in the modern world of relatively high and variable inflation rates, and rapidly changing asset prices. But inflation, as we saw for the case of England, is a modern problem generally absent from the Malthusian era. So typically in England the nominal return on assets, the annual payment to the owner divided by the price, provided a good measure of the real return on capital before 1800. For England we have two measures of the rate of return that stretch back with relatively few interruptions from the modern era to 1200. The first is the return on ownership of farmland, the major asset before 1800. The second is the return on *rent charges*. Rent charges were perpetual fixed nominal obligations secured by land or houses. The ratio of the sum paid per year to the price of such a rent charge gives the interest rate for another very low risk asset, since the charge was typically much less than the rental value of the land or house.

Both these assets have the additional attraction as a measure of returns on capital for the pre-industrial era in Europe in that they were both excused from any taint of usury under Catholic Church doctrine. Since land and houses were productive assets it was not usurous to collect a return on the ownership of land or housing, and there were never even limitations on the amount of this return. Such an exemption was fortunate since all across medieval Europe the Church was the greatest owner of land and rent changes.

Figure 8.1 shows the percentage return on land and rent charges by decade in England from 1200 to 2000. Medieval England had real rates of return typically 10 percent or greater. By the eve of the Industrial Revolution rates of return had fallen to 4-5 percent.

The rates of return witnessed for Medieval England were in fact typical of Europe in this period. Table 8.1 shows the returns on land purchases and rent charges for other areas in Europe 1200-1349. There is surprisingly little variation across the different countries. The decline in interest rates witnessed in England was echoed across the rest of Europe. Rates of return by 1600 had fallen from these medieval levels in Genoa, the Netherlands, Germany and Flanders.[177]

All societies before 1400 for which we have sufficient evidence to calculate interest rates show high rates by modern standards. In ancient Greece loans secured by real estate generated returns of close to 10 percent on average all the way from the fifth century BC to the second century BC. The temple of Delos, which received a steady inflow of funds in offerings, invested them at a standard 10 percent mortgage rate throughout this

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[177] Clark, 1988. Cipolla, 1993, 216-7, de Vries and van der Woude, 1997, 113-129, de Wever, 1978.

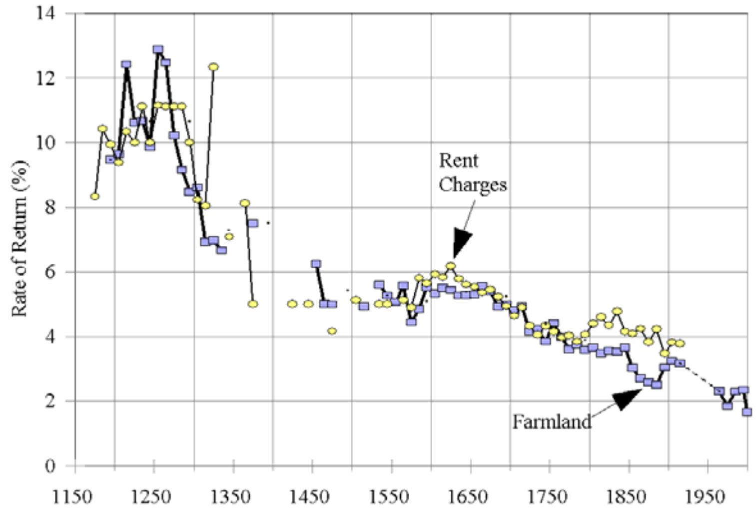

Figure 8.1 The Return on Land and on Rent Charges, 1170-2003 (by decade)[178]

Table 8.1 The Rate of Return on Capital across Europe, 1200-1349[179]

Place	Land	Rent Charges
England	10.0	9.5
Flanders	-	10.0
France	11.0	-
Germany	10.2	10.7
Italy	10.1	10.7

[178]For the years before 1350 the land returns are the moving average of 3 decades because in these early years this measure is very noisy. Clark, 1988, 1998. Modern returns from farmland ownership from UK, DEFRA, prices and rents of agricultural land.

[179]Clark, 1988, table 3. Herlihy, 1967, 123, 134, 138, 153 (Pistoia, Italy).

period.[180] Endowments in Roman Egypt in the first three centuries AD were invested on land security at a typical rate of 12 percent.[181]

Medieval India similarly had high interest rates. Hindu law books of the first to ninth centuries AD allow interest of 15 percent of loans secured by pledges of property, and 24-30 percent of loans with only personal security. Inscriptions recording perpetual temple endowments from the tenth century AD in South India show a typical income yield of 15 percent of the investment.[182] The return on these temple investments in South India was still at least 10 percent in 1535-1547, much higher than European interest rates by this time. At Tirupati Temple at the time of the Vijayanagar Empire the temple invested in irrigation improvements at a 10 percent return to the object of the donor. But since the temple only collected 63 percent on average of the rent of the irrigated land, the social return from these investments was as high as 16 percent.[183]

While the rates quoted above are high, those quoted for earlier agrarian economies are even higher. In Sumer, the precursor of Ancient Babylonia, between 3000 BC and 1900 BC rates of interest on silver loans were 20-25 percent. In Babylonia between 1900 BC and 732 BC the normal rates of return on loans of silver (as opposed to grain) was 10-25 percent.[184] In the sixth century BC the average rate on a sample of loans in Babylonia was 16-20 percent, even though these loans were typically secured by houses

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[180]Compound interest was not charged, so since some of the loans ran for a number of years the actual rate charged was somewhat lower than 10%. See Larsen, 1933, 368-379.

[181]Johnson, 1933, ---.

[182] Sharma, 1965, 59-61.

[183] Stein, 1960, 167-9.

[184]Homer and Sylla, 1996, 30-1.

and other property. In the Ottoman Empire in the sixteenth century debt cases brought to court revealed interest rates of 10-20 percent.[185]

When we consider forager societies the evidence on rates of return becomes much more indirect, because there is no explicit capital market, or lending may be subject to substantial default risks given the lack of fixed assets with which to secure loans. Anthropologists, however, have devised other ways to measure people's rate of time preference rates. They can, for example, look at the relative rewards of activities whose benefits occur at different times in the future: digging up wild tubers or fishing with an immediate reward, as opposed to trapping with a reward delayed by days, as opposed to clearing and planting with a reward months in the future, as opposed to animal rearing with a reward years in the future.

A recent study of Mikea forager-farmers in Madagascar found, for example, that the typical Mikea household planted less than half as much land as was needed to feed themselves. Yet the returns from shifting cultivation of maize were enormous. A typical yielded was a minimum of 74,000 kcal. per hour of work. Foraging for tubers, in comparison, yielded an average return of 1,800 kcal. per hour. Despite this the Mikea rely on foraging for a large share of their food, consequently spending most time foraging. This implies extraordinarily high time preference rates.[186] James Woodburn claimed that Hadza of Tanzania showed a similar disinterest in distant benefits, "In harvesting berries, entire branches are often cut from the trees to ease the present problems of picking without regard to future loss of

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185 Pamuk, 2006, 7.

186 Tucker, 2001, 299-338. Maize and manioc cultivation had higher yield variances, and so were riskier than foraging.

yield."[187] Even the near future mattered little. The Pirahã of Brazil are even more indifferent to future benefits. A brief overview of their culture included the summary,

> *Most important in understanding Pirahã material culture is their lack of concern with the non-immediate or the abstraction of present action for future benefit, e. g. 'saving for a rainy day.' (Everett, 2005, Appendix 5).*

Why did interest rates decline?

The real rate of return, *r*, can be thought of as composed of three elements: a rate of pure time preference, ρ, a default risk premium, *d*, and a premium that reflects the growth of overall expected incomes year to year, θg_y. Thus

$$r \approx \rho + d + \theta g_y.$$

People as economic agents display a basic set of preferences – between consumption now and future consumption, between consumption of leisure or goods – that modern economics has taken as primitives. Time preference is simply the idea that, everything else being equal, people prefer to consume now rather than later. The rate of time preference measures how strong that preference is.

The existence of time preference in consumption cannot be derived from consideration of rational action. Indeed it has been considered by some economists to represent a systematic deviation of human psychology from rational action, where there should be no absolute time preference. Economists have thought of time preference rates as being *hard-wired* into peoples' psyches,

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[187] Woodburn, 1980, 101.

and as having stemmed from some very early evolutionary process.[188]

The "growth premium" in interest rates reflects the fact that if all incomes are growing it is harder to persuade people to lend money and defer consumption. Suppose everyone knows that in twenty years time their income will have doubled, which has been the case in a number of modern economies. They will all prefer to borrow from the future to enjoy better consumption now, rather than save money when they are poor to spend when they are rich. Only through interest rates rising to high levels can sufficient people be persuaded to save rather than consume now. Since sustained income growth appeared in the economy only after 1800, the income effect implies a growth in interest rates as we move from the Malthusian to the modern economy, which of course we do not observe.[189] We should be the high interest rate society, not the Malthusian era.

Default risks also cannot explain high early interest rates. The default risk premium, *d*, reflects the fact that all investment involves some risk that the capital invested will not result in future consumption, but will be lost. The loss could come from the death of the investor, though if they have altruism towards their children this will reduce the compensation needed for this risk. However, the risk of the death of the investor, we know from the evidence presented above on mortality in the Malthusian era, was unchanged over time, and thus cannot explain any of the decline in interest rates.

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188 Rogers, 1994, gives an evolutionary argument for why positive time preference would exist, deducing however that the time preference rate would always be the 2.5 percent or so observed in high income modern societies.

189 The strength of this effect depends on θ, which in turn depends on how quickly the marginal physic benefit of a unit of consumption falls with greater consumption.

So the extra 6-8 percent return that capital offered in Medieval England, if it came from default risks, had to stem from the risk of expropriation of the asset. But in the previous chapter I have emphasized that in fact medieval England was a very stable society, and that investments in land were in practice very low risk. Confiscation or expropriation was extremely rare, and real land prices were very stable over the long run.

The medieval land market offered investors a practically guaranteed 10 percent or more real rate of return with almost no risk. It was a society where anyone could significantly change their social position just by saving and investing a modest share of their income. Suppose, for example, if a landless farm worker in thirteenth century England, at the bottom of the social ladder, were to start at age 15, invest 10 percent of their annual wage earnings in land, reinvesting any rents received. By age 50 they would have accumulated 85 acres to pass on to their children, or support them in comfort in old age, making them among the largest peasant proprietors in most medieval villages.

One other source of risk does exist in any society in purchasing land, and that is the risk that another claimant with a prior title will appear. Was it that the medieval legal system was so imperfect as to make all property purchases highly insecure?

A problem of any such interpretation is that different parts of England in the middle ages had very different jurisdictions and legal structures. Sometime before 1200, for example, London had secured from the Crown a large set of privileges. The first of these was that the city was allowed to pay a lump sum for taxes to the King "the farm of the city", and arrange its own collection within the city of this annual sum. The town was also allowed to appoint its own judges even in cases before the crown courts so that Londoners would only ever be judged by Londoners. Land cases were to be settled according to the law of the city, even in the king's courts. Londoners were free from trial by battle, the Norman tradition that resulted in some property cases being determined by armed combat as late as the 1270s.

In the reigns of Richard I and John (1189-1216) the kings' fiscal problems led them to sell off to many other towns similar rights and privileges to those of London. Thus by 1200 or soon thereafter there were a host of local legal jurisdictions in urban areas in England under which property would be held. If the high returns on land and rent charges were the result of deficiencies in property laws and their enforcement, then we would expect some of these jurisdictions to perform much better than others. In those with the best defined property rights returns would be lowest. In the sample of rent charge returns I have for the years before 1349 I have enough data on a small group of cities and towns to compare their average rate of return with the national average. The results are shown in table 8.2. There is little difference between returns in the five specific locations and the national average rate of return. If property right insecurity explains high medieval rates of return different jurisdictions amazingly created systems with roughly the same degree of insecurity.

The third problem with an insecure property rights interpretation is that even if property rights were generally insecure in early societies, there would have been periods of greater and lesser security. Thus we would expect if the confiscation risk was the source of high early interest rates that interest rates would fluctuate from period to period, and would be connected to political developments. Yet not only were average rates of interest very

Table 8.2 Rent Charge Returns 1170-1349 by location (%).[190]

Location	Number of Observations	Mean Return	Median Return
ALL	535	11.0	10.1
Canterbury	30	11.8	12.2
Coventry	48	11.4	10.0
London	84	10.3	10.0
Oxford	68	10.2	10.0
Stratford-upon-Avon	8	11.7	12.3
Sudbury	8	11.1	12.3

high, they tended to be high and relatively stable over time where they can be measured reasonably well as with rent charges. Thus in figure 8.1 note that the rate of return on rent charges in the decades from the 1180s to the 1290s all fall within about 1% of the average rate of 10.4%. If these returns are so high because of the radical insecurity of property why did they not show any substantial deviations between decades, despite the huge changes in political regimes in this era?

In the thirteenth century, for example, the reigns of John (1199-1216) and Henry III (1216-1272) were ones of greater turmoil in England. There was open rebellion in the last years of John's reign by the barons and again in the 1260s under Henry III. Edward I (1272-1307) ushered in nearly 40 years of stability and

[190] In calculating the mean returns 21 observations implying rates of return below 4% or above 25% were dropped. The mean without dropping these observations for the entire sample would be 11.5%.

strong central government. But his son Edward II (1307-1327) was again a weak ruler who was eventually deposed and murdered by his wife and her lover and replaced as ruler by his son. But there is no correspondence between the periods of calm and stability, as under Edward I, and the prevailing interest rate. It is always high before 1300, whatever the high politics, but shows signs of declining in the turbulent years 1307-1327 (see figure 8.1).

The implied return on investments in land in Zele in Flanders, an area that suffered greatly from war and civil strife in the years 1580-1720, is shown in figure 8.2. These returns again show the influence of the war years with much higher returns on land purchases in the years 1581-92. But notably, despite the problems of war, the average return on land is only about 4 percent. The Netherlands and Belgium were the first areas in Europe to come close to modern rates of return in the pre-industrial era. And even in the worst years of the Spanish re-conquest in 1581-92, when many Protestants were fleeing from areas like Zele to the Dutch Republic, the average return on capital invested in land was still below the steady rate of 10% found even in the most secure circumstances in medieval Europe.

Literacy and Numeracy

At the same time as we see interest rates decline, there is evidence that there were significant increases in the basic literacy and numeracy of societies as we approach the Industrial Revolution. We certainly can find interesting evidence that the average numeracy and literacy of even rich people in the classical and medieval eras in Europe was surprisingly poor. Table 8.3, for

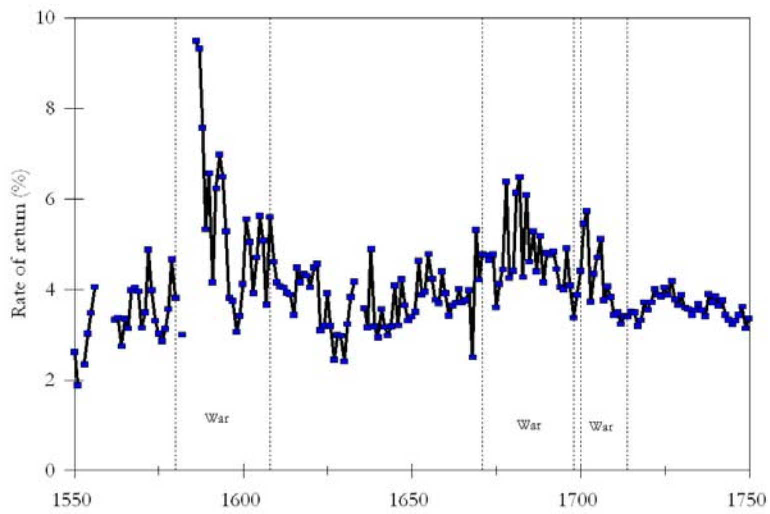

Figure 8.2 Returns on Land Holding, Zele 1550-1750[191]

example, shows five age declarations of a prosperous land owner, Isidorus Aurelius, in Roman Egypt in the third century A.D. No two of the declarations are consistent. Clearly Isidorus had no clear idea of his age. Within two years time he gives ages that differ by 8 years. Other sources show Isidorus was illiterate.[192] Isidorus's age declarations show a common pattern for those who are innumerate and illiterate. That is a tendency to round the age to one ending in a 0 or a 5. In populations where ages are recorded accurately, 20 percent of the recorded ages will end in 5or 10. We can thus construct a score variable *Z*, which measures the degree of "age heaping" where

$$Z = \frac{5}{4}(X - 20)$$

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[191]de Wever, 1978.

[192] Duncan-Jones, 1990, 80.

Table 8.3 Age-Reporting by Aurelius Isidorus[193]

Date	Declared Age	Implied Birth Year
April 297	35	262
April 308	37	271
August 308	40	268
pre-June 309	45	264
June 309	40	269

and X is the percentage of age declarations ending in 5 or 10, to measure the percentage of the population whose real age is unknown. This measure of the percentage of people who did not know their true age correlates moderately well in modern societies with literacy rates.

A lack of knowledge of their true age was widespread among the Roman upper classes as evidenced by age declarations made by their survivors on tombstones, which show a high degree of age heaping, as table 8.4 shows. Typically half had ages unknown to their survivors. Age awareness did correlate with social class. More than 80 percent of office holder's ages were known to relatives. When we compare this with death records for modern Europe we find that by the eve of the Industrial Revolution age awareness in the general population had increased markedly. In the eighteenth century in Paris only 15 percent of the general

193 Duncan-Jones, 1990, 80.

population had unknown ages at the time of death, in Geneva 23 percent, and in Liege 26 percent.[194]

We can also look at the development of age awareness by looking at censuses of the living. Some of the earliest of these are for medieval Italy, including the famous Florentine *Catasto* of 1427. Even though Florence was then one of the richest cities of the world, and the center of the Renaissance, 32 percent of the city population did not know their age. In comparison a census of 1790 of the small English town of Corfe Castle, with a mere 1,239 inhabitants, most of them laborers, shows that all but 7 percent knew their age. The poor in England around 1800 had as much or more age awareness as office holders in the Roman Empire.[195] Table 8.4 shows these trends.

Another feature of the Roman tombstone age declarations is that many ages were greatly overstated. We know that life expectancy in ancient Rome was perhaps as low as 20-25 at birth. Yet the tombstones record people as dying at ages as high as 120. In North African, 3 percent allegedly died at 100 or more.[196] Almost all these great ages must be complete fantasy. In comparison, a set of 250 relatively well off testators in England circa 1600 whose ages can be established from parish records, had a highest age at death of 88. Yet the children and grandchildren who memorialized richer Romans did not detect any implausibility in recording these fabulous ages.

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194 Duncan-Jones, 1990, ---.

195 The exception to this trend is ages recorded in the censuses of Roman Egypt, taken every 7 years. Here age heaping is modest, and the age structure is much more plausible than the tombstone ages (or ages in mummy inscriptions in Egypt). But this accuracy may be explained by the census procedures. If children first enter the census at an accurate age, and then have their ages updated by the census takers every 7 years from the previous census, accuracy will be preserved, even if the individuals themselves have little idea of their age. Bagnall and Frier, 1994.

196 Hopkins, 1966, 249.

Table 8.4 Age Heaping over time[197] *denotes ages of the dead.

Place	Date	Type	Group	Z
[a]Rome*	Empire	Urban	Rich	48
[a]Roman Africa*	Empire	Both	Rich	52
[a]Carthage*	Empire	Urban	Rich	38
[b]England	c. 1350	Both	Rich	61
[a]Florence, Italy	1427	Urban	All	32
[a]Pistoia, Italy	1427	Urban	All	42
[a]Florentine Territory	1427	Rural	All	53
[c]Corfe Castle, England	1790	Urban	All	8
[c]Corfe Castle, England	1790	Urban	Poor	14
[d]Ardleigh, England	1796	Rural	All	30
[e]Terling, England	1801	Rural	Poor	19
[f]Cotton Operatives, England	1833	Both	Workers	6

On literacy the early measure we have is the ability of people to sign their name on various legal documents, shown in figure 8.3. For England these proxy measures for literacy go back to the 1580s: such things as the percentage of grooms who signed the marriage register, or the percentage of witnesses in court cases

[197] Since age heaping is much more evident with the elderly the table was constructed using only ages between 23 and 62. [a]Duncan-Jones, 1990, 84-90. [b]Russell, 1948, pp. 103-11, [c]Dorset Record Office, ……. [d]Essex Record Office, D/P 263/1/5. [e]Essex Record Office D/P 299/12/3. [f]Parliamentary Papers, 1834, 21-31.

who signed their depositions. These measures similarly show a long upward movement in implied literacy rates as England approached the Industrial Revolution.

It is hard to get measures of actual literacy before 1580, but we know in medieval Europe that literacy rates must have been extremely low. In England, for example, after the Norman Conquest of 1066 clergy had the privilege of being tried in ecclesiastical courts. The test for receiving benefit of clergy became established as the ability to read a passage from the Bible. By 1351 this was established as the test in Law. In the medieval period the numbers of those outside those with clerical training who could read was so low, that the ability to read was regarded as a good enough test.

The low levels of literacy and numeracy in early societies go along with what has been called "the chronic vagueness" of early mentalities. Fabulous numbers are quoted in accounts and chronicles, even when a little enquiry would show how fallacious they were. Gervaise of Canterbury, for example, a contemporary, writing on the campaign of Henry II of England against the Count of Toulouse in 1159, notes that the king funded the war with a special tax of £180,000. English Treasury records suggest the actual sum was about £8,000. Roger of Wendover, a leading scholar of the age, notes that in 1210 there were 3,000 masters and scholars in Oxford. The actual figure would be not above 300. Tacticus, the great Roman historian, notes an incident at a private gladiatorial context in the small town of Fidenae, near Rome, at which a wooden stand collapsed killing 50,000 people. More recent experience with such collapses at large sporting events suggests a likelier figure would be less than 100 deaths.[198]

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[198] Ramsay, 1903.

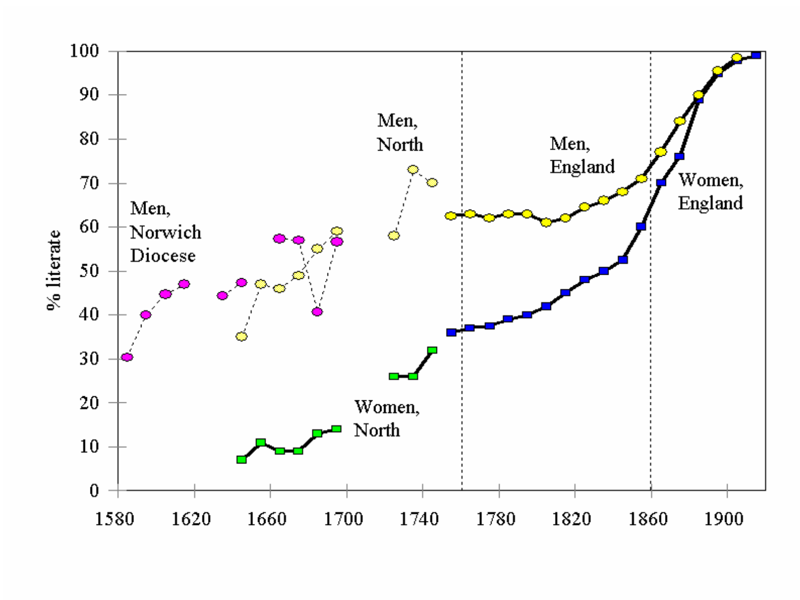

Figure 8.3 Literacy in England, 1580-1920[199]

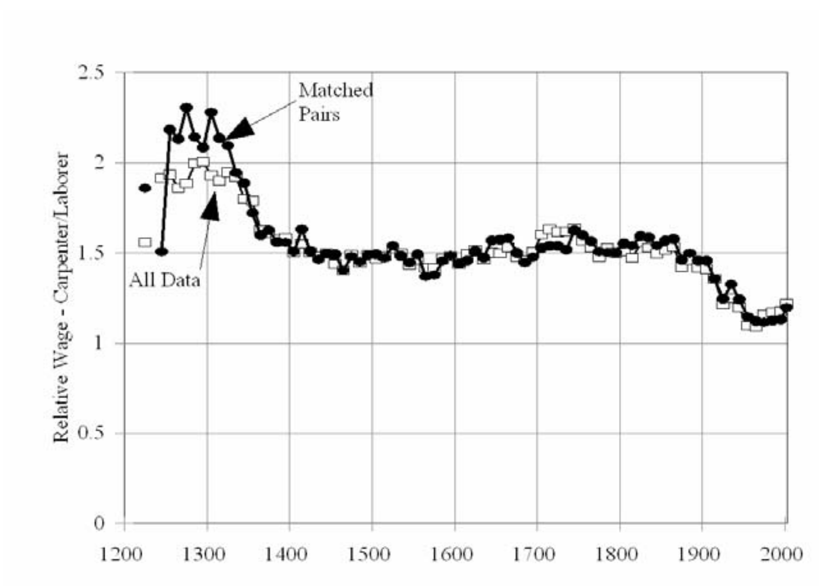

Figure 8.4 The Wage of Craftsmen relative to Laborers.

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199 1750s-1920s, Schofield, 1973, men and women who sign marriage resisters. The north, 1630s-1740s, Houston, 1982, witnesses who sign court depositions. Norwich Diocese, 1580s-1690s, Cressy, 1977, witnesses who sign ecclesiastical court declarations.

These rising standards of numeracy and literacy do not seem to have been driven by any market signals from inside the Malthusian economic system. There is no sign, for example, that the rewards to numeracy and literacy were any higher in 1800 in England than they were in 1200. We cannot measure this directly, but certainly the premium for other skills in the labor market seems to have actually declined over the long run. Thus if we measure the wage of building craftsmen to that of the laborers who assisted them, as in figure 8.4, we find that the skill premium was at its highest in the interval 1200-2000 in the earliest years, before the onset of the Black Death in 1349. Then a craftsman earned nearly double the wage of a laborer. If there was ever an incentive to accumulate skills it was in the early economy. Thereafter the skill premium declined to a lower but relatively stable level from about 1370 until 1900, a period of over 400 years, before declining further in the twentieth century. Thus the time of the greatest market reward for skills and training was long before the Industrial Revolution.

Nor, in places like England, was higher numeracy or literacy before 1800 the creation of any kind of government regulation or intervention. The education that people were acquiring was largely privately funded, though aided by growing numbers of charitable foundations.

Thus despite the static living conditions of the pre-industrial world we have seen that somehow a very different society had emerged by 1800, at least in some parts of Europe. Returns on capital had fallen close to modern levels, work efforts were much higher in forager societies, skill premiums declined, interpersonal violence rates also declined, literacy and numeracy rose. Places like England were becoming more stereotypically middle class at all levels of the society.[200]

Selection Pressures

Why was Malthusian society, at least in Europe, changing as described as we approached the Industrial Revolution? Social historians may invoke the Protestant Reformation of the sixteenth century, intellectual historians the Scientific Revolution of the seventeenth century or the Enlightenment of the eighteenth. Thus

> *The Enlightenment in the West is the only intellectual movement in human history that owed its irreversibility to the ability to transform itself into economic growth (Mokyr, 2005, 336).*

But a problem with the invocations of movers from outside the economic realm is that it merely pushes the problem back one step. Like invoking God to explain the creation of the world, it necessarily invites the question of the creation of God.

Protestantism may explain rising levels of literacy in northern Europe after 1500. But why after more than 1000 years of entrenched Catholic dogma was an obscure German preacher able to effect such a profound change in the way ordinary people conceived religious belief? The Scientific Revolution may explain the subsequent Industrial Revolution. But why after at least five millennia of opportunity did systematic empirical investigation of the natural world finally emerge only in the seventeenth cen-

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200 Mokyr argues in an analogous way that the stock of *useful knowledge*, meaning the knowledge economic agents had about their physical environment, in Europe had been expanded greatly by 1800. The idea of performing experiments had diffused widely, for example. He ascribes this to the intellectual developments of the Age of Reason and the Enlightenment. Mokyr, 2002, 28-77. Mokyr, 2005, 286.

tury?[201] And had the unexpected and inexplicable Scientific Revolution never occurred would the world have forever remained in the Malthusian trap? Ideologies may transform the economic attitudes of societies. But ideologies are themselves also the expression of fundamental attitudes in part derived from the economic sphere.

There is, however, no need to invoke such a deus ex machina in the Malthusian era, given the strong selective processes identified in chapter 6. The forces leading to a more patient, less violent, more hard-working, more literate and more thoughtful society were inherent in the very Malthusian assumptions that undergird pre-industrial society. Figure 8.5, for example, shows literacy rates for men circa 1630 as a function of bequeathed assets. As was shown in chapter 6, the wealthiest testators who were almost all literate left twice as many children as the poorest, of whom only about 30 percent were literate. Generation by generation the sons of the literate were relatively more numerous than the sons of the illiterate.

Agrarian societies differed in two crucial ways from their forager predecessors. Agriculture allowed for much higher population densities, so that instead of living in communities of 20-50, people now lived in communities of hundreds to thousands. Already by 2,500 BC the cities of Sumeria are estimated to be as large as 40,000 people.[202] Agrarian societies also had large stocks of assets that were owned by specific people: land, houses, and animals. The sizes of these societies allowed the extensive use

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[201] Mokyr, in personal communication, argues that the Scientific Revolution and subsequent Enlightenment were themselves by products of the development of commercial capitalism in early modern Europe. But that, of course, creates another regress.

[202]Gat, 2002, --.

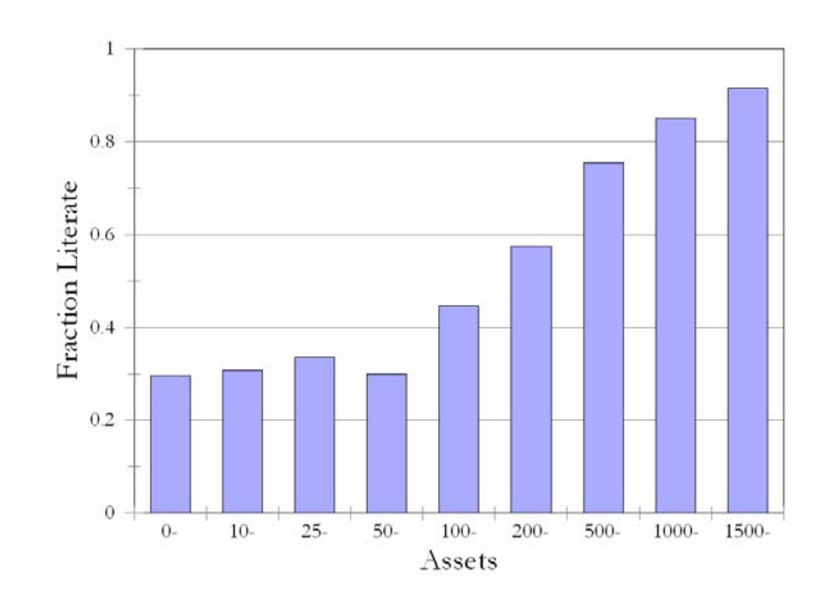

Figure 8.5 Literacy and Assets, England, male testators, 1630

of money as a medium of exchange. Their size, and the importance of the income streams from these assets, created a need for enduring records of property ownership and property transfers. Thus a mass of clay tablets recording leases, sales, wills, and labor contracts survive from Ancient Sumeria and Babylonia. Figure 8.6 shows the most common type of cuneiform tablet, a receipt for delivery of goods.

In the institutional and technological context of these societies, a new set of human attributes mattered for the only currency that mattered in the Malthusian era, which was reproductive success. In this world literacy and numeracy, which were irrelevant before, were both helpful for economic success in agrarian

Figure 8:6 Receipt for delivery of cattle, Mesopotamia Ur III (2112 – 2004 BC)[203]

pre-industrial economies. Thus since economic success was linked to reproductive success, facility with numbers and words- was pulled along in its wake. Since patience and hard work found a new reward in a society with large amounts of capital, patience and hard work were also favored.

Trade and production in turn also helped stimulate innovations in arithmetic and writing systems designed to make calculations and recording easier. The replacement of Roman numerals by Arabic numerals in Europe, for example, was aided by the demands of trade and commerce. In medieval Europe,

> *the needs of commerce formed one important stimulus to the spread and growth of arithmetic (Murray, 1978, 191).*

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[203] Snell, 1997, figure 7.

In Europe religious bodies and the state, insulated from market pressures, were the slowest to adopt these innovations. The English Treasury was still employing Roman numerals in its accounts in the sixteenth century. But from the thirteenth century on Arabic numerals increasingly dominated commerce, and many treatises on arithmetic were clearly aimed at a commercial audience.[204]

So the market nature of settled agrarian societies stimulated intellectual life in two ways. It created a demand for better symbolic systems to handle commerce and production. And it created a supply of people who were adept at using these systems for economic ends. While living standards were not changing, the culture, and perhaps even the genes, of the people subject to these conditions were changing under the selective pressures they exerted. All Malthusian societies, as Darwin recognized, are inherently shaped by survival of the fittest. They reward certain behaviors with reproductive success, and these behaviors become the norm of the society.

What were societies like at the dawn of the settled agrarian era with the Neolithic Revolution of c. 8,000 BC? Based on observation of modern forager and shifting cultivation societies we expect that the early agriculturalists were impulsive, violent, innumerate, illiterate, and lazy. Ethnographies of such groups emphasize high rates of time preference, high levels of interpersonal violence, and low work inputs. Abstract reasoning abilities were limited.

The Pirahã, a forager group in the Brazilian Amazon, are an extreme example of this. They have only the number words "hói" (roughly one), "hoí" (roughly two), and "aibaagi" (many). On tests they could not reliably match number groups beyond 3.

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[204] Murray, 1978, 167-191.

Once the number of objects reached as large as 9, they could almost never match them.[205] Yet the Pirahã perform very well as hunters, and in tests of spatial and other abilities. Similarly the number vocabulary of many surviving forager societies encompasses only the numbers 1, 2 and many. So forager society must thus have had no selective pressures towards the kinds of attitudes and abilities that make an Industrial Revolution.

The new world after the Neolithic Revolution offered economic success to a different kind of agent than were typical in hunter gatherer society: those with patience, who could wait to enjoy more consumption in the future. Those who liked to work long hours. And those who could perform formal calculations in a world of many types of inputs and outputs of what crop to profitably produce, how many inputs to devote to it, what land to profitably invest in. And we see in England, from at least the middle ages on, that the kind of people who succeeded in the economic system – who accumulated assets, got skills, got literacy – were increasing their representation in each generation. Thus it is plausible that through the long agrarian passage leading up to the Industrial Revolution man was becoming *biologically* more adapted to the modern economic world.

This is not in any sense to say that people in settled agrarian economies on the eve of the Industrial Revolution had become "smarter" than their counterparts in hunter gatherer society. For, as Jared Diamond points out in the introduction to *Guns, Germs and Steel*, the skills that ensure the survival and reproduction of hunter gatherers are many and complex.[206] This is illustrated by

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[205] Gordon, 2004.

[206] Diamond even goes so far as to argue that selection in agrarian economies would be based on resistence to epidemic diseases that arise with more concentrated populations, so that the people of forager societies were more intelligent than those of long settled agrarian economies. Diamond, 1997, ---.

Figure 8.7 Output over the lifetime, hunter gatherer versus agrarian society[207]

figure 8.7 which shows the earnings profile of a group of agricultural laborers with age in England around the 1830s, alongside the earnings profile of Ache hunters (measured in kilograms of meat). An English farm laborer reached peak earnings around age 20, while for an Ache hunter the peak did not come until the early 40s. This was despite the fact that the Ache reached a peak of physical strength in their twenties.

Clearly hunting, unlike agricultural labor, was a complex activity that took years to master. The argument is not that agrarian society was making people smarter. For the average person the division of labor agrarian society entailed made work

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[207] Hunting success and strength, Hill and Hawkes, 1983. English farm wages, Burnette, 2005.

simpler and more repetitive. The argument is instead that it rewarded with economic and hence reproductive success a certain repertoire of skills and dispositions that were very different from those of the pre-agrarian world: such as the ability to perform simple repetitive tasks for hour after hour, day after day. There is nothing natural or harmonic, for example, in having a disposition to work even when all the basic needs of survival have been achieved.

The strength of the selection process through survival of the richest also seems to have varied depending on the circumstances of settled agrarian societies. Thus in the frontier conditions of New France (Quebec) in the seventeenth century where land was abundant, population densities low, and wages extremely high the group that reproduced most successfully was the poorest and the most illiterate.[208] The more stable a society was, the less reproductive success could be attained by war and conquest, the more chance these mechanisms had to operate.

The claim thus is that it is no real surprise that China, despite nearly a generation of extreme forms of Communism between 1949 and 1978, emerged unchanged as a society individualist and capitalist to its core. The effects of the thousands of years of operation of a society under the selective pressures of the Malthusian regime could not be uprooted by utopian dreamers.

Below we shall consider how these selective pressures might help explain the timing and nature of the Industrial Revolution.

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[208] Hamilton and Clark, 2006.

9 Modern Growth: the Wealth of Nations

> *Behold, I make a covenant. Before all your people I will do marvels, such as have not been wrought in all the earth or in any nation* (King James Bible, Exodus, 34)

Growth Since 1800

Around 1800, in northwestern Europe and north America, man's long soujorn in the Mathusian world ended. The iron link between population and living standards, where any increase in population caused an immediate decline in wages, was decisively broken. Between 1770 and 1860, for example, English population tripled. Yet real incomes, instead of plummeting, rose (see figure 9.1). A new era dawned.

The seemingly sudden and unpredictable escape from the dead hand of the Malthusian past in England around 1800, this materialist crossing of the Jordan, was so radical it has been forever dubbed the *Industrial Revolution*.

The *Industrial* part of the label is, however, unfortunate and misleading. It was conferred mainly because the most observable component of many changes in England was the enormous growth of the industrial sector: cotton mills, potteries, foundries, steel works. Most Malthusian economies had 70 or even 80 percent of the population employed in agriculture. By 1861 that share was 21 percent in England. But that switch to industry, as we shall see, owed to the idiosyncracies of England's geography and demography. There is, in fact, nothing inherently *industrial*

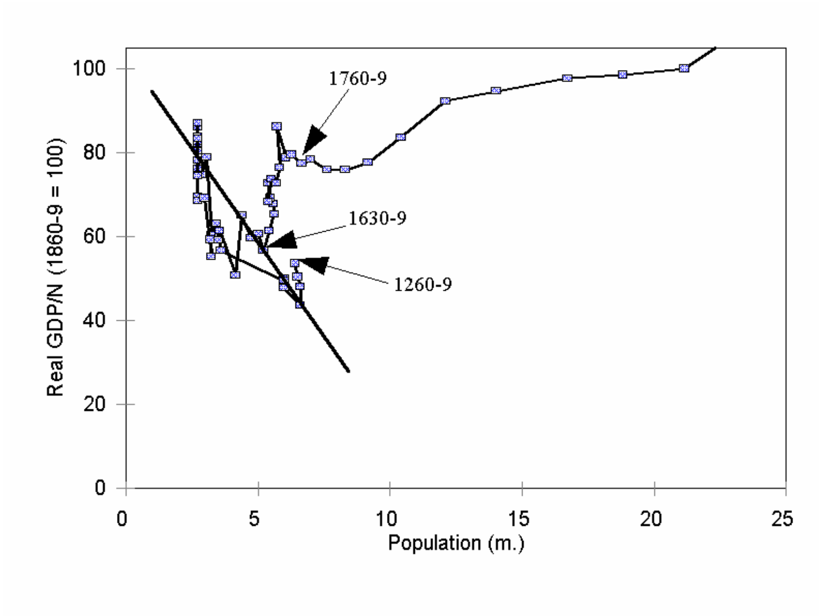

Figure 9.1 Output per Person and Population, England 1260s to 1860s[209]

about the *Industrial Revolution*. Since 1800 the productivity of agriculture has increased by as much as that of the rest of the economy, and without these gains in agriculture modern growth would have been impossible. We have to resign ourselves to the fact that one of the defining events in human history has been mislabeled.

Material well-being has marched upward in successful economies since the Industrial Revolution to levels no-one in 1800 could have imagined. Figure 9.2 shows, for example, income per capita in England by decade from the 1260s to the 2000s. After 600 years of stasis, income has increased nearly 10 fold since

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[209] Clark, 2006b.

1800. It continues its inexorable rise. Note, however, that though the conventional date for the onset of the Industrial Revolution in

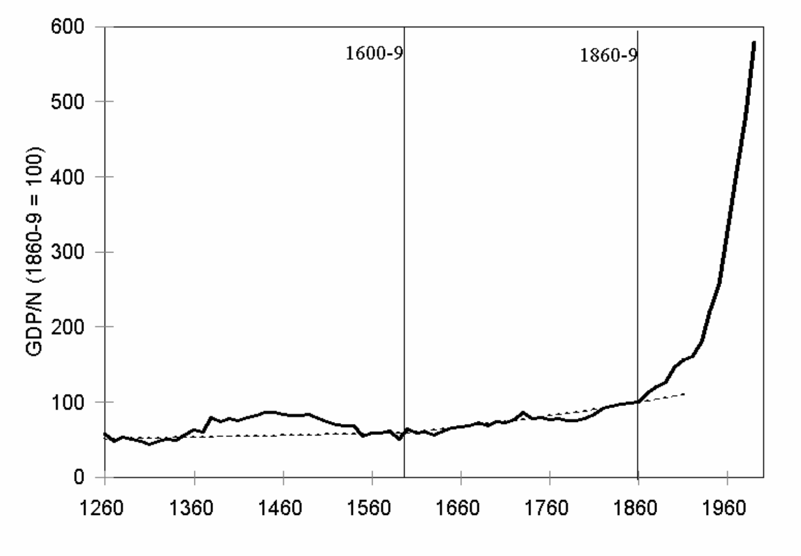

Figure 9.2 Real Output per person in England, 1260s-2000s[210]

Britain is the 1760s there is little sign of rapid growth of income per person till the decade of the 1860s.

As a result of the Industrial Revolution the citizens of the economically successful countries – such as Britain, the USA, France, Japan - are enormously richer than their Malthusian ancestors.

Another unusual feature of the modern economy, however, is that the gap between the living standards of people in rich and poor economies is an enormous chasm compared to the era before 1800. In the pre-industrial epoch societies with the most favorable demographic factors could attain incomes perhaps four times those with the least favorable demographic regimes. They

[210] Clark, 2006b.

looked down on their less favored brethren from a modest knoll. Now the richest countries stand on a mountain compared to the poorest. The gap between rich and poor in the modern world is in the order of 40 to 1.

Most of the change in the structure of economic life in the advanced economies can be traced directly to one simple fact: the unprecedented, inexorable, all pervading rise in incomes per person since 1800. The lifestyle of the average person in modern economies was not unknown in earlier societies: it is that of the rich in ancient Egypt or ancient Rome. What is different is that now paupers live like princes, and princes live like emperors.

As incomes increase, consumers switch spending between goods in very predictable ways. We saw already that the increase in demand with income varies sharply across goods. Most importantly, food consumption increases little once we reach high incomes. Thus in Germany real incomes per person rose by 133 percent from 1910 to 1956, while food consumption per person rose by only 7 percent, calorie consumption per person fell by 4 percent and protein consumption fell by 3 percent. Indeed the calorie content of the modern European diet is little higher than that of the eighteen century, even though people are 10 to 20 times wealthier.[211] The character of the diet, however, has switched towards more expensive calorie sources. As people get sated with calories their demand for variety, in the form of more expensive foods, becomes insatiable: goodbye to bread, hello to sushi.

Thus as income marched upward, the share of farm products in consumption treaded downward, and the share of farmers in

211 People in the eighteenth century engaged in heavy manual labor, walked to work and market, and lived in poorly heated homes, so they easily burnt off these calories without the modern problem of obesity.

producers declined in step. In pre-industrial economies farmers were 50 to 80 percent of the population. Now if we had a free market in food, two percent of the population could feed everyone. The farm population share in the USA for example, is 2.1 percent. Half of these people are kept in farming by government subsidies futilely trying to stem the inexorable exodus from the land and from rural communities. A mountain of EU subsidies keeps 3.3 percent of the French in their beloved *Champagne*. The less sentimental British, with a much more efficient agricultural system, employ only 1.8 percent in farming.[212] The *Industrial Revolution* looks peculiarly industrial largely because of the switch of population and production out of agriculture and into industry created by higher incomes.

The switch of labor out of agriculture has profoundly affected social life. In Malthusian societies most of the population lived in small rural settlements of a few hundred souls. They had to be close to the daily grind of their work in the fields, since they walked to work. In the south east of England, for example, villages in the eighteenth century were only two miles apart on average. Typically they had less than 100 residents. The countryside was densely settled because of all the labor required in inefficient pre-industrial agriculture: ploughing, reaping, threshing, hauling manure, tending animals.

With an ever dwindling proportion of the population tied to the land through agriculture, modern populations are footloose. People can locate anywhere, but have concentrated increasingly in urban centers because of the richer labor market and social amenities these offers. In particular the rise of the two wage-earner family makes denser urban labor markets attractive to

[212] Data from the year 2000 from the FAO. Densely populated Britain does, however, import about half its food requirements.

people, despite the costs associated with huge agglomerations. The urbanization of rich economies has, in turn, produced many social changes we associate with Industrial society. Income - the unending, inexorable rise in income – drives all this change. Why are we on the march to endless wealth?

Explaining Modern Growth

Modern economies seem on the surface to be breathtakingly complex machines whose harmonic operation is near miraculous. Hundreds of thousands of different types of goods are sold in giant temples of consumption. The production, distribution, and retailing of these products, from paper cups to personal expresso machines, involves the cooperation of thousands of different types of specialist buildings, machines, and workers. Understanding why and how economies grow would seem to require years of study, and Ph.D. level training. But in fact understanding the essential nature of modern growth, and the huge intellectual puzzles it poses, requires no more than basic arithmetic, and elementary economic reasoning.

For though modern economies are deeply complex machines, they have at heart a surprisingly simple structure. We can construct a simple model of this complex economy, and in that model catch all the features that are relevant to understanding growth.

This model reveals that there is one simple and decisive factor that drives modern growth. It is generated overwhelmingly by investments made in expanding the stock of production knowledge in societies. To understand the Industrial Revolution is to understand why such activity was not present, or was unsuccessful before 1800, and why it became omnipresent after 1800.

The simple model collapses the immense complexity of all economies down to just five summary variables: output *Y*, labor *L*, physical capital *K*, land *Z* and the level of efficiency *A*. In this picture of the economy it is a giant machine that receives inputs of physical capital, labor and land and turns them into a single sausage-like output, with *A* indexing how much output is received per unit of input.

Then we need to specify how these quantities are related. And here again we find that despite the huge variety of economies, there is a simple relationship that holds for all time and all places, the *fundamental equation of growth,*

$$g_y = ag_k + cg_z + g_A$$

where g_y, g_k, g_z, and g_A are respectively the growth rates of output per worker, capital per worker, land per worker, and efficiency.[213] When we are looking at long run growth the efficiency term measures overwhelmingly the sophistication of the technology of the society. *a* and *c* are the shares of output received by the owners of capital and land.

This equation shows the percentage change in output per worker resulting from a one percent change of any of capital per worker, land per worker, or efficiency. It is a matter of only a brief formal argument, given in the technical appendix, to demonstrate this basic connection.

Some of the elements of this equation are obvious and intuitive. If the efficiency of the economy grows by one percent, then so does output per person. Less intuitive, but nevertheless clear, is the effect of more capital per person. If we increase the

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[213]Robert Solow first derived this result, in Solow, 1956, though he had predecessors, as discussed in Griliches, 1996.

capital stock per person by one percent we only increase output per person by the amount *a*, the share of capital in national income. Since that share is typically about 0.24 this implies that if we expand the capital stock per person by 1 percent, we increase output by only 0.24 percent.

This implies that growing faster by investing in more capital is costly. The physical capital/output ratio in richer modern economies averages about 3. To increase the capital stock per person by 1 percent, requires switching 3 percent of current output from consumption to investment. But for that switch is purchased an increase in income in future years of only 0.24 percent.

The first surprising implication of this fundamental growth equation is that in the modern world, land per person, which had completely dominated income determination before 1800, no longer matters in economic growth. This is because land rents have fallen to only a few percent of total output in modern high income economies. Figure 9.3 shows this process in the case of England. Farmland rents, which were 23 percent of national income in 1760, fell to 0.2 percent by 2000. In part this was offset by a rise in the site rental value of urban land. But by 2000 urban land rents represented only 4 percent of national income, even in crowded England with its very high housing costs. Thus though population growth tends to make g_z negative in modern economies, this drag on income is inconsequential at present. Indeed so unimportant is land in the current economy that for most purposes economists simplify the *fundamental equation of growth* to the even more stark,

$$g_y \approx a g_k + g_A$$

Whereas in the pre-industrial world the amount of land per person was a crucial determinant of the wealth of a society, now it is

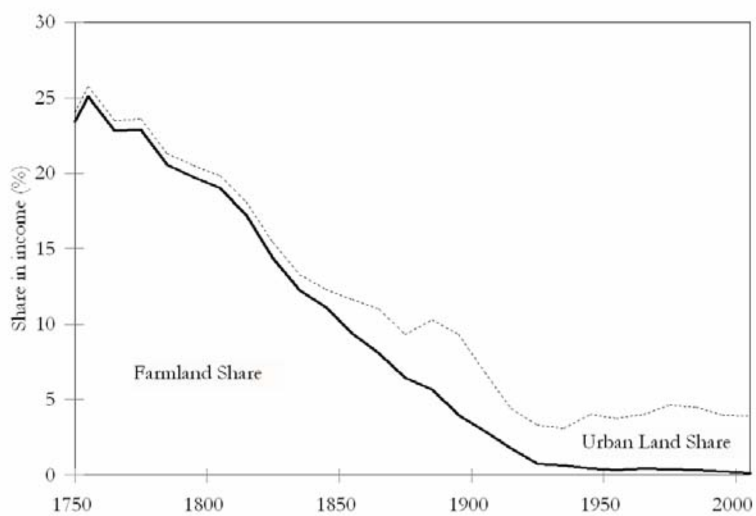

Figure 9.3 Farmland Rents as a Share of Income, England, 1750s to 2000s[214]

largely irrelevant, except for a few resource abundant economies. Countries like Singapore and Japan with very little land per person can be just as rich as those like Australia with huge amounts.

Thus despite all the complexities of economies since the Industrial Revolution, the persistent growth we have witnessed since 1800 can be the result of only two changes. The first is more capital per worker, the second is a greater efficiency of the pro-

214 Income, Clark, 2006b. Urban Land Rents 1845-1913 from Singer, 1941, 224. Urban land rents 1947-2004 estimated from the difference between the asset value of dwellings and structures in the UK and the net capital stock embodied in these, assuming a 3 percent return on land until 1997, when the rent was estimated from dwelling rent trends (UK, Office of National Statistics). Urban land rents in other years estimated from the value of the housing stock.

duction process. At the proximate level all modern growth in income per person is that simple!

This conclusion has been derived for an economy with only one output, one type of labor, one type of land, and one type of capital (which is just stored up output). But it generalizes easily into an analogous expression for realistic economies, as the appendix details

The second surprising implication of the fundamental equation is that physical capital accumulation directly explains only one quarter of the growth of output per person since the Industrial Revolution. Efficiency advance explains the other three quarters.

To see this we need, note that the physical capital stock of economies since the Industrial Revolution has grown at roughly the same rate as output. Thus the ratio of capital to output has remained surprisingly unchanged. For the OECD economies it is estimated at 2.93 in the 1960s compared to 2.99 in the 2000-1.[215] Table 9.1 shows the figures for the growth rate of output per work-hour person and capital per work-hour for 1960 to 2000 for a group of these economies. On average for a group of 22 OECD economies the growth rates were the same in this interval.

Since on average the share of capital rental payments in income was only .24 for these economies, this implies that only about a quarter of the growth of output per worker-hour stems from physical capital investments. The bulk of growth is explained by efficiency advance.

The efficiency term in the above equation, g_A, is frequently referred to as the *residual*. This is because while the other terms in the equation can be directly measured and calculated, efficiency growth is simply a balancing quantity thrown in to make the sides equate. It is, in the famous phrase of Moses Abramovitz, merely a

215 Kampf, 2004.

Table 9.1 Modern Economic Growth, 1960-2000[216]

Country	Growth rate of *y* (%)	Growth rate of *k* (%)	Share of capital in income, *a*	% output growth from capital
New Zealand	1.18	1.55	0.27	35
USA	1.75	1.59	0.20	18
Australia	1.97	1.65	0.30	25
UK	2.40	2.87	0.23	27
Germany	3.29	3.07	0.25	23
Ireland	4.20	3.98	0.15	14
Japan	4.47	5.34	0.27	32

"measure of our ignorance."[217] It is the difference between what we see, and what economists can account for. For the typical successful economy the measured efficiency with which inputs are translated into outputs has risen at 1 percent or more per year since the Industrial Revolution.

The residual can be slimmed a little by expanding the measure of capital to include also human capital, the investments made in the education and training of workers. Unskilled, uneducated

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216 *y* is output per worker hour, *k* capital per worker hour. Sources: Capital and output, Kamps, 2004. Work Hours 1970-2000, OECD. Labor Force, 1961-1970, Earth Trends. Capital Share in income, 1985-2000, OECD productivity Database.

217 Abramovitz, 1956.

Table 9.2 Replacement Cost of the Human Capital Stock in the USA, 2000[218]

Education	Years	Cost per person ($)	Labor Force (m)	Direct Social Cost ($ b.)	Fore-gone earnings ($ b.)
< High School	10	77,000	11	879	0
High School	12	122,000	63	5,963	1,767
College	14	199,000	32	4,167	2,155
Post-Graduate	16	312,000	35	7,075	3,727
Labor Force		183,000	141	18,084	7,650

workers produce much less than skilled, educated ones. Part of this gain in productivity is attributable to the investment in skills and education.

Table 9.2 shows a rough estimate of the value of the human capital stock per worker, and for the economy as a whole, in the USA in 2000. The labor force is divided into four broad workers produce much less than skilled, educated ones. Part of this gain in productivity is attributable to the investment in skills and education.

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218 The foregone earnings per year are assumed for each level of education to be 70% of the average wage and salary compensation a person with education at the category below aged 25-29 earned (this is assuming that students take classes or study for 1,350 hours per school year – undoubtedly an overestimate).
Source:

Table 9.2 shows a rough estimate of the value of the human capital stock per worker, and for the economy as a whole, in the USA in 2000. The labor force is divided into four broad education categories – less than High School, High School, some college, and some post-graduate training – with the associated capital cost of each type of worker. These costs are both the direct expenditures for teachers and classrooms, and the indirect expenditures of wages sacrificed by spending time in schooling. The estimate is that the average US worker now embodies as much as $183,000 in capital. In the economy as a whole there was about $26,000 billion of human capital.

The stock of physical capital per worker in the US in 2000 was still somewhat greater at $210,500, but the calculation here shows the importance of human capital in modern economies. The share of income derived from this human capital investment per worker, assuming a 10% return on the investment, was 26%, compared to 20% for physical capital.[219]

Thus the true share of income earned by capital in the modern USA might be 46% of all income. But it is also evident that accounting for human capital alone, while it reduces the size of the residual, does not eliminate efficiency as an important source of growth. Thus if we estimate the fundamental equation of growth for the USA in the years 1990-2000, even with human capital included residual productivity growth was 1.36% per year,

219 George Psacharopoulos calculated the social rate of return to education in the richer economies in 1993 as being 14.4% per year for primary education, 10.2% for secondary education and 8.7% for higher education (Psacharopoulos, 1994). But this probably exaggerates the true return to capital, since they attribute all the higher wages of the more highly educated to the education.

which was still a full 72% of the growth of output per worker hour.[220]

In earlier times, such as in Industrial Revolution England, the stock of human capital was much smaller, since most people had not even completed grade school, and so again counting it reduces the size of the residual, but the residual is still the major direct explanator of growth.

What generates the residual? This stems from a largely un-measured forms of capital accumulation, innovation: the myriad of investments, small and large, made by producers each year to try and improve the efficiency of their production processes.
Knowledge that is proprietory, that is legally owned, is counted in the modern capital stock, since it is an asset of firms that earns them a return. Table 9.3 thus shows the capital stock in the UK in 1990, separating out the parts that are structures, vehicles, plant and machinery, and intangible capital which includes patent rights and other forms of proprietary knowledge. But such knowledge constitutes a tiny share of the modern capital stock, even if we measure capital by how much rent it earns (which is higher in the case of intangible capital).

But most of the knowledge capital that underlies the modern economy is not owned by anyone, and is available free for all to use. The legal system only gives protection to certain classes of new ideas, and then only for a limited period. After that they enter the common pool of knowledge available to all. But most of the knowledge capital of the modern economy is not owned by anyone, and so would not get counted in this way. It cannot be kept private by its creators and so is utilized for free by others.

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220 Income per worker hour grew at 1.9% per year. Physical capital growth at at 1.3% per year explained 0.36% of this. Human capital grew at 0.7% explained another 0.18%.

Table 9.3 The UK Capital Stock in 1990[221]

Type of capital	Share in stock (%)	Share in rental payments (%)
Buildings	72	54
Intangibles	1	3
Plant and Machinery	17	31
Vehicles	10	12

The difficulty of profiting from the creation of knowledge is revealed, for example, by the emblematic industry of the Industrial Revolution, cotton textiles. In the next chapter we will learn that about half the measured efficiency gains of the Industrial Revolution era stemmed from textile innovations. Yet the typical earnings of the entrepreneurs in textiles, who were remaking the world they lived in, was no higher than that in such stagnant sectors as retailing or boot and shoe making. The gains from their innovations were instead flowing to consumers in England and across the world in the form of lower prices for textile products.

[221] Oulton, 2001.

The time and energy innovators invested in new methods thus yielded a much higher social return than the meager private return they reaped. To eliminate the appearance of free efficiency growth thus external benefits need to be added into the private return on capital in calculating *a*.

Thus the fundamental equation of growth actually reduces, for the world since the Industrial Revolution, to the approximate expression

$$g_y \approx a^* g_{k^*}$$

where k* is an augmented measure of capital which includes all the capital stock of the economy - physical capital, human capital and knowledge capital, and a* is an augmented expression for the share of income in the economy that would flow to capital, were all the spillover benefits from investment in knowledge directed to the investors.

Note, however, that when we arrive at this final truth as to the nature of modern growth we have lost all ability to empirically test its truth. It is a statement of reason and faith, not an empirical proposition. Physical capital can be measured, as can the share of capital income in all income in the economy. But the generalized spillovers from innovation activities are not in practice measurable. Nor is the total amount of activity designed to improve production processes measurable either. Investments in innovation occur in all economies. But unknown factors speed and retard this process across different epochs and different economies.

Innovation Explains All Modern Growth

The *fundamental equation of economic growth* seems to suggest that growth since the Industrial Revolution has had two independent sources. Most important there is efficiency growth fueled by investment in "knowledge capital" which has large social external benefits that show up in the residual. But there is also a substantial contribution from investments in physical capital and human capital, which explains 30-50% of the growth in income per person.

But the efficiency growth from innovation is actually the true source of all growth, and it also explains the growth of physical capital. The apparently independent contribution of physical capital to modern growth is illusory.

If efficiency advances and physical capital were truly independent sources of modern income growth, then there would be economies with rapid growth of physical capital per person, but no efficiency gains, and economies with rapid efficiency gains but little growth of physical capital per person. In practice, both across time and across countries at any given time, the growth of the capital stock and efficiency growth are always closely associated in free market economies.[222]

Figure 9.4, for example, shows for a group of OECD countries at different income levels their efficiency growth rates 1960-2000 compared to their capital per worker growth rates. Despite capital stocks being notoriously difficult to measure, the correlation between capital growth and efficiency growth is close.

222Command economies such as the old U.S.S.R. were characterized by rapid capital accumulation but slow efficiency advance.

When two variables are so closely correlated one must cause the other.[223] The expansion of efficiency must be also driving up the stock of capital per worker. The process through which this occurs is shown in figure 9.5.

The lower curve in the figure shows the output in an economy of given efficiency level as a function of the stock of physical capital employed per worker, k. Adding more capital always increases output, but at a smaller and smaller rate as the capital stock per worker increases. Investors will expand the stock of capital to the point k_0 where the net additional output created from another $1 of capital, dy_0, equals the real interest cost of $1. Thus the real interest rate, the price of capital, determines the capital stock in any economy.

An increase in efficiency moves the production curve upward everywhere, as figure 9.5 shows. It also increases the net additional output from adding more capital, to dy_1 in the diagram. Thus investors buy more capital until once again the return equals the interest rate at the new capital stock k_1. At the new capital stock once again addition of a unit of capital increases output by dy_0. So as long as interest rates do not change, innovation induces physical capital investment.

Thus a one percent increase on the efficiency of the economy though innovation leads to a more than one percent increase in output because it induces more physical capital accumulation.

The shape of the production function in modern economies, pictured in figure 9.5, is such that the ratio of physical capital to output has changed little since the Industrial Revolution, as a result of these induced investments from technological advance. That implies that the growth of the physical capital stock has been

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[223] For completeness, there could be a single independent cause of both.

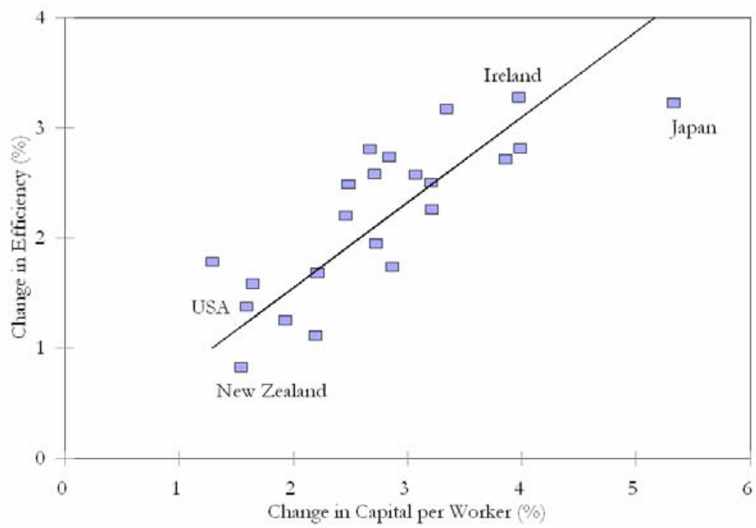

Figure 9.4 Efficiency Growth Rates versus Capital per Worker Growth Rates, 1960-2000[224]

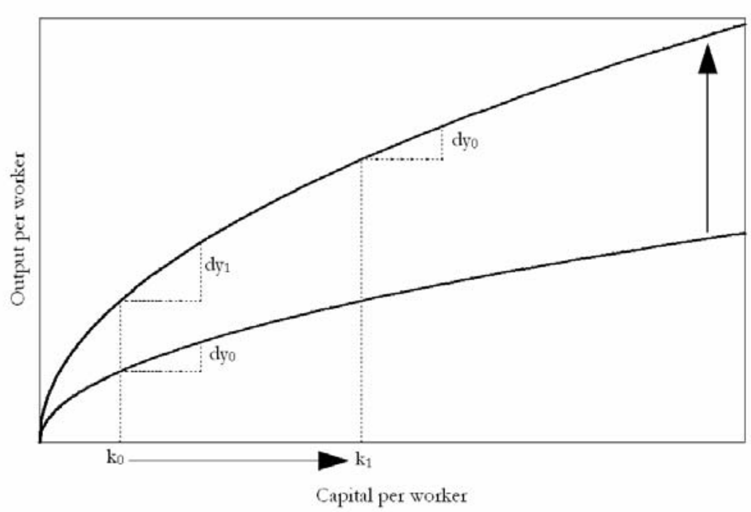

Figure 9.5 The effect of efficiency gains on the capital stock

224 Capital and output, Kamps, 2004. Work Hours 1970-2000, OECD. Labor Force, 1961-1970, Earth Trends.

as fast as the growth of output. In that case the direct effect of technological advance, plus the indirect effect from induced investment, makes a one percent gain in efficiency create about a 1.3 percent gain in output. Thus,

$$g_y \approx g_k \approx \frac{g_A}{(1-a)}$$

Thus investments in knowledge capital that generated efficiency growth not only explain most of modern economic growth at a proximate level, they explain all modern growth.

The Agenda

Enhanced production of "knowledge capital," seemingly starting around 1800, generated great external benefits throughout the economy. This increased the measured efficiency of the economy, and with it the stock of physical and human capital. Thus the path to explaining the vital event in the economic history of the world, the Industrial Revolution, is clear. All we need explain is why there was in all societies – warlike, peaceful, monotheist, polytheist - in the millennia before 1800 such limited investment in the expansion of useful knowledge, and why this seemingly changed for the first time in Britain some time around 1800. Then we will understand the history of man.

10 The Problem of the Industrial Revolution

> *So the Industrial Revolution was the only significant event that happened in all world economic history. And you have no explanation for the Industrial Revolution. What kind of theory is this?* (Irad Kimhi, 2006)

Introduction

The mystery of why the Industrial Revolution was delayed until around 1800 is the great and enduring puzzle of human history. In this chapter I will outline what makes explaining the Industrial Revolution an almost impossible challenge, and the various attempts to resolve this challenge.

We saw that economic growth after 1800 was the product of small, but highly productive, investments in expanding the stock of useful knowledge in societies. Since the benefits of these investments mostly do not flow to the investors, the result is a seemingly costless expansion of the efficiency of the economy. These gains in efficiency in turn induced more investment in the physical capital. We saw also that the average rate of expansion of technology before 1800 was extremely slow.

What makes the Industrial Revolution so difficult to understand is that we need to understand why despite the huge variation in the customs, mores and institutions of pre-industrial societies, none of them managed to sustain even moderate rates of productivity growth, by modern standards, over any long time period. What is different about ALL pre-industrial societies that generated such low and faltering rates of efficiency growth? What change to such a stable non-growth configuration generated the Industrial Revolution?

Theories of the Industrial Revolution

This book adopts a particular view of the Industrial Revolution, which is that it emerged only millennia after the arrival of institutionally stable economies in societies such as ancient Babylonia, because in the interim institutions themselves interacted with and changed human culture. Millenia of living in stable societies under tight Malthusian pressures that rewarded effort, accumulation and fertility limitation encouraged the development of cultural forms – in terms of work inputs, time preference, and family formation – which facilitated modern economic growth.

In part I will argue for this explanation by showing that given the nature of the question we have to answer, there is no other explanation which can meet the exacting requirements on any theory of the Industrial Revolution. For the existing theories of the Industrial Revolution, offered by a variety of historians, economic historians, economic theorists, and sociologists, end up falling into three basic types each of which faces characteristic difficulties. These three types are:-

Exogenous Growth Theories: Some feature outside the economy, such as the legal institutions of the society, or the relative scarcities of different inputs in production, changed. This change induced investment in expanding production techniques by potential innovators within economies. Such a change would include, for example, changes in the institutions governing the appropriability of knowledge, or the security of all property. Thus Douglass North and Barry Weingast argue that the arrival of the constitutional monarchy in England in 1689 was a key political innovation that ushered in modern economic growth.[225] These theories would predict that we will find in England in 1760 or soon before, or perhaps more widely in Europe, institutional forms or other social innovations not seen before in earlier societies. An example of such a theory might be Joel Mokyr's view that the Enlightment in Europe was a key stimulant of the Industrial Revolution, though Mokyr himself would argue that the Enlightenment itself had its roots in the earlier commercial expansion of the European economy.[226]

Multiple Equilibrium Theories: Some shock - disease, war, conquest of new lands - lead the economy to jump from the bad, stagnant equilibrium to the good, dynamic equilibrium of the modern world. A particular class of theories that has recently attracted adherents in economics is one where families switch from an equilibrium where everyone has large numbers of children, each of whom they invest little time in, to one where families have small numbers of children, on whom they lavish much attention.[227]

Endogenous Growth Theories: Some feature internal to the economic system evolved over time in the long pre-industrial era to eventually create the pre-conditions for modern economic growth. The Industrial Revolution was thus pre-determined from the time the first human appeared on the African Savannah. It was just a matter of time before the economic conditions for rapid technological progress were created. The question then is "what is different about the economy of England in 1760, compared to

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225 North and Weingast, 1989.
226 Mokyr, 2005.
227 Becker, Murphy and Tanura, 1990. Lucas, 1988, 2002.

Florence in 1300, China in 500, Rome at the time of Christ or Athens at the time of Plato?" Posited internal drivers of the economic system that eventually created the Industrial Revolution have included the size of the population itself, and an evolution of the characteristics of the population.[228]

This chapter reviews the major varieties of these theories before we examine the Industrial Revolution in detail, to consider whether it conforms with, or contradicts, these theories.

Exogenous Growth Theories

For economists the great exogenous force that is continually invoked as determining the lives of men and the fates of economies are the institutions that govern society, determining who owns what, how secure property is, and how property gets transferred. The preferred assumption is that the desires and rationalities of people in all human societies are essentially the same. The medieval peasant in Europe, the Indian coolly, the Yanomamo of the rainforest, the Tasmanian aboriginal, share a common set of aspirations, and a common ability to act rationally to achieve those aspirations. What differs across societies, however, are the institutions that govern economic life. If sustained rapid productivity advance is not observed before 1800 in any society, it must be because all these societies were even worse at rewarding innovation than our own. Thus:

> *Institutions form the incentive structure of a society, and the political and economic institutions in consequence, are the underlying determinants of economic performance." (North, 1994, 359).*

[228] Kremer, 1993, Galor and Moav, 2002.

Consider how the … economy would behave in the absence of property rights. In this case, innovators would be unable to earn the profits that encourage them to undertake research in the first place, so that no research would take place. With no research, no new ideas would be created, technology would be constant, and there would be no per capita growth in the economy. Broadly speaking, just such a situation prevailed in the world prior to the Industrial Revolution (Jones 2002, 121).

Studying institutions sheds light on why some countries are rich and others poor…The quality of these institutional foundations of the economy and the polity is paramount in determining a society's welfare. (Greif, 2006, 3-4)

The advantage of a theory which relies on an exogenous shock to the economic system, however, is that it can hopefully account for the seeming sudden change in the growth rate of measured efficiency around 1800. Institutions can change suddenly and dramatically – witness the French Revolution, the Russian Revolution, or the 1979 Iranian Revolution that overthrew the Shah

The sophisticated proponents of such theories among economic historians realize, however, that the difference in institutions between technologically static pre-industrial societies and modern growth economies, as we have seen, must be relatively subtle.[229]

However, this approach has a powerful hold over the economics profession because, in part, of the very limited historical knowledge of most economists. The caricature many modern economists thus have of the world before the Industrial Revolu-

229 See, for example, Greif, 2006.

tion is hence composed of a mixture of all the bad movies ever made about early societies: Vikings pour out of long ships to loot and pillage defenseless peasants and burn the libraries of monasteries. Mongol hordes flow out of the steppe on horseback to sack Chinese cities. Clerical fanatics burn at the stake those who dare to question arcane religious doctrines. Peasants groan under the heel of rapacious lords, whose only activity is feasting and fighting. Aztec priest, wielding obsidian knives, cut out the hearts from screaming, writhing victims. In this world who has the time, the energy, or the incentive to develop new technology?

Two considerations, however, suggest that such a theory faces almost insurmountable problems despite its grip on both economic history and economists.

First empirically we shall see that there is no sign of any improvement in the appropriability of knowledge until long after the Industrial Revolution was well under way.

Second there is no evidence that institutions can, in the long run at least, be a determining factor in the operation of economies, that is independent of the economic system. For there is another view of how institutions affect economic life, which is that over the long run they adapt to the technology and relative prices of economies, and play a secondary role in economic history. Interestingly enough this was the view of Douglass North, in 1972, in *The Rise of the Western World*, before he converted to the view that institutions are exogenous determinants of economic performance.[230] Let us call this the "efficient institutions" hypothesis.

The argument for such endogeneity of institutions is as follows. Economic institutions, being just a set of rules about who owns what, and how ownership is determined, can be

[230] North and Thomas, 1972.

changed at small resource costs. It typically costs no more to have efficient institutions, those that maximize the potential output of a society, as to have inefficient institutions. If an institution impeded the production of the maximum potential output from a society, there would be pressure to change it towards one promoting greater efficiency. Many people would gain from the change, and their net gains will be bigger than the losses of the losers. They will thus find a way to compensate the losers in order for them to accept the change. Even pre-industrial people are not insensitive to material gain. Institutions destructive of output will be reformed. Thus institutions mainly vary across time and place because differences in technology, relative prices, and people's consumption desires, make different social arrangements efficient.[231]

In this view institutions play no role in explaining long run economic development. Their evolution is interesting, but is driven by more fundamental economic forces. The history of the institutions is also not important for explaining current outcomes, since their origins will have little bearing on their current functioning. Where you started from makes no difference: there is no path dependence, at least in the long run, from institutional history.[232]

This "efficient institutions" view can accept, especially in dealing with long run history, that there may be periodic ideological pushes to adopt inefficient institutions as a result of episodes of religious fervor or social turmoil. Examples of religious fervor would be the arrival of Christianity in Europe, of Islam in 622 AD

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231 This view in many ways echoes Marx's famous statement that "The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of social consciousness." Marx, 1859.

232 Acemoglu et al., 2001, 2002 assert empirically that the past of societies really does predict the future.

in the Middle East, or of Khomeinism in Iran in 1979. Incidents of social turmoil would include the French Revolution of 1789, the Russian Revolution of 1917, and the subsequent Communist takeovers of North Korea in 1946, and China in 1949. But if the new institutions are economically inefficient they will quickly, measured in historical time, evolve towards efficiency.

History is full of examples of inefficient institutions that were over time subverted and refashioned because they were inefficient. One example of this, for example, is the method of deciding legal cases in medieval England by "wager of battle." The Norman conquerors of 1066 imported the right of a defendant in legal cases, including property disputes, to prove their case by "wager of battle." In this procedure the defendant would duel with the plaintiff in a ritualized combat that could be fought to the death of one of the parties. They did this because of the warrior origin of Norman society, and because of the belief that God would intervene to favor the side in the right.[233]

From the earliest records, the parties named champions to fight these duels for them.[234] The great religious houses with much land, and hence many territorial disputes, even kept champions in training. Thus in 1287 the Abbey of Bury St Edmunds fought a duel for possession of two manors. The Abbey Chronicle records that:

> *The abbot paid a certain champion called Roger Clerk,.., 20 marks in advance from his own money. After the duel Roger was to receive 30 marks more from him. The cham*

233 Von Moschzisker, 1922, 160, Russell, 1959, 242.

234 Till 1275 champions had to swear that they personally knew the facts of the case, so committing obvious perjury in many cases. This again illustrates the elasticity of even concepts like truth when they proved institutionally inconvenient.

Figure 10.1 Fallen Lenin Statue, Riga, Latvia. The weak economic performance of Societ style economies helped ensure the end of the Soviet regime in Latvia in 1991, 46 years after its imposition. Copyright © 2000–2004 Jurg Wittwer

> *pion during the whole time of waiting* [for the battle] *stayed with us, accompanied by his trainer.... On St Calixtus's day our enemies were victorious and our champion slain in judicial combat in London. And so our manors of Semer and Groton were lost without hope of any recovery.*[235]

Since the annual wages of a laborer at this time would be less than 3 marks, the champion who was to receive 50 marks if successful was a highly skilled worker. Unlike the example above, the men who fought for pay generally did not fight to the death, and typically one would yield before fatal injury.[236] This, it could be argued, not an institution that ensured productive land use, or encouraged investment in land.[237]

But as early as 1179 a tenant whose possession of land was challenged could, for a price, apply to the royal courts for a "writ of peace" prohibiting battle and requiring the case be settled by a jury of twelve knights from the locality. Since the defendant could elect to settle the dispute by battle or by jury, duels were still fought in frequently when the party in possession of the land either knew they had bad title, or feared the views of their neighbors who would form the jury. Even though it still formally existed until 1819, the right to be tried by combat fell into disuse in the 1300s, replaced completely by the jury.[238] Without any formal reformation the system evolved to a more efficient form.

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235 Gransden, 1964, 88-9.

236 Russell, 1959.

237 It is not clear, however, whether armed combat in settlement of property rights is any worse a way of settling disputes than hiring high priced attorneys to explore the niceties of legal theory.

238 The 1819 repeal of "wager by battle" followed celebrated case in 1817. The defendant, Abraham Thornton, a bricklayer, was accused of raping and murdering Mary Ashford. After a jury acquittal him her brother privately prosecuted Thornton for the murder. Under ingenious legal advice, the

The general evidence on whether institutions do evolve towards efficiency is mixed. But institutions with large social costs tend to disappear. Indeed the forces of economic interest are so powerful that when an ideology conflicts with economic interest the solution has generally been to adapt the ideology to resolve the conflict.

An example of this is the payment of interest on loans. In early Christianity, and still in Islam, the taking of such interest was regarded as usury, an immoral activity.[239] The idea lying behind this, at least in the case of Christianity, was that money by itself was sterile. If someone borrowed money, and repaid it after a year, why should they have to pay interest for the loan? The money itself was not capable of producing anything, so a bargain that required interest was unjust to the borrowing party.

But banning all lending at interest frustrates many possible mutually beneficial bargains in any economy. Thus in both Christianity and Islam religious scholars soon sought ways of reconciling the pure principles of faith with the profit opportunities of the market.

Thus while the Catholic church formally adhered to the doctrine against usury throughout the middle ages, ingenious theologians showed that most types of interest payment were actually non-usurous. Since the church itself was a major lender, there was considerable pressure to find just such a reconciliation.

Thus by 1300 the following exceptions to collecting interest on loans were all well accepted in Christian Europe.

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defendant, a strapping youth, demanded trial by combat. The plaintiff refused to fight, so the defendant won (Complete Newgate Calendar, v. 5, 167-71).

239 Modern Islam maintains the usury prohibition. The Koran prohibits "usury." Thus [2.275] "*GOD permits commerce, and prohibits usury.*" Many Muslim countries have laws against the taking of interest on loans. But Islamic scholars differ in their interpretation of whether usury is any taking of interest for loans, or just the taking of excessive interest.

1. Profits of Partnership. As long as each partner took the risks, returns were allowed on capital directly invested in an enterprise (i.e. equity finance was allowed).

2. Rent Charges. Anyone could sell a proportion of rent on land or house in return for a lump sum. Thus a perpetual loan secured by real estate was allowed. Indeed the Church itself bought many rent charges as an investment for its substantial endowment.

3. Annuities. An annuity is a fixed annual payment paid in return for a lump sum until the person named in the annuity dies. This was permissible since the amount of the payment was uncertain. The Prior of Winchester sold these, and they were popular in German cities.

4. Foregone Profits. A lender could collect compensation for profits foregone in making a loan.

5. Exchange Risk Premium. A lender could collect a premium on a loan if it was made in one currency and repaid in another, to cover the exchange rate risk. To exploit this loophole lenders would draw up contracts in which they lent across foreign currencies twice in one transaction, so eliminating all currency risk, but still collecting the premium.

The formal prohibition on usury had very little cost to pre-industrial Christian society. It outlawed only certain types of bond finance. Since there was still a demand for such loans this was met in two ways. The first was by allowing Jews, as non-Christians, to engage in such lending. The second was by simply ignoring the church rules when it proved convenient. Large scale finance - lending to Princes and the Vatican - was largely untouched by such regulations. There was even an international financial crisis in 1341 when Edward III of England defaulted on his debts, causing the bankruptcy of two of the three largest banks in Europe (the Peruzzi in 1343 and the Bardi in 1346).

Islamic societies similarly found ingenious ways to circumvent the ban. The primary one was the *double sale*. In this transaction the borrower would get, for example, both 100 dinars cash and a small piece of cloth valued at the absurdly high price of 15 dinars. In a year he would have to pay back 100 dinars for the laon of the cash, and 15 for the cloth. These debts were upheld by Sharia courts. A study of Islamic court records in the Ottoman Empire in the sixteenth century found, even more blatantly, literally thousands of debt contracts being enforced by the courts. Similarly the foundations set up by pious Muslims to maintain mosques, pay imans, support the poor, or provide public goods, the *waqfs*, frequently held cash assets that they lent at interest.[240] Even modern Muslim states that ban usury have banking arrangements where depositors still collect interest on their money, though in a "partnership" instead of explicitly as "interest." Such banks operate in Egypt, Kuwait, the Gulf Emirates and Malaysia currently.

In England usury itself became legal after the Catholic Church was replaced by the Church of England, as a result partly of the marital problems of Henry VIII. But for 300 years the law fixed a maximum interest rate. A loan violating the usury restriction was not legally enforceable. If the legal interest rate had been set very low, it might have seriously interfered with the capital market. But in practice the legal interest rate was set normally set at or above the free market rate. Loans to the Crown were exempted from usury restrictions. This was because the Crown, an unreliable borrower, paid rates well above the market rate before about 1710. Further the specified interest rates in the

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240 Pamuk, 2006, 7-8.

usury laws were impossible to enforce, since the contracting parties could easily inflate the size of the amount stated to be loaned in the written contract in order to circumvent the usury restrictions. On this first view usury laws survived in England because they imposed very little restriction on the economy.

We can find even more startling examples of the power of economic interest to undermine ideology. In Western Samoa in the Pacific, for example, the traditional rule in choosing chiefs was that the person be a close relative of the previous chief. Interviewed by an anthropologist people claimed they observed these rules. To confirm the legitimacy of the chief elaborate lineages were kept by each clan. But members have an economic interest in choosing as chief a rich person, since one of the duties of the chief is to provide feasts for the clan. The solution that was frequently used was that the lineages were distorted to make frequently used was that the lineages were distorted to make whoever was chosen seem more closely related to the previous chief. The interviewer would find that between visits to a community the new chief would be described as more closely related to the previous chief than he was.[241]

Multiple Equilibrium Theories

To have both institutions that evolve in response to economic pressures, and also the possibility that institutions can explain the Industrial Revolution, we need a theory of persistent bad institutions. The key idea here is that while "bad" institutions

[241]The British colonial administrators upset this compromise system by keeping bureaucratic records that established once and for all the actual familial relationship of individuals. Pitt, 1970.

always cost output as a whole, they can and do benefit some individuals. If these individuals have the political or police power to preserve the institution, then they will seek to preserve it whatever the cost to society as a whole.

Thus medieval guilds by keeping out new entrants to crafts may have hurt output in the economy as a whole, but they might have helped the members of the guilds themselves, who thus clung to the guild form. The guilds in London, for example, were politically powerful in England in the years before 1688 because they were able to raise money from their members to help the king at times of need. The consumers who might be hurt by guild regulations were less politically powerful because they were a more diffuse group with less ability to organize financial support for the king.

We can hence have a theory of institutions, a "political economy" of institutions, which explains the rise and fall of institutions in terms of the material interests of a ruling class. Acemoglu, Johnson and Robinson, for example, propose the schema for any future theory of institutions as in figure 10.2. The basic driver of societies is no longer their economies, as in the efficient institutions view, but their political structure, as well as the distribution of resources among the various political actors. Those who end up with political power will arrange economic and political institutions to maximize their own economic benefits, not the efficiency of the economy as a whole. The system can still be shocked into changes by exogenous shocks that change the income distribution and hence political power within the current political institutions. But now differences in initial political

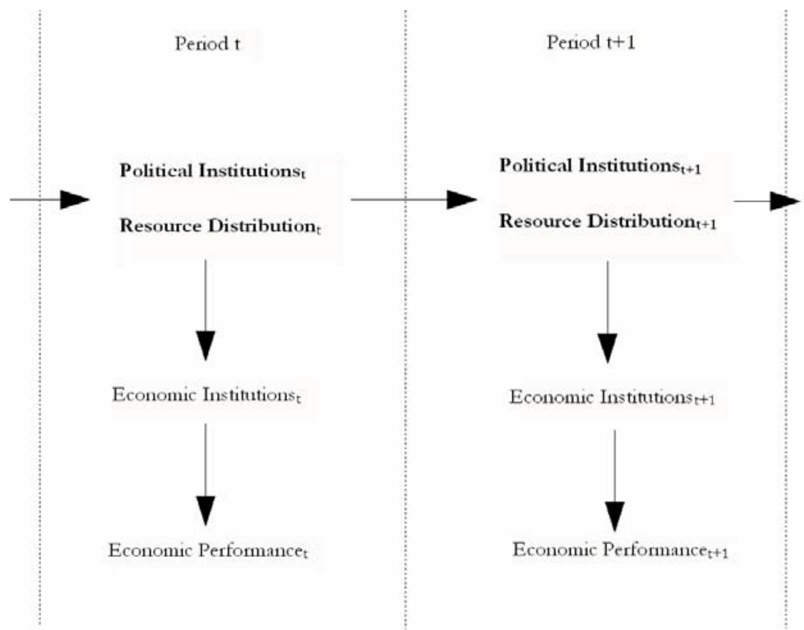

Figure 10.2 Politics as the economic driver[242]

institutions or resource distributions can have long lasting effects.[243]

The issue for the "political economy" of institutions as an explanation of slow growth before 1800 is to explain why systematically early societies had institutions that discouraged growth. For if institutions were are chosen as the result of the interplay of various interest groups, or even if they were randomly chosen, why would all societies in the thousands of years before 1800 end up with bad institutions? Wouldn't there be at least some by chance that would evolve good institutions? There must be

[242] Acemoglu, Johnson and Robinson, 2005.

[243] This is the structure of the argument about the economic success of former colonies in Acemoglu et al., 2001, 2002a, 2002b. Such a structure is also found in Engerman and Sokoloff, 2002.

something *systematic* that keeps early societies from rewarding innovation. When the English arrived in Australia in 1788, to find a society with no technological advance for 50,000 years, they also found that there were more than 300 distinct aboriginal languages, including 5 among the 5,000 inhabitants of Tasmania. Thus there was not one Aboriginal society that failed to show any technological advance, but more than 300.[244]

The common feature that Douglass North, Mancur Olson and others point to is that pre-industrial societies were systematically "predatory states" ruled by "stationary bandits" who maximized their reward at the expense of economic efficiency. Only with the development of democracy were economic institutions developed that made modern economic growth possible.[245] By the time England achieved its Industrial Revolution it was a constitutional democracy where the king was merely a figurehead.[246] The USA, the leading nation in the world in economic terms since at least the 1870s, has always been a democracy also.[247] Where a small class ruled by force a disjuncture arose between the property rules that maximized growth, and the property rules that maximized the gains of the ruling elite.

Consider, for example, the example of a slave or serf societies: the US south until 1860, Haiti until 1793, Brazil until the 1880s, Russia till 1861. It is frequently argued that slavery and serfdom were inefficient.[248] Since the owner can seize all the output at any time, it is hard to give slaves incentives to produce

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244 Blainey, 1975, 37-8. -----.

245North and Weingast, 1988. Olson, 1993.

246 The franchise was limited, however, being restricted to male property owners. Also since the vote was by a public ballot vote buying was common.

247 Though again a limited democracy for much of that time.

248Serfdom was a form of slavery widespread across pre-industrial Europe where the owner had property rights in the serf, but custom limited the exactions.

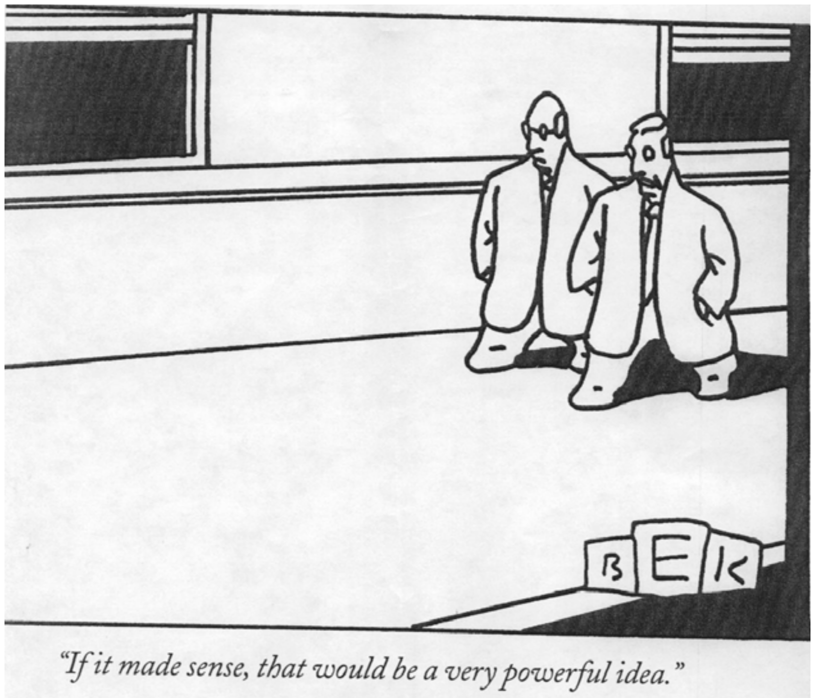

Figure 10.3 Institutionalism?

well. And the owner has to engage a lot of resources in monitoring the work of the slave. Robert Fogel and Stanley Engerman cast doubt on these beliefs through their empirical work on slavery in the US South suggested.[249] But for the sake of argument let us assume that slavery and serfdom were inefficient.

The statement that slavery is an inefficient institution is equivalent to the statement that if we freed a slave the total output of the society would increase. Suppose the output of a slave, the extra amount they produce for their owner is y_s. Their marginal output as a free worker would then be higher than under slavery.

[249]Fogel and Engerman, 1974.

The measure of the marginal output of a free worker, the amount they add to the output of society, is their wage, w. Thus if slavery is inefficient

$$w > y_s$$

Suppose that the owners have to spend the equivalent of a wage of w_s to feed, clothe and house slaves. The annual profit from owing a slave, the surplus he produces, is thus

$$\pi_s = y_s - w_s$$

The surplus the freed slave produces, $\pi_f = w - y_s$ is greater than this. That means that the slave could pay π_s to their former master and still have a surplus over their former subsistence consumption. The slave and the master can reach an agreement giving each of them part of this surplus, and both be better off.

Thus if slavery really is a socially inefficient institution it should end spontaneously, just through market forces. There should be no need for abolition movements, anti-slavery crusades, and Civil Wars. Indeed in ancient Athens it was common for skilled slaves to live on their own in the cities and just make an annual payment to their owners, who otherwise left them to their own devices.

But suppose that the freed slaves instead of using their freedom to happily make their annual payments to their former masters, instead used their freedom to organize and overthrow the unjust social order that condemned them to labor for the former ruling class. Or they could even just use their freedom to migrate to some adjacent society where they did not have to pay the annual exaction.

Then even though emancipation increases the total amount of social product, it reduces the income to the ruling class. This situation is portrayed in figure 10.4. Suppose that a society with

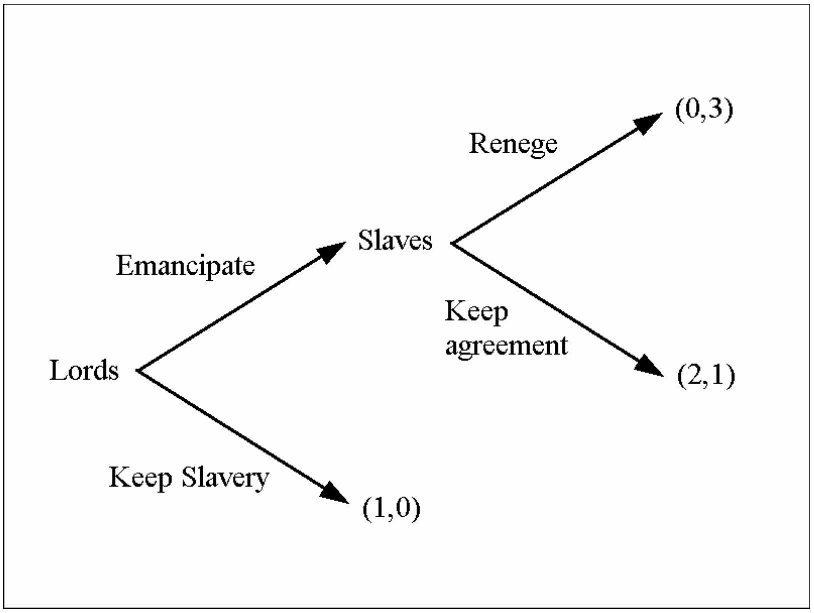

Figure 10.4 The emancipation decision[250]

slavery produces a total surplus of 1 unit, which all goes to the ruling class. The existing set of payoffs are shown as the number pair (1,0) in the bottom part of the diagram, where the first number denotes the lords' surplus, and the second number the slaves' surplus. Suppose also that emancipation would increase the total surplus to 3 units. Then the conditions for slaves buying themselves out of slavery seem to exist.

In particular a deal where after emancipation the lords get 2 units of the new surplus, while the ex-slaves get one unit should be accepted by both parties. This outcome is shown as the pathwhere the lords' emancipate and the ex-slaves keep to the

[250] In technical terms the decision tree above is called a "prisoners' dilemma" game.

agreement. But once emancipation occurs, suppose that the ex-slaves get to control the distribution of income. Then they would take all the surplus themselves, leaving the lords' worse off. In this situation slaves cannot commit to uphold the initial deal, and thus lords will never agree to it. Without an outside arbiter of property rights, the agreement, even though it increases output, will be rejected by the ruling class.

This example with slavery is just a specific example of what "institutionalists" would argue is the general problem of pre-industrial society: the unresolved struggle over the distribution of goods and power limited output. Note, however, that in many pre-industrial societies, but not all, slaves did buy their own freedom, or worked independently and paid just a fixed sum per year to their owners. Thus though there was a huge slave population in Roman Italy around 1 AD, as a result of captures in Roman conquests, by 200 AD, without any emancipation movement, most of these slaves had disappeared. In medieval England the large numbers of slaves and serfs recorded in the *Doomsday Book* of 1086, the majority of the population, were all free by 1500, without any emancipation movement.

So the general argument "institutionalists" would make is that pre-industrial elites – typically a military ruling class - did not undertake policies to foster technological advance because economic growth would have seen them expropriated. Somehow, through chance, a social structure emerged in countries like England prior to 1800 where the interests of a larger share of the population came to be represented in the government, which then was induced to pursue economic efficiency. Why, however, did this happen only once in the history of the pre-industrial world? Why were there not many societies where the rulers were secure enough that they were happy to reap the benefits of technological advance?

Human Capital

This argument that pre-industrial society was stuck in a bad equilibrium has taken other forms. The one that has attracted most attention by economic theorists recently is that in the Malthusian world parents were induced to have large numbers of children, each of whom they provided little to in the way of training or education. One of the great social changes in the advanced industrial economies since the Industrial Revolution is a decline in the number of children the average woman gave birth to, from 5-6 to 2 or less. Proponents of this interpretation of the Industrial Revolution such as Nobel Laureates Gary Becker and Robert Lucas argue that this switch, induced by changing economic circumstances, has been accompanied by a great increase in the time and attention invested in each child. People are not the same in all societies. With enough parental attention they can be transformed into a much more effective actor. The continual efficiency growth of the modern world has thus been created by higher quality people.

Chapter 7 gives evidence that literacy and numeracy had increased greatly by the eve of the Industrial Revolution. We saw that in chapter 9 that modern growth is seemingly the product of an expansion of the knowledge stock by investment in creating new techniques. The institutional view above assumes that the demand for innovation was increased by better social institutions. But this alternative interpretation is that changes in family size resulted in economic actors who were more educated and hence more effective at producing new techniques. The quality of the human agent depends on the time input of parents, which in turn depends on family size. The contrast between these views is portrayed in figure 10.5. The proponents of institutional change as the cause see a change in the private reward to innovators as spurring the Industrial Revolution, while the proponents of human capital investments see an increase supply of innovations at a given private reward as the key. We thus need not see any increase in the private returns to innovation in the Industrial Revolution era under the human capital interpretation.

What would spark a switch of families towards fewer but better educated children? From the point of view of the individual family there must be some signal in the form of higher relative earnings for educated children. But why would such a change appear in the Malthusian economy? If education for children is in part a consumer good purchased by parents, then one obvious trigger for a change in behavior would be just the higher incomes we have witnessed since the onset of the Industrial Revolution. But this would imply that higher income families would have begun to reduce family size long before the Industrial Revolution. And we saw in chapter 5 that in fact in the pre-industrial world the effective family size, measured by the numbers of children alive at the death of fathers, was significantly higher for higher income parents, all the way up to very high income levels.

Another possible cause of a reduction in child numbers in favor of fewer better educated children would be an increase in the premium that the market offered for those children with better education. Here, however, we find absolutely no evidence of any market signal to parents as we approach 1800 that they need to invest more in the education or training of there children. Figure 8.4, for example, showed that the skill premium in the

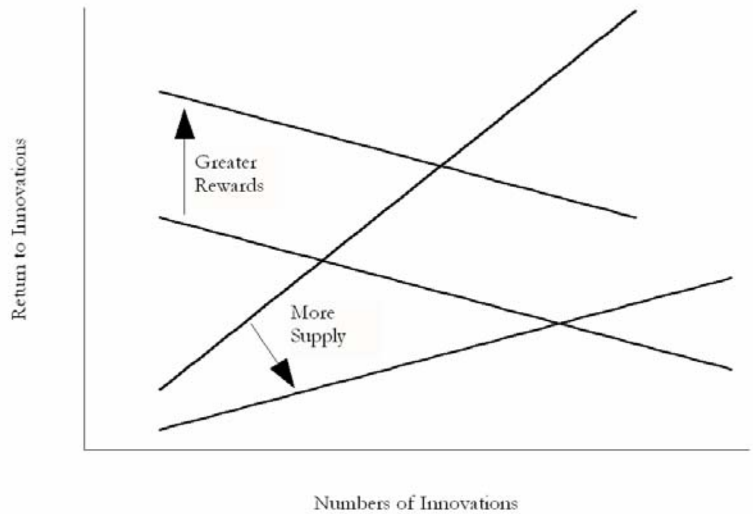

Figure 10.5 Demand and Supply Interpretations of the Industrial Revolution

earnings of building craftsmen relative to unskilled building laborers and assistants was actually at its highest in the interval 1200-2000 in the earliest years, before the onset of the Black Death in 1348, when a craftsman earned nearly double the wage of a laborer. If there was ever an incentive to accumulate skills it was in the early economy. Thereafter it declines to a lower but relatively stable level from about 1370 until 1900, a period of over 400 years, before declining further in the twentieth century. Thus the time of the greatest market reward for skills and training was long before the Industrial Revolution.

Proponents of a switch from a pre-industrial low human capital equilibrium in the pre-industrial world are extraordinarily vague about what would trigger the switch between equilibria. Becker, Murphy and Tamura, for example, thus argue the transition was caused by

> *Technological and other shocks ………. improved methods to use coal, better rail and ocean transports, and decreased regulation of prices and foreign trade (*Becker et al., 1990, S32-3).

But the need here is for an explanation of these technological shocks.

A final empirical hurdle human capital theories of the Industrial Revolution face is that the timing of the *Demographic Transition* in Europe and in the USA places it circa 1880, 120 years after the traditional dating of the Industrial Revolution. Figure 10.6, for example, shows the demographic transition in England and Sweden, two relatively well documented countries. In both cases the decline in fertility does not start in any substantial way until well into the late nineteenth century, 100 years after the traditional dating of the Industrial Revolution. We thus see a very poor match between the elements that would seem to go into a human capital story of the Industrial Revolution – the Industrial Revolution itself, the average size of families, and the premium paid in the labor market for skills.

Further for England we have proxy measures for literacy that go back to 1580: such things as the percentage of grooms who signed the marriage register, or the percentage of witnesses in court cases who signed their depositions. These measures do show a long upward movement in implied literacy rates. But they show very little change, at least for men, in the years 1760-1860, those of the classic Industrial Revolution, as figure 8.3 showed.

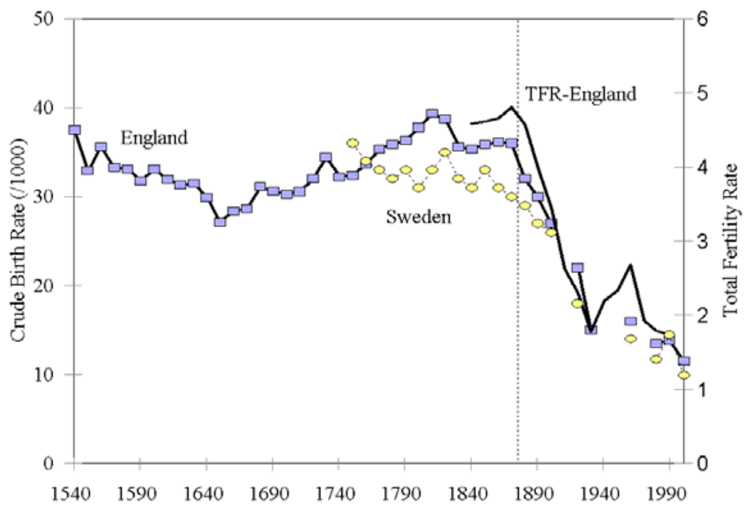

Figure 10.6 The Demographic Transition in Europe

Endogenous Growth Theories

None of the above theories of institutional changes or a switch between equilibria explain why the Industrial Revolution had to happen, or why it happened in 1760 as opposed to 1800 BC in old Babylonia, or 500 BC in Ancient Greece. Endogenous growth theories attempt to explain not just how the Industrial Revolution took place, but also why it occurred when it did. They argue that there was an internal evolution of the economic system that eventually lead to modern growth.

A nice example of such an endogenous growth theory is that of Michael Kremer. Kremer assumes that the social institutions that provide the incentives to individuals to create knowledge are the same in all societies. Each person thus has a given probability of producing a new idea. In this case the growth rate of knowledge will be a function of the size of the human community. The more people you are in contact with the more you get to benefit from the ideas of others. There was substantial but slow productivity growth in the world economy in the years before 1800, and that all got translated into a huge expansion of the world population. Sheer scale is what produces modern economic growth.

Kremer adduces two kinds of evidence for his position. The first is on population growth rates for the world as a whole in the pre-industrial era. In the years before 1850, where population growth rates effectively index the rate of efficiency advance, there is a strong positive correlation between the size of world population and the implied rate of efficiency advance, as shown in figure 10.7.

The second evidence Kremer brings forward is population densities circa 1500 across the major continents that had been isolated from each other for millennia: Eurasia, the Americas and Australia. Why was Eurasia so far ahead of the Americas, and even further ahead of Australia when contact was finally established? Kremer argues that the large land mass of Eurasia allowed for a much greater population at any level of technology. This greater population created more rapid technological growth rates in Eurasia.

There is clearly a core of sense to the idea that increased population size, the product of past technological change in the pre-industrial era, did increase the rate of technological advance. But it is also clear that world population alone cannot explain the acceleration in efficiency growth rates after 1800 seen in table 10.6. At the best possible case for his argument the growth rate of ideas would be proportionate to population size.

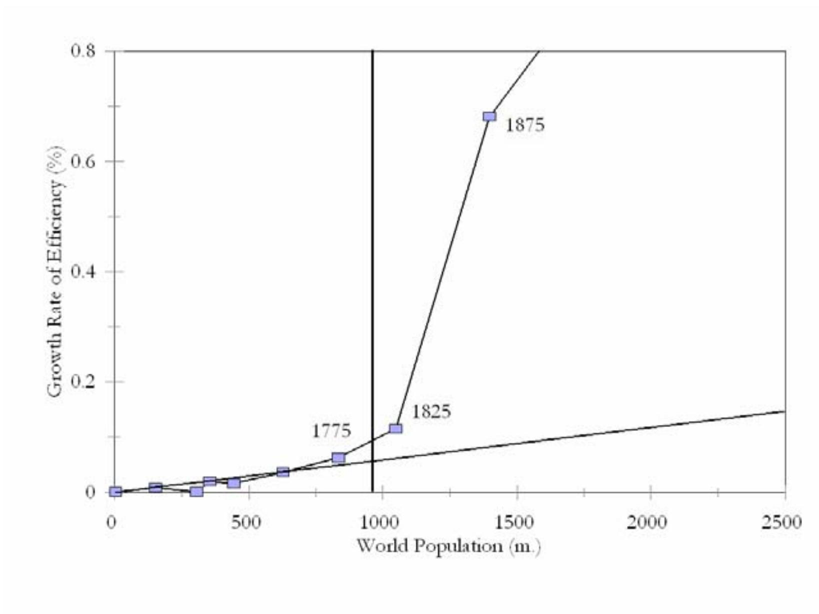

Figure 10.7 World Population and Efficiency Growth Rates[251]

Even to get such an effect of population on the growth rate of the stock of knowledge we have to assume that there is no rivalry in idea production. That is no tendency for a larger population to produce many simultaneous introductions of the same ideas, so that idea production expands less rapidly than population. We also must assume idea production is proportion to the existing ideas stock. Each idea creates possible extensions: the more we know, the more easily we can add to knowledge.[252]

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251 World Population is from the same sources as for table 7.1. The rate of efficiency advance is estimated from population until 1850, and thereafter from the fundamental equation of growth.

252 Formally we assume $\Delta A = hNA$ where A, the level of efficiency now is also an index for the stock of ideas, ΔA is the addition to the stock of ideas in any year, and N is the population level, and h is just a constant. This implies that the growth rate of ideas, which is also the growth rate of efficiency, is

$$g_A = \frac{\Delta A}{A} = hN \quad .$$

With this assumption we can take the world population observations from before 1800 and fit the relationship between the population size and efficiency growth rates. This is shown as the solid line in figure 10.6. When we use this line to predict the expected rate of efficiency growth for the 50 year periods after 1800 we see that increasingly the actual efficiency growth rates deviate from the predicted rates.

The misfit seen here is going to be a problem of any endogenous theory of the Industrial Revolution: its seeming discontinuous nature. Thus Oded Galor and Omer Moav propose a theoretical model that combines the Kremer population mechanism with endogenously changing household preferences for quality as opposed to quantity in children. They do not, however, show that this produces the required discontinuity.[253]

Conclusions

There are many competing theories for the great break that the Industrial Revolution represents for human history. Each is problematic for its own reasons, and none looks particularly plausible on its face. The next chapter considers the details of the Industrial Revolution, and whether they can be reconciled with any particular theory of the event.

253 Galor and Moav, 2002.

11 The Industrial Revolution in England

> *In the eighty years or so after 1780 the population of Britain nearly tripled, the towns of Liverpool and Manchester became gigantic cities, the average income of the population more than doubled, the share of farming fell from just under half to just under one-fifth of the nation's output, and the making of textiles and iron moved into the steam-driven factories. So strange were these events that before they happened they were not anticipated, and while they were happening they were not comprehended.*[254]

The Industrial Revolution in England, the seemingly abrupt break in this tiny island nation in less than a generation from millennia of pitifully slow economic progress, is one of history's great mysteries. Its apparent suddenness, in a society that was, and still is, noted for the evolutionary nature of all social change, represents a baffling challenge to economic explanation.

In one of the more delicious ironies of history the Industrial Revolution was precisely coupled with that other model of human liberation, the French Revolution. But the political revolutionaries who proclaimed their love for all humanity in 1789 were soon awash in the blood of an ever expanding list of enemies. As the revolutionaries fed on each other, revolutionary equality soon yielded to a vainglorious military dictatorship that led hundreds of thousands to a starving frozen end on the Russian steppes. Meanwhile a "nation of shopkeepers," incapable it seemed of vision beyond their next beef pudding, was transforming the possibilities for all humanity. And in the process, as we shall see,

[254] McCloskey, 1981, 103.

they ushered in more egalitarian societies than likely had been witnessed for thousands of years.

The events of the Industrial Revolution, thanks to 200 years of historical enquiry, are widely known and reasonably well agreed. But their significance and interpretation are hotly contested, with probably no two scholars agreeing what caused the Industrial Revolution, and what its wider significance is.

Here, after briefly detailing the major events of the Industrial Revolution, I argue that contrary to appearances the Industrial Revolution actually stretched back hundreds of years in its origin, and was a gradual and evolutionary development that affected other European economies almost as much as England. It was the product of a gradual progress of settled agrarian societies towards a more rational, economically oriented mindset, which showed in many dimensions.

While there is no doubt that a revolutionary change took place at some point between pre-industrial society with its 0% growth rate of productivity and modern society with growth rates of productivity exceeding 1% per year, the precise date of that transition is hard to identify, and may be forever indeterminate.

In particular, individual personalities and events, so beloved of narrative historians, do not matter. World history would have not changed in any significant respect had the future Sir Richard Arkwright, the sometime Bolton hairdresser, wig maker, and pub owner, who introduced mechanized factory spinning in 1768, instead opened a fish shop. We would not still be sitting in the Malthusian era had James Watt, inventor of separate condensers for steam engines in 1769, instead have found God and trained for the Ministry.

The appearance of a sudden shock to the economic system was created instead by accidents and contingencies. In particular the enormous growth of population in England after 1760, Britain's military successes in the Revolutionary and Napoleonic Wars, and the development of the United States all contributed to make this seem like an abrupt departure, as opposed to a continuation of more gradual changes.

The Industrial Revolution

Though the Industrial Revolution had many aspects, the one feature that made it unique in world history was the sudden appearance in the economy of a more rapid rate of efficiency advance than had been witnessed over sustained periods by any earlier economy.

The efficiency of any competitive economy, or indeed of any sector within the economy, can be estimated simply as the ratio between the average cost of the production inputs - capital, labor and land - per unit and the average output price per unit. That is

$$A = \frac{\text{average cost of a unit of inputs}}{\text{average price of a unit of output}}.$$

More efficient economies produce more output per unit of input. Since the value of payments to inputs has to equal the value of outputs, in more efficient economies output prices are low relative to input prices. The exact details of this computation are given in the technical appendix, but the concept itself is simple.

The unique stability of England from at least 1200 onwards meant that records of wages, prices, population, rents and returns of capital can be constructed throughout these years, allowing us, unusually, to estimate the efficiency of the English economy back as far as 1200.

Figure 11.1 shows the efficiency of production of output calculated in this way in 1700-1850. In the immediate run up to the Industrial Revolution in the eighteenth century there is no sign of any sustained efficiency growth. The English economy of the eighteenth century looks as Malthusian as any that came before. Then, around 1790, the steady, inexorable upward march of efficiency that characterizes the modern age began. From the 1780s to the 1860s the efficiency growth rate was still only 0.5% per year, less than half the typical modern rate. But it was an unprecedented period of sustained efficiency advance.

The immediate sources of the productivity advance after 1790 are well understood. Table 11.1 shows the overall productivity growth rate from the 1760s to 1860s, as well as the contributions from the major sectors with known innovations. As noted, a nice property of the aggregate productivity growth rate is that it is just the sum of productivity growth rates in each sector weighted by the share of the value of output in that sector in the national value of output (see the technical appendix).

As the table shows productivity advance in textiles accounted for more than half of all productivity advance for the hundred years of the Industrial Revolution. A small additional contribution came from coal and iron, but the major other contributing sectors were transport and agriculture. Transport because there was rapid productivity advance here. Agriculture because, even though productivity advance was slow, the size of the sector allowed it to make a significant national contribution.

Textiles was the flagship industry of the Industrial Revolution. Efficiency in converting raw cotton into cloth increased 14 fold from the 1760s to the 1860s, a growth rate of 2.4% per year, faster than productivity growth rates in most modern economies. In the 1860s the output of the economy was about 27% higher

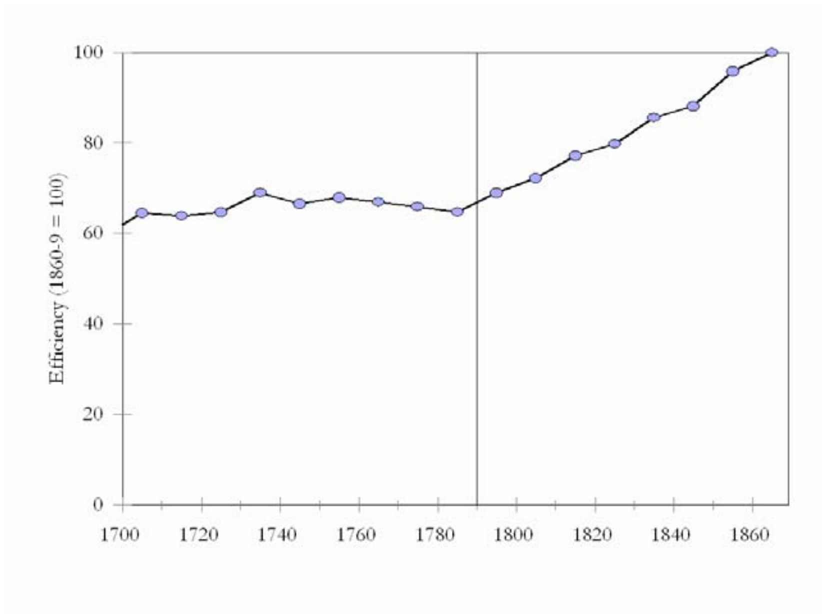

Figure 11.1 Production Efficiency in England by decade, 1700-1869[255]

than it would otherwise have been solely on account of textile innovations, a gain in income equivalent to £169 million pounds a year.

While it took the equivalent of 18 man-hours to transform a pound of cotton into cloth in the 1760s, by the 1860s this was done in the equivalent of 1.5 man-hours. The cause of this gain is also clear. A stream of technological innovations in textiles, beginning in the 1760s, some famous but most of them anonymous, transformed the industry.

Institutionalists assert that an increased rate of innovation must stem from greater inducements being offered by the economy to innovators. Yet textile innovators, even those who succeeded and are now famous, typically earned small returns.

[255] Clark, 2006b.

Table 11.1 The Sources of the Industrial Revolution, 1760s-1860s[256]

Sector	Efficiency Growth Rate (%)	Share of national income	Contribution to National Efficiency Growth Rate (%)
All Textiles	-	0.11	0.24
Cottons	*2.4*	*0.06*	*0.18*
Woolens	*1.1*	*0.04*	*0.05*
Iron and Steel	1.4	0.01	0.02
Coal Mining	0.2	0.02	0.00
Transport	1.2	0.08	0.09
Agriculture	0.3	0.30	0.07
Identified Advance	-	0.51	0.42
Whole Economy	-	1.00	0.40

Table 11.2 shows the financial gains of the most famous innovators in the textile industries in the Industrial Revolution. These men, the few who succeeded where many others tried and failed, who helped revolutionize textiles, typically gained little from their endeavors. Even in Industrial Revolution England the market was just not very good at rewarding innovation.

The profit rates of major firms in the industry also provide good evidence that most of the innovations quickly leaked from

256 Clark, 2006b.

Table 11.2 The Gains from Innovation

Innovator	Device	Result
John Kay	Flying Shuttle, 1733	Impoverished by litigation to enforce patent. House destroyed by machine breakers 1753. Died in poverty in France.
James Hargreaves	Spinning Jenny, 1769	Patent denied. Forced to flee by machine breakers in 1768. Died in workhouse in 1777.
Richard Arkwright	Water Frame, 1769	Worth £0.5 m at death in 1792. By 1781 other manufacturers refused to honor patents. Made most of money after 1781.
Samuel Crompton	Mule, 1779	No attempt to patent. Grant of £500 from manufacturers in the 1790s. Granted £5,000 by Parliament in 1811.
Reverend Edmund Cartwright	Power Loom, 1785	Patent worthless. Factory destroyed by machine breakers. Granted £10,000 by Parliament in 1809.
Eli Whitney (USA)	Cotton Gin, 1793	Patent worthless. Later made money as a government arms contractor.
Richard Roberts	Self-Acting Mule, 1830	Patent revenues barely covered development costs. Died in poverty in 1864.

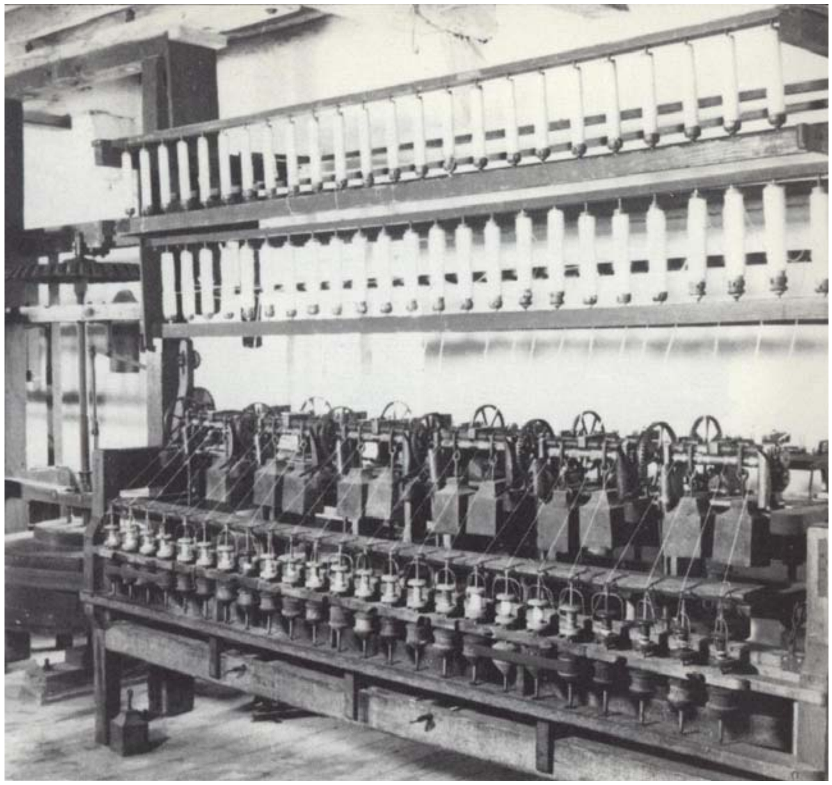

Figure 11.2 A water frame of 1785 from Arkwright's Cromford Mill.

the innovators to other producers, with little reward to the originators. The cotton spinners *Samuel Greg and Partners* earned 12% average profits in 1796-1819. This was just a very normal commercial return for any type of commercial venture. If innovative firms could have guarded their discoveries, by secrecy or patents, they would have made large profits compared to their competitors. Similarly *William Grey and Partners* made less than 2% per year from 1801 to 1810: a negative economic profit rate. Innovations in the cotton spinning mainly reduced prices, benefiting consumers. Thus *Richard Hornby and Partners,* in the weaving sector which was not mechanized until the 1810s, had an average profits of 11% in 1777-1809. This was as high as *Samuel Greg* in the innovating part of the industry. [257]

Thus the host of innovations in cotton textiles do not seem to have particularly rewarded the originators, famous or obscure. Only a handful, such as Arkwright and the Peels, became wealthy. Of the 379 people dieing in the 1860s in Britain who left estates of more than £0.5 million, only 17, or 4%, were in textiles.[258] Yet the industry produced 11% of national output, and generated the majority of Industrial Revolution efficiency advance. The Industrial Revolution economy was still spectacularly bad at rewarding innovation. Wage earners and foreign customers, not entrepreneurs, were the overwhelming beneficiaries of Industrial Revolution innovation. This is why Britain has few foundations to rival the great private philanthropies and universities of the U.S.A. The Industrial Revolution did not make paupers into princes.

A similar tale can be told for the other great nexus of innovation in Industrial Revolution England: coal mining, iron and steel, and railroads. Coal output, for example, exploded in England in the Industrial Revolution era Figure 11.2 shows that output by the 1860s was nearly twenty times as great as in the 1700s. This coal heated homes, made ore into iron, and powered railway locomotives. Yet there were no equivalents of the great fortunes made in oil, railways and steel in America's late nineteenth century industrialization.

The new industrial priesthood, the engineers who developed the English coalfields, railways and canals, made prosperous but typically moderate livings. Though their names survive to history - Richard Trevithick, George and Robert Stevenson, Humphrey

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[257]Harley, 1998. The risk free return on capital in these years was 5% or above.

[258]Rubinstein, 1981, ---.

Davy – they again captured very little of the social rewards their enterprise wrought. Richard Trevithick, the pioneer of locomotives, died a pauper in 1833. George Stevenson, whose famous locomotive *The Rocket* in a trial in 1829 ran loaded at 15 miles an hour, an unheard of speed for land travel in this era, did much better. But his country house in Chesterfield was, however, a pitence compared to his substantial contributions to railway engineering. But other locomotives competed in the famous trial, and soon a swarm of locomotive builders for the spreading railway network.

As figure 11.3 illustrates innovation in the Industrial Revolution era typically benefited mainly consumers in the form of lower prices. As coal output exploded real prices to consumers steadily declined: the real price in the 1700s was 60% greater than in the 1860s. Coal, iron and steel, and rail carriage all remained highly competitive in England in the Industrial Revolution era. The patent system offered little protection to most of the innovations in these sectors, and innovations quickly leaked from one producer to another.

The rise in innovation rates in Industrial Revolution England was not induced by unusual rewards to innovation, but by a greater supply of innovation at still modest rates of reward. Figure 10.3 illustrated two ways in which innovation rates might increase. The institutionalist perspective is that the rewards offered by the market shifted upwards compared to all previous pre-industrial economies. There is no evidence of any such change. The last significant reform of the patent system was in 1689, more than 100 years before efficiency gains became common. And the patent system itself played little role for most innovation in Industrial Revolution England.

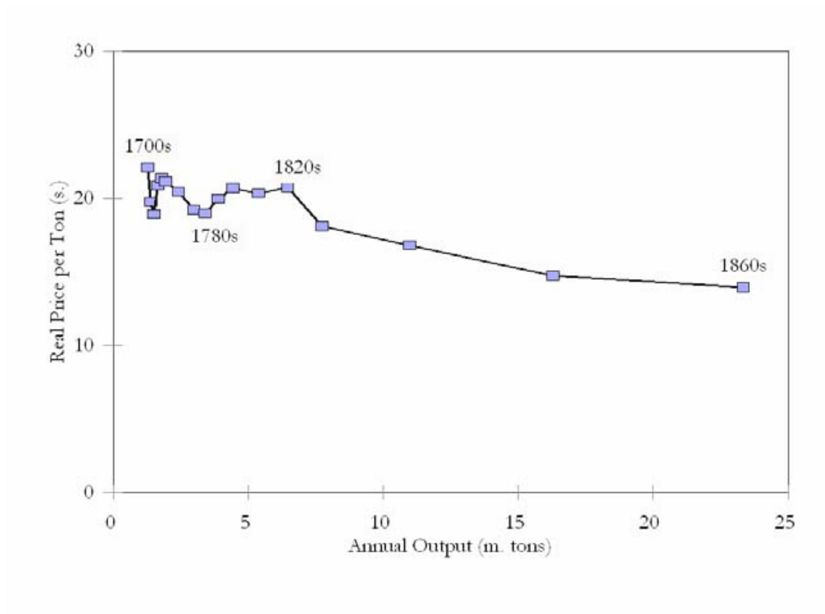

Figure 11.3 Coal Output and Real Prices, 1700s-1860s[259]

Instead the upsurge in innovation in the Industrial Revolution period, in terms of figure 10.3, reflected a surge in supply. With the benefits to innovation no greater than in earlier economies, the supply still rose substantially. Facing the same challenges and incentives as in other economies British producers were more likely to attempt novel methods of production.

The experience of agriculture in the Industrial Revolution era supports the idea that the Industrial Revolution represented mainly a change in the supply of innovation, rather than improved incentives. Historians have long written of an agricultural revolution accompanying the Industrial Revolution. Indeed generations of English school children have read, probably with bored bemusement, of the exploits of such supposed heroic innovators as Jethro Tull, author in 1733 of *An Essay on Horse-*

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[259] Clark and Jacks, 2006.

Hoeing Husbandry, "Turnip" Townsend, and Arthur Young. But this heroic agricultural revolution is a myth, created by historians vastly overestimated the gains in output from English agriculture in these years.[260] The productivity growth rate in agriculture was instead modest, at 0.27% per year, lower than for the economy as a whole. But even these modest gains still represented considerably faster productivity growth than was typical over the years 1200-1800. Figure 11.3, for example, shows wheat yields per seed sown in England from 1211 to 1453. Medieval agriculture seems to have been totally static over hundreds of years.

Yet the Industrial Revolution era agricultural improvements had no discernable connection with events in industry. Mechanization was minimal in English agriculture even by 1860, the only task substantially mechanized being grain threshing. Similarly, despite the insistence of the school curriculum, there were no heroic innovators as in textiles and steam - no Hargreaves, Cromptons, Watts, or Stephensons - just an amorphous collection of anonymous sons of the soil somehow bringing home more bacon. All subsequent accounts have been of incremental changes, carried out by a broad swath of farmers, across a long sweep of time.[261]

Thousands of individual cultivators in Industrial Revolution England somehow learned from their neighbors, or their own observations, incrementally better methods. They did this though their medieval cousins, with the same incentives, were unable to progress.

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[260] These output estimates were based on the food needs of a growing and also wealthier population. But they did not take into account the way coal and imported raw materials substituted for former agricultural production of energy and raw materials, allowing English agriculture to feed more people with not a great deal of extra total output.

[261] See, for example, Overton, 1996, 4.

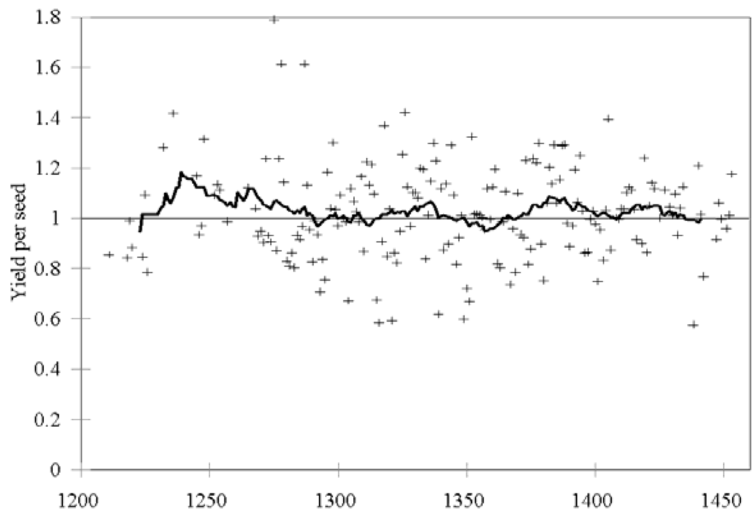

Figure 11.4 Wheat Yields in England, 1211-1453[262]

When was the Industrial Revolution?

The discussion above suggests that the transition between the static Mathusian economy, which lasted at least 100,000 years, and the modern economy can be dated to 1760-1800. But that appearance of a definitive break between the two regimes, in the blink of an eye in terms of human history, is mistaken. Instead a whole series of contingencies conspired to make the break seem much more definitive and sudden than it was.

The first sign that the transition date is more ambiguous than the traditional histories suggests comes from an examination of

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[262]The crosses show annual yields, and the solid line a 21 year moving average of these annual yields. Clark, 2001.

the efficiency of the English economy back all the way to 1246. The efficiency measured here is the efficiency at producing income, whether the goods consumed came from England or abroad.[263] This is because with the enormous rise in trade in these years, trade often with territories abroad ruled by British settlers and overlords, the boundary of the English economy becomes increasingly ill defined. Figure 11.4 shows this from 1250 to 2000 as a 10 year moving average.

Overall the dramatic transition from the pre-industrial to the modern world is evident. But the acceleration of efficiency growth in the Industrial Revolution era, around 1800, is not so evident on this longer perspective. It is also clear that England experienced steady, but not spectacular efficiency growth in the 160 years preceding 1760. The annual rate of 0.2% per year was slow by modern standards. But this slow growth of the era 1600-1760 was still enough to increase the measured efficiency of the English economy 37% over these years, a much more rapid pace of advance than was seen in general in the Malthusian era. Indeed had this growth continued from 1760 without the hiatus in efficiency growth witnessed in the last decades of the eighteenth century, the efficiency of the economy in the 1860s would have been at 95% of the level achieved after the Industrial Revolution.

The growth rate in the efficiency of production of income increased to only 0.33% per year from 1760-1869. Fast by the standards of the Malthusian era, but still slow by modern standards. So one way the Industrial Revolution could be interpreted is as a phase of a general transition that the English economy underwent from Malthusian stasis to modern growth

263 In contrast table 11.1 refers to the growth rates of efficiency of production of goods within England, which was faster since much of textile output was exported.

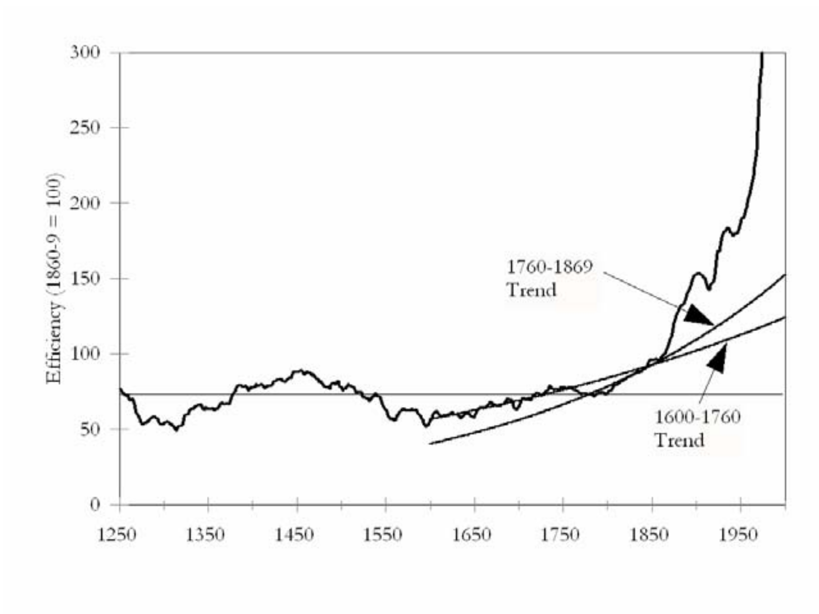

Figure 11.5 Long Run Efficiency of the English Economy, 1250-2000[264]

that started around 1600. It was not an abrupt start, but a continuation and acceleration of a process that, with ups and downs, brought us to the present.

If growth really did begin in the early seventeenth century then it suggests again that simple Institutionalist explanations of the Industrial Revolution, which have focused on the arrival of modern democracy in England with the Glorious Revolution in 1688-9, look decidedly unpromising. Figure 11.6 shows in close up efficiency by year from 1600 to 1760, and the 10 year moving average. None of the political events – the Civil War of 1642-8, the reign of Parliament and Cromwell in the failed Interregnum, the Restoration of the Monarchy in 1660, or the Glorious Revolution of 1688-9, makes any apparent difference to the slow

[264] Clark, 2006b.

upward move of the efficiency of the economy. Harvest successes and failures make much more impact than political events. And the rise of efficiency clearly started in the seventeenth century, before the great institutional change cited by Douglass North and his followers, the Glorious Revolution.

But figure 11.5 also reveals that before 1600 there were mysterious swings up and down in the measured efficiency of the English economy. Around 1450 at its late medieval maximum the measured efficiency of the economy was within 88% of its level in the 1860s. Around 1300 at its minimum it was only 55% of the level of the 1860s. This leads to the possibility that the efficiency growth witnessed in the years 1600-1800 was really just a catch up towards the average medieval efficiency level, and 1800 does represent the true beginnings of a break from the medieval regime. Without further information there is no way to tell.

Why Did the Industrial Revolution Appear so Dramatic?

The efficiency growth rates above suggest a muted, gradual transition between the Malthusian and the modern economy took place in England around 1800. Rapid productivity growth rates fully equal to modern economies did not appear until the late nineteenth century.

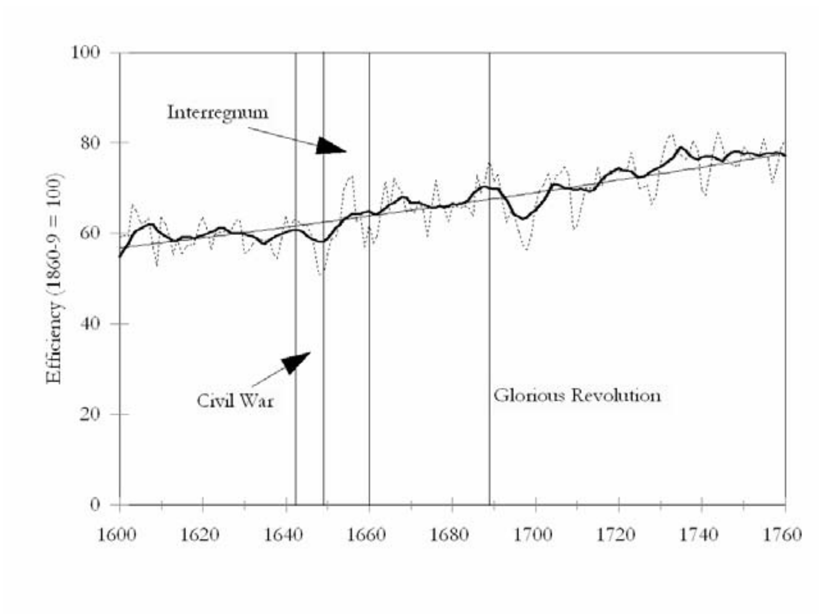

Figure 11.6 Efficiency in the approach to the Industrial Revolution[265]

Why then did the Industrial Revolution appear so dramatic to contemporaries, and to later observers? Why did non-farm output increase almosy 9 fold between the 1730 and the 1860s? Why the new giant cities where before there had been only villages and fields, the transformation of the countryside through the enclosure of common lands, the building of a dense network of 20,000 miles of new turnpike roads? Why the mining of vast quantities of coal – coal output was 18 times as great in the 1860s as the 1730s, with the scarring of the landscape by coal waste tips?

Why finally the ascendance of this minor country on the northwest corner of Europe, which in 1700 had a population less than one-third that of France, and about 4% that of both China

[265]Clark, 2006b.

and India, to the position of world dominance it achieved by 1850, if not for dramatic gains from the Industrial Revolution?

The answer proposed here is that the appearance of dramatic discontinuity in the Industrial Revolution comes from the coincidence of faster productivity growth in England with an unexpected and unrelated explosion in English population in the years 1750-1870. Britain's rise to world dominance was thus a product more of the bedroom labors of British workers than of their factory toil. English population rose from 6 million in the 1740s, not any more than its medieval maximum in the 1300s, to 20 million in the 1860s, more than tripling. Other countries in Europe experienced much more restricted population gains. The French in the same interval, for example, increased only from 21 million to 37 million. Also the expansion westward of the USA was steadily adding more acres of farm output to the world economy.

The population explosion seems completely unrelated to the productivity gains in textiles, steam, iron and agriculture that characterized the Industrial Revolution. For a start, the growth of population was well under way before there were significant productivity gains in any sector. By the 1790s population was already 37% higher than in the 1740s. That was why Malthus writing in the 1790s saw just a problem of excess population, not a population growth driven by economic changes. Since mortality declined little in the Industrial Revolution era, most of the increase in population thus came from fertility increases.

Chapter 4 showed how the birth rate was restrained in preindustrial England by women on average marrying late, by large numbers of women never marrying, and by women remaining celibate outside marriage. Even though fertility was unrestricted within marriage, this marriage pattern at its extreme around 1650 avoided half of all possible conceptions.

In the early eighteenth century, the age of first marriage of women began to decline. Figure 11.7 reveals that this drop began in the 1720s. This decline in age of first marriage was enough on its own to raise the birth rate by a fifth by 1800. At the same time as women married younger, more of them married. In 1650 a fifth of women never married. By the early eighteenth century the lifetime unmarried had fallen to 10%, and the rate remained at this lower level through the Industrial Revolution. The greater frequency of marriage added another 12% to fertility. Finally thought there were fewer women at risk of this, illegitimate births increased, adding another 5% to overall fertility. Multiplying these factors we get an increase in fertility between 1650 and 1800 of 40%. Thus while in 1650 the net reproduction rate was only 1.93 children per women and population was declining, by 1800 it was 2.68, and population was growing rapidly.

The sources of these changes in nuptiality do not seem to be economic. They occurred in both the north and the south of England even though the north was much transformed by the Industrial Revolution, and the south was largely unaffected. They occurred in parishes where employment was mainly in agriculture as well as in parishes mainly engaged in trade, handicrafts and manufacturing, as table 11.3 shows. The only feature of this period that might explain earlier and more frequent marriage is the decline of maternal deaths from childbirth. Table 11.4 shows that in the seventeenth century 1.5% of pregnancies ended with the death of the mother.[266] A woman marrying at 25, who gave birth

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[266]The chance of dying as a result of the complications of pregnancy in England is now less than 0.006% per birth

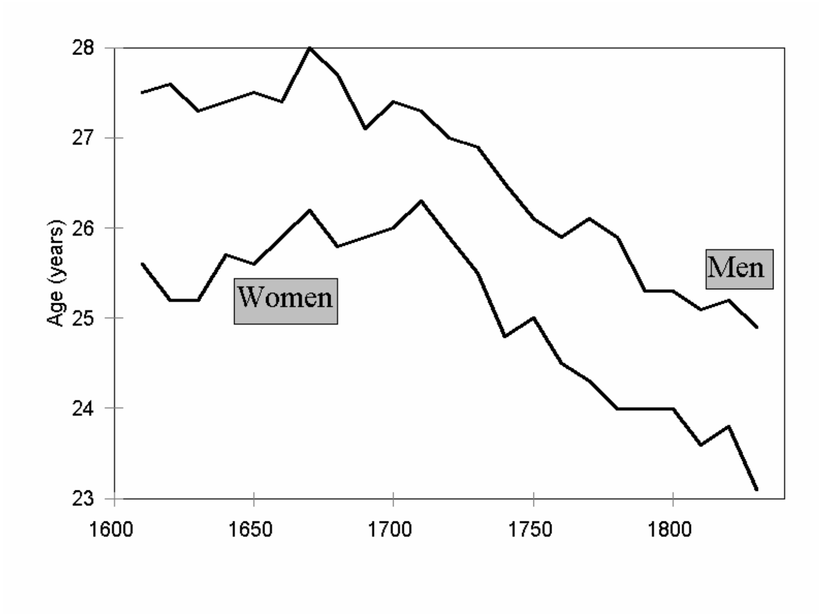

Figure 11.7 Age of First Marriage by Decade[267]

Table 11.3 Women's Average Age of First Marriage by Parish Type[268] Numbers of parishes in parentheses.

Period	Agricultural Parishes (8)	Retail and Handicraft Parishes (5)	Manufacturing Parishes (3)	Mixed Parishes (10)
1700-49	25.2	26.5	26.6	26.3
1750-99	24.3	24.8	24.6	24.7
1800-37	23.7	24.0	23.4	23.7

[267] Ages for batchelor/spinster marriages. Wrigley et al., 1997, 149.
[268] Ages for batchelor/spinster marriages. Wrigley et al., 1997, 187.

Table 11.4 Deaths from pregnancy[269]

Period	% pregnancies resulting in death of mother	Female mean age of marriage	Deaths from pregnancy of women marrying at 20 (%)
Pre 1600	1.23	-	-
1600-49	1.34	25.4	9.7
1650-99	1.63	25.9	11.3
1700-49	1.28	25.7	9.0
1750-99	0.92	24.4	7.1
1800-37	0.55	23.5	4.3

to the average of numbers of children for such a marriage, 5.6, would have a 9% chance of dying in pregnancy. By 1800 the mortality risk from pregnancy had dropped by two thirds, even though there was little decline in overall mortality. Women would be well aware of the mortality risks of marriage. The high level of these risks in the seventeenth century might thus explain both delaying marriage as a way of reducing these risks, and also the decision by many women to eschew marriage altogether.

The limited efficiency gains of the Industrial Revolution era, detailed above, means that population growth was more important than efficiency in driving up the output of the English economy in the Industrial Revolution era. Figure 11.8 shows the rise of total

[269] Wrigley et al. 1997, 134, 313, 399. The percentage of mothers dying from childbirth complications is calculated assuming that these were the only risks of mortality of married women. Deaths from other causes in ages 20-49 would reduce this percentage.

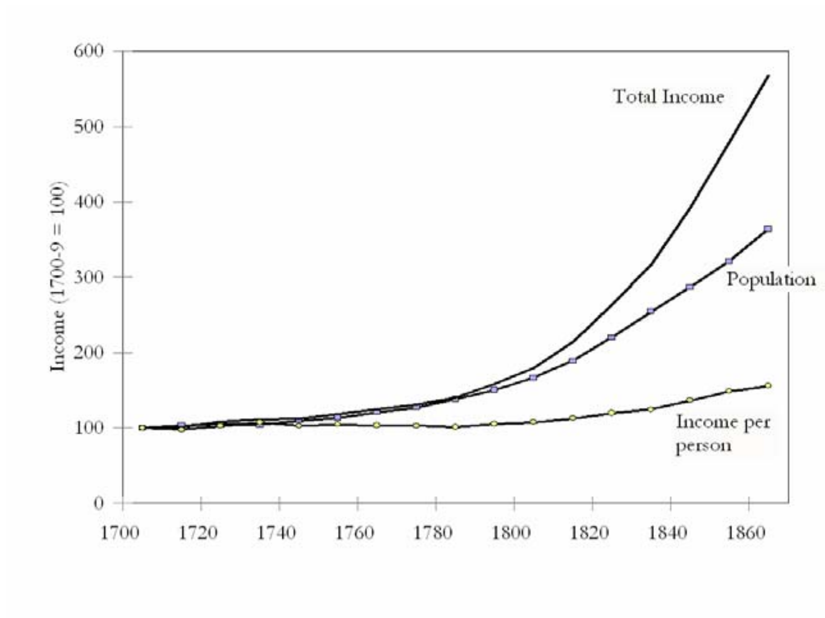

Figure 11.8 Population and Economic Growth, England[270]

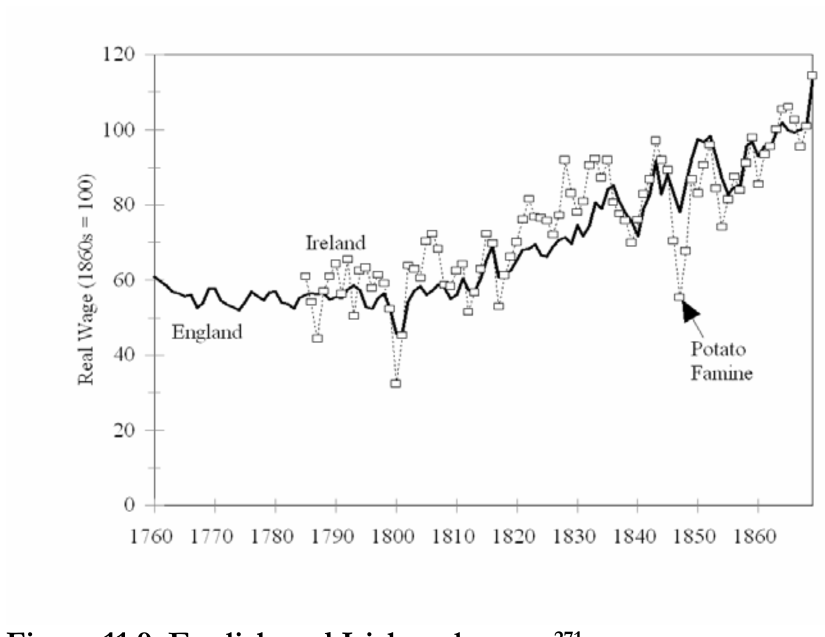

Figure 11.9 English and Irish real wages[271]

270Clark, 2006b.

271 Clark, 2005. Geary and Stark, 2004.

income in England 1700-9 to 1860-9 compared to the rise in population and the gain in income per person. While total output of the English economy was nearly 6 times as large by the 1860s, population growth alone explains most of this gain.

Further the gain in population was even more important to the relative size of the English economy than to its absolute size. The productivity gains in the Industrial Revolution had almost as much effect on the incomes of Britain's competitors in Europe as it did on England itself. This was for two reasons. The first was direct exports of cheaper textiles, iron and coal by England to other countries. The second was the establishment of new manufacturing enterprises in these countries exploiting the new technologies of the Industrial Revolution.

Thus Ireland, a country which became more agricultural and indeed de-industrialized in response to the English Industrial Revolution seems to have experienced as much income gain as its trading partner England. Real wages for Irish building workers rose as much as those in England in the years 1770-1869, as figure 11.9 shows. The figure reveals that these wage gains occurred before the Irish Potato famine of 1845 led to substantial population losses and outmigration. Indeed between 1767 and 1845 it is estimated that Irish population rose as much proportionately as that in England.

Similarly there is little sign that England was gaining significant income per person relative to the Netherlands in the Industrial Revolution era. Figure 11.10 shows income per person in England by decade from the 1800s to 1910-13, taking Dutch income per person in 1910-13 as 82% English. Between the 1800s and 1860s England, the white-hot center of the Industrial Revolution fire, saw income per person increase 44%. In that

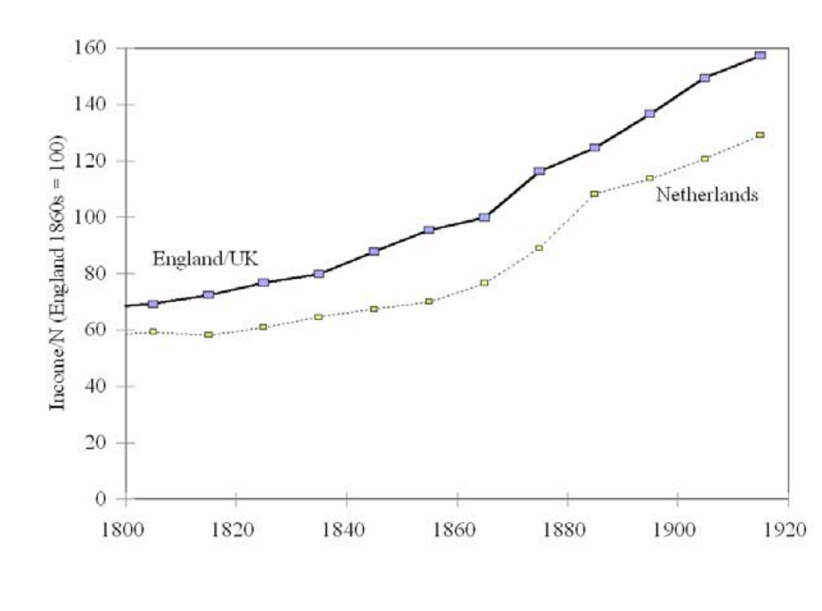

Figure 11.10 Real Income per person, England and the Netherlands, 1800s to 1910-13[272]

same interval the Netherlands, a peripheral player with little or no independent contribution to Industrial Revolution innovations, saw income per person rise by 29%. So England gained 11% on the Dutch in terms of income per person in the Industrial Revolu tion era. This was trivial compared to the 64% gain in English total income relative to Dutch from the 1760s to 1860s as a result of faster English population growth.

The English population boom, the rise of real incomes in the Industrial Revolution, the fixed land area of England, and the limited productivity gains in English farming meant that domestic agriculture could not meet the food and raw material demands of

[272] Clark, 2006b. The estimate of English income per person till 1869 is continued to 1913 using an index of UK GDP per person from Feinstein, 1972, table T21. Dutch income per person is from Smits, Horlings and Van Zanden, 2000.

Table 11.5 Population Growth and Food and Raw Material Supplies (£ m. 1860-9)[273]

	1700-9	1760-9	1860-9
Population (millions)	5.5	6.7	20.1
English Farm net output	£65 m	£71 m	£114 m
Net Food Imports	£2 m	£3 m	£80 m
Net Raw Material Imports	-£2 m	-£5 m	£61 m
Domestic Coal Output	£2 m	£3 m	£37 m
Non-Farm Food and Raw Material Supplies	£2 m	£2 m	£178 m
All Food and Raw Materials per person	£12	£11	£15

the English economy. As table 11.5 shows while population more than tripled in the course of the Industrial Revolution domestic agricultural output did not even double. By the later years of the Industrial Revolution England moved from being a country where food and raw material imports were unimportant to one where they were substantial relative to GDP. In the 1860s net food and raw material imports were equivalent to 22% of GDP.

This trade of manufactures for food and raw materials was made at still relatively favorable terms because of the addition of

273 Imports 1860-9: Parliamentary Papers, 1870. Imports 1700-9 and 1760-9: Schumpeter, 1960, tables XV, XVII. Exports 1700-9 and 1760-9: Schumpeter, 1960, tables VII, IX, X, XII, XIII, Mitchell, 1988, 221-2. Coal output, Clark and Jacks, 2006.

substantial new areas to the north Atlantic trading area with the expansion westward of settlement in the USA. Table 11.6 shows the vast size of the areas added to farm acreage in the USA by the 1860s.

The food and raw material imports of the Industrial Revolution had to be paid for by exports of manufactured goods. It was this, rather than technological advances, that made Britain "the workshop of the world." Had English population remained at 6 million into the 1860s its domestic agricultural sector would have been able to feed and provide raw materials for the English population. The exports of manufactures which constituted by the 1860s nearly 20% of GDP, would have on net been close to zero. Thus without population growth non-farm output in the 1860s, instead of being nearly 10 times its level in the 1730s would have been only double the earlier level.

Hence the unusual growth of population in the Industrial Revolution period in England, as well as the expansion of the cultivated area in the USA, was more important for the transformation of the economy and society associated with the Industrial Revolution than the specific technological advances of these years.

How gradual was the transition to modern growth?

Figure 11.5 suggests that the date of the transition between the pre-industrial world of almost no efficiency growth, and the modern world of constant efficiency advance, is impossible to determine from aggregate productivity levels. But the figure reinforces the idea that the pre-industrial world, at least as represented by England, was largely one of technological stasis.

Table 11.6 Farmland and population in England relative to Europe and the USA[274]

	1800-9	1860-9
England		
Population (m)	9.2	21
Farm Area (m. ac.)	26	26
Acres/N	2.8	1.2
Western Europe		
Population (m)	103	152
Farm Area (m. ac.)	317 [a]	317[a]
Acres/N	3.1	2.1
Russia		
Population (m)	53	74
Farm Area (m. ac.)	702 [a]	702[a]
Acres/N	13.2	9.5
USA		
Population, USA (m)	6.2	35
Farm Area, USA (m. ac.)	-	407
Acres/N	-	11.6

The measured aggregate productivity level of the economy was as high in the thirteenth century as the eighteenth century. This does not mesh with intellectual and social history, where we see in Europe from the middle ages on, a slow but steady diet of

[274]Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland. [a]Based on modern areas from the Food and Agriculture Organization. *Sources*: FAO, statistics database. Mitchell, 1998a.

innovations in technology, science, architecture and the arts. Table 11.7 shows a brief summary of significant innovations in Europe in all area fields before 1670. Clearly this was not a world in which nothing was happening. The puzzle is that the developments occurring had so little impact on production technologies.

However, the aggregate productivity measure reported in figure 11.5 is the sum of productivity advance in the production of individual goods, but the sum weighted by the share of expenditure on each good. As explained in chapter 7 economists use this weighting because economics is concerned with people's welfare, and this weighting measures how much technical changes mattered to the average consumer.

But if we are concerned with measuring the average rate of innovation in a society this measure need not index that well. Significant innovations may only have an effect on the mass of people long after they are made. At the time of the innovation people may not happen, because of their income or circumstances, to employ such goods very much. A classic example of this is the introduction of the printing press in Europe in 1452 by Johannes Gutenberg. Before the printing press books had to be copied by hand, with copyists on plain work still only able to copy 3,000 words per day. Producing one copy of the Bible, for example, at this rate would take 136 man-days. A 250 page book in modern octavo size would take about 37 days. Also the imprecision of hand writing meant that print had to be of larger size demanding about twice the area of page per word as modern books, driving up the costs of materials and binding.

Table 11.7 Innovations in Europe, 1100-1670

Date	Innovation	Place/person
1120-	Gothic Architecture	France, England
c. 1200	Windmill	N. Europe
1275	Gunpowder	Germany
c. 1285	Mechanical Clock	N. Europe
c. 1315	*The Divine Comedy*	Florence (Dante)
c. 1325	Cannon	N. Europe
c. 1330	Crown Glass	France
c. 1350	Spectacles	Venice
c. 1350	*The Decameron*	Florence (Boccaccio)
c. 1390	*Canterbury Tales*	England (Chaucer)
c. 1400	Harpsichord	Flanders
1413	Perspective in Painting	Italy (Brunelleschi)
c. 1450	Printing Press	Germany (Gutenberg)
c. 1450	Quadrant (navigation)	-
c. 1450	Arabic numerals adopted	-
c. 1475	Musket	Italy, Germany
1492	Discovery of Americas	Spain (Columbus)
1498	Sea route to India	Portugal (da Gama)
1512	European Postal Service	Franz von Taxis
1522	World Circumnavigation	Spain (Magellan)
1532	Potato introduced	Spain
1544	Tomato introduced	Italy
c. 1587	*Tamburlaine the Great*	England (Marlowe)
1589	Knitting Frame	England (Lee)
1600	Discovery of Electricity	England (Gilbert)
1600	Opera – *Euridice*	Florence
1602	*Hamlet*	England (Shakespeare)
1608	Telescope	Holland (Lipperhey)
1614	Logarithms	Scotland (Napier)
c. 1650	Mechanized silk spinning	Italy
1654	Modern thermometer	Italy
1656	Pendulum Clock	Holland (Huygens)
1665	Microscope	England (Hooke)

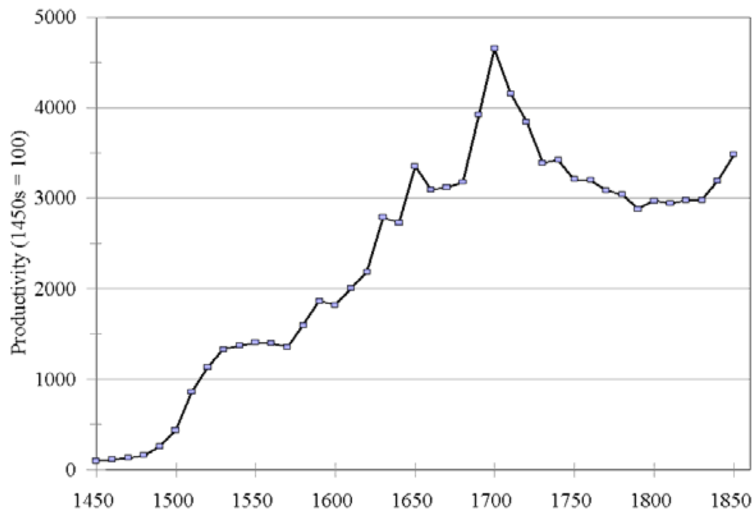

Figure 11.11 Productivity in Book Production in England, 1450s – 1850s. 1450s = 100.[275]

Figure 11.11 shows the estimated productivity level in book production by decade from the 1450s to the 1850s, calculated as the ratio between the wage of building craftsmen and the price of a book of standard characteristics.[276] The rate of productivity growth from the 1450s to the 1550s was 2.6% per year, as fast as for cotton textiles in the Industrial Revolution. In the next hundred years productivity grew more slowly, at only 0.8% per year. But this was still faster than most of the economy in the Industrial Revolution. From the 1650s to the 1850s there were apparently no further productivity gains in printing, however. But

275 Clark and Levin, 2001.

276 We can do this since both under hand production and with the printing press the main ultimate cost in book production was labor (paper and parchment production costs were both mainly labor costs).

all this increase in the efficiency of book production had no appreciable impact on the measured efficiency of the economy before the 1650s, since books were such a tiny share of expenditure for most of the pre-industrial era. In the first decade of the sixteenth century the average annual output of books was about 20,000 volumes, about 0.02% of English national income. By the 1550s this had risen to 100,000 volumes, but because of the falling prices of books that was still only 0.11% of national income.

Books were not the only goods that saw very substantial efficiency advances in the years before 1800, yet made little or no impact on the aggregate efficiency of the economy because they were such a small share of aggregate expenditure. Thus table 11.8 shows the price of nails by 50 year periods, compared with wages, and the implied efficiency in nail production. A pound of nails in the early thirteenth century cost 3.3 d., while a day's wage for a craftsman was 2.4 d. Thus a pound of nails cost more than a day's wage. By the years 1850-69 the day wage had increased about 17 fold, to 40 d. per day. But nail prices were only 3.2 d. per pound, so a craftsman could buy more than 12 pounds of nails with his day's wage.[277]

But most of the gain in efficiency in nail production was achieved before the Industrial Revolution, so that the efficiency of production was nearly 7 times as great on the eve of the Industrial Revolution than it had been in 1200. Yet again this could have little economic impact, since nails were always a small share of construction costs for buildings and furnishings. Other goods that had their prices relative to wages substantially improved

[277] The near constancy of nail prices in nominal terms explains why still in the USA nails are designated as "2d" nails, "3d" nails. These were the prices of 100 such nails in the fourteenth century in England, which became established as the name of that type of nail, since their price changed so slowly.

Table 11.8 Productivity Growth in Nail Production, 1200-1869[278]

Half Century	Cost of nails (d/lb)	Day Wage (d/day)	Efficiency of Production	Efficiency Growth (% per year)
1200-49	3.3	2.4	100	0.31
1250-99	2.9	2.4	117	0.09
1300-49	2.9	2.5	122	-0.35
1350-99	5.3	4.0	102	0.72
1400-49	4.3	4.6	147	0.34
1450-99	3.8	4.8	174	0.38
1500-49	3.3	5.0	211	0.39
1550-99	4.6	8.6	256	0.63
1600-49	4.6	12	351	0.67
1650-99	4.6	16	492	0.40
1700-49	4.2	18	603	0.21
1750-99	4.2	21	670	1.05
1800-49	4.5	36	1,132	0.81
1850-69	3.2	40	1,693	-
1200-1799				0.38

before 1800: paper, glass, spectacles, clocks, musical instruments, paints, spices such as pepper, sugar, fine textiles such as silks, tobacco, and gunpowder. None of these had much impact on living costs simply because they were mainly luxury goods consumed by only those with the highest incomes. The bulk of

[278] The efficiency growth rate for each period is calculated as average efficiency growth between the beginning of the half century and the end. This is why efficiency growth in the period 1300-49 is negative.

expenditure was for basic foods, clothing and shelter: not for these luxury items.

But if we were to measure the rate of technological advance in England from 1200 to 1869 not by looking at the consumption of the average person, but by looking at the consumption of people like us, we would have a very different impression about the relative stasis of the economy before 1800. Figure 11.12 thus shows the hypothetical real wage of workers with tastes like the modern consumer - priests, doctors, lawyers - in terms of foods, reading material, clothing and house furnishings compared to the actual real wage of farm workers for 1280-1869. This is a hypothetical real wage since we do not know the average wages of the professional class in these years. All we can do here is assuming that the wage of this group was unchanged relative to the wage of farm workers. The calculated real wage of this professional and upper class group is nearly 2.5 times as great by the mid seventeenth century as in 1280-1349.

In contrast the real wage of farm workers increased by only one third in the same interval. Also the rate of real wage gain for this hypothetical group is nearly as fast in the years 1300-1700 as in the years 1760-1860, those of the classic Industrial Revolution. 1280-1760 the hypothetical real wage for the rich grows at 0.26% per year. 1760-1869 these real wages grow at the same 0.26%, though the growth rate 1800-1869 is a much faster 0.67% per year.

Thus the dynamism of the English economy in different periods seems to depend crucially on the consumption interests of the observer. From the perspective of the lowest paid workers, farm laborers, even by the end of the Industrial Revolution they had not attained the living standards of the golden years of the

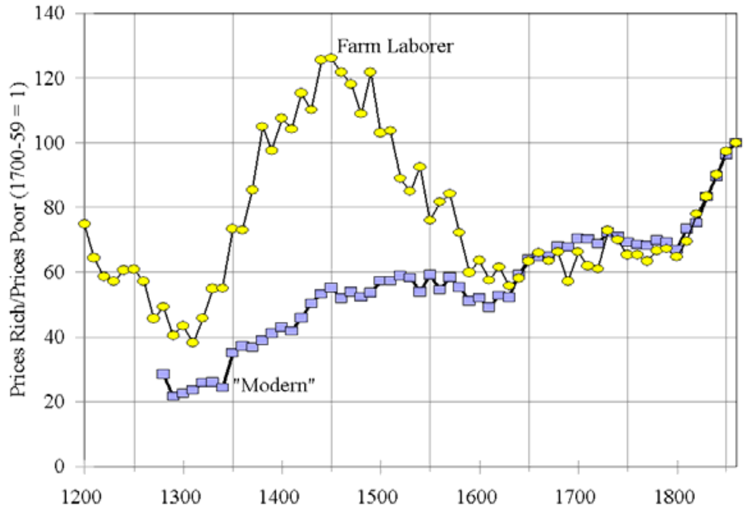

Figure 11.12 Real Wages of Farm Workers and, Hypothetically, Modern Consumers (1860-9 = 100)

later middle ages. From the perspective of someone with middle class consumption habits in modern America there was a world of change in consumption possibilities even before 1800. These changes made it possible to live in light flooded houses, with painted or papered walls, and eat a wide range of tasty foods from fine china and glassware. They made reading a daily newspaper possible. They extended the length of the day by providing cheap artificial illumination.

If innovation were an activity that followed an economic logic where the budget of innovative effort was devoted to producing the maximum value of productivity advance per research dollar, then the aggregate efficiency standard would be the most appropriate of measuring the innovation rate of a society. But if instead innovative activities were guided mainly by non-economic forces – curiosity, a love of novelty, a desire to impress others – then aggregate efficiency growth might provide a very poor guide to the rate of innovation in a society, or to the relative innovativeness of societies. The evidence from Industrial Revolution England suggests that at least in early societies the profit motive would be a relatively weak stimulus to innovation. In that case measuring the rate of innovation using aggregate efficiency growth will not be appropriate.

The Switch to Inorganic Technologies

As Anthony Wrigley has emphasized, an interesting aspect of the Industrial Revolution was that it represented the beginnings of a switch from a largely *organic* system of production to the increasingly *inorganic* systems of the modern world. The bulk of food, energy and clothing and construction materials in the world before 1800 were produced in the farm sector using organic methods. The classic Industrial Revolution, with its reliance on coal and iron, was the first step towards an economy that relied less and less on current sustained production through plants and animals, and more on mining stores of energy and minerals.[279]

Organic production systems have three important features. The first is that all outputs drawn from the system in the long run have to be balanced by equivalent inputs. Every pound of nitrogen consumed off the farm in grain products in pre-industrial England had to be balanced by a pound of nitrogen fixed from

[279] Wrigley, 1990.

the air in the farm system. This severely restrained potential output.[280]

The second feature is that, unlike inorganic systems where the baseline rate of productivity advance is 0, in organic systems without any innovation, efficiency growth is negative. Weeds and pathogens are constantly adapting, through the blind forces of natural selection, to reduce the productivity of crops and animals. Indeed some modern grain crops, such as rye, are believed to have evolved within crops of barley and oats as crop weeds. In the harsher growing conditions of northern Europe rye proved to be more productive than the original grains, and was eventually cultivated deliberately.[281]

The inherent tendency to productivity decline in farming systems is revealed most dramatically in such episodes as the Irish Potato Famine of 1845, or the Phylloxera attack on grape vines in Europe in the 1860s. Thus the absence of measurable productivity growth in the farm system in England before the Industrial Revolution need not imply an absence of innovation. The move from a 0% rate of productivity advance in the years before 1800 to a 0.3% rate of advance in 1800-1860 may seem like an important phase change. But suppose this represents instead, for example, a change from a rate of innovation of 0.4% per year to one of 0.7%, being countered by a constant natural degredation of technique of 0.4% per year. Then again the upward movement of innovation rates in the Industrial Revolution era would be less dramatic, and less of an apparent change in regime.

The third feature of organic systems of production is that experiments to devise better production methods are inherently difficult. In a cotton mill, for example, controlled experiments

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[280] Clark, 1992.

[281] Palumbi, 2001. Ghersa et al., 1994.

can be done in changing manufacturing methods. Spindle speeds can be increased by 10% and the resulting changes in production costs observed immediately. But in agriculture observing the effect of any change is difficult. The production period is longer, and may be years in the case of animals. Changes in the weather and in pathogens impart huge shocks to output each year. Soil conditions vary from field to field, and even within fields, so a change that might be beneficial in one environment could prove ineffective or damaging in another. Thus again the switch to more inorganic means of production may bias the seeming upturn in innovation rates in favor of the modern era.

Conclusion

The Industrial Revolution in England in 1760-1860 saw dramatic changes in the English economy. But it is uncertain if we can identify the general switch from economies with little innovation in production techniques to modern economies where innovation is continuous with the years 1760-1800. The upturn in productivity growth rates was a drawn out process. Aggregate productivity growth rates are only one way of weighting the gains in efficiency across the many production techniques in any society, and on other weightings the transition to modern growth would come sooner than 1800. Also the assumption that the rate of efficiency growth with no innovation in a society is 0 is incorrect for pre-industrial societies where innovation was needed just to maintain the productivity of organic production systems.

12 The Social Consequences of the Industrial Revolution

In proportion, therefore, as the repulsiveness of the work increases, the wage decreases (Marx and Engels, 1848).

Sharing the Spoils

The Industrial Revolution was driven by the expansion of knowledge. Yet, stunningly, unskilled labor has reaped more gains than any other group. Marx and Engels, trumpeting their gloomy prognostications in *The Communist Manifesto* in 1848, could not have been more wrong about the fate of unskilled workers. Figure 12.1 shows a typical image of Industrial Revolution misery that somehow has worked its way into modern popular consciousness.[282] The reality is very different. By 1815 real wages in England for both farm laborers and for the urban unskilled began the inexorable rise that has created affluence for all.[283]

Nor was it even the case that the gains to land and capital initially exceeded those of labor. From 1760 to 1860 real wages in England rose faster than real output per person.[284] The innovators, the owners of capital, the owners of land, and the owners of human capital, all experienced modest rewards, or no reward,

282 A google search under the words "Industrial Revolution" and "misery" showed over 1 million pages.

283 Clark, 2001, 2005.

284 See figure 12.3 showing how wages rose as a share of national income 1760-1860. Allen, 2005, 1, states to the contrary "Between 1800 and 1840, GDP per worker rose 37%, real wages stagnated and the profit rate doubled." This result, however, is grounded on the real wage series of Feinstein, 1998. Clark, 2001, 2005 shows this to be too pessimistic. The earlier, more optimistic, real wage series of Lindert and Williamson, 1983, 1985, turn out to be accurate.

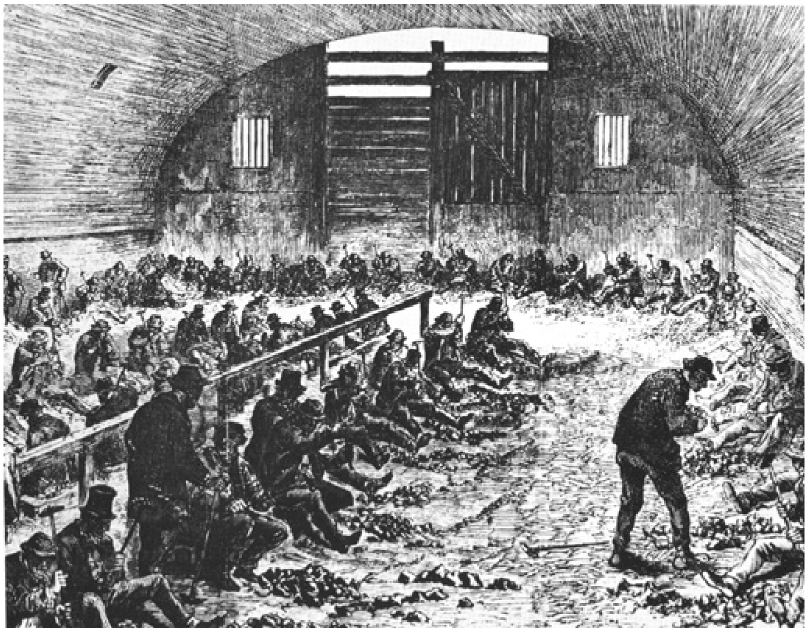

Figure 12.1 Able-bodied poor breaking stones for roads in Bethnal Green, London, 1868[285]

from knowledge advances. Thus modern growth, right from its start, by benefiting the most disadvantaged groups in pre-industrial society, particularly unskilled female workers, has reduced inequality within societies.

But while growth so far has been benign, there is no guarantee that growth will continue to promote equality within societies. We soon may face the gloomy dystopia feared by many writers, where the wages of unskilled labor drop below the socially determined "subsistence wage," and societies are forced to support permanently through the public purse a large fraction of the population.

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285 Illustrated London News, 15 February 1868.

To see why unskilled labor got the bulk of the gains from efficiency advance in the modern economy note that when more output is produced per unit of capital, labor and land engaged in production, then the average payments to these three factors of production must increase. But there is nothing in the fundamental equation of growth that describes exactly how the factors share the gains. All that must happen formally is that

$$g_A = ag_r + bg_w + cg_s$$

where g_r, g_W, and g_s, are the growth rates of the real payments to capital, labor and land. A one percent gain in efficiency must average a one percent increase in payments to the factors of production. But the equation alone allows an infinity of patterns of gains, and even of losses.

Land, in the long run, got none of the Industrial Revolution gains. David Ricardo, the first economist to focus explicitly on the distribution of income, writing in the early Industrial Revolution in the England of 1817, foresaw a future in which wages would stay at subsistence, land rents would increase, and the return on capital decline as population increased, because land was the fixed factor in production.[286] The actual future in England again could hardly be more different.

Figure 12.2 shows the real rent of farmland, the nominal rent per acre divided by the average price of goods, in England from the early thirteenth century to 2002. Real farmland rents peaked in the mid-nineteenth century, but declined since. The rent of an acre of farmland in England currently only buys as many goods as it did in the 1760s. Indeed the real earnings of an acre of land is

286 Ricardo, 1821.

little higher than in the early thirteenth century.[287] Without the Common Agricultural Policy subsidies to farmers the real earnings from land would undoubtedly be less than in the High Middle Ages.

As farmland rents declined, urban rents increased. Indeed in 2000 in England while an acre of farmland sold for an average of £2,900, an acre of building land cost £263,000, and an acre of building land with outline planning permission was worth £613,000.[288] But as figure 9.3 shows even in densely populated England, where urban site rents may be two or three times the level in most countries at this income level, they are still only about 4 percent of national income.[289]

Because there is a fixed stock of land, the failure of real rents per acre to increase much has meant that as economic output marched upward, the share of land rents in national income has correspondingly declined to insignificance (as is shown in figure 9.3). Precisely because land is in fixed supply, this result, so counter to the Ricardian expectation, is surprising, and is considered further below.

Physical capital owners also got none of the gains from growth. The real rental of capital (net depreciation) is just the real interest rate. But consider figure 8.1. It shows that the real interest rate, if anything, declined since the Industrial Revolution.

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287 This does not take into account changes in the value of urban land, where it is much more difficult to get long term measures, and where the implicit rental value may have risen by much greater amounts. But even taking this into account the conclusion would remain that very little of the productivity growth since the Industrial Revolution was collected by land owners.

288 UK, DEFRA and Department of Communities and Local Government.

289 The US Department of Defense overseas housing allowances imply the rental cost of housing in England is nearly double that of other European countries at the same income level. Thus urban site rents would be no more than 2 percent of all income in these countries.

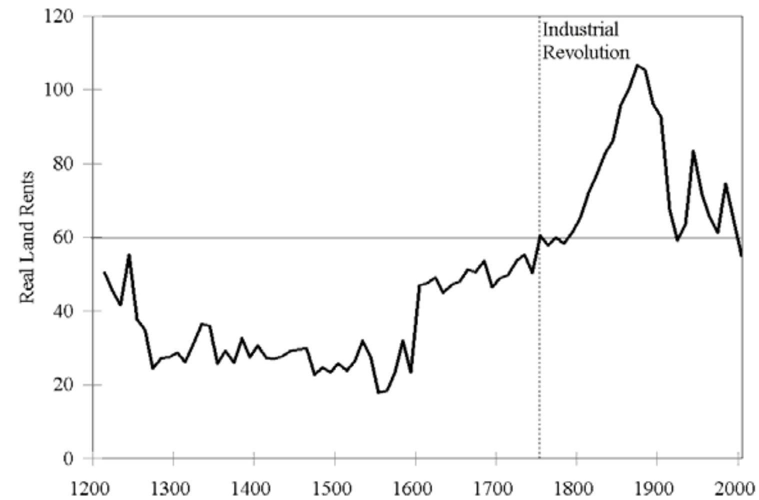

Figure 12.2 Real English Farmland Rents per acre, 1210-2000

Total payments to capital have expanded enormously since the Industrial Revolution, but only because the stock of capital grew rapidly. The stock of capital has been indefinitely expandable. It has grown as fast as output, and its abundance has kept real returns per unit of capital low. The product ag_r has been 0. Thus all the efficiency gains have shown up as wage increases. That is

$$g_A \approx bg_w$$

Since b≈0.75 every 1% efficiency advance since the Industrial Revolution has thus tended to increase wages on average by 1.3%.

We might have expected wage gains to have gone disproportionately to skilled workers with much human capital, especially since innovation and new technology was the basis of growth. But as figure 8.3 showed unskilled male wages in England have risen more since the Industrial Revolution than skilled wages, and this result holds for all advanced economies.[290] The wage premium for skilled building workers has declined from about 100 percent in the thirteenth century to 25 percent now. Figure 12.3 shows the real wages per hour for building laborers, the unskilled, in England from 1200 to 2000. The enormous gains even for these unskilled workers are very evident.

A simple interpretation of the shrunken skill premium is that it is at least partly the result of the declining rate of return to capital. The wage pattern over the lifetime for skilled workers is typically that in the earliest years they earn less than the unskilled, since they have to spend time training or working as an apprentice to acquire the skills. In the pre-industrial period parents would often have to pay a significant lump sum for a child to secure an apprenticeship. The relative supply of skilled workers will thus be influenced by the interest rate on capital. At high interest rates, such as prevailed in the medieval era, financing training by borrowing is expensive, and funds spent on training have a high return if invested elsewhere. Hence we would expect the skill premium to be higher in high interest rate societies.

Another trend is the narrowing gap between men's and women's wages. In the pre-industrial era women's wages averaged less than half men's. Even in unskilled occupations the gap was great. Women's wages as field laborers in England across the years 1770-1860 were only 43 percent those of male farm

290 Van Zanden, 2004.

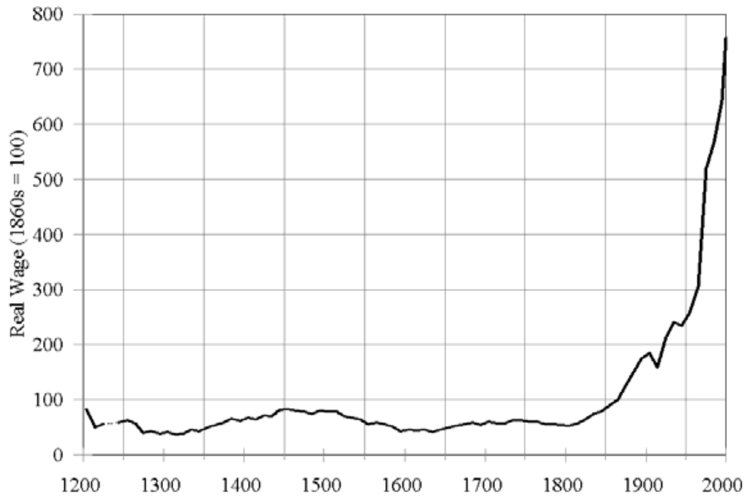

Figure 12.3 Real Building Laborers' Day Wages, 1200 to 2000[291]

laborers.[292] Now unskilled female workers in the UK earn 80 percent of the male unskilled hourly wage.[293]

The low wages of unskilled women laborers in the pre-industrial era seemingly did not reflect discrimination against women once they entered the labor market (though there was undoubtedly discrimination against training women for skilled occupations). Pre-industrial societies typically had little objection to hiring women as brute laborers. In England, for example, women show up as basic agricultural laborers, weeding grains and reaping, in the very earliest records from the thirteenth

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291 Clark, 2005.

292 Burnette, 1997. Clark, 2003.

293 UK, Annual Survey of Earnings and Hours. Office of National Statistics.

century. Where they had a comparative advantage, such as in reaping or winnowing grain, they were widely employed. In building in the medieval period, thatchers' assistants were often female, since the preparation of the straw was not a task requiring great strength. The low relative pay for women seems instead to have reflected the premium attached to physical strength in a world where humans still supplied brute strength.[294] In an era where men and donkeys were relatively close substitutes, women competed at a disadvantage.

The Industrial Revolution improved woman's economic position in two ways. First rising incomes switched the emphasis of production away from sectors such as agriculture which demanded strength towards such things as manufacturing and service industries where dexterity was more important through the operation of Engel's law. Secondly the Industrial Revolution innovations in power delivery eventually reduced the demand for humans as suppliers of brute strength. Instead skills such as dexterity, in which women had no disadvantage, became more important.

For England in the late nineteenth century we get measures of men and women's comparative productivity on some factory textile tasks such as weaving. In 1886 women cotton weavers in Lancashire averaged 82 percent of male weaver's production. The average woman in cotton textiles still only earned 68 percent of the average man, because only men were in such skilled occupations as foremen, mechanic, or mule spinner.[295] But despite these barriers to promotion, their relative wage was already an improvement on the situation in pre-industrial agriculture.

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294 Burnette, 1997.

295 Wood, 1910, 620-4.

By reducing the gap in earnings between men and women the Industrial Revolution again narrowed overall inequality in modern societies. Thus unambiguously the payment per unit of unskilled labor rose more as a result of the Industrial Revolution than the payment for land, capital, or even the payment per unit of skilled labor.

Income Inequality

While it is unambiguous what happened to the rewards of the different types of factors cooperating in production, the story as far as the distribution of income across individuals or families is more complex. For each family possesses a portfolio of unskilled labor, skilled labor, land and capital. And the amount of some of the elements in this portfolio, particularly skilled labor and capital, have expanded greatly with modern growth. Also income inequality is not something that can be measured by one number: how it is best measured depends on how important to the enquirer are income differences at different points in the distribution.

Did the Industrial Revolution increase or reduce income inequality, even before taxing and redistributing measures, on average in modern industrial societies? There is an enormous literature that debates whether there was an initial association between faster growth and inequality, the so called Kuznets Curve, in the transition out of the Malthusian state.[296] There is not room here to address that issue in any detail, though the faster growth of real wages than real income, and the stability of the skill

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296 See van Zanden, 1995, on this in Europe on the eve of the Industrial Revolution.

premium over these years suggests that rising inequality was unlikely.[297]

Instead the question addressed is just whether in the long run Malthusian economies were likely to have greater inequality than modern industrialized economies. On balance it would seem even pre-tax income is more equally distributed than in the pre-industrial world.

We saw that the payments per unit rose only for labor, and increased most for unskilled labor. But there has also been an enormous increase in the stock of physical capital per person. In all societies the ownership of capital and land tends to be highly unequal, with a large share of the population possessing no marketable wealth. Table 12.1, for example, shows the distribution of wage income in the UK in 2004 (for full time workers) compared to the distribution of marketable wealth. Despite the much greater importance of human capital in modern societies than in earlier economies, the distribution of wages is still much more equal than is the distribution of the ownership of capital. The lowest paid decile still gets about 40% of the average wage, and the highest paid decile gets less than three times the average wage. With wealth the poorest decile has none, while the richest decile has five times the average wealth per person.

Thus one crucial determinant of inequality in any society is the share of labor income in all income. The larger this is, the lower will inequality, ceteris paribus, tend to be. Figure 12.4 shows this share for England from 1750 to 2004. The share of labor in net national income seems to have risen from about 0.63 in the early eighteenth century to closer to 0.75 now. There is

297 Partly driving the idea that inequality must have increased have been indicators of living standards such as food consumption and heights that in the Industrial Revolution did not rise as much as the real wage series would imply (Mokyr, 1988, Komlos, 1998).

Table 12.1 Distribution of Wages and Wealth, UK, 2003-4[298]

Decile	Share of wages	Share of net assets
90-100	26.3	44.6
80-90	14.2	16.2
70-80	11.5	10.3
60-70	10.0	9.7
50-60	8.7	7.9
40-50	7.7	5.3
30-40	6.7	3.5
20-30	5.8	1.8
10-20	4.9	0.1
0-10	4.2	0.0

reason to believe that this trend must be general in the transition between Malthusian and the modern world. Land rents were typically 20-30 percent of income in settled agrarian societies, so that once we also allow for returns to capital it was generally the case that the share of labor in all incomes would be we lower in the pre-industrial world.

However earlier, in foraging societies which had no individual ownership of land, and almost no capital goods, labor income was essentially all income. Thus over the long stretch of human history there may well have been a type of Kuznets curve. The Neolithic Revolution, which brought settled agriculture, increased

298 The wage distribution is for full time adult workers. Wealth ownership is the assets of those deceased in 2003. UK, Annual Survey of Earnings and Hours. UK, Department of Internal Revenue, Distribution of Personal Wealth, 2003, table 13.1.

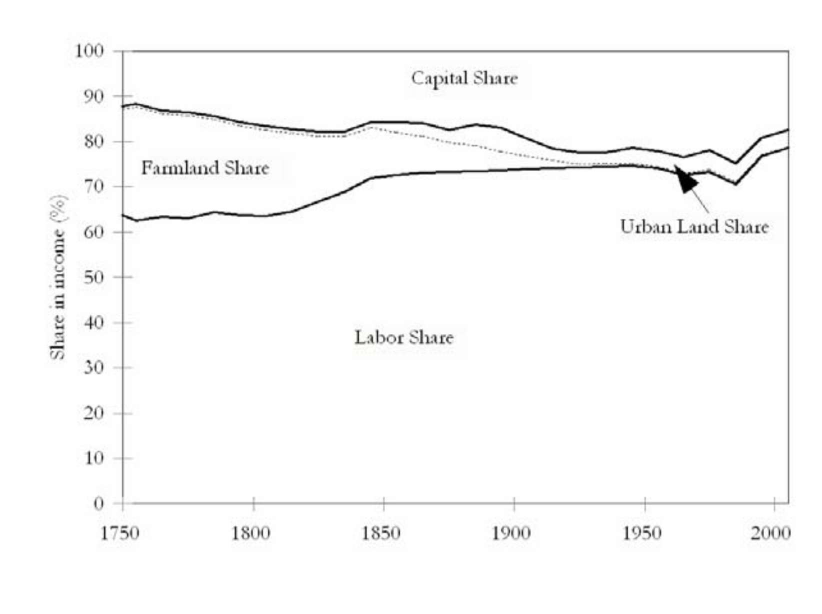

Figure 12.4 Wage, Capital and Land shares in net national income, England, 1700-2000[299]

greatly the share of assets in all income, raising inequality. But in turn the Industrial Revolution, by wiping out the value of land as an asset, has again raised the importance of labor income in income determination. Since labor, the one income source that every citizen has an equal allocation of, and the one income source that people cannot alienate, has become more important in the modern world this promotes income equality.

Further, what evidence there exists suggests that in the Malthusian world, at least in Europe, wealth inequality was greater than after the Industrial Revolution. Table 12.2 shows different measures of wealth inequality going back to 1292 for various places in Europe. These are the share of assets held by the top

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299 The urban and farmland shares derived as in figure 9.3.

Table 12.2 Pre-Industrial Wealth Distributions[300]

Place	Source	Year	Top 1%	Top 5%	Gini
Perugia[f]	Taxes	1285	18	29	0.72
Paris[a]	Taxes	1292	26	52	0.75
London[a]	Taxes	1319	34	57	0.76
Florence[b]	Taxes	1427	27	67	0.79
England (Suffolk)[c]	Estates	1630	19	50	0.83
England[d]	Estates	1670	49	73	-
England[d]	Estates	1740	44	74	-
England[d]	Estates	1875	61	74	-
UK[e]	Estates	2003	17	32	0.60

1% and 5% of households or persons, and the Gini coefficient of the wealth distribution.[301]

All these samples suggest great wealth inequality in the pre-industrial world compared to the typical industrialized country now. The earliest of these samples are household tax assessments that were based on assets in large cities such as London and Paris.

300 [a]Sussman, 2005, table 9. [b]van Zanden, 1995, table 1, 645. [c]Calculated from the sample described in Clark and Hamilton, 2006, assuming those without wills had 0 wealth. [d]Lindert, 1986, 1145. [e]Source as for table 12.2. [e]Blanshie, 1979, 603.

301 A Gini of 0 implies complete equality, and of 1 that one person owns everything.

They may show more inequality than for countries as a whole because of the special conditions of large cities.[302] But the sample of English wills c. 1630 is for a representative subgroup of the population. Since it is based on bequests it is very similar to the modern wealth inequality data for England derived by the Department of Internal Revenue. Asset inequality was greater in 1630 than in 2000, whether we measure the share of the top 1 or 5 percent, or the Gini coefficient. The estimates by Peter Lindert for the entire population of households in England in 1670, 1740 and 1875 finds even greater inequality compared to modern data.

Thus assets were a greater share of total income in the pre-industrial world, and assets were held more unequally than in recent years.

Table 12.3 focused on the position of the upper income groups and says little about the position of the unskilled wage laborer over time relative to the rest of society. Table 12.3 attempts in a crude way to measure that for England. It shows the annual pre-tax earnings of unskilled laboring couple, per adult, relative to average income per adult in the society as a whole. In 1770 and 1851 agricultural laborers were taken as representing unskilled workers. In 1770 the family of a male agricultural laborer would earn an average of £10.4 per person, assuming women were employed in the same proportion as at the 1851 census. These earnings would represent 47% of the average income per adult in the society. This ratio was unchanged by 1851, even though farm wages declined relative to urban with the great growth of English cities and the migration out of the countryside. But by 2004 a typical couple where both were

302 Van Zanden, 1995, notes that wealth inequality was less in the Tuscan countryside than in Florence in 1427.

Table 12.3 Unskilled Incomes Relative to Average Incomes, England[303]

	1770s	1850s	2004
Annual Wage, Unskilled Men	£15.4	£27.2	£16,898
Annual Wage, Unskilled Women	£6.9	£12.3	£12,516
Women/Men Workers	(0.38)	0.38	0.79
Annual Wage, Unskilled Couple, per person	£10.4	£18.5	£13,393
Average Adult (16+) Income	£22.0	£40.0	£23,452
Unskilled, Average income relative to all adults	47%	46%	57%

unskilled laborers would earn 57% of the average income per adult in the UK. Thus the poorest families seem to have improved their relative position in England as a result of the Industrial Revolution.

Inequality in Life Prospects

The material above concerns only material incomes. But other aspects of the quality of life include life expectancy, health,

303 Agricultural laborers are taken in the 1770s and 1850s as the unskilled laboring class. Earnings in 2004 from the UK, New Earnings Survey.

numbers of surviving children, and literacy.[304] In all these other dimensions the differences between rich and poor probably narrowed since the Industrial Revolution. Table 12.4 thus shows for the rich and the poor circa 1630 (except for heights) and 2000 in England the differences in heights, life expectancy, surviving children and literacy. In the pre-industrial world the rich were significantly taller than the poor. Sandhurst Cadets circa 1800 were nearly 6 cm taller than the regular soldiers of the army. By 1991 men whose origins were in professional families were only 1% taller than those from manual backgrounds. Based on the numbers of surviving children, and on adult life expectancy for testators of different asset classes, life expectancy of the poorest testators was only 31 at birth, compared to 39 for the richest, a difference of 26 percent. Further rich testators had twice as many surviving children, and nearly triple the chance of being literate. Thus the life prospects of the rich were markedly better than for the poor in the pre-industrial era.

By 2000, these differences in life prospects still existed, but were much more muted. The rich are still taller, but by very modest amounts. They still have greater life expectancy, but againby relatively much more modest amounts. The rich are more literate, but with nearly universal literacy, their advantage is again very modest. And now the rich in England had fewer children than the poor (though in some other advanced economies there was no difference between rich and poor).[305]

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304 Thus the United Nations *World Development Report* ranks countries through a *Human Development Index* which includes measures of life expectancy and education.

305 Dickmann, 2003.

Table 12.4 Life Prospects of Rich and Poor, England[306]

Period, Group	Stature (males, cm)	Life Expectancy	Surviving children	Literacy (%)
Pre-Industrial				
Rich	174.0	39	3.85	85
Poor	168.5	31	1.93	30
Difference	3%	26%	99%	183%
Modern				
Rich	178.2	80.8	1.33	100
Poor	176.0	74.3	1.64	?
Difference	1%	9%	-19%	?

Thus in terms of the general life prospects of the rich and the poor, the Industrial Revolution seems to have narrowed the differences even more than would be suggested by measures of income distribution or asset distribution alone.

306 Pre-industrial. Heights, 1790s, 1800s: poor 20-23 year old English soldiers, Komlos, 1998, 781, rich, Sandhurst cadets, adjusting heights of 15 year olds to 19 year olds by adding 11.5 cm Komlos, 2004, figure 7. 14. Life expectancy. Children, literacy based on testators c. 1630 leaving less than £25 in assets versus those leaving £1000 or more. Clark and Hamilton, 2006. Modern. Height in 1991, parent social class I and II versus social class IV and V, Power et al., 2002, 132. 1997-2001, UK, Office of National Statistics, social class I (professional) versus social class V (unskilled manual). Fertility. 1999, children in household by income, Dickmann, 2003, 17.

Why did land owners not get the gains?

Given that we had an Industrial Revolution that improved first the productivity of the industrial sector relative to the agricultural, why did land owners not benefit hugely from an increased scarcity of land as population and incomes rose rapidly after 1800, as Ricardo imagined? The reasons that land, after some initial gains early in the Industrial Revolution saw declines in real returns, are threefold.

First the income elasticity of the demand for many products intensive in land has been low. Thus the number of calories consumed per day by modern high income consumers is *lower* than for workers before the Industrial Revolution, because a major determinant of calorie consumption is the amount of physical labor people undertake.

In the pre-industrial era people supplied a lot of the power in production, whether as farm laborers digging, hauling and threshing, or as wood hewers, brick makers, metal formers and porters. In our society not only do we have machines to perform all these tasks, we also have machines to move us from house, to coffee shop, to the doors of our work places. Within these work places machines haul us up and down between floors. Thus despite our very high incomes, and relatively large stature, the average male in the modern USA consumed only about 2,700 kcal. per day, and still many have gained substantial amounts of weight. In the 1860s male farm workers in some areas of Britain, generally smaller and lighter than modern US males, consumed 4,500 kcal. per day.[307] They consumed this much because they engaged in physical labor 10 hours a day for 300 days per year. Thus as

[307] Clark, Huberman and Lindert, 1995.

incomes expanded, the demand for land in production expanded much less than proportionately.

Second there has been enormous growth in the productivity of agriculture, specifically in land saving technologies, so that despite the fixed factor land, farm output has risen faster than population.

Third the mining of fossil fuels, coal and oil principally, has provided the energy to modern societies that agriculture used to be a major provider of. By mining the energy produced by the land over eons, and stored in the ground for the ages, our society has temporarily at least expanded the land supply by enormous amounts. By the 1860s in England, for example, farm outputs were worth £114 million per year. Coal outputs by that date, valued as deliveries to consumers, were £66 million per year, so that energy from coal already added a huge supplement to the output of the agricultural sector.[308]

Technological advance and unskilled wages

We think of the Industrial Revolution as practically synonymous with mechanization, with the replacement of human labor by machine labor. Why is there still in high income economies a robust demand for unskilled labor? Why are there still unskilled immigrants with little command of English walking across the deserts of the US southwest to get to the labor markets of the major US cities because of the enormous rewards to their labor, even as undocumented workers, in these places? Why were there people camped out for months and even years at the Channel

308 Clark, 2002. Clark and Jacks, 2006.

Tunnel freight depot in northern France waiting for a chance to break through the security fence and onto a train for Britain?

Soon after the arrival of the Industrial Revolution the *Machinery Question* became a matter of debate among the new Political Economists. Would new labor saving machines reduce the demand for labor? Famously Ricardo, who had initially defended the introduction of machinery as benefiting all, by 1821 constructed a model in which some types of labor-saving machinery produce technological unemployment.[309] Ricardo's demonstration, however, relied on workers receiving a fixed subsistence wage, and it was later appreciated that as long as there are sufficient substitution possibilities between capital and labor, there will always be a positive marginal product for each type of labor, and hence the possibility of full employment.

This general reassurance from economic reasoning is of little practical value, however, since it offers no assurance on what the actual level of wages will be. Why was it that there was not only a job for all unskilled workers, but also a well paying job? After all there was a large class of employees at the beginning of the Industrial Revolution whose jobs and livelihoods largely vanished in the early twentieth century. This was the horse. The population of working horses actually maximized in England long after the Industrial Revolution, in 1901, when 3.25 million were at work. Though they had been replaced by rail for long distance haulage and for driving machinery, they still ploughed fields, hauled wagons and carriages short distances, pulled boats on the canals, toiled in the pits, are carried armies into battle. Finally the arrival of the internal combustion engine in the late nineteenth century rapidly displaced these workers, so that by 1924 there

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309 Ricardo, 1821

were less than 2 million.[310] There was always a wage at which all these horses could have remained in employment. But that wage was so low that it did not pay their feed, and certainly did not pay to breed fresh generations of horses to replace them. Horses were thus an early casualty of industrialization.

Many tasks performed by people seemed as replaceable as those of horses. And a number of human tasks were quickly mechanized. Threshing grains, the staple winter occupation which absorbed as much as a quarter of agricultural labor input was mechanized by the 1860s. Reaping and mowing followed in the later nineteenth century. But the grim future of a largely unemployable unskilled labor force has not resulted. Instead the earnings of these unskilled workers, as evidenced in figure 8.3, has risen relative to that of the skilled.

Two things seem to explain the relatively high value to the modern economy of even unskilled labor. The first is that unlike horses, people have attributes that machines so far cannot replace, or can only replace at too high a cost. The first of these is that people supply not just power, but also dexterity. We are very good at identifying objects and manipulating them in space, and machines are still surprisingly poor at these tasks. Thus the fast food industry that feeds legions of Americans every day a highly standardized product does so using human labor still to bring the meat to heat, and singed flesh to bun. Houses and hotel rooms are still cleaned by people, gardens are still weeded by human gardeners. People guide trucks and cars on highways, and they guide powered tools in farming, mining and construction. Supermarkets contain thousands of standardized packages of product,

310 Thompson, 1976, 80.

Figure 12.5 McDonalds – the foundation of an egalitarian society?

but they are still placed on the shelves by people, and priced and bundled at checkout by people. Recently there have been attempts to develop services where customers order groceries on the web and have then delivered to their homes. Some purveyors invested in large custom designed automated warehouses where machines assembled the order from the already encoded instructions of the customer and packed them in containers. These attempts were unsuccessful, however, and the surviving online grocery purveyors combine high tech ordering of the groceries with unskilled workers who pick the goods from the shelves and pack them in containers.

Ironically computers have found it much easier to replace what we think of as the higher cognitive functions of humans – calculating amounts due, calculating engineering stresses, taking integrals – than they have to replace the simple skills we think of even the most unlearned as possessing.

The second difficult to replace ability of people is our ability to interact with other people. We have a social intelligence that alerts us, at least in some part, to the thoughts and moods of others, and that ability can be very valuable in modern commerce. The increasing returns to scale inherent in most modern production processes implies that for the typical transaction the price, p, is much greater than the marginal cost, mc, the cost of producing the last unit of the good sold. That means that modern markets for industrial products, unlike the markets for farm produce in the pre-industrial era where for all goods $p = mc$, are imperfectly competitive.

The difference between price and marginal cost means that producers have an incentive to spend resources in trying to sell more product at the current price, through trying to get customers to choose your product rather than the near identical product of your competitor. Selling is a huge part of modern economies, and on the front lines in that war of commerce people are still very useful foot soldiers. A pleasant interaction with the seller can make customers choose to eat in this restaurant as opposed to that, shop here as opposed to there. Customer service agents in call centers are thus now guided by computers through a decision tree that direct them as to how to interact with customers. They are not called upon to exercise much judgment or discretion, they are just the human face of a planned strategy of interaction, but a face that is still very much necessary.

The past in this, however, is no guide to the future. As long as computer processing power keeps becoming cheaper the threat will always be present that these last scarce attributes of even unskilled human labor will lose their value. Then truly there will be a class of displaced workers forced for their subsistence to look to the charity of their fellow citizens.

While these attributes of the human machine are hard to replace, the other big change since the Industrial Revolution that has kept unskilled wages high has been the unexpected curtailment in the supply of people in the most rapidly growing economies. We saw for the Malthusian era in England that the evidence is that the more income and assets people had at the time of their death the more surviving children they had. Economic success and reproductive success went hand in hand. If this pattern had continued to the present population would have grown enormously, and the Ricardian dystopia where growth is eventually curtailed by the constraint of the fixed area of land would have been closer to realization. Below I consider these demographic changes in detail.

The Demographic Transition

Demography mattered crucially to living standards in the Malthusian era because the fixed factor, land, was an important share of national income. Any increase in population substantially reduced living standards.

After the Industrial Revolution the share of land and natural resources in national income has dropped to insignificance in the industrialized world. Demography would thus seemingly be a minor cause of the surprising shift of income to unskilled labor. Only in the poorest countries, as in sub-Saharan Africa, and in those with large natural resource endowments, such as Saudi Arabia, are population levels now important determinants of income per person.

But the small share of land in national income is plausibly the result of the fact that the income gains of the Industrial Revolution ceased to get translated into more surviving children and instead went into material consumption. Demography is now unimportant in such societies as England or the USA because of reductions in fertility. Following the Industrial Revolution there was another possible world in which much of the technological advance resulted in larger and larger populations, pressing on the resource base of the world, and eventually choking off the growth in incomes per person.

Figure 12.6 shows the course of the so called *demographic transition* in England. The figure shows two measures of fertility. The first is the gross reproduction rate, *GRR*, the average number of daughters born per woman who lived through the full reproductive span, by decade. Such a woman would have given birth to nearly 5 children all the way from the 1540s to the 1890s. Since in England 10-20 percent of each female cohort remained celibate, for married women the average number of births was close to 6.

The *demographic transition* to modern fertility rates began only in the 1890s, and then progressed rapidly. By 2000 English women gave birth on average to less than 2 children. This transition in England was similar in timing to that across a whole range of European countries at the end of the nineteenth century.

The second measure of fertility is the Net Reproduction Rate, *NRR*, the average number of daughters that would be born though their lifetime by the average female born in each decade. If the *NRR* is one, then each female born just replaces herself over the course of a lifetime. Net reproduction rates fell much less. Indeed for the average pre-industrial society the *NRR* would

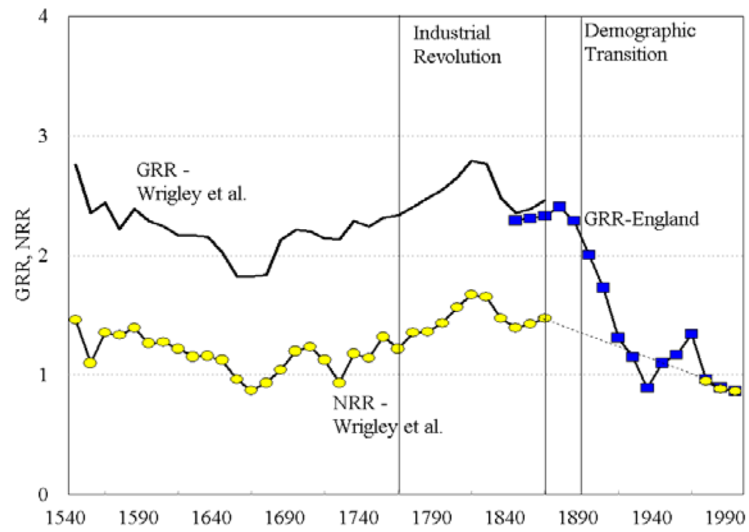

Figure 12.6 English Fertility History, 1540-2000[311]

be much closer to 1 than in prosperous pre-industrial England in the years 1540-1800. So the decline in *NRR* with the arrival of the modern world has been minimal. As we saw in the last chapter the *GRR* and *NRR* both rose in the era of the classic Industrial Revolution in England.

What triggered the switch to the modern demographic regime with few children despite high incomes? In particular was this another independent innovation, as significant for human history as the Industrial Revolution? Or was this just a delayed echo of the earlier Industrial Revolution?

The first possibility is that the general rise of incomes reduced fertility. The decline in gross fertility, the number of children born to women, is clearly correlated with income, both if we look across societies and if we look at particular societies over

311 Wrigley et al., 1997, 614. Office of National Statistics, UK.

time. This fact has led some economists, such as Gary Becker, to posit that the driving force in declining fertility was just the great gain in incomes since the Industrial Revolution.[312] That would make the *demographic transition* a mere echo of the Industrial Revolution, another consequence of the technological break from the Malthusian regime.

But if people have fewer children as incomes rise it implies that children in economic terms are "inferior" goods, in the same category, for example, as potatoes. Why do people want more housing space, more cars, and more clothes as they get richer, but not more children? Becker argued that the demand for children can be analyzed as for any commodity, as long as we are careful to note that there are two constraints on consumption. The first is the budget constraint: how much a person has to spend. The second is the time constraint: there are only 24 hours in each day with which to consume things. As incomes have risen and the budget constraint relaxed, the time constraint on consumption became ever more important. Richer consumers switched consumption away from time intensive activities towards goods that use less time. Thus as people get richer they tend to buy many time saving services, such as prepared foods or restaurant meals.

Children as a consumption item are time intensive in the extreme. Thus higher income consumers have switched consumption away from children to goods that use less time: expensive homes, fancy cars, nice clothes. Further, Becker argues, the way to measure the amount of "child services" parents consume is not just by counting the number of children. Parents can invest more or less quality in each child. As time gets more expensive for parents they choose to have fewer children measured in numbers,

312 Becker, 1981.

but children that they invest more in so that they provide more flow of services to the parents.

Figures 8.3 and 12.2, for example, which showed the hourly real wage of English building workers from 1200 to 2000 reveals that real income gains were actually modest until after the 1860s. Thus the long delay in the decline in fertility till long after the onset of the Industrial Revolution would be explicable if income drives fertility. Similarly in the modern world there is a strong negative gross fertility-income relationship across countries.

We also see in late nineteenth century England during the demographic transition a negative association between income and numbers of children born. Table 12.5 shows for 1891, 1901 and 1911 the estimated of numbers of children present in households by the occupation of the male household head. The numbers of children born in 1891 were unchanged from the pre-industrial era for low income groups, but had already fallen for the professional classes. In all the cross sections the high income group had lower gross fertility, even as by 1911 the gross numbers of children begin to fall for the poorest groups.

Income, however, certainly cannot alone explain the modern fertility decline. For we saw already for the pre-industrial period that net reproduction rates were *positively* associated with income. Even the male testators in England in 1585-1639 with wealth that would make them rich even by the standards of 1891 left nearly four children each. Their gross fertilities would be as high as for the working classes in England in the 1890s. Figure 12.7 shows surviving children as a function of wealth even up to those with assets of £1,500 or more (averaging £2,600). These assets would produce an income equivalent to about £260 a year in 1891, well above the annual earnings of about £80 per year in this period for building craftsmen, or £50 for laborers. Had income alone been

Table 12.5 Children Born per Married Man, 1891-1911, England[313]

Occupation	1891	1901	1911
Professional	4.9	4.7	3.8
Miner	6.7	6.5	5.9
Construction laborer	6.4	5.6	5.4
General laborer	6.4	6.4	5.2
Agricultural laborer	6.6	5.9	4.9

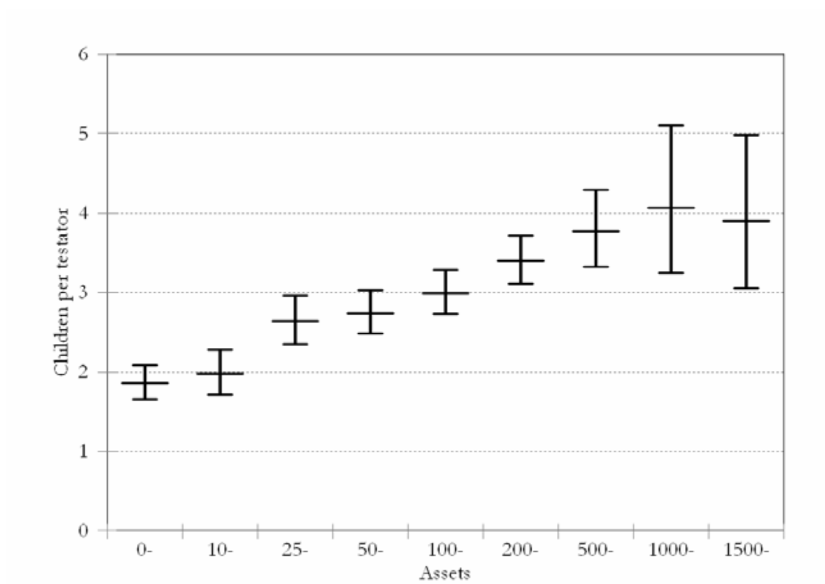

Figure 12.7 Surviving Children as a function of Wealth England, c. 1620[314]

313 Garrett et al., 2001, 291, 297.

314 The bands for each wealth class show the region within which we can be 95% confident that the true numbers of surviving children per testator lay.

determining fertility then already the rich in the pre-industrial world would have been restricting fertility.

Could the rich of the pre-industrial world have actually wanted fewer children, but been unable to achieve that desire because of a lack of contraceptive techniques? No. Figure 12.6 shows that most of the decline towards levels of gross fertility characteristic of modern developed economies was accomplished in England (and indeed elsewhere in Europe) by the 1920s, long before modern condoms, hormonal contraceptive pills, legalized abortion or vasectomies.

Using only abstinence, withdrawal, and less developed barrier methods, technologies available in England at least as early as the seventeenth century, birth rates for married women by the 1920s were reduced to less than half their previous levels. This also happened in a social environment where birth control was rarely discussed in public forums. Even more persuasively, in the late eighteenth century the French began reduced their fertility rates within marriage. Already by the 1850s they had fertility levels equivalent to England in 1901. Thus the possibility of controlling fertility existed long before the *demographic transition* of the late nineteenth century. The lack of fertility control before then was an issue more of motivation than of means.

Another indication that income alone cannot explain fertility declines is the lack of any association in modern high income economies between income and fertility. For example, for both 1980 and 2000 there was no link between household income and fertility, measured as the numbers of children present in the households of married women aged 30-42, for any of Canada, Finland, Germany, Sweden, the UK, and the USA.[315] It is only in the course of the demographic transition that we observe a

315 Dickmann, 2003, Table 2

negative income fertility relationship across income groups in a society.

An alternative possibility is that the desired number of children per married couple is actually independent of income, and was always for just two or three surviving children. But to get a completed family size of even two children in the high mortality environment of the Malthusian era required 5 or births.

Also the random nature of child deaths meant that in order to ensure a reasonable good chance of a surviving son, average family sizes had to be large. Figure 12.8 shows the distribution of the numbers of surviving sons for men leaving wills in England c. 1620. Nearly 40% of the poorest married men leaving wills had no surviving son. Even among the richest married men nearly one fifth left no son. The average rich man left four children because some families had large numbers of surviving children. Hence the absence of any sign of fertility control by richer families in pre-industrial England may stem more from the uncertainties of child survival in the Mathusian era. With a greater fraction of child deaths the variance of resulting family sizes at an average completed family size of two children would necessarily be greater. As the fraction of children surviving increased risk-averse families could afford to begin limiting births.

In the late nineteenth century child mortality in England had fallen substantially from the levels of the eighteenth century, and the rate of that decline was strongly correlated with income. For families living in homes with ten or more rooms only 13% of children failed to reach age 15, while for those in one room still47% of children failed to reach that age.[316] Thus the lower gross fertility of high income groups at the end of the nineteenth century portrayed in table 12.5 translates into a more muted

316 Haines, 1995, 303.

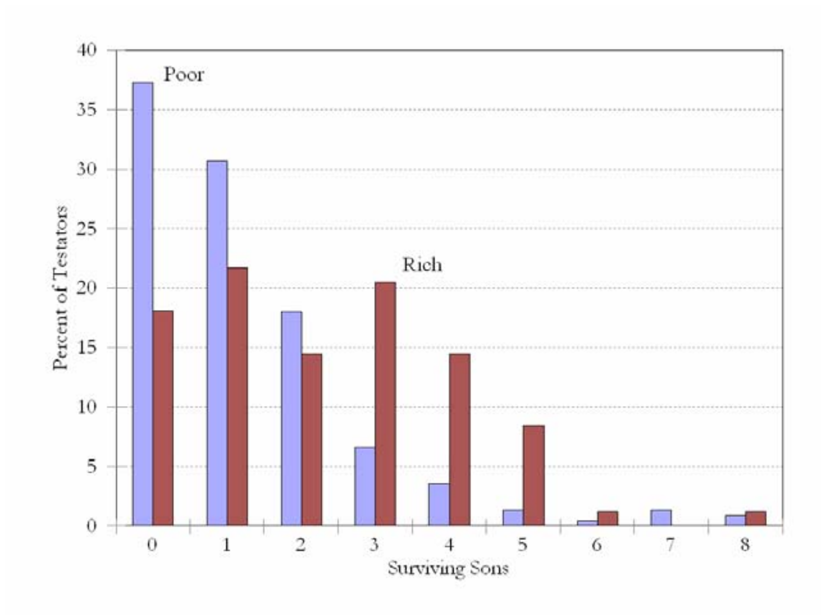

Figure 12.8 Percentage of men with each number of sons, England, 1585-1638.

decline in net fertility amongst higher income groups. And these groups faced a substantially reduced variance in family size outcomes compared to low income groups.

Another possible element in the decline of fertility since the Industrial Revolution is also the increased social status of women. Men may well have had greater desire for children in pre-industrial society than women. Women, not men, bore the very real health risks of pregnancy, and did most of the child rearing. But typically men had a much more powerful position within the family. Thus women may always have desired smaller numbers of surviving children than men, but only been able to effectuate those desires in the late nineteenth century.

Women's relative status and voice was clearly increasing in the late nineteenth century in England. Literacy rates for women had advanced to nearly equality with those of men in the late nineteenth century. Women had gained access to universities by 1869, enhanced property rights within marriage by 1882, votes in local elections in 1894, and finally a vote in national elections in 1918. The gain in the relative status and voice of women also proceeded most rapidly among higher income groups.

These assumptions could explain why net fertility falls after the late nineteenth century even though in cross section in the sixteenth century and in 2000 there is either a positive connection between income and net fertility or no connection. They could also explain why the demographic transition appeared first in the higher socio-economic status groups, so that net fertility is negatively related to income in the transition period.

Why did Capital owners not gain more?

Chapters 9 and 10 showed why innovators have from the Industrial Revolution on generally collected little of the productivity advance their innovations produced. The returns to capital employed in industrial production have often exceeded the competitive market return on capital. But the presence of these higher returns seems to owe more to the ability of some firms to create barriers to entry to their sector, than to the existence of rapid productivity growth in the sector. These entry barriers generally have little to do with technological advances. They owe more to factors such as increasing returns to scale, or the ability through advertising to create brand images.

Productivity growth in cotton textiles in England from 1770 to 1870, for example, far exceeded that in any other industry. But the competitive nature of the industry, and the inability of the patent system to protect most technological advances, kept profits low. Cotton goods were homogenous. Yarn and cloth sold in wholesale markets where quality differences were readily perceptible to buyer. The efficient scale of cotton spinning and weaving mills was always small relative to the market. New entrants abounded. By 1900 Britain had about 2,000 firms in the industry. Firms learned improved technique innovating firms through hiring away their skilled workers. The machine designers learned improved techniques from the operating firms. Thus the entire industry – the capital goods makers and the product producers - over time clustered more and more tightly in the Manchester area. By 1900 40% of the entire world output of cotton goods was produced within 30 miles of Manchester. The main beneficiaries of this technological advance thus ended up being two parties: consumers of textiles all across the world, and the owners of land in the cluster of textile towns which went from being largely worthless agricultural land to valuable building sites.

The greatest of the Industrial Revolution cotton magnates, Richard Arkwright, is estimated to have left £0.5 m. when he died in 1792. His son, also Richard Arkwright, inherited his father's spinning mills. But though his son had managed his own mills and had much experience in the industry which was still showing rapid productivity growth, he soon sold most of his father's mills, preferring to invest in land and government bonds. He did well at this leaving £1.5 m when he died in 1830 despite sinking much money into a palatial country house for his family. But Arkwright Senior accumulated less wealth than Josiah Wedgwood, who left £0.6 m in 1795, even though Wedgwood operated in a sector, pottery, which had far less technological progress (potteries were still hand enterprises by and large even in the late 19th c).

Though the first great innovations of the Industrial Revolution era did not offer much in the way of supernormal profits because of the competitive nature of the industry, the second, railroads seemed to offer more possibilities. Railways are a technology with inherent economies of scale. At minimum one line has to be built between two cities, and once it is built a competitor has to enter with a minimum of a complete other line. Since most city pairs could not profitably support multiple links, exclusion, and hence profits, thus seemed possible.

The success of the Liverpool-Manchester line in 1830 – by the 1840s equity shares on this line were selling for twice their par value - inspired a long period of investment in railways. Figure 12.9 shows the rapid growth of the railway network in England from 1825 to 1869, by which time more than 12,000 miles of track had been laid across the tiny area of England. This investment and construction was so frenetic that so called *railway manias* struck in 1839 and 1846.

But again the rush to enter quickly drove down profit rates to very modest levels, as table 12.7 shows. Real returns, the return on the capital actually invested, by the 1860s were no greater than for very safe investments in government bonds or agricultural land. While railway lines had local monopolies, they ended up in constant competition with each other through roundabout routes. Thus while, for example, the Great Western may have controlled the direct line from London to Manchester, freight and passengers could cross over through other companies to link up with the East Coast route to London. Again profits inspired imitation which could not be excluded and the profit was squeezed out of the system. Consumers were again the main beneficiaries.

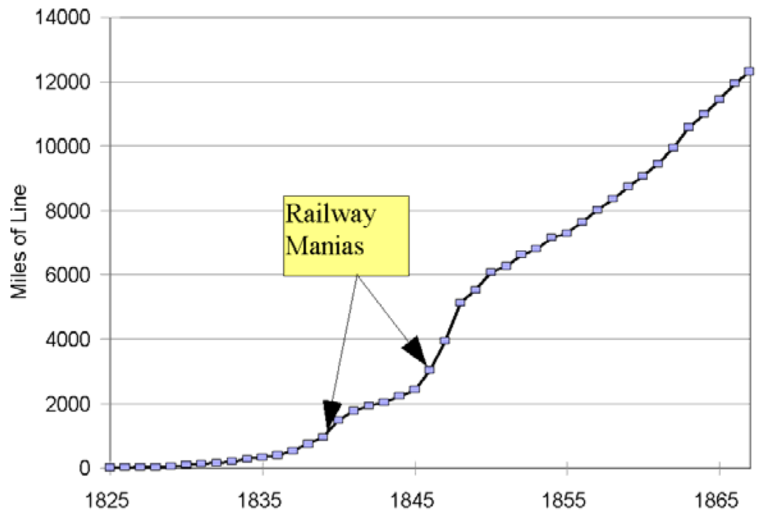

Figure 12.7 English Railroad Construction, 1825-1869[317]

Table 12.7 Profit Rates on the Capital Invested in British Owned Railways, 1860-1912[318]

Period	Rate of Return, UK (%)	Rate of Return, British Empire (%)	Rate of Return. Foreign Lines (%)
1860-9	3.8	-	4.7
1870-9	3.2	-	8.0
1880-9	3.3	1.4	7.7
1890-9	3.0	2.5	4.9
1900-9	2.6	1.6	4.4
1910-13	2.6	3.1	6.6

317 Mitchell and Deane, 1971, ----.
318 Edelstein, 1982, ----.

It is for this reason that in Britain, unlike in the USA, there are very few universities and major charities funded by private donors.[319] The Industrial Revolution did not result in great individual or family fortunes in England. By the 1860s the rich were still by and large the descendants of the landed aristocracy. Of 379 men dying between 1860 and 1879 in Britain who left at least £0.5 million, 256 (68%) owed their wealth to inherited land. Only 17 (4%) were textile magnates, despite textiles being the driving industry in Industrial Revolution productivity advance.[320]

The lack of any inherent connection between more rapid technological advance and the generation of supernormal profits by firms, with consumers instead gaining most of the benefits of technological advance, again explains the equalizing tendencies of growth since the Industrial Revolution.

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319 For some reason the industrialization of the United States created much greater private and family fortunes.

320 Rubinstein, 1981, 60-7.

13 The Great Divergence. World Economic Growth, 1800-2000

> *The bourgeoisie, by the rapid improvement of all instruments of production, by the immensely facilitated means of communication, draws all, even the most barbarian, nations into civilization. The cheap prices of commodities are the heavy artillery with which it forces the barbarians' intensely obstinate hatred of foreigners to capitulate. It compels all nations, on pain of extinction, to adopt the bourgeois mode of production; it compels them to introduce what it calls civilization into their midst, i.e., to become bourgeois themselves. In one word, it creates a world after its own image (Marx and Engels, 1848).*

By the mid nineteenth century the efficiency of the English economy was clearly growing at an unprecedented pace. That this improvement in efficiency was based on knowledge creation, rather than physical capital accumulation or natural resource exploitation, seemed to imply the rapid worldwide spread of the techniques and industries of the Industrial Revolution. For while developing knowledge is an arduous task, copying the inventions of others can be easy. In particular, the new technologies of the classic Industrial Revolution were not sophisticated. Thus they were quickly transmitted to other European countries, despite British bans on exports of machinery and of artisans.

The increasing prosperity and economic power of Britain impressed both foreign governments and individuals, especially since it went along with growing military and political power. Thus there were soon both individual and government attempts to import the new British technologies. A series of eighteenth century Parliamentary Acts restricted the export of artisans, machinery, plans, or models in the textile and other industries. Only after 1825 were artisans free to work abroad, and only after 1842 were machinery exports deregulated.[321] But England still swarmed with foreign dignitaries, industrial spies, adventurers, and prospective manufacturers doing the rounds of the mills, foundries, factories, mines and railways. Skilled workers were regularly propositioned with promise of riches abroad. Despite the difficulties of travel, and the language and cultural barriers, thousands responded.[322] Canute probably had as much success in holding back the tide as did British governments in protecting Industrial Revolution trade secrets.

Table 13.1 quantifies the rapidity of the spread of cotton mills, Watt type steam engines, and steam railways to other countries. The table shows the time in years between the introduction of the new technique in England and its first known use in other countries. Clearly there was a diffusion lag. For western European countries it was in the order of 13 years. For eastern and southern Europe more like 22 years: India 35 years, Latin America 52 years. Such lags would translate into moderate differences in the efficiency levels of economies. At the rates of efficiency advance for England in the Industrial Revolution era even a county such as India would have an income per person that was only 17 percent less than in England as a result of the delay in acquiring the most up to date techniques.

But in the nineteenth century the advance of technology operated particularly on the speed of travel of information and on the cost of travel of goods. Thus there was every hope that by

321 Henderson, 1965, 4, 139-41.

322 It was estimated that by 1824 there were perhaps 1,400 British artisans in France alone. Henderson, 1965, 141f.

Table 13.1 Time Lags in the International Diffusion of Innovations[323]

Country	Cotton Mill 1771	Watt Engine 1775	Steam Railway 1825
Ireland	19	15	9
France	7	3	7
Germany	13	8	12
Netherlands	24	10	14
Belgium	28	16	10
Switzerland	23	49	22
U.S.A.	20	28	5
Austria	30	42	13
Hungary	-	28	21
Spain	-	7	23
Portugal	-	28	31
Italy	-	12	14
Sweden	-	23	30
Russia	22	23	11
Denmark	-	29	19
Canada	-	36	11
Brazil	75	35	29
Mexico	64	43	48
India	46	30	28

the late nineteenth century the world was sufficiently globalized that diffusion lags would drop rapidly, and industrialization proceed in the even the poorest countries.

323 The table gives the time to the first use found by a survey of the literature. More rapid adoption is possible. Watt Engine: Robinson, 1974, Tann and Brechin, 1978. Cotton mill: Clark, 1987. Steam railway: Mitchell, 1995, 1998a, 1998b.

The Instruments of Globalization

In the course of the late eighteenth and nineteenth century there were a series of technological, organizational and political developments that seemed to imply the coming integration of all countries into a new industrialized world.

The technological changes were the development of railways, steamships, the telegraph, the mechanized factory. The organizational change was the development of specialized machine building firms in Britain, and later the USA, whose business was the export of technology. The political changes were the extension of European colonial empires to large parts of Africa and Asia, and internal political developments within Europe.

The world before 1800 was one in which information and people traveled at astonishingly slow speeds. We have a nice example of the speed of information flow for the later Roman Empire, for example, from the work of Richard Duncan-Jones. Legal documents in Roman Egypt under the Empire listed both the calendar date and the name of the reigning emperor. When the emperor changed in Rome there was thus a period when legal documents Egypt had, incorrectly, the name of the previous emperor. The length of this period indicates how long it took information to get to Egypt.[324] The estimated average transmittal time, shown in table 13.2, was 56 days. Thus along the major trade of the Roman Empire information flowed at an average speed of 0.7 miles per hour.

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324 Since few documents survive for each transition between emperors, the first document with the correct name of emperor provides just an upper bound on the transmittal time. Equally the last document with the wrong Emperor name gives a lower bound. The mean of these two estimates gives an unbiased estimate of the true transmittal time.

Table 13.2 The Speed of Travel of Information in the Mediterranean[325]

Period	Journey	Distance (miles)	Days	Journeys	Speed (mph)
54-222	Italy-Egypt	1,323	56	23	1.0
1500	Damascus-Venice	1,514	80	56	0.8
1500	Alexandria-Venice	1,366	65	266	0.9
1500	Lisbon-Venice	1,189	46	35	1.1
1500	Palermo-Venice	507	22	118	1.0

We also have estimates of travel speeds in the Mediterranean circa 1500 from the diaries of Venetians. These show the days between events occurring elsewhere, and a report of them appearing in a Venetian diary. The speed of information travel is very similar to Imperial Roman times.

Thus in the Malthusian era people lived in a world where information spread so slowly that many died fighting in battles for causes that were already decided. The Battle of New Orleans, fought January 8, 1815 between the British and the Americans, and resulting in 1,000 deaths, occurred because neither commander knew that the Treaty of Ghent had concluded a peace between the countries on December 24. The British commander, who had moved on to take Biloxi, heard the news only on February 13.

325 Distance is calculated along the great circle. Duncan-Jones, 1990, 7-29.

Information flows were not much faster in 1800 than in the classical world. The Times of London reported Nelson's triumph at the Battle of the Nile on August 1, 1798 only on October 2, 62 days later: the news traveled at 1.5 miles per hour. Nelson's victory over the French and glorious death at Trafalgar off the Portuguese coast on October 21, 1805 was first reported in the Times 17 days later: a transmission speed of 2.7 miles per hour. Table 13.3 gives a general tabulation of how long it took news of events elsewhere in the world in the nineteenth century to reach the Times of London. By the early nineteenth century information flowed at somewhat faster rates than in the Classical and Medieval worlds. But news could still take 6 months to reach Britain from India.

In mid nineteenth century the introduction of the telegraph in 1844, and particularly the later undersea telegraph cable, changed by a factor of nearly 100 the speed of travel of information. In 1851 the first submarine telegraph cable was laid the short distance between France and England. The dramatic technical feat was the establishment in 1866 of a successful undersea transatlantic telegraph service.[326] By 1870 India was linked to Britain by telegraph, partly over land and partly submarine, which could transmit messages in 24 hours. This explains the explosion in the speed of information transmission witnessed in table 13.3 between 1858 and 1881.

The costs of carriage for goods also declined dramatically in the nineteenth century, both on land and across sea. Table 13.4 shows the miles of railroad completed in selected countries by 1850, 1890, and 1910. The great expansion of the rail network in the late nineteenth century, even in countries otherwise little

[326] An earlier cable laid in 1858 failed.

Table 13.3 The Speed of Travel of Information to London, 1798 to 1914[327]

Event	Year	Days till report	Distance (miles)	Speed (mph)
Battle of the Nile	1798	62	2,073	1.4
Trafalgar	1805	17	1,100	2.7
Earthquake, Kutch, India	1819	153	4,118	1.1
Treaty of Nanking	1842	84	5,597	2.8
Charge of the Light Brigade, Crimea	1854	17	1,646	4.0
Indian Mutiny, Delhi Massacre	1857	46	4,176	3.8
Treaty of Tien-Sin (China)	1858	82	5,140	2.6
Lincoln Assassination	1865	13	3,674	12
Assassination of Archduke Maximilian, Mexico	1867	12	5,545	19
Assassination of Alexander II, St Petersburg	1881	0.46	1,309	119
Nobi Earthquake, Japan	1891	1	5,916	246

affected by the Industrial Revolution such as Russia and India, improved communication immensely.

Ocean transport was similarly revolutionized in this period by the development of faster, more cost-effective, ocean steamships. Already by the 1830s steam ships were speedier and more reliable than sailing ships, but they were used only for the most valuable

327 Distances calculated as great circle distance.

Table 13.4 Railway Mileage Completed (000 miles)[328]

	1850	1890	1910
Britain	6.1	17	20
USA	9.0	208	352
Germany	3.6	27	38
France	1.8	21	25
Russia	0.3	19	41
India	0.0	17	33

and urgent freight such as mail. Their high coal consumption limited the amount of cargo they could carry. To sail from Bombay to Aden in 1830 the *Hugh Lindsay* "had to fill its hold and cabins and pile its decks with coal, barely leaving enough room for the crew and the mail." [329] The liner *Britannia* in the 1840s required 640 tons of coal to cross the Atlantic with 225 tons of cargo. Thus even in the 1850s steam power was used only for perishable cargoes, and only then even on some routes. [330]

But in the 1850s and 1860s four innovations lowered the cost of steam ocean transport: the screw propeller, iron hulls, compound engines, and surface condensers. Screw propellers translated power into motion in the water more effectively. Iron hulled boats were 30-40% lighter and gave 15% more cargo capacity for a given amount of steam power. Compound engines converted coal into mechanical power more efficiently. Surface condensers

328Mitchell, 1995, 1998a, 1998b.

329 Headrick, 1988, 24.

330Headrick, 1988, 24.

conserved on water. Previously ocean steamships had to use seawater to make steam which produced corrosion and fouling of the engine.

These last two innovations greatly reduced the coal consumption of engines per horse-power-hour. In the 1830s it took 10 pounds of coal to produce one horse-power-hour, but by 1881 it was down to 2 pounds. This directly reduced costs, but since it also allowed ships to carry less coal and more cargo there was a further reduction in costs.[331]

Steamship speeds also increased. On the Atlantic the *Great Western* in 1838 had a maximum speed of 10 miles per hour. By 1907 the *Mauretania* could make 29 miles per hour, nearly three times as fast.[332]

Finally the completion of first the Suez Canal in 1869, and then the Panama Canal in 1914, greatly reduced distances on some of the major ocean routes. The Suez Canal saved 41% of the distance on the journey from London to Bombay, and 32% of the distance on the journey from London to Shanghai. It thus brought substantially closer the markets of the two great population centers in the nineteenth century, Europe and Asia.

The result of these technological changes was a substantial decline in real ocean transport costs by 1900. In 1907, for example, it cost £0.4 to carry a volume ton of cotton goods by rail the 30 miles from Manchester to Liverpool, but only £0.9-1.5 to ship those goods the 7,250 miles from Liverpool to Bombay.[333] Since a volume ton of cotton textiles at that time would have a value of about £80, these costs represented a mere 2 percent of the value

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331 Headrick, 1988, 24-31.

332 Kirkaldy, 1914, Appendix XVIII.

333 A volume ton was 50 cubic feet. For textiles that weighed 12 cwt.

Table 13.5 Transport Costs from England in 1907, Cotton Goods[334]

From	To	Ocean distance (miles)	Cost per 40 ft^3 (£)
Manchester	Bombay	6,851	0.93
Manchester	Calcutta	8,751	1.50
Birkenhead	Shanghai	11,676	1.66
Birkenhead	Japan	12,461	1.66
Manchester	Buenos Ares	6,844	1.75
Liverpool	Sydney	12,366	1.78
Liverpool	Java	9,441	1.88
Birkenhead	Manila	10,667	2.08
Liverpool	Cape Town	6,663	2.12
England	Lagos	4,199	2.25
Manchester	Limon (Costa Rica)	5,337	2.38
England	Valparaiso	8,060	2.50
Manchester	Rio de Janeiro	5,577	3.25

of the product.[335] In comparison the rate for cotton goods carried from Bombay to London by the East India Company in 1793 was £31 per ton.[336] In terms of day wages shipping costs to the East were only 2% the level of 1793 by 1906. Much of this decline in costs, however, was achieved by the 1840s, with sailing vessels and

334 Transport costs, Parliamentary Papers, 1909. Distances between ports from U.S. Naval Oceanographic Office "Distances Between Ports", publication 151.

335 Deane and Cole, 1967, 187.

336 MacGregor, 1850, 389. It is not clear if this was a weight or volume ton.

before the Suez Canal opened. In the 1840s it cost £3.6 per ton to ship a volume ton of goods from Calcutta to England.[337]

By the late nineteenth century industrial locations with good water access which were on well established shipping routes – Bombay, Calcutta, Madras, Shanghai, Hong Kong – could get access to all the industrial inputs of Britain at costs not too much higher than many firms in Britain. Table 13.5 shows, for example shipping costs per ton for cotton goods from English ports to various destinations in 1907. By 1907 production of goods like cotton textiles was feasible anywhere in the world close to an ocean port.

Figure 13.1 shows the costs of another important industrial input, energy, measured as coal costs at various ports around the world, standardized to the price of Welsh steaming coal. The low shipping costs meant that British coal was available in a surprising range of ports across the world. The dark squares in the figure show places where British coal was available. In 1907 steamers at such distant locations as Singapore, Colombo, Alexandria, Buenos Ares, and Istanbul could fuel using English coal. Coal costs were higher in many countries than in northern Europe and the USA, but the range of costs for such a heavy material as coal, found in such uneven distribution across the world, was remarkably small: little more than 2:1.

The last of the great technological changes of the nineteenth century was the introduction of the mechanized factory. Industrial production before the Industrial Revolution was generally directed by many skilled artisans who learned their crafts

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337 McGregor, 1850, 917. O'Rouke and Williamson 2002a, 2002b, argues that from 1500-1800 transport cost declines between Asia and Europe were minimal, the gains in trade volume being largely a function of increased European demand.

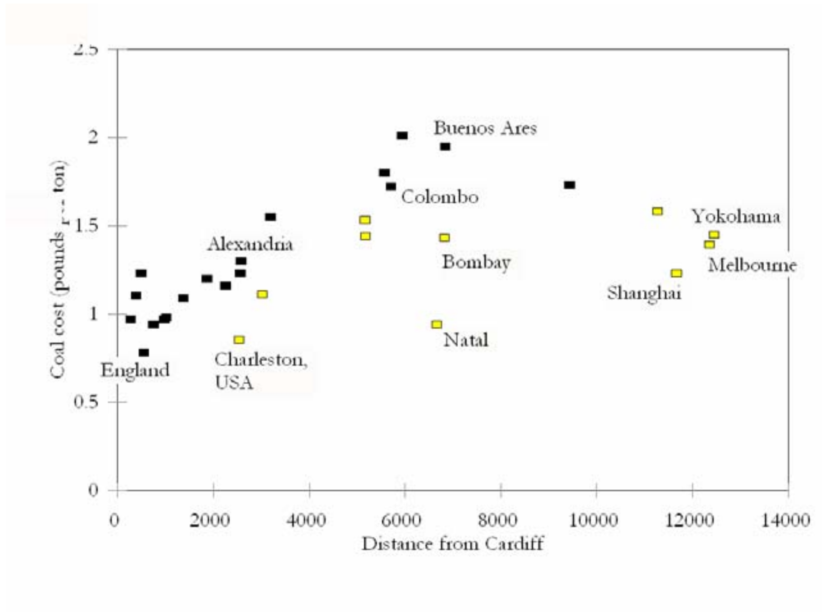

Figure 13.1 Steam coal costs at world ports, 1907[338]

through personal apprenticeships. In the pre-industrial period when countries wanted to acquire new industries they generally had to recruit whole communities of foreign artisans. The French in the 1660s even went so far as to abduct a group of Swedish iron workers in hopes of having them establish an iron industry.[339]

The Industrial Revolution textile industry was revolutionary in its rate of productivity advance. But it was also revolutionary in its ability to employ, with minimal skilled supervision, large numbers of unskilled, untrained and short term workers. The replacement of skilled lifetime workers by cheaper forms of labor did not occur at once, and was not completely possible until the development of the ring spindle in the late nineteenth century. But all through the nineteenth century adult males, traditionally

338 Parliamentary Papers, 1909.
339 Cipolla, 1972, 50-1.

the most expensive and intractable form of labor, were less than 30% of cotton textile operatives, even in Britain where skill-intensive mule spinning predominated.[340] By the late 1930s for example, when the Japanese cotton spinning industry had labor productivity levels not much below that of Britain, the labor force in Japan was 88.5% female, and the average female cotton operatives was 17 years old, and had 2.3 years experience in the industry.[341]

The ability of the textile industry to keep operative skills, education, and supervision requirements to a minimum is well illustrated by ring spinning. This was a spinning technique developed in the nineteenth century which succeeded in part because it minimized worker skills. Since then ring spinning operatives have performed exclusively the following five tasks:

Piecing. Twisting together the broken pieces of thread when a break occurs in the spinning process.

Creeling. Replacing the bobbins that supply the unspun cotton to the ring spindle.

Cleaning. Wiping away tufts of loose cotton fibers which accumulate on the spinning frames.

Doffing. Removing the full bobbins of spun yarn and replacing them with empty bobbins. This is normally done at regular planned intervals by specialized squads of doffers.

Patrolling. Walking around the machines inspecting for spindles in need of operations 1 to 3.

Work organization was extremely simple. Each spinner (*piecer* in India) was assigned a set of spindles. During their shift the spinner walked around the set of spindles on the same path. Each spindle was inspected to see if it needed piecing, creeling or

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[340]Deane and Cole, 1967, 190.
[341]Shindo, 1961, 233-6.

cleaning. If so the task was performed. Spinners needed no literacy, or even any special strength or dexterity. Nor did they need to plan ahead. They merely proceeded from spindle to spindle doing whichever of the three tasks is necessary.

The foreman could check if operatives have been diligent simply by periodically counting how many of the spindles under their care were stopped (in the terminology of the industry, how many *ends* were down), and comparing that with the rate for other operatives. If it was high the operative was not creeling, piecing and cleaning diligently.

The tasks in other parts of spinning industry mainly had exactly the same character. It was for these reasons that the textile industry was hailed by some, and reviled by others, as the precursor of a new industrial order where work would be machine regulated and machine paced.

Thus while the sophistication of technology was increasing after the industrial revolution, for many production processes the tasks, by design, were simplified and routinized. Technology might be designed by the countries with high levels of education after the Industrial Revolution, but much of it was seemingly well fitted for employment in poor economies such as India and China.

Added to the various technological ways in which world industrialization was been seemingly hastened were organizational changes that made diffusion of technologies easier.

In the early nineteenth century the heroic age of innovation by the lone inventor ended, and a specialized machine building sector developed within the Lancashire cotton industry. These machinery firms had an important role in exporting textile technology. As the rate of growth of the English industry slowed in the late nineteenth century British machine makers looked abroad for markets. The textile machinery makers Platts, for example, exported at least 50% of their production as early as 1845-1870. Such capital goods firms were able to provide a complete "package" of services to prospective foreign entrants to the textile industry. The package included some or all of technical information, machinery, construction expertise, and the supply of managers and skilled operatives. By 1913 the six largest machine producers in textiles employed over 30,000 workers mainly producing for the world market.[342] These firms reduced the risks to foreign entrepreneurs by such practices as selling machines on a trail basis, and undertaking to supply skilled workers to direct operations and train the local labor force.

Table 13.6 shows a sample of the number of orders for ring spinning frames Platt took, where each order typically involved numbers of machines, in each of the periods 1890-1914 and 1915-1934. For ring frames England was a small share of Platt's market throughout these years.

Similar capital goods exporters developed in the railway sector, and later in the U.S. in the boot and shoe industry. In the railways British construction crews completed railways in many foreign countries under the captainship of such flamboyant entrepreneurs as Lord Brassey.[343] The reason again for the oversees exodus was in part the saturation of the rail market within Britain by the 1870s after the boom years of railway construction. By 1875 in a boom lasting just forty-five years 71% of all the railway line ever constructed in Britain was completed. As table 13.4 shows thereafter the major markets for British contractors and engine constructors were overseas. India, for example, got most of its railway equipment from Britain, and the

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[342] Bruland, 1989, 5, 6, 34.

[343] Brassey built railways in Britain, France, the Netherlands, Prussia, Austria, Spain, Italy, Canada, India, and in South America.

Table 13.6 Platt Ring Frame Orders by Country, 1890-1936[344]

Country	Sales, 1890-1914 (9 years)	Sales, 1914-1936 (9 years)
Austria	4	0
Belgium	17	15
Brazil	95	43
Canada	15	17
China	5	64
Czechoslovakia	14	10
Egypt	0	5
England	110	74
Finland	1	0
France	41	31
Germany	47	6
Guatemala	1	1
Hungary	0	4
India	66	132
Italy	69	29
Japan	66	117
Mexico	75	7
Netherlands	7	2
Nicaragua	2	0
Peru	7	0
Poland	41	8
Portugal	8	0
Russia	131	23
Spain	95	35
Sweden	3	0
Switzerland	3	0
Turkey	0	6
USA	2	0
West Africa	0	2

344 Lancashire Record Office, Platt Ring Frame Order Books.

Indian railway mileage by 1910 was significantly greater than that of Britain.

The final set of developments in the nineteenth century that should have speeded world industrialization was political. The most important of these was the expansion of European colonial territories. By 1900 the European states controlled as colonies 35% of the land surface of the world, even excluding from this reckoning Asiatic Russia. Of a world area of 58 million square miles Europe itself constitutes only 4 million square miles, but by 1900 its dependencies covered 20 million square miles. The British empire was the largest covering 9 million square miles, the French had nearly 5 million square miles, The Netherlands 2 million square miles, and Germany 1 million square miles.

Even many countries formally independent were forced to cede trading privileges and special rights to Europeans. Thus at the conclusion of the First Opium War in 1842 China, by the Treaty of Nanjing, was forced to allow European imports, including opium, at low tariff rates, to allow foreign residence in treaty ports such as Shanghai, and to concede Hong Kong to the British. Further conflicts resulted in more Chinese defeats, and the creation of what was essentially an international city in Shanghai.

Despite the many unpleasant aspects of imperialism, as a force for world industrialization it would seem to have been all good. Foreign entrepreneurs investing in independent countries always faced the danger of expropriation if local political conditions changed. The political control by countries such as Britain of so much of the world by the later nineteenth century allowed European entrepreneurs to export machinery and techniques to low wage areas with little risk of expropriation.

The most important colonial empire was the British, whose major possessions by the end of the nineteenth century included most of India, Pakistan, Burma and Sri Lanka, South Africa, and Egypt. The nature of British imperialism also ensured that no country was restrained from the development of industry, up until 1918, by the absence of a local market of sufficient size. Because of the British policy of free trade Britain itself, and most British dependencies, were open to imports with no tariff or else a low tariff for revenue purposes only.

In cotton textiles, the major manufacturing industry of the world before 1918, table 13.7 shows the major net exporters and importers of cotton yarn and cloth in the international market of 1910. India, the largest market, was served almost exclusively by English mills, but was in fact open to all countries with the only barrier a 3.5% revenue tariff on imports. Even this impediment had been balanced by a countervailing tax applied to local Indian mills, at the insistence of Manchester manufacturers. The Chinese market, the next largest, by the fiat of the Imperial powers, was protected also by only a 5% ad valorem revenue tariff. Australia also maintained an ad valorem tariff of only 5%, having no domestic industry to protect.

Thus in 1910 the total size of the open cotton textile market was in the order of $400 m., a quarter of world production. This market would be enough to sustain 35 m. spindles and 400,000 looms. In 1910 the British industry, the largest in the world, had only 55 m. spindles and 650,000 looms in operation. The total stock of spindles in the world was only 135 m. By the early twentieth century a vast market for cotton textile products was open to any entrant in the industry.

The pre World War I *Pax Britannica* was also a major element in reducing transport costs on the oceans. Prior to the nineteenth century shipping rates were often driven up by armed conflicts and by piracy. The supremacy of the British navy, and its mandate

Table 13.7 Net Exports of Cotton Yarn and Cloth, 1910[345]

Country	*All*	*Yarn, thread*	*Gray woven*	*Colored*
Major Exporters ($ m.)				
UK	453	83	100	270
Japan	26	22	5	–1
Italy	24	4	3	17
France	23	–3	4	22
Germany	15	–11	–3	29
Major Importers ($ m.)				
British India	–100	18	–53	–65
China	–81	–41	–11	–30
Argentina	–29	–3	–1	–25
Australia	–25	–2	–1	–22
Ottoman Empire	–20	–1	–7	–11
Egypt	–18	–1	–17	
Canada	–12	–2	–1	-9
Brazil	–11	–2	0	–9

to keep sea lanes open for trade, ensured that military conflicts were rarely a barrier to commerce and piracy was banished from the seas.

British imperialism thus seemed to contain the seeds of its own downfall. It had created across Asia and the Middle East, giant new coastal cities such as Alexandria, Bombay, Madras,

345 Other large net importers were Romania (–10), Chile (–9), Algeria (–9), British South Africa (–8), Venezuela (–4), Bulgaria (–4). United States, Tariff Board, 1912, Vol. 1, Appendix A, pp. 212-18.

Calcutta, and Shanghai that enjoyed the cheapest labor in the world, security of property, complete freedom to import technicians and machinery, freedom for import of capital and entrepreneurs, easy access to major sea routes, and access to the largest market in the world. Any manufacturer from anywhere in the world could set up a cotton mill in Alexandria, Bombay, Calcutta or Shanghai and be assured that he or she would have access to an extensive market in the British Empire on the same terms as British producers.

An outstanding example of the freedom within the British Empire is the history of the Sassoon family. The founding member of this family was David Sassoon, a Sephardic Jew born to the richest merchant family in Baghdad in 1792. Arrested for defending the Jewish community's rights by the Ottoman Governor in 1828, he was ransomed by his father, and fled first to Bushire in Persia. From there he relocated to Bombay in 1832.[346] He and his large family prospered as traders in rapidly growing Bombay. Though he spoke not a word of English, in 1853 he became a British citizen, and proudly flew the Union Jack. Figure 13.1 shows David Sassoon with three of his sons in Bombay in 1858.

By 1844 his son Elias moved to China to pursue the opium trade with India, moving to Shanghai in 1850. Elias soon invested also in the China Steam Navigation Company, and in undeveloped urban land. Another son, Sassoon David was sent to London in 1858 to facilitate the growing trade in cotton and cotton goods. By the 1880s the family constituted several global enterprises, investing as well as in trade in docks and cotton

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346 To add to the exoticism he brought with him a number of slaves bought from Arabic tribes, who continued to serve the family in Bombay. Jackson, 1968, 32.

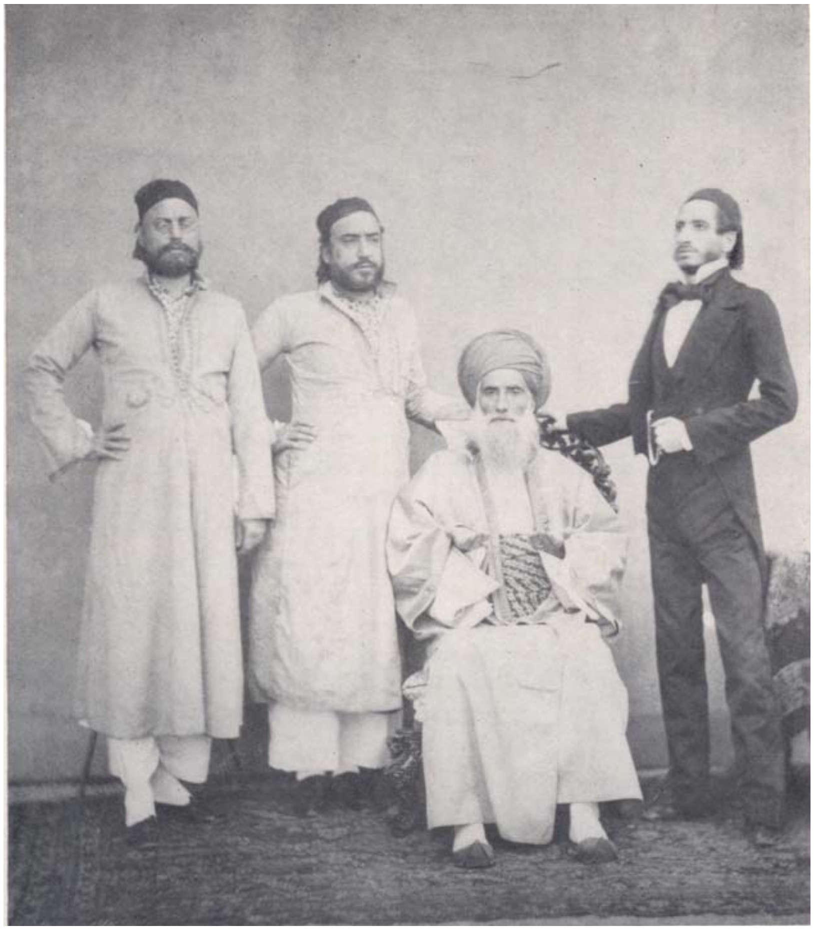

Figure 13.2 David Sassoon with three of his eight sons in 1858. His son, Sassoon David Sassoon, was the first of the family to adopt western dress.[347]

factories in Bombay, and housing developments in Shanghai. By the 1920s they owned more than one tenth of the Bombay cotton mills, and were the most innovative of the mill owners.

Many of the family moved to England and were quickly absorbed into the English aristocracy. David Sassoon's great

[347] Jackson, 1968, facing page 32.

grandchildren thus included Siegfried Sassoon, the World War I poet, Sir Phillip Sassoon, friend of Churchill and the Prince of Wales, and Sybil, Marquess of Cholmondeley, and Rabbi Solomon Sassoon, president in Israel of the largest Sephardic seminary. Figure 13.3 shows Sir Phillip playing polo.

The world thus seemed poised for rapid economic growth by the 1850s, and for the eventual convergence of international income differences.

The golden age of the first globalization, 1850-1914 came to an end with World War I. The disruptions of the war itself were followed by six decades of relatively turbulent times in the world economy. In the 1920s monetary problems led to the imposition of tariff controls and limits on capital movements. The Communist takeover isolated the Russian Empire from the world economy. The world Depression of the 1930s led to further disintegration of the world economy as nations lost faith in free markets and strove to solve their problems through protection, capital controls, and currency devaluations. After the disruptions of World War II, there was further fragmentation of the world economy with the creation of a raft of new Communist regimes, and the breakup of much of the British Empire into independent states.

Inspired by economic models that rejected the classical liberal economics of the British and emphasized instead autarky and centralized government planning, countries such as India imposed control on technology, managerial and capital imports. The international currency stability of the Gold Standard in the years 1870-1914 was impossible to recreate in the long run with the Bretton Woods system, leading by the 1970s to floating currencies that fluctuated wildly in value. By then also inflation and unem

Figure 13.3 Sir Phillip Sassoon (left) with the Prince of Wales and Winston Churchill in 1921[348]

ployment became persistent problems in many industrialized countries in a way that was not witnessed in the nineteenth century. Only in the 1980s did a new era of globalization emerge, with worldwide moves towards freer trade in goods and capital amongst democracies, combined with the ending of Communist rule, or its transformation into Communism in name only as in China.[349]

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348 Jackson, 1968, facing page 209.

349 O'Rourke and Williamson, 2001. Obstfelt and Taylor, 2004.

World Growth since 1800

What actually happened? The answer, of course, is that instead of following England and the other European countries on the path to rapid growth, much of the rest of the world languished in poverty. In India, after more than 100 years of British rule, there were still at work 50 million hand spindles and 2 million hand looms in the 1920s. Figure 13.4 shows just how primitive this technology was.

The divergence of national incomes and living standards that began with the Industrial Revolution continues to widen to the present day. In a world of ever more rapid communication of information, and ever falling transport costs, the gaps between countries based on material living standards has become enormous. The gap between material living standards in the richest and poorest economies of the world is now more than 50 to 1, while in 1800 it was probably at most 4 to 1. Material living standards have increased only 10 fold successful economies such as England and the USA since the Industrial Revolution. So the poorest economies now, places like Tanzania or Ethiopia, are poorer than the average society before the Industrial Revolution. Just as income inequalities have been compressed within countries since the Industrial Revolution, so have they widened across countries.

Figure 13.5 shows income per person for a sample of countries – Britain, USA, India, Argentina, Bolivia, and Ethiopia - from 1800 to 2000, all measured in US dollars at the prices of 2000.

The divergence in fortunes since 1800 is very clear. What is also clear is that the divergence was well under way in the first period of globalization 1870-1913, continued through the period of international economic disintegration 1913-1980, and contin

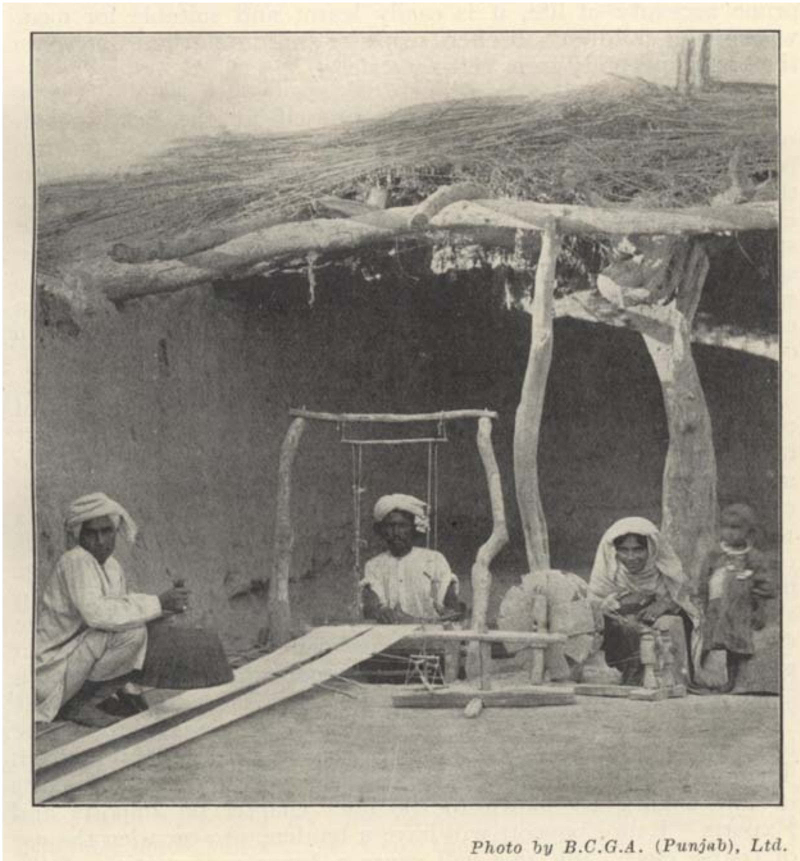

Figure 13.4 Hand spinning and weaving in India, 1920s[350]

ued further as we returned to a more globalized international economy in the last 25 years.

The most notable case of success was the USA which seems to have surpassed Britain in terms of income per capita even before 1870.[351] Thus by 1913 the USA was the richest economy

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[350] Pearse, 1930, 25.

[351] Relative incomes per person in the USA and the UK in the nineteenth century are a matter of continuing controversy. Ward and Devereux, 2003, argue for high US incomes from early on. Broadberry and Irwin, 2004, argue

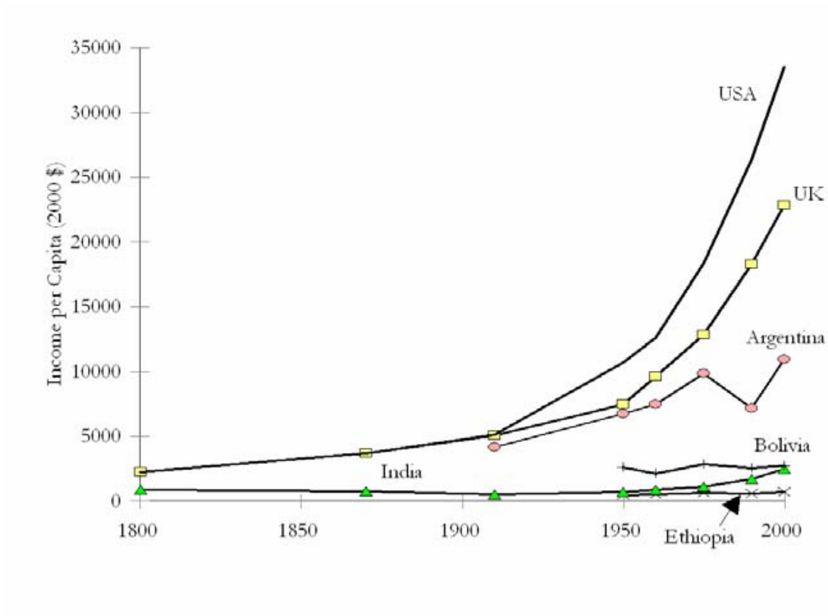

Figure 13.5 Incomes per Capita (2000 $)[352]

in the world. It was also the biggest economy with 17% of the entire material output of the world economy, a position it has remained in until this day.

Within Europe the countries of north west Europe – Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France and Switzerland – all behaved as expected and maintained an income per capita relative to Britain that was similar to the level in 1800. They all lay in 1913 within about 80% of the income per capita of England.[353] Also a number of countries of mainly

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that for the traditional interpretation that the USA only overtook Britain late in the nineteenth century.

[352] 1910, Prados de la Escosura, 2000, 1950-2000, Penn World Tables.

[353] Prados de la Escosura, 2000.

European settlement had incomes also close to Britain: Canada, Australia, New Zealand and Argentina. But outside this club, the technologies of the Industrial Revolution had surprisingly little effect on incomes per person, even within Europe. Ireland, only 50 miles across the sea from Britain, still maintained an income per person that was only 60% of British levels, and steadily depopulated after 1845 as its workers emigrated to better opportunities in Britain and the USA. All of southern and Eastern Europe remained poor, with incomes per person only 40-60 percent of British levels. These countries also remained largely devoted to peasant agriculture by 1914 as they had been in the 18th century. In 1914 the share of the population employed in agriculture in Britain was a mere 8%. In Romania it was 80%, and in Bulgaria 82%.

Outside Europe the effects of the Industrial Revolution more than 100 years after its onset in England were even more slight. Estimated per capita industrial output actually declined in both India and China up to 1913, as these countries moved into position of exporting raw materials (wheat, jute, indigo, and opium in the case of India) to pay for manufactured imports from Britain. Table 13.8 shows, for example, for British India the composition of its imports and exports in 1912. As a result of the Industrial Revolution and the British policy of free trade, low wage India found its comparative advantage in trade to be in exporting food and raw materials, and importing manufactured products.

Indeed, most dramatically India raw cotton was being exported through Bombay 6,851 miles to Lancashire mills, where workers paid 4-5 times the daily wages of mill operative in Bombay manufactured it into cloth, which was then shipped back 6,851 miles through Bombay to be sold back to the cultivators of

Table 13.8 The Commodity Trade of British India, 1912-13[354]

Commodity	Imports $ m.	Exports $ m.	Net Exports $ m.
Grain, pulse and flour	0	196	195
Jute, raw	0	88	88
Cotton, raw	7	91	84
Seeds	0	74	74
Hides and Skins	1	53	52
Tea	0	43	43
Opium	0	36	36
Oils	17	3	-14
Sugar	46	0	-46
Other raw materials	34	65	31
All Raw Materials	**106**	**648**	**542**
Cotton goods	196	40	-156
Jute goods	0	74	74
Metals	50	4	-47
Railway plant	21	0	-21
Other Manufactures	127	6	-121
All Manufactures	**393**	**123**	**-270**

the raw cotton. The net raw material export of India in 1912 was about $460 million. With Indian GDP measured in US prices at about $11.5 b. in 1910 this implies that net exports of raw materials were about 4% of Indian GDP. Since the agricultural sector

[354] United States, Department of Commerce, 1915.

experienced little measurable productivity growth in the years from 1870 to 1949, India benefited from the Industrial Revolution largely through improving terms of trade for its manufactured imports.

In the case of India because we have relatively good GDP figures back to 1873 we can measure its economic decline relative to Britain and the USA from 1873 until 2000. Figure 13.6 shows calculated GDP per capita in India from 1873 to 1998 measured relative to the USA and Britain. India did show a substantial increase in absolute GDP per capita over these years. Real incomes per capita in 1998 were 3.6 times those estimated for 1873. But relative to both Britain and the USA Indian income per person fell from 1873 to the mid-1980s, before rising from 1987 to the present. As late as 1931, 150 years after the factory was introduced in Britain, less than 1% of Indian workers were employed in modern factory industries.

Many other countries that have witnessed a declining relative income level have done so in circumstances where political and social institutions have suffered breakdowns. Thus many of the countries of Africa, which are now among the world's poorest have suffered from ethnic strife, and the collapse of political institutions, since their independence. But the Indian economy experienced its decline in a long period of relative political and social stability, first under British colonial rule until 1947, and even after independence.

The result of the Industrial Revolution was thus an increased concentration of world economic output in a very small portion of the world. Table 13.9 shows estimates of the world distribution of income for 1800, 1870, 1913 and 2000. For most countries outside Europe, North America and Oceania income per person in the years before 1913 is taken as just the same as in 1913, on

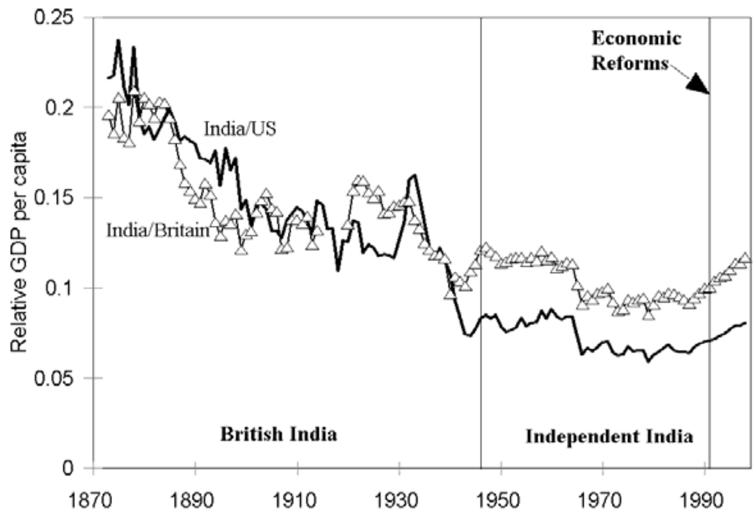

Figure 13.6 Indian GDP per Capita relative to Britain and the USA, 1873 to 2000[355]

the grounds that these were still Malthusian economies then. North America and Oceania is Canada, USA, Australia and New Zealand.

In 1800 West Europe, North America and Oceania had 12% of world population, but 27% of world income. Thus even before the Industrial Revolution Western Europe and its settlements were a relatively rich area of the world, producing more than a quarter of world output. By 1913, as a result of the Industrial Revolution and its delayed diffusion, these two regions saw their population grow to 20% of the world total, and were producing

[355] India. Pre-1947, Heston, 1983. 1950-1980, Penn World Tables (PWT 5.6). 1981-1998, Statesforum. USA. 1873-1929, Balke and Gordon, 1992. 1930-1998, Economic Report of the President (2001). UK/Britain. 1873-1965, Feinstein, 1972, 1965-1998, UK, National Statistical Office.

Table 13.9 World Population and Income Shares, 1800-2000[356]

Region	Measure	1800	1870	1913	2000
W Europe	N	11	15	14	6
	Output	24	37	31	20
N. America, Oceania	N	1	4	6	6
	Output	3	10	20	25
E and S Asia	N	64	56	56	53
	Output	47	31	24	32
Latin America	N	2	3	4	8
	Output	4	4	4	8
Africa	N	7	7	5	13
	Output	9	7	4	4

51% of all economic output in the world. Output per person in these regions averaged more than four times that in the rest of the world.

By 2000 the share of world output from these regions had fallen to 45%. But that was mainly because their population share had fallen to 12% of the world total. Output per person in

[356] The shares are in percents. West Europe includes Sweden, Germany, Austria, Italy and all countries to the west. The sources are the Penn World Tables for 2000, Maddison, 2001, and Prados de la Escosura, 2000, for 1913, Maddison, 2001, for the income and populations of European countries in 1870. For 1800 incomes in Western Europe relative to England were estimated from van Zanden, 1999 and Allen, 2001.

Western Europe, North America and Oceania had now actually risen to be six times that in the rest of the world.

South and East Asia have always held the majority of world population, though that preponderance has been declining. But by 1870 its share of world output had fallen to less than one third, and it was still less than one third in 2000. While by 2000 output per person in Asia was rising relative to the rest of the world, this has been balanced by a steady decline in Africa. While Africa's share of world population has increased, output per person in Africa is now just 30% of the world average. Output per person in North America and Oceania in 2000 was 14 times that of Africa.

There is now almost instant communication between different countries of the world, a huge exchange of foods, decoration styles and music, and an ever rising flow of goods internationally. But the divergence of incomes is making the poor countries of the world as exotic to the rich as they were in the seventeenth or eighteenth centuries. Even in as relatively prosperous a part of the underdeveloped world, as in Bombay in India, workers new to the city sometimes still sleep on the streets, as portrayed in figure 13.7. Thousands live in improvised shacks without water or toilet facilities on public lands, on pavements, or along the edges of the commuter rail lines. In India as a whole in 2002 the average dwelling area per person was 84 square feet.[357]

In contrast, in the richest major country in the world, the average American in 2001 lived in a dwelling with 750 square feet per person, and even the poorest fifth of the population enjoyed 560 square feet per person. 8% of American houses now have 4,000 square feet or more, for an average family size is 2.6 peo

[357] Government of India, Report on Housing Conditions in India, 2004.

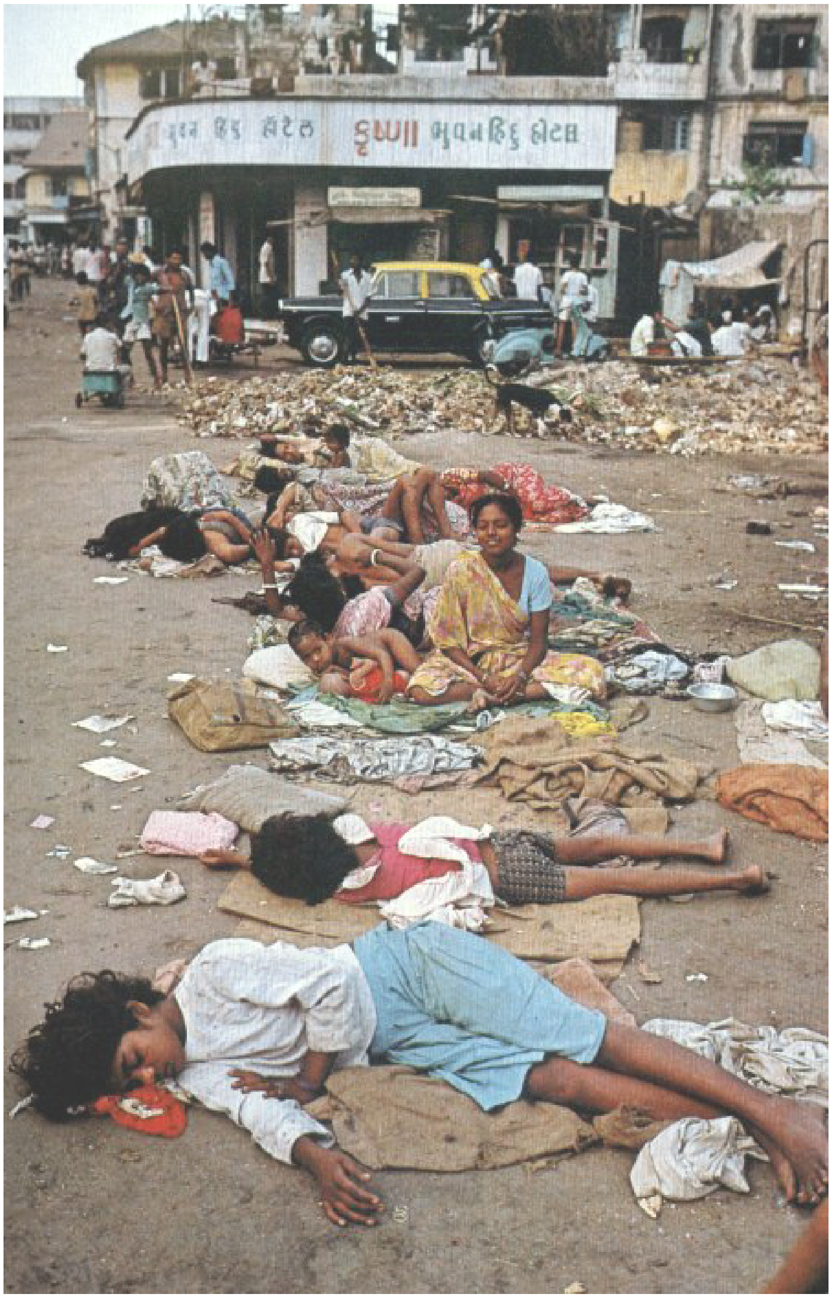

Figure 13.7 Pavement Dwellers in Bombay

Figure 13.8 Middle class living in the USA

ple.[358] These new *McMansions*, portrayed in figure 13.8, are now a standard feature of middle class American life. How did such a world arise?

[358] US Department of Energy, Residential Consumption Survey, 2001.

14 The Anatomy of Divergence

True philosophy invents nothing; it merely establishes and describes what is (Victor Cousin)

Why did world development since 1800 and the Industrial Revolution involve the surprising divergence described in the previous chapter? This has been the subject of a mountain of print, and a storm of debate, ever since the increasing gap between rich and poor nations became apparent in the late nineteenth century.

Commentators, having visited climate, race, nutrition, education and culture, have persistently returned to one theme, the failure of political and social institutions in poor countries. Yet, as we shall see, this theme can be shown to manifestly fail in two ways. It does not describe the anatomy of the divergence we observe: the details of why poor countries remain poor. And the medicine of institutional and political reform has failed repeatedly to cure the patient.[359]

Yet, like the physicians of the pre-scientific era who prescribed blood letting as the cure for ailments they did not understand, the modern economic doctor continues to prescribe the same treatment year after year through their cult centers such as the World Bank and the IMF. If the medicine fails, then the only possible conclusion is that more is needed.

Like growth itself, described in chapter 9, differences in income per person across economies can only have three basic sources: differences in capital per person, differences in land per person, and differences in efficiency.

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[359] See, for example, Easterly, 2001.

This chapter shows that, at the most general level, differences in efficiency are again the ultimate source of the great majority of the gap in incomes between rich and poor countries in the modern economy. Just as with growth over time, discussed in chapter 9, the proximate cause of differences in income per person across countries is about one quarter the stocks of physical capital per person, and three quarters the efficiency of utilization of all inputs.[360] But, to an approximation, we can take the world capital market as integrated since the nineteenth century improvements in the costs and speed of communication and trade. In a world where capital flowed easily between economies, capital per worker itself *responded to* differences country efficiency levels. In that case inefficient countries ended up with small capital stocks, and efficient ones with a lot of capital. And efficiency differences explain almost all differences between countries in income levels.

Differences in efficiency could stem from differences in access to the latest technologies, from economies of scale, or from failures to utilize imported technologies appropriately. The argument below is that the major source of these efficiency differences was a failure to utilize technologies effectively. But this failure had a peculiar form. It was concentrated around a failure to effectively employ labor in production, so that output per worker was peculiarly low, even on the latest technology, in the poorest countries.

[360] See, for example, Easterly and Levine, 2000.

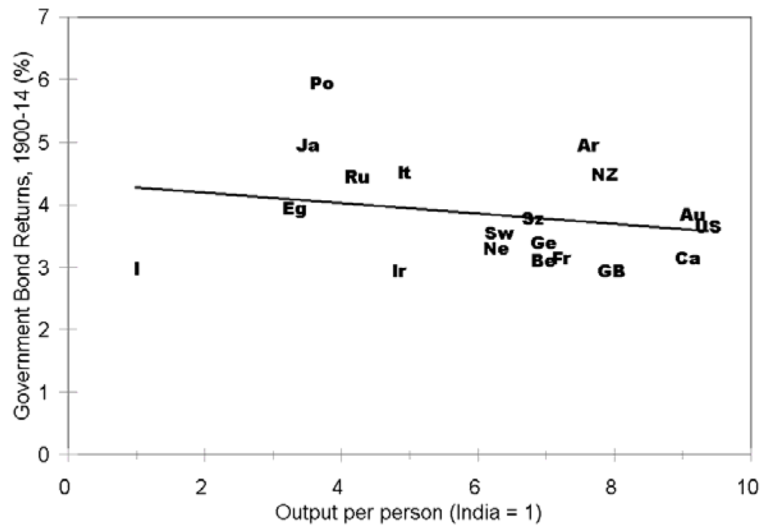

Figure 14.1 Government Bond Returns, 1900-14[361]

Capital and Divergence

There is plenty of evidence that capital returns, the interest rate earned on capital, though not fully equalized, were close enough that we can regard capital as flowing freely around the

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[361]Absent national bonds, for the US Municipal Bonds were used. Egyptian income per person was assumed the same as the Ottoman Empire. Irish returns were assumed the same as British. The symbols are: Au, Australia, Ar, Argentina, Be, Belgium, Ca, Canada, Eg, Egypt, Fr, France, Ge, Germany, GB, Great Britain, Ir, Ireland, It, Italy, Ja, Japan, Ne, Netherlands, NZ, New Zealand, Po, Portugal, Ru, Russia, Sw, Sweden, Sz, Switzerland, US, United States of America.
Souces**:** Table 14.1. Edelstein, 1982, 125 – realized returns India, New Zealand (1870-1913). Homer and Sylla, 1996 – Britain, Ireland, USA, France, Germany, Belgium, Netherlands, Canada, Italy, Switzerland. Mauro, Sussman and Yafeh, 2006 – Argentina, Egypt, Japan, Russia, Sweden, Portugal, Australia (sterling bonds in London).

world by 1900.[362] Figure 14.1, for example, shows rates of return on government bonds in nineteen countries at a variety of income levels in 1900-14 as a function of the relative level of output per capita in each country in 1910. There was variation in the rates of return on these bonds in the range of about two to one. So the market is clearly not functioning perfectly. But whatever variation there was had little correlation with the income level of the country. Indeed there is no statistically significant decline in bond returns with income. As far was we know capital returns were not correlated with the income level, and hence efficiency, of countries, and so cannot explain why richer countries had more capital.

We can also get rates of return on private borrowing by looking at returns on railway debentures. Railways were the biggest private borrowers in the international capital markets in the late nineteenth century. And their capital needs were so great that if they were able to borrow at international rates of return it would help equalize rates of return across all assets in domestic capital markets. Table 14.1 shows the *realized* rates of return, the returns after taking into account defaults, earned by investors in railway debentures in the London capital market between 1870 and 1913. Again there are variations across countries. But importantly for our purposes this variation does not correlate with output per person. Indeed India, one of the poorest economies in the world had among the lowest railway interest costs because the Indian Government guaranteed the bonds of the railways as a way of promoting infrastructure investment.

World capital markets were well integrated by 1914 for three reasons: the huge overseas investments of the British, the British

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[362] International capital markets did disintegrate in the economic and political troubles of the 1920s and 1930s, and have only recently returned to their level of integration of 1870-1914. See Obstfelt and Taylor, 2004.

Table 14.1 Realized Rates of Return on Railway Debentures, 1870-1913[363]

Country or Region	Output per Person ($ 2000)	Rate of Return (%)
USA	5,116	6.03
Canada	4,953	4.99
United Kingdom	4,300	3.74
Argentina	4,136	5.13
Brazil	-	5.10
Western Europe	3,320	5.28
Eastern Europe	2,231	5.33
British India	544	3.65

Empire, and the popularity of the gold standard. The British by 1910 had overseas investments that amounted to about twice their GDP. This implied that about one third of the capital owned by British investors was invested abroad. The existence of this huge pool of investment seeking a home overseas helped make London the pre-eminent world financial center before 1914. But it also helped lubricate the market by creating a center where investors and borrowers could gather, and where information about opportunities could be aggregated. The British Empire aided the export of capital from all the advanced economies to the poorer ones by giving investors security through the guarantee offered by imperial laws and protections. Finally the pegging of many currencies to

[363] Edelstein, 1982, 125.

gold in the late nineteenth century removed a lot of the currency risk from investing abroad, since the relative value of many currencies remained unchanged for 30 or 40 years prior to 1914.

This rich capital market allowed poor countries to borrow large sums. This rough equalization of returns to poor and rich countries was achieved by significant capital flows into these countries. By 1913 Egypt, the Ottoman Empire, Argentina, Brazil, Mexico and Peru had all attracted at least $50 per head of foreign investment. This implies that nations such as the Ottoman Empire, with an estimated income per person of $125 in US prices of 1913, had significantly augmented their capital stock through foreign borrowing.[364]

The numbers in table 14.1 show how the London market valued railroad investments, not the actual rate of return on the money spent on the railway infrastructure in these countries. If the creators of railroads in poorer countries, for example, had access to monopoly opportunities or franchises, then the rate of return on the investments could exceed the rate of return available to financial investors on the London market. Though the financial rate of return in London would still indicate the cost of borrowing for railway enterprises in these countries.

Lance Davis and Robert Huttenback calculated by the actual profit rate of firms located in various parts of the world by comparing earnings to the book value of their capital (the cost of their initial investment). In 1870 to 1913 the returns were: British companies investing at home, 11%, British companies investing in the British Empire, 13%, and British companies investing in other foreign countries, 11%.[365] The similarity in rates of return suggests that whatever was slowing down the rate of industrialization

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[364] Pamuk, 1987. Relative incomes from Prados de Escosura, 2000.

[365] Davis and Huttenback, 1988, ---.

in poor countries it was not a lack of capital – for capital invested abroad seems to earn no more than capital invested at home in the case of British investors. This is what we would expect if capital markets functioned reasonably well.

The one case we can find where capital markets seem to have functioned very badly is, ironically, within the USA, the world's richest economy. Here rates of return throughout the nineteenth century were much higher in the west than in the older settled east. In the 1860s, for example, as the central valley of California was being settled mortgage loans were at the rate of 26 percent per year at a time when mortgages in Boston were at 6 percent. Rates fell rapidly in California, but in 1889 West Coast interest rates were still 4-6% above those in the Northeast.[366] These disparities were created by legal limitations on the development of interstate banking in the US, which made it difficult for capital to flow from Europe or the east of the USA to the west. Yet despite the persistently high cost of capital, the American West developed rapidly in the late nineteenth century. So in the late nineteenth century capital was scarce in the richest economy in the World, the USA, and cheap in perhaps the poorest, India.

The second important element in the costs of capital, along with the rate of return, is the cost of capital goods. If these were very expensive in poor economies then this would also drive up the overall cost of capital.

We can measure this cost for textile mills around 1910 across the richest and poorest countries. Figure 14.6 shows the cost per spindle for a fully equipped new textile mill in 1910 in various countries around the world, as a function of levels of income per person. There is no correlation between the cost of these capital

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[366] Rhode, 1995, 789. Rates in California were 9.0 percent, as opposed to 5.6 percent in Massachusetts. Eichengreen, 1984, 1010.

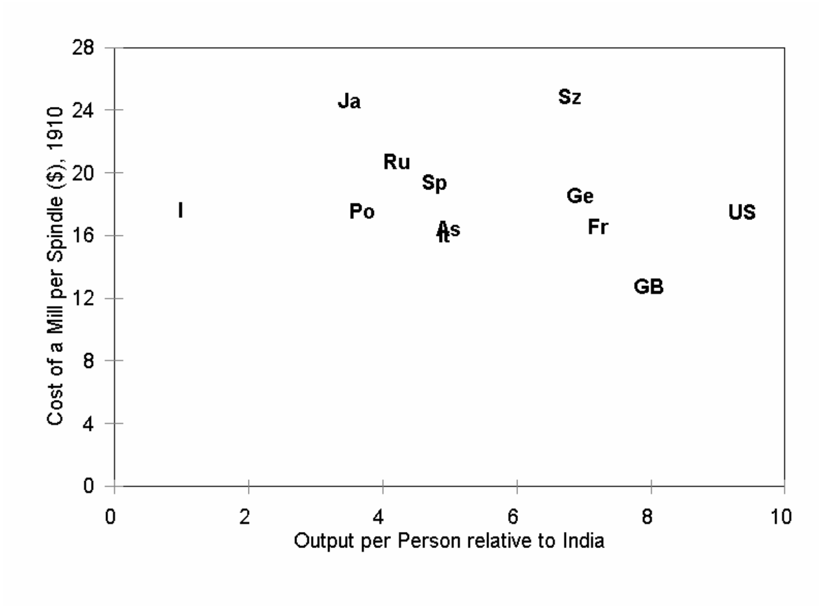

Figure 14.2 The Estimated Purchase Price of Capital Goods, Textile Mills, 1910[367]

goods, in textiles generally imported from Britain, and the level of income per person. On average, at least by 1910, poor countries had access to capital goods in a major industry like textiles on just the same terms as rich ones.

Resources and Divergence

The improvements in transportation discussed in chapter 13 also ensured that access to the resources needed for industrializa

[367] Output per person is measured as an index with India set equal to 1. The symbols are: As, Austria, Fr, France, Ge, Germany, GB, Great Britain, I, India, It, Italy, Ja, Japan, Po, Portugal, Ru, Russia, Sp, Spain, Sz, Switzerland, US, United States of America. Sources: Table 14.1, Clark, 1987.

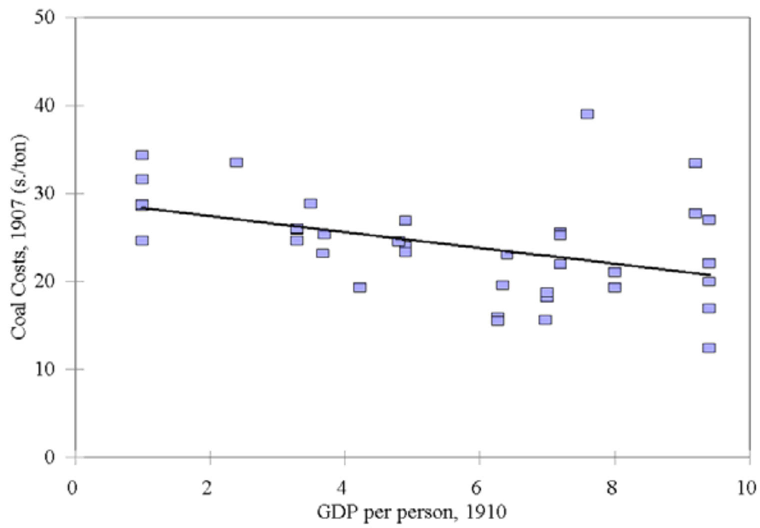

Figure 14.3: Coal Costs versus GDP per person, circa 1910[368]

tion was not a big obstacle for most economies by 1900. Figure 14.3 shows, for example the cost of a ton of coal of constant quality relative to the GDP per person in various economies in 1907. Coal, the main source of energy for industry in 1907, was slightly cheaper in the high income economies, but the difference was modest. Geography and access to resources will explain little of the divergence in incomes. The world created by the Industrial Revolution is one where lack of possession of resources became unimportant as a barrier to industrialization, except for a few landlocked or topographically disadvantaged countries.

368 Coal costs from table 13.6 and Clark, 1987. Incomes from Prados de la Escosura, 2000.

Efficiency and Divergence

The unimportance of resources, and the relatively uniform cost of capital, at least for 1870-1914, implies that differences in efficiency must be the overwhelming cause of differences in income per capita across countries in the modern world.

It is true that there is always a strong association between physical capital per person and income per person across countries in the modern world. Figure 14.4 shows this association for a sample of countries in 1990. Thus at a proximate level capital per person explains perhaps a quarter of income differences across countries in the modern world. But with capital free to flow across countries, and earning a rental that does not differ much with the income level of countries, efficiency differences explain most of these differences in capital stocks. So at a deeper level, efficiency differences are the core of why income per capita varies across economies since the Industrial Revolution. The same formula that explained how income grew over time,

$$g_y \approx g_k \approx \frac{g_A}{(1-a)},$$

explains why income varies across countries in the modern world. Indeed taking the income levels of a group of countries across the world in 1913, and making corrections for the amount of land per person, and the effect of the return on capital on capital stocks, we still see that overwhelmingly income per person variation is associated with efficiency differences.

Figure 14.5 shows this connection. By 1913 the efficiency of economies around the world, the amount of output per unit of all inputs, varied by a factor of at least 5 to 1. In a world of free flowing capital differences in the efficiencies of economies get

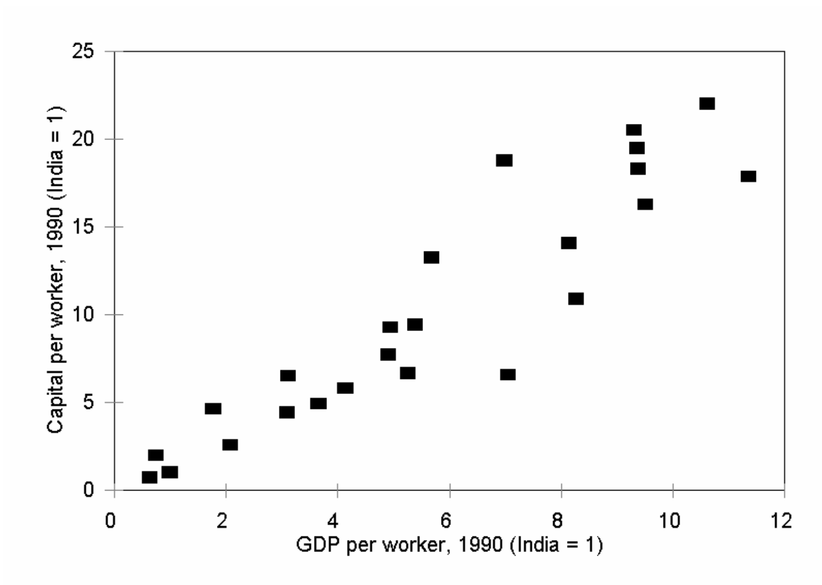

Figure 14.4 Capital per worker versus income per worker, 1990[369]

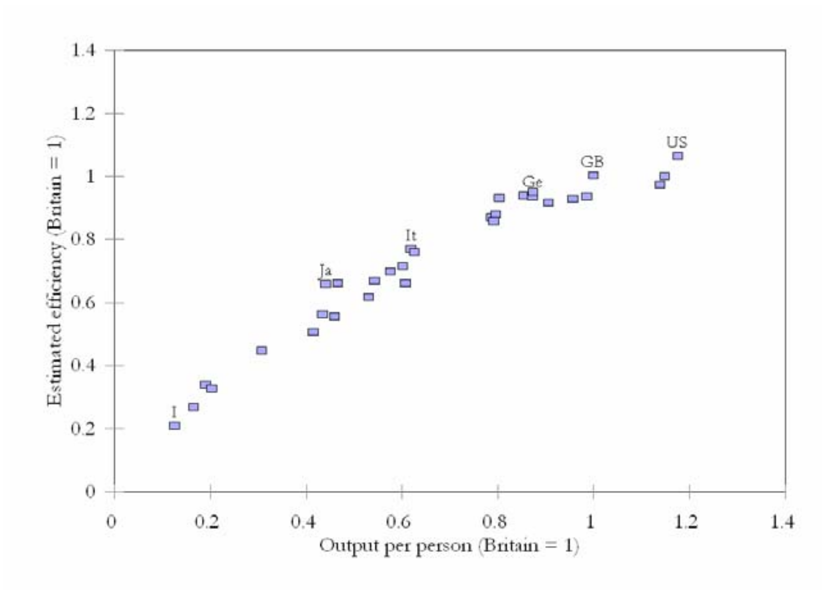

Figure 14.5 Efficiency versus income per worker, 1913[370]

369 Penn World Tables (5.6).

translated into much bigger differences in income through the concentration of capital in the high efficiency areas. Thus Britain is estimated to have five times the efficiency of the Indian economy in 1913, but nearly eight times the income per person.

Thus there is a surprising isomorphism in the sources of growth of incomes over time since the Industrial Revolution, and the causes of the divergence in incomes between economies in the modern world. But the cause of the differences in efficiency across countries is very different than the cause in differences in efficiency over time

Why were poor countries inefficient?

Poor economies since the Industrial Revolution have been mainly characterized by inefficiency in production. Their problem, however, was not typically getting access to the new technologies. The problem, it turns out, was in using these new technologies effectively. We can see this most clearly by looking at the two major industries that were found in almost all economies by 1910, factory production of cotton textiles, and railways.

Cotton textiles seemed to be a path to industrialization for the poorer countries of the world before World War I. There was a ready local market for textile products in all countries, and we have seen also a huge open international market. Textile mills were not very capital intensive. And the optimal size of a mill was small compared even to markets in the smallest countries. In practice, as table 13.8 shows, England dominated the world market, with only modest competition from Japan, Italy, France and Germany.

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[370] The share of land in income is taken as 5%.

We have already seen that the technology was readily available internationally, at reasonable prices, through exports of machinery by British engineering firms. Further in cotton textiles unskilled labor was the majority of production costs in countries such as England. And the poor countries had abundant quantities of cheap unskilled labor. A contemporary writer on the cotton industry thus noted that:

> *India enjoys a great advantage over England, for the advantage which England possessed in regard to skilled labor most certainly does not apply as in former years ... with the marvelously perfect and self-acting machinery of today no special skill is required on the part of the attendant. The machinery itself supplies the intelligence; all that is required from the workman is attention in "following up" the machinery, such as piecing up broken ends, doffing, and other simple details, which are performed by the native Indian cotton factory operative almost as well as by his European brethren, and at far less cost to the spinner (Walmsley, 1893, 50).*

From at least the 1850s onwards poor countries should have taken over the cotton textile industry, driving out the British from the unprotected markets. Their labor cost advantages were huge.

Table 14.2 shows the comparative costs of England and some low wage competitors in 1910. Wages in the textile industry varied widely. They were 10 times those of China in England. Indeed wages were so low in China that some mills searched workers leaving the mills to ensure they had not stuffed any cotton into their pockets, since even small amounts of cotton would have added significantly to their wages (a pound of raw cotton was worth about $0.25). Wages were the most important element in producing cloth, after the costs of the raw cotton, in most countries. Thus in England in 1911 the costs (excluding

Table 14.2 Cotton Textile Costs in 1910[371]

County or Region	Weekly Wage $/55 hours	Plant and Machinery $/spindle	Coal $/ton	Total Cost England = 100	Implied Profit Rate %
US South	6.5	17	3.8	130	–1
England	**5.0**	**13**	**2.5**	**100**	**8**
Spain	2.7	19	6.5	91	10
Mexico	2.6	19	10.0	94	10
Russia	2.4	21	7.2	91	10
Italy	2.4	16	7.2	81	14
Japan	0.8	25	2.6	73	14
India	0.8	18	5.0	61	19
China	0.5	16	3.2	53	22

cotton) were: wages, 62%; machinery depreciation plus supplies, 12%; power, 3%; interest costs on capital, 22%.

Machinery was less expensive in Britain that in most other countries. This was because England was the center of the cotton machine building industry, and most other countries bought their machinery from England. Their costs were thus inflated by the costs of transporting the machinery to their mills, and the additional costs of setting it up when mechanics had to be brought out from England. It is estimated that the cost of shipping English machinery to US mills was about 25% of the value of the machin-

[371] Clark, 1987.

ery. The countries which had very high machine costs such as Russia often had a tariff on machine imports.[372]

England also had low power costs, because the cotton industry lay on top of a coal field. Some other countries such as Mexico had very high power costs because coal had to be imported first by sea and then by rail from the port. But as figure 14.2 shows the costs were only very slightly higher on average for low wage countries.

The fourth column of table 14.2 shows what total manufacturing costs should have been in each country based on the costs in columns 2 to 4, if each country used exactly the same technique as in Britain. That is if they opened the same number of hours, used boilers on their steam engines that used as much fuel per hour as in England, and ran the machines at the same speed as in England. The last column shows the implied profit rate in each country if they were to sell output in the English market, assuming English mills made an 8% return. Most of the low wage competitors should have been able to sell output profitably in Britain in 1910. Some of them, such as India and China, should have made enormous profits selling in the open international market.

The low wage countries actually had one further major advantage in common over British producers. The struggles of social reformers and labor unions in England in the nineteenth century had led to a series of Factory Acts that sought to tame the savage mastery of machine over worker. These laws limited adult workers to 55 hour weeks, children to half these hours. Women and children were prohibited from night work. Since women represented over 60% of the English mill labor force, and an even higher proportion in some occupations such as weaving, the mills

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[372] Japanese mills were very expensive per spindle because the costs included dormitories built to accommodate the workers who were mostly teenage girls.

Table 14.3 Cotton Textile Costs adjusted for hours, 1910[373]

County or Region	Hours per year	Plant and Machinery $/spindle	Total Cost England = 100	Implied Profit Rate %
US South	3450	16	126	–1
England	**2775**	**13**	**100**	**8**
Spain	4455	15	84	14
Mexico	6750	12	82	14
Russia	4061	16	84	17
Italy	3150	16	79	14
Japan	6526	13	62	25
India	3744	15	58	23
China	5302	12	48	33

chose not to run at night. Thus the average English mill ran for only 2,775 hours per year.

Low wage countries either had no such restrictions, or legal restrictions that were not enforced. Most chose to run long hours using night work. Mexican mills, for example, ran 6,750 hours out of 8,760 in the year, an average of 18.5 hours per day. The work day was longer, double shifts were worked, and fewer holidays were taken.

Longer hours reduced the capital costs of production substantially, by reducing the capital costs per spindle hour. Table 14.3 shows the hours of operation of the mills in the various countries and their revised capital costs, total manufacturing costs, and implied profit rates. Now all the low wage countries look as

373Clark, 1987.

though they ought to have been able to undersell the English. Some seemingly ought to have made enormous profits, as in the case of the Chinese mills. The puzzle is all the stronger since many of the lowest wage producers both had cotton and access to major ocean trade routes. Thus, India, China, Egypt, Uganda, Russia, Peru, Mexico, and Brazil all produced cotton, and India, China, Egypt and Brazil all had excellent access to ocean transport.

Yet up till 1914 England remained the low cost producer in producing both yarn and cloth, as witnessed by table 14.2. Its only competitors were Japan, Italy, France and Germany. Table 14.5 shows the share of imports of each category of good into India, which had market open on all terms to every country, supplied by Britain. Only in coarse yarns is there any serious competition from other producers.

What kept high wage England in the world market was that the mills in these other countries could never attain English efficiency levels. But their inefficiency had a peculiar form. They were inefficient in the use of labor, but not in the use of capital. Even though they were using the same machines as the high wage economies, they employed many more workers per machine but without obtaining any additional output from the machines. Thus in ring spinning one worker in the north of the USA tended 900 spindles, while one worker in China tended only 170. On plain looms a worker in the northern US managed 8 looms at a time, in China only 1 or 2. Thus the numbers of workers per machine varied by about 6:1 internationally.

Figure 14.6 shows actual labor costs per unit of output versus the wage rate per 55 hours in the international cotton textile industry around 1910. Wage costs were lower in the lowest wage countries on average, but by very modest amounts compared to

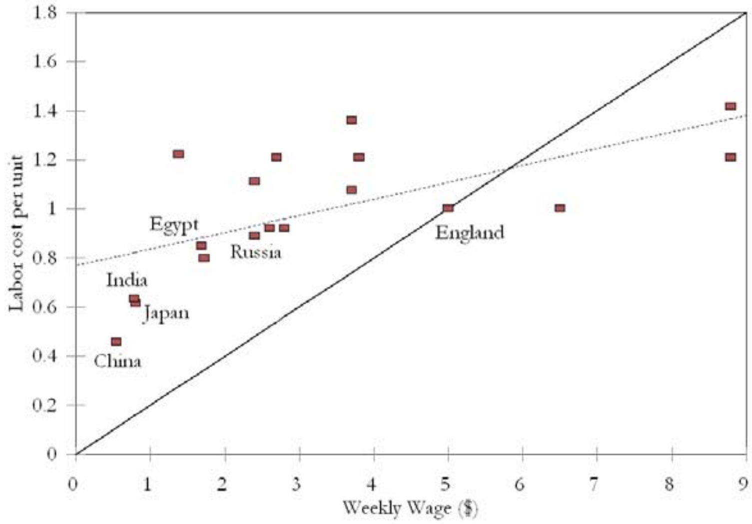

Figure 14.6 Labor costs per unit compared to wage rates, 1910[374]

economy labor costs per hour varied by 16:1, labor costs per unit of output only ranged by 3:1.

This extra labor employed in the low wage countries was not an attempt by management to utilize expensive machines more intensively. There is no sign that mills in low wage countries gained more output per machine by employing these supernumary workers. Output on ring spinning machines, for example, was almost entirely a function of the speeds the machines ran at. It was possible to vary the speeds of machines, with faster running requiring more tenders per machine since then the threads broke more frequently. Figure 14.9 shows the speeds specified for ring spinning machines ordered from different countries from Platts as a function of the wage of operatives in those countries. The

374 Clark, 1987, 152.

Figure 14.7 Ring Spinning, USA, 1939 (Carter D. Poland)

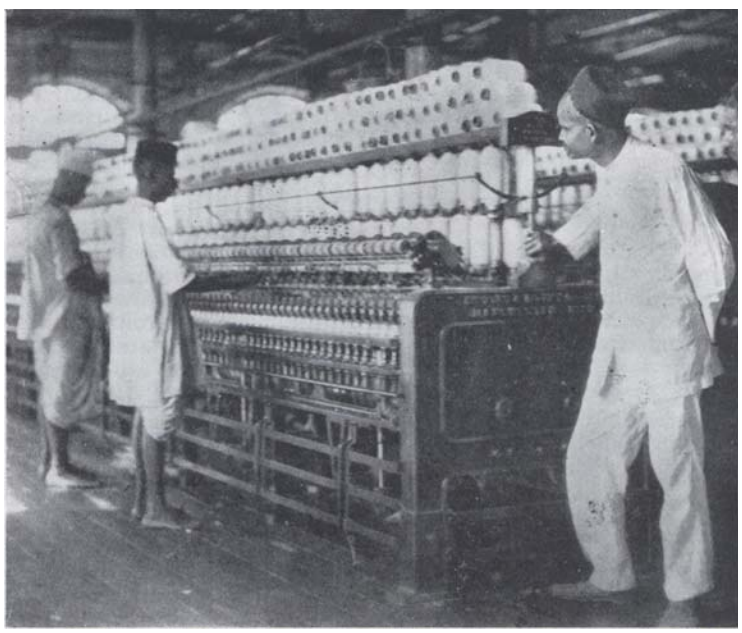

Figure 14.8 Indian Ring Spinners and Supervisor, 1920s[375]

375 Pearse, 1930, 132.

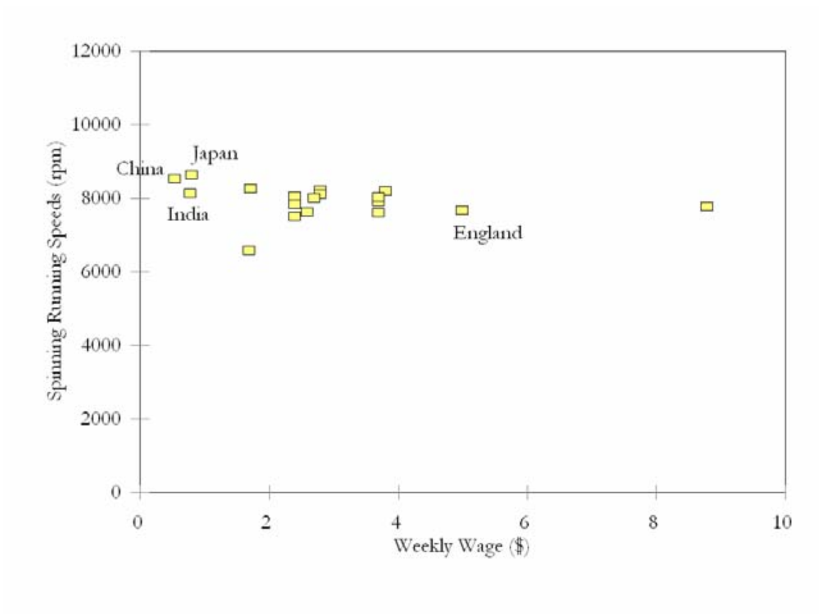

Figure 14.9 Machine Outputs and Operative Wages, 1910

poorest countries specified slightly faster operating speeds, but this was an insignificant difference compared to the extra labor they employed.

Another modern industry found in both the richest and poorest countries before 1914 was the railway. As with cotton textiles, there seems to have been little variation in the technology between rich and poor countries. Many railways across the world were built by British engineers, who employed the latest British technology. British locomotive constructors in the late nineteenth century produced the bulk of their locomotives for foreign markets, particularly those in the British Empire. Figure 14.10 shows and a show a standard of the Indian railways, the 0-6-0 locomotive and its English counterpart from the same period. Even to the untrained eye the technology looks the same.

The major complaint about railways in India in the British period was indeed not inferior technology, but railways that were built to an uneconomically high standard. Encouraged by the guarantee system which promised bond holders a generous minimum return, railroad builders in India were happy to indulge their British engineers' taste for high quality rails, locomotives and rolling stock. A manager of the Eastern Bengal State Railway, touring the US in 1901, remarked that most American railways were not up to "European or Indian standards."[376]

But if the equipment was often British, what was very un-British was the staffing practices of railways in poorer countries. Figure 14.11 shows the revenue generated per worker-hour in 22 countries around 1914. The range in output per worker-hour is about 6:1, with again the USA the highest and India the lowest.

Note that the Indian rail system had extensive English expertise in its operation. In 1910 the Indian railroads employed 7,207 "Europeans" (mainly British) and 8,862 "Eurasians" (principally Anglo-Indians) who occupied almost all the supervisory and skilled positions. Indian locomotive drivers were employed only after 1900, and even as late as 1910 many of the locomotive drivers were British.[377]

Yet again the extra workers in India, and other poor countries, do not seem to have procured for Indian firms any increase in output per unit of capital. Because of the very different operating conditions of railways in different countries capital utilization is hard to compare. But there are partial indicators of that suggest no gains for countries that employed huge excesses of labor.

376 Headrick, 1988, 75.

377 Morris and Dudley, 1975, Headrick, 1988, 322.

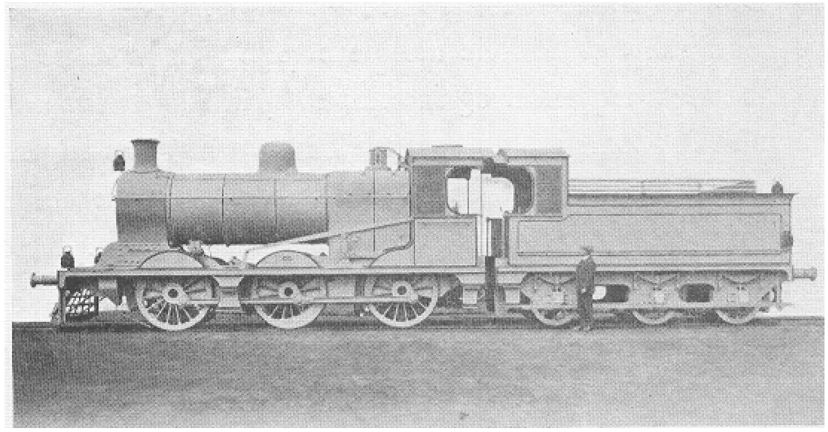

Figure 14.10 Indian and English locomotive of the same class, built in 1903 and 1905. Which is which?

One that is available for most of the countries, shown in figure 14.10, is the miles run per locomotive per year. Locomotive utilization was not any higher in low income, low output per worker countries. Managers of railways in these countries seemingly again, as in cotton textiles, gained nothing from their extra labor inputs.

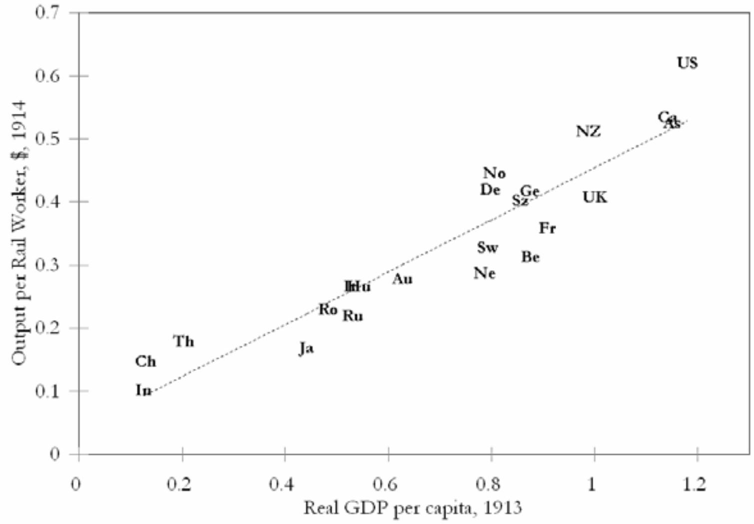

Figure 14.11 Output per worker-hour on railways, 1914.

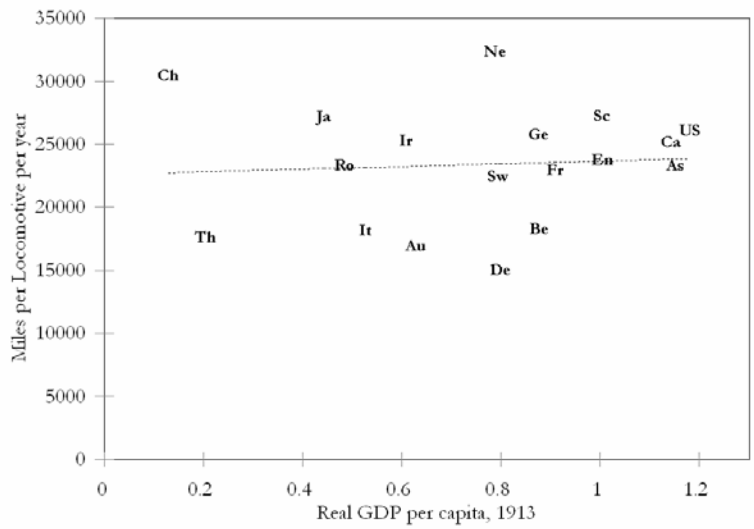

Figure 14.12 Capital Utilization across countries, 1914

Thus in both cotton textiles and the railways around 1910 we observe the same picture. Poor countries used the same technology as rich ones. They achieved the same levels of output per unit of capital. But in doing so they employed so much labor per machine that they lost most of the labor cost advantages of poor countries.

The problem of persistent inefficiency in the use of labor in poor countries like India was the main barrier to the spread of the modern technologies of the Industrial Revolution. Table 14.4, for example, shows the gross profit rates of Bombay cotton mills by quinquennia from 1907-9 to 1935-8, as well as the size of the Bombay industry, and the output per worker in Bombay as an index with 1905-9 set at 100. Since the mills operated in a very competitive market profits were never high. At the best years for the industry, during World War I and its immediate aftermath, profit rates were still only 7-8%. Despite profit rates that averaged only 6.5% between 1907 and 1924, the industry in Bombay still grew by 45%. This is once again testimony to the smooth functioning of international capital markets in these years.

However, from 1907 to 1924 there was no increase, and perhaps a decline, in output per worker in Bombay. At the same time the Japanese cotton industry increased output per worker by 80%. By the late 1920s Japanese competition had eliminated all profits from the Bombay industry. As output per worker in Japanese mills marched ever upward through the 1920s and 1930s, Bombay mills on average were hardly able to even cover their operating costs. By 1938 nearly 15% of the capacity in the Bombay mills had been scrapped.

The situation found in 1910, where excess labor without apparent benefits in the form of capital utilization was found in low

Table 14.4 The Bombay Cotton Textile Industry, 1907-1938[378]

Year	Gross profit rate on fixed capital %	Industry size m. spindle-equivalents	Output per worker 1905-9 = 100	Output per worker Japan 1905-9 = 100
1907-9	6	3.1	100	100
1910-4	5	3.4	103	115
1915-9	7	3.7	99	135
1920-4	8	4.0	94	132
1925-9	0	4.5	91	180
1930-4	0	4.4	104	249
1935-8	2	3.9	106	281

income countries, persisted throughout the twentieth century in the cotton textile industry. A 1969 study by the English Textile Council looked at output per machine hour and per worker hour in the best quarter of cotton textile spinning and weaving firms across 11 major producer nations in 1967. Howard Pack added to this comparison also the performance of the best quarter of Kenyan and Philippines firms in 1980 (on the same vintage of equipment as the earlier study). Figures 14.13 and 14.14 show the estimated output per machine-hour, averaged over spinning and weaving, and output per worker-hour.

[378]Profits and output per worker were calculable only for the mills listed in the *Investor's India Yearbook*. Wolcott and Clark, 1999.

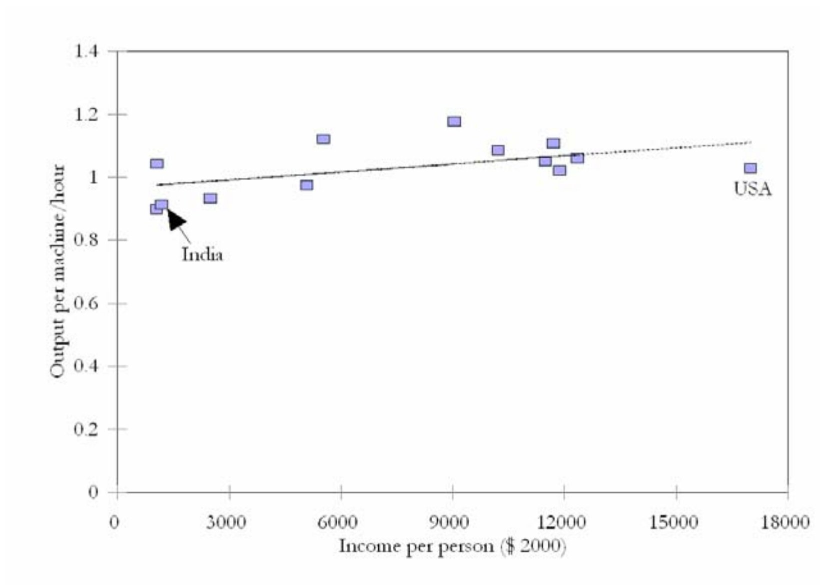

Figure 14.13 Output per machine hour, 1967[379]

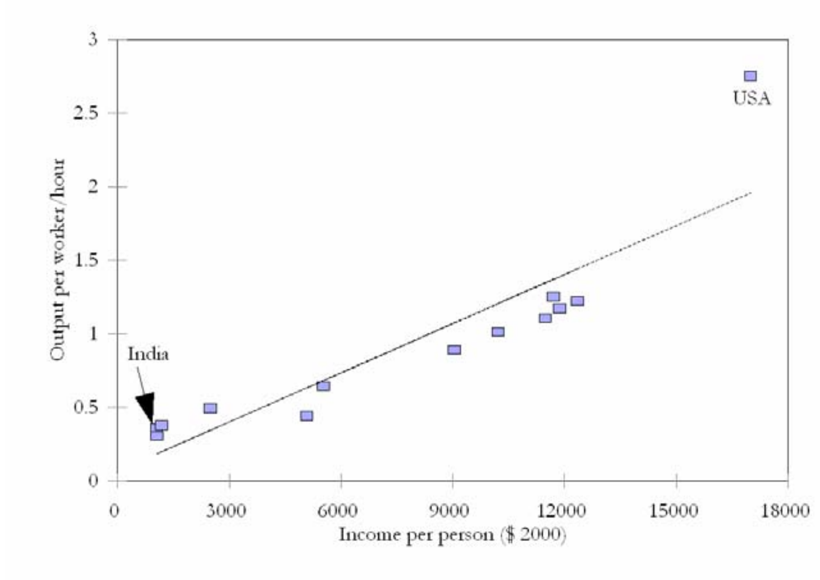

Figure 14.14 Output per worker hour, 1967[380]

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379 Pack, 1987, 140-5.

380 Pack, 1987, 140-5.

The strong correlation between wages and output per worker continues until the present day, as do the surprisingly high labor costs in low wage countries. The increased divergence in incomes between regions, even since 1910, has created an even greater divergence in the wages manufacturers face in different countries of the world by 2000. Figure 14.15 shows the full hourly labor cost of production workers in garment manufacture, a simple industry using very small amounts of capital, across various countries in 2002. Even discounting the outliers, labor costs varied from $0.40 per hour to $12 per hour, a range of about 30 to 1.

The technology in industries such as garment making and textiles is relatively standard. Labor costs in making a pair of Jeans, even in such low wage economies as Mexico, Nicaragua and China are about 75% of all costs, including transport to the US market. The cost of shipping a pair of Jeans from a clothing workshop almost anywhere in the world to the high wage markets of the USA and the EU is no more than 9 cents per pair (1% of the wholesale cost of about $8).[381] With the ending of quotas in the US market, and the agreement of the EU countries to allow in tariff free manufactures from the 50 poorest countries, as well as twelve Mediterranean countries, we would expect to see apparel manufacturing booming across Africa, and apparel industries disappearing in any high wage country.

While there have been major increases in imports into countries like the USA, a number of surprising features appear. First is that despite its extraordinarily high labor cost US production of apparel in 2004 was still 42% of its consumption.[382] The

[381] Abernathy et al., 2005, table 2.
[382]Abernathy et al., 2005, figure 1.

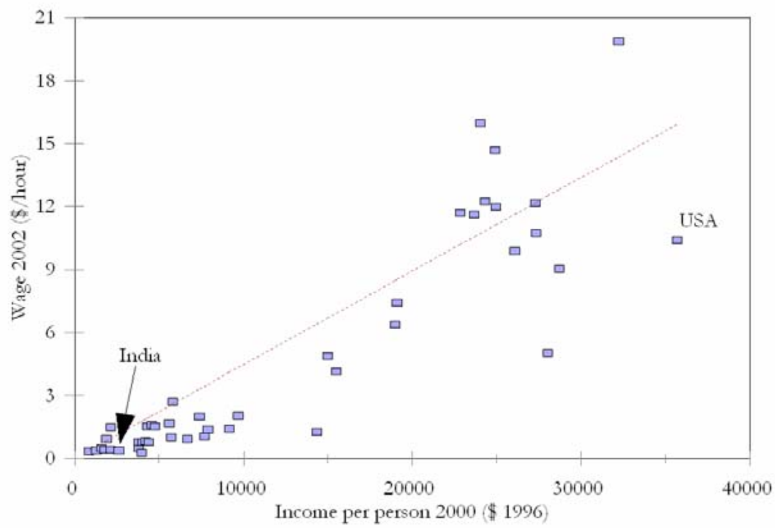

Figure 14.15 Wages in garment manufacturing in 2002 versus income per person in 2000.[383]

second was that the major exporters to the US and EU were often countries with high wages compared to sub-Saharan Africa. Thus Mexico and Costa Rica continue as major suppliers to the US market, even though they have wages more than six times those of most sub-Saharan countries and of the Indian subcontinent. Turkey, with wages similar to Mexico, continues as a major supplier of the EU in free competition again for some time with sub-Saharan countries and the Indian subcontinent.[384] Indeed African exports of apparel remain extremely small.

It is clear once again that a factor sustaining this situation is differences in output per worker across exporters that correlate with the country wage level. Figure 14.16 shows for Mexico,

[383]Wages from Abernathy et al., 2005, table 1, and US Department of Labor, Bureau of Labor Statistics, 2006.

[384]Abernathy et al., 2005, table 5-6, figure 2.

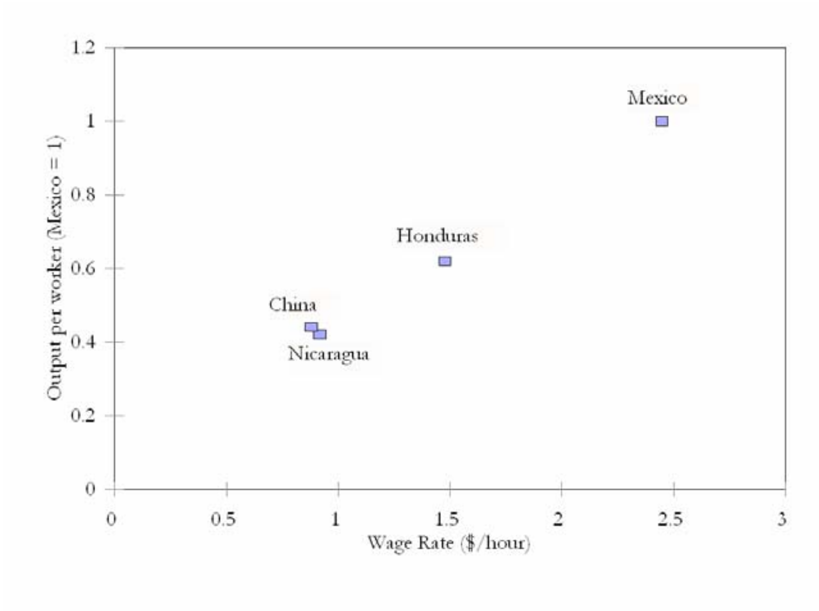

Figure 14.16 Wage rates and Output per Worker, Clothing Production, 2002[385]

Honduras, Nicaragua and China labor productivity in 2002 versus the industry wage rate.

There has been a suggestion that Africa's soils and climate has been the major impediment explaining its recent extreme poverty.[386] The majority of the populations in Tropical Africa still depend on agriculture for their livelihoods. But any such considerations would quickly become irrelevant had African countries been able to exploit their expected cost advantage in such basic manufacturing industries as apparel and textiles. But we know that as far back as the 1950s textile manufacturers from India and

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385 Abernathy et al., 2005, table 2.

386 Gallop and Sacks, 2000. Sacks, 2001.

England were finding that mills established in Uganda and Kenya offered little or no profit despite protective tariffs.[387]

Thus the crucial variable in explaining the success or failure of economies in the years 1800-2000 seems to be the efficiency of the production process within the economy. And inefficiencies in poor countries seemingly took a very specific form, the employment of extra labor in production in poor countries without any corresponding gain in output per unit of capital.

387 Clarence-Smith, 200?, 35-6.

15 Why Isn't the Whole World Developed?

> *It is difficult to conjecture, from the conduct of him whom we see in a low condition, how he would act if wealth and power were put into his hands.* Samuel Johnson[388]

In the last chapters we saw that one of the surprising features at the root of the increasing differences in income across the world was low outputs per worker, with no compensating gain in output per unit of capital, even when the most modern techniques were used. This finding again makes institutional explanations of the Great Divergence hard to sustain. Why would institutions influence the internal efficiency of production enterprises once they have been established?

These international differences in output per worker appeared in the cotton textile industry by the 1840s, and are even more pronounced in many areas now. This chapter asks what these patterns could stem from. And how would this explain the pattern of increasing divergence in incomes seen since the Industrial Revolution?

The first argument of this chapter is that these differences in labor productivity must stem from differences in the quality of labor in production across societies, differences that stem largely from the local social environment. That much can be firmly established.

At the deeper level of why these differences have had a more profound influence on differences in income per capita in the modern world than before we can pose a number of hypotheses. The first is that the ending of the Malthusian era allowed existing

[388] Rambler #172 (November 9, 1751).

differences in social energy across societies to translate into much larger differences in income than before. The second is that modern medicine has reduced the floor established through the subsistence wage. The third is that the technology developed since the Industrial Revolution has been of a kind much less forgiving of deficiencies in the quality of the labor input.

Finally at the even deeper level of what the ultimate source of these socially determined differences in labor quality we can offer only the most tentative of ideas. The strange thing about world history is that while the world before 1800 is fairly knowable, the world sense then has become increasingly difficult to understand. In the reverse of astronomy, it is not the distant universe that contains the strange objects like Quasars. Instead it is our own solar system that seems to defy explanation.

Is Labor the Problem in Poor Countries?

Despite the fact that we observe empirically in low wage economies many more workers per machine than we would expect, without any greater output per machine, it is not obvious that deficiencies in the labor input are the problem. An alternative view is that the problem was one of management.

The idea that there were great differences in the quality of labor forces between rich and poor countries was certainly a staple of writing on trade and industry in the era of the *Pax Britannica*.

When Britain was at its economic apogee in the mid and late nineteenth century, a number of writers argued that the ability of Britain, to pay high wages and still prosper in international competition, derived mainly from the much greater intensity of labor in Britain compared its low wage competitors. These writers argued that British workers were able to operate more machinery per worker, mitigating or even eliminating the wage cost advantage of the low wage countries.

Karl Marx himself, interestingly, endorsed this view. The first volume of *Capital* published in 1867 contains a short chapter, "National Differences in Wages," which attributes high output per worker in British textile mills to high labor intensity.[389] For Marx it was a further proof of the poor treatment of workers under capitalism that the higher wages of workers in the advanced capitalist economy were in large part the result of greater efforts by the workers. Per unit of effective labor, workers in Britain were still paid the subsistence wage.

This view of higher British labor intensity was not original to Marx. He was merely quoting what seems to have been for British and American economists of the late nineteenth century a kind of orthodoxy. British managers had plenty of experience by the late nineteenth century working with foreign labor in railway construction, and as managers in the international textile industry. Under British management, production in different countries required different amounts of labor. Indeed there were overtly racist discussions at the time focused on such questions as how many Chinese, Indian or African workers were the equivalent of one British.[390] There were also discussion about whether differences in labor efficiency did or did not completely offset differences in day wages, making that the real cost of labor constant internationally.[391]

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389 Marx, 1867, ----.

390 Stuart, 1902.

391 See, for example, Brassey, 1879, 157-96, Jeans, 1884, 623-4, Schulze-Gaevernitz, 1895, 85-130.

This was probably the dominant view of the cause of differences in output per worker in modern industry across countries up until World War II. A 1922 report by an agent of the U.S. Department of Commerce informed potential purchasers of machinery for use in Asia

> *One of the most common errors made in selecting machinery for Asia is in connection with labor-saving devices. It is felt that labor is so cheap that it need not be saved….Because of the extreme inefficiency of Asiatic labor, well-informed buyers will invest heavily in labor-saving devices* (Rastall, 1922, 71).

A 1929 report in the *Journal of the Textile Institute* on the Indian industry states baldly, "India is obliged to engage three persons in place of one employed in the Lancashire mills."[392] Arno Pearse, the international textile expert, stated in 1930,

> *Labour in India is undoubtedly on a very low par, probably it comes next to Chinese labour in inefficiency, wastefulness, and lack of discipline* (Pearse, 1930, 188).

Despite the unchanging nature of the international differences in performance in the industry the "labor quality" explanation disappeared after WW II from economics. Economists now mainly attribute the poor performance of industry in underdeveloped economies not to labor problems but to a generalized failure by management to productively employ all the inputs in production – capital and raw materials as well as labor. Unskilled labor is assumed to be of the same quality everywhere.[393] Managers, however, differ internationally, with the poorest countries having the least effective management.

Why, in this case, is output per machine-hour the same across economies while output per worker is much lower in low wage

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392 Cotton Yarn Association, 1929, T11.

393 See, for example, Pack, 1987.

countries? On the modern view this is because two things occur simultaneously in poor economies. The first is that because managers were, and are, deficient in low wage economies they employ both more capital and more labor per unit of output than is required in the advanced economies. This is shown in figure 15.1. The vertical axis shows the capital used per unit of output, the horizontal axis the labor employed. To produce a unit of output there will typically be many possible choices of capital and labor inputs per unit, but a range of choices shown in the figure as the curve running through point A. By using more capital, some labor can be saved. And vice versa. For example, in ring spinning if the speed of the machines is reduced, the capital input per unit of output increases. But since at lower speeds there are fewer thread breakages, some labor in repairing these is saved.

A country with less effective management will also face a tradeoff between capital and labor in production. But this trade-off will lie further from the origin in figure 15.1, as at point B. For any given ratio of capital to labor, the country with the less effective management needs more of both inputs. In cotton spinning, for example, if the raw cotton is not blended correctly the breakage rates in spinning will be higher, reducing both output per worker and per unit of capital. With ineffective management machines will break down more often, idling both capital and labor.

A second thing happens, though, in low wage economies. Managers there are encouraged by the low wages to substitute labor for capital. For them labor is cheap, and capital relatively expensive. So in the ring spinning case, for example, they will be encouraged to speed up machines and employ more labor to fix the resultant breaks. Thus managers in low wage economies like

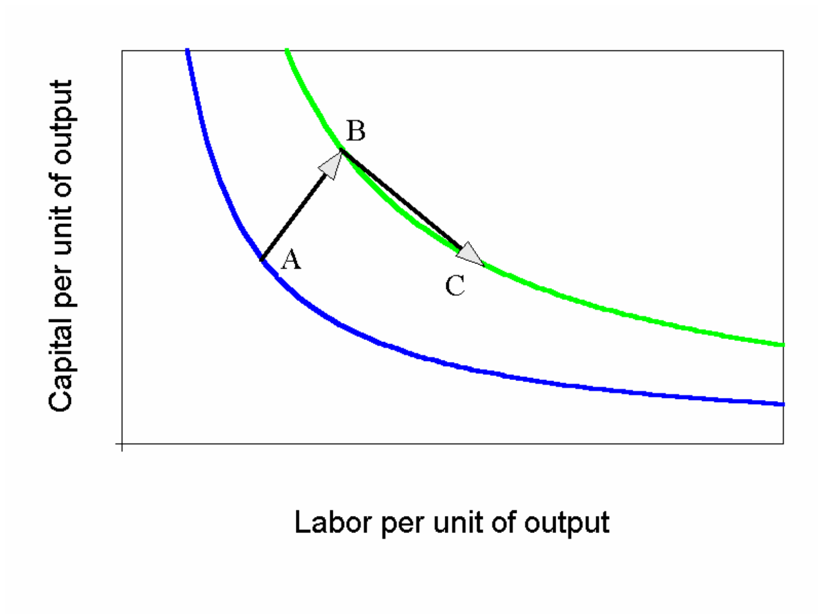

Figure 15.1 Production Choices in the USA and India

India, faced with very cheap labor, rationally choose to use the combination of capital and labor represented by point C.

To see how this process operates in practice consider weavers assigned to looms. If there was one weaver per loom, as in India in 1910, then whenever the looms ran out of weft thread, or a warp thread broke, the worker could immediately fix the problem. Thus there should have been a high level of output per unit of capital. If, as in the US, each worker tended 8 looms, then it would typically take some time for the loom to be put back in service after the weft ran out or the warp broke. For the weaver was not constantly watching each loom, since he or she was often busy repairing one of the other looms. Here output per worker should have been high, but output per machine low.

The modern view of the cotton textile industry is that the low wage costs in poor countries lead managers to add so much more labor per machine that they were able to get output per machine back up to the level of the advanced economies despite their general inefficiency. But they did so at the expense of further reducing output per worker.

Capital required per unit of output is driven up by managerial inefficiencies, but then driven down again by substituting cheap labor for capital. In balance the effects cancel out. In contrast labor required per unit of output is driven up by managerial inefficiencies, but then driven up again by substituting cheap labor for capital.

For this explanation of the observed international patterns of capital and labor productivities to work, there has to be plenty of room for substitution of capital and labor in production.[394]

What we see then is that there are two competing visions of the economic problems in production in poor countries. The nineteenth century view that stresses the problem lay with the quality of workers, and the twentieth century view where the problem lay in managerial failings. If all we have are records of output, labor and capital, from each industry then we cannot tell the difference between these views, since they are at this level observationally equivalent.

But in the case of the international textile industry, where we can get much more evidence on management, equipment, and labor assignments, it becomes very apparent that the nature of the labor force was the key issue limiting efficiency in low wage economies.

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[394]For the process to produce the observed effects production processes have to be Cobb-Douglass.

Management in Low Wage Economies

Did poor countries suffer from poor management? Managers, like machines, can be imported in low wage economies if the local supply is deficient. This was particularly easy in the cotton textile industry since cotton mills had a relatively small managerial structure. The managers supervised the purchase of the cotton, set the machines for the type of output that was being produced and supervised the workers. But since the workers had, as noted above, well defined tasks whose completion was easy to check, supervision should have required modest amounts of time.

In the cotton textile industry around 1910 when the differences in manning levels were already very clear Britain not only exported machines, it also exported large numbers of managers and skilled workmen to foreign mills. India, China, Russia, Brazil and Mexico all had significant numbers of British managers around 1910.[395] Thus in 1895 there were 55 mills in Bombay, the center of the Indian industry. 27 of these had British managers. In these mills there were 190 weaving masters, spinning masters, carding masters and engineers. These were the deputy managers who supervised the loom sheds, the spinning and carding rooms and the steam machinery of the mills. Of these 77 were British.[396] Similarly least a third of the Chinese industry was under British management in 1915, and some of the mills owned by Chinese entrepreneurs were operated by British mill managers. Most Brazilian mills had British managers, room bosses, and engineers. Unless there was a selection, for which there would be no economic rationale, where only the least competent British managers went to the lowest wage economies, those with the

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[395] Clark, 1987.

[396] Rutnagar, 1927.

intermediate competence going to middle wage societies, and the best staying in high income economies, management cannot have been the issue.

In places like Bombay the industry was highly competitive. Table 14.4 above showed that profit rates even in growth years in the industry in 1907-1924 were very modest. Managers were thus under constant pressure to improve the efficiency of their mills. Thus in 1925 of 85 cotton textile mills in Bombay, 45 had failed and been reconstituted under new management at some point in their history. 16 others had transferred managerial control voluntarily.[397] There is no sign of any obvious managerial failings persisting in the industry such as choosing the wrong types of machinery, or the wrong scale, or the wrong level of vertical integration.[398]

Substitution Possibilities

The modern view of the excess labor forces in factories, mills, and railways in poor countries depends on the management choosing to substitute labor for capital. But there are some techniques in cotton mills where such substitution is not possible, and so the staffing levels should be much closer, or even be the same as, high wage economies.

One such task is doffing. Doffers remove the full spindles of yarn at set intervals from the spinning machines. The machines must be stopped while the doffing is done all. So all 400 or so spindles on a frame are doffed at the same time. Machines

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[397] The first mill was built in 1856, but the industry began to grow strongly only in the 1880s. Rutnagar, 1927.

[398] Wolcott and Clark, 1999.

spinning the standard yarn would be doffed once every three hours in India in the 1930s or 1940s. Since it took about 3.3 seconds to doff each spindle, if one person only were to doff the entire frame, the spindles would be stopped for doffing for 20 minutes out of each 200, or 10% of the time. To avoid this utilization loss doffing was done by specialized teams of. This reduces the doffing time per frame to 2–4 minutes, about 1–2% of running time.[399]

Table 15.1 shows doffer's work rates per hour in the USA, Britain and India over the years 1907-1978. The Indian rates of doffing are extraordinarily low all the way from 1907 to 1978, and show very limited improvement. In the 1940s Indian doffing rates were 16% of US rates. Echoing this, if we use time and motion estimates of the tasks of ring spinners, then in India in the 1920s given the staffing levels workers were working only 18-23% of the time.[400]

Why is labor quality so low in poor economies?

While it seems clear from the above that the cause of the "overmanning" in poor countries resides principally in the workers, explaining why there are so many seemingly surplus workers employed in production in low wage economies is not easy. Even in cases where we have lots of information, as on the textile mills of Bombay in the 1890-1938, an explanation is not

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[399] In Japan in 1929 Pearse reports doffing squads of 5-8 workers who would doff a frame in about 1 minute. In India in 1930 the doffing of the whole frame seems to have taken longer, 2–3 minutes, but we do not know the size of the doffing gangs. Pearse, 1929, 55, 65. Pearse, 1930, 129, 133, 138.

[400]Wolcott and Clark, 1999, 400.

Table 15.1 Doffs per Hour, US, Britain and India[401]

Year	USA	Britain	India
1907	-	-	*102*
1921	*728*	-	*118*
1944-9	770	462	*124*
1959	1000	-	-
1969	-	600	-
1978	-	-	*160*

obvious. Bombay mill workers seemingly worked at low intensity, and in a slapdash manner, so that employers were forced to assign many workers per machine to get full output from the capital.

The managers in Bombay in the 1920s knew that by the standards of Britain and the USA their mills were overmanned. Also after 1924 the industry was under severe stress with many mills suffering losses, and little or no new investment. Why didn't they get rid of the excess workers?

The answer seems to be that reducing manning turned out to have no benefits in terms of costs. Some firms did move aggressively to reduce manning levels in the 1920s and 1930s. But these

[401] Figures in italics are doffing rates inferred from the number of spindles per doffer, or the number of lbs doffed per hour per doffer. *Sources*: Clark, 1907. Cotton Spinning Productivity Team, 1951. Doraiswamy, 1983. Ratnam and Rajamanickam, 1980. Shirras, 1923. Textile Council, 1969.

firms' profits were no higher than those of the firms who took no steps in this direction. There was no strong market signal that this was the right direction to move in.

We can divide the firms into two groups – *rationalisers* who made some significant reduction in the numbers of workers per machine in 1924-38, and the *non-rationalizers* who did not change worker numbers. On average the *rationalizers* reduced worker numbers by 35 percent. But in 1935-8 the average gross profit rate of the rationalizers was 1.7%, while that of the non-rationalizers was 2.0%. There was nothing in the experience of the Bombay industry to suggest that shedding surplus labor lead to higher profits.

Bombay Dyeing and Manufacturing was the most profitable of the *rationalizers*. But its average profit rate for 1935-8 was still only 6 percent. Even this mill was not a great success, at least in the eyes of its managers. According to the minutes of the Bombay Dyeing Board of Directors meetings, the profits of the mill company were sufficient to induce replacement of some worn out equipment. Between 1930 and 1938 the Board authorized average annual expenditures on equipment of Rupees 374,469, approximately 1.3 percent of the value of their fixed capital stock. But on net, the number of their spindles and looms declined. And during these years, the Board also authorized large expenditures of profits on government bonds. By 1938, the market value of the company's holdings of government bonds was Rupees 8,026,989 - sufficient to extend their capital stock 25 percent, had they regarded investment in the cotton industry as profitable.[402]

Shedding labor did not result in higher profits mainly because firms which shed labor paid higher wages to the remaining workers. Thus in 1935-37 the average day wage in the *rationalized*

[402] Walcott and Clark, 1999, 409.

mills was Rs. 1.26 compared to Rs. 1.11 for *non-rationalized* mills. This disparity was entirely a creation of the *rationalization* process. From 1924 to 1935-8 *rationalized* mills' nominal day wages fell 6 percent, while *non-rationalized* mills' wages fell 21 percent. Further the increase in machinery could not be just foisted upon the workers. Preparations were undertaken to minimize the effort requirements per machine, despite the apparently minimal tasks of the workers before rationalization. There were also ongoing costs. These included better machine maintenance and better cotton quality, both being designed to reduce the breakage rate.

In a competitive labor market workers can be employed under terms that would imply differing amounts of effort per hour. Firms that demand greater efforts will have to pay higher wages. Thus it could well be that firms in Bombay had on average chosen the optimal wage-effort combination given the capacities and inclinations of the workers. Those that tried to extract more effort from their workers had to pay more to retain them.

It was claimed by many observers, for example, that the reason for low labor productivity in places like Bombay was that Indian workers clung to outdated work norms such as one worker per side of a ring frame. Thus

> *Before independence, work allocation was purely on an ad hoc basis and was dependent on the tradition of that particular region. If a worker attended to 200 spindles in one mill, he did the same in all the mills in the locality* (Sreenivasan, 1984, 172).

But if labor resistance based on outdated work norms in the declining center of Bombay was the problem, rationalizing managers would have had enormous incentive to move to new locations. The day wages of workers were generally cheaper outside the established textile centers. In fact, there was enormous growth in such places as Ahmedabad, Cawnpor, Nagpur, Madras, Delhi and Coimbatore in the interwar period. But while machinery and employment expanded, productivity there also remained at its prewar levels. If staffing levels in the main centers of the industry were purely conventional why did the managers of these new mills in isolated locations not train the workers to operate 800 spinning spindles each, as should have been feasible?

Also manufacturers were clear that low machine assignments were often made for fear of losses of output per machine if workers looked after more machines. Thus one manufacturer testified to the Factory Commission in 1908 that,

> *They had one man to each loom, because if they gave two looms to one man it would mean a loss of three-eighths of the loom's capacity. They would prefer to stop a loom altogether rather than hand it over to a man working another loom* (British Parliamentary Papers, 1909, 315)

The Buckingham and Carnatic mills in Madras, one of the largest and most profitable textile enterprises in India, introduced automatic looms in the 1920s. The staffing of ordinary looms at this time in India was still often one worker per loom, compared to one worker per eight looms in the USA. There would be 20-30 automatic looms per worker in the USA. Three automatic looms only were assigned to each weaver in the Buckingham and Carnatic mills. Since the looms were new to the workers, since they had no reason to expect three looms per weaver any more than ten looms per weaver, if the limitation on staffing previously was a convention, why not choose this moment to establish a more profitable convention?

Another sign that outdated work norms were not the problem was that between 1890 and 1929 managers of Indian mills moved towards purchasing new machines that used less labor. One way of using less labor was to make the input and output packages larger so that they had to be changed less often. Thus the average size of the output bobbins spinning 20s yarn went up from 14 in^3 circa 1890 to 16 in^3 circa 1929. Similarly the average size of the input bobbins on 20s yarn moved up from 80 in^3 circa 1890 to 115 in^3 circa 1929. Managers were choosing machines that occupied more floor space, but that saved on labor. Why would they do this if they were constrained to have a fixed number of spindles per worker?

So it is very clear from the detailed experience of the Bombay industry in the 1920s and 1930s that problems in the employment of labor were the key difficulty. A further sign that there really were differences in the attitudes and behaviors of Indian workers compared to workers in high wage economies was the conditions of employment in Indian mills, conditions that continued at least into the 1960s.

Indian mills had, by western standards, very lax discipline. The cotton mills in England were noted for their early introduction of strict systems of factory discipline. Workers, even those who were on piece rate, were expected to appear at opening time each morning, to work all the hours the mill was open, to stay at their own machines, and to refrain from socializing while working.[403] Indian mills by comparison were very undisciplined, at least up until 1930. There continued to be a very high rate of absenteeism in mills at least into the 1960s.

The Indian Factory Labour Commission report of 1909 is full of testimony by the employers as to the conditions in the mills, though of course we have to be wary of the biases of the employers. A substantial fraction of workers would be absent on any given day, and those at work were often able to come and go from the mill at their pleasure to eat or to smoke. Other workers would supervise

403 Clark, 1994.

their machines while they were gone, and indeed some manufacturers alleged that the workers organized an informal shift system among themselves.[404] The mill yards would have eating places, barbers, drink shops and other facilities to serve the workers taking a break.[405] Some mothers would allegedly bring their children with them to the mills. Relatives of workers would bring food to them inside the mill during the day. "There was an utter lack of supervision in the Bombay mills." One manager even goes so far as to state that while in the factory the worker "washes, bathes, washes his clothes, smokes, shaves, sleeps, has his food, and is surrounded as a rule by his relations."[406]

It is very hard to get any reliable estimate of how much time workers were absent from the machinery during the work day. The manufacturers in 1908 alleged that 10-30% of the work time was spent in the mill yard. To partially control this absenteeism some employers used a pass system, where a worker could only leave the mill if they had a pass for their department. Each department would have passes equal to 10-25% of the labor force. But even this modest measure was sometimes successfully resisted by the workers.[407]

This lack of discipline persisted throughout the free market period of the industry under British rule up till 1947, and probably beyond. Thus R. K. P. Mody, a lecturer in textile technology at the Victoria Jubilee Textile Institute in Bombay who had worked in both English and Indian mills, in an article in 1951 giving "practical hints to jobbers," assumes that even a good jobber will allow workers to leave the mill rooms during work, as long as they

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[404]British Parliamentary Papers, 1909, 111, 170.

[405]Morris, 1965, 114-5.

[406]British Parliamentary Papers, 1909, 21, 27, 78, 111, 204.

[407]British Parliamentary Papers, 1909, 25, 35, 72, 111, 139, 148-9, 170, 181, 197, 200.

had tokens. This refers to the pass system introduced by some employers as early as 1909 under which a worker could only leave the mill if they had a pass for their department.[408]

Mody condemns as bad, but apparently not uncommon supervision practices, by jobbers and Mukadams allowing workers to go out without tokens (Chhapas) in twos or more at once "leaving machines and other work unattended," as well as allowing workers to read newspapers inside departments, allowing sleeping inside departments, and allowing children in the departments.[409] What is interesting is that by the time of the later Industrial Revolution

Certainly mill attendance was irregular in Bombay even in the 1940s. Daily absenteeism in Bombay mills was reported at an average of 10.7% in the years 1939-1944, in Ahmedabad mills had absenteeism rates of 4.5%.[410]

Irregular attendance by workers continued to be a feature of the Indian industry, at least into the 1960s. Table 15.2 summarizes a study of 16 mills in South India which found high absenteeism rates apparently tolerated by mills in the 1950s and 1960s. In 1955, for example, 7% of the workers were absent for 25% or more of the work days. Absenteeism also increased on days after wage payments, on days after bonus payments and on days after holidays. Yet management continued to employ such workers, even though a relatively small identifiable group created many of the days lost from work.

Table 15.2 Absenteeism in Indian Mills, 1955, 1965[411]

[408]Mody, 1951.

[409]Mody, 1951,720.

[410]Deshpande, 1946, 8.

[411] Rudraswamy, 1957, 1967.

Period	Urban (%)	Rural (%)
Average, 1955	8.0	5.7
Average, 1965	10.6	8.9
First day after wage payment, 1965	11.0	6.1
Second day after wage payment, 1965	10.8	-
Third day after wage payment, 1965	10.2	-
First six days after twice yearly bonus payment, 1965	12.4	7.7
First day after a holiday, 1965	10.5	7.9

This irregularity was not just a product of the annual movement of workers back to their villages at the wedding season or for harvest. Mills often had regular leave systems that workers could utilize for such occasions. Rather there was a lot of day to day absenteeism.

Many mills made attempts to limit absenteeism, but by rather weak methods. Thus the rules of the Madura Mill Company in 1946 specified that any worker who was absent from the mill without permission for **8 days or more** was subject to suspension or dismissal.[412] More commonly they relied on relatively modest bonuses offered workers for better attendance.

More than just taking a relatively liberal attitude towards absences, Indian mills even allowed workers to effectively subcontract their work for periods where they were absent. At least in the 1920s weavers in Bombay, a relatively skilled group of workers, were allowed to hire their own substitutes (*badlis*) for the days they were missing.[413] The weavers were paid on piece rates, so they would get the payment for whatever output the substitute produced. The substitute was paid by the weaver with no intervention or supervision by the firm.[414]

So the experience of India strongly supports the idea that labor problems were at the root of India's failure to industrialize under the British Raj, and subsequently under independent Indian governments. This does not rule out that whatever socially induced lethargy that afflicted Indian labor did not extend all the way through Indian society. Just that if there was a deficiency in the ranks of Indian managers and entrepreneurs then these inputs could be relatively easily imported, as we saw already in the case of the Sassoon family.

Why Divergence?

If the fundamental force underlying the differences in incomes between economies is the quality of the labor force across various economies, then why are the differences in income

[412] Deshpande, 1946.

[413] Newman, 1981.

[414] In some of the firms there does seem to have been a limit on how many consecutive days a *badli* could be employed by a weaver.

today so much greater than in 1800? The differences in social capabilities between societies now are presumably not any greater than they were in 1800.

There are three reasons why the same differences across societies now would lead to a much greater divergence in incomes per person.

The first is that in the pre-industrial world, because of the Malthusian mechanism, these differences in labor effectiveness had no consequences for the average level of output per person across societies. As we saw in chapter 3, leisurely societies were just as well off as hard working ones. Now that income per person is no longer constrained by Malthusian mechanisms, the existing differences in capabilities between societies can express themselves through income per person rather than population densities. The escape from the Malthusian era is one factor in the Great Divergence.

The second is that, as we saw, modern medicine has substantially reduced the subsistence wage in areas such as Tropical Africa, allowing populations to continue growing at incomes which are substantially below the average of the pre-industrial world.

The third, more tentatively, is that the new production techniques introduced since the Industrial Revolution have raised the wage premium for high quality labor.[415] In the pre-industrial world production processes tended to be "shallow," meaning that they did not involve a large number of steps. Also they were typically tolerant of error and inattention along the way. Consider the production of wheat in pre-industrial agriculture. The ground was plowed, the seed sown, the grain reaped, and lastly threshed and winnowed. If too much was seed was sown then some seed

415 This idea is due to Kremer, 1993.

was lost, if too little then some land input was not fully utilized. If the threshing was done badly then some grain remained with the straw, which anyway was fed to the farm animals, so only part of the value was lost. But errors or poor performance at each step of the process tended to have modest costs.

Poland in the early nineteenth century, for example, was a major supplier of wheat to Britain, and so its agriculture was of interest to the British. The Englishman William Jacobs, who made a tour of enquiry in the 1820s, noted the generally poor performance of agricultural workers there. Of threshers he states, "a much greater proportion of the grain was left among the straw, than in that which has passed under an English flail." His data implied that Polish threshers, even with less care, threshed only half as much per day as English threshers. The grain exported from Eastern Europe was also very imperfectly winnowed, and had to be rescreened on arrival to exclude the large amount of foreign material left in the grain.[416] The grain from the interior of Poland was floated down to the Baltic on wooden barges unprotected from the rain and sun, so that by the time it arrived there the top layer would have sprouted and begun to grow. This sprouted layer was just peeled off on arrival.

As noted, the production system was fairly tolerant to the slapdash work ethic of the Polish workers. If threshers did not work hard, more could be added to complete the task. If the grain was not winnowed well, then it could be screened a further time. If some grain sprouted then it could be discarded.

The new technologies of the Industrial Revolution involved a more extensive division of labor, and were less tolerant to errors along the way. In pottery factories in Britain, for example, by the nineteenth century there were 29 different steps in the division of

416 Clark, 1987b, 425, 427.

labor. The fourteenth in making cups, for example, was attaching the handle.[417] If this was not done correctly, then the final cup was worthless. There could be no re-screening as with the Polish wheat. In such a situation, Kremer argues, mistakes by the labor force will have a multiplicative effect.[418] As portrayed in figure 15.1, if there is a chance p of a mistake in each of n steps in the production process, and each is fatal to producing a saleable product, then the chance of getting a saleable product will be $(1-p)^n$. If, for example, the chance of a failure at each stage in the pottery works was p = 0.1, and there were 29 stages, then the fraction of successful cups made would be 0.05.

In this situation, manufacturers might find the current African labor force, even offered at extremely low wages, not a cost effective option. Or when confronted with a workforce with low work rates, or high chances of error, manufacturers might find it cost effective to add more workers at each stage of the process in order to ensure flow and prevent errors. This could lead to the situation found in the empirical results of chapter 14: large amounts of extra labor in low wage countries, but just the same output per unit of capital as in the rich.

So this argument would be that the direction of technology in successful high income economies is towards production processes that, developed in the work environments of these economies, give a high premium to regular and meticulous completion of work tasks. In economies where labor is more relaxed and less disciplined, these technologies can only be utilized with extravagant amounts of extra labor to compensate for the characteristics of the labor force.

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417 Clark, 1994, 153-4.

418 Kremer, 1993a.

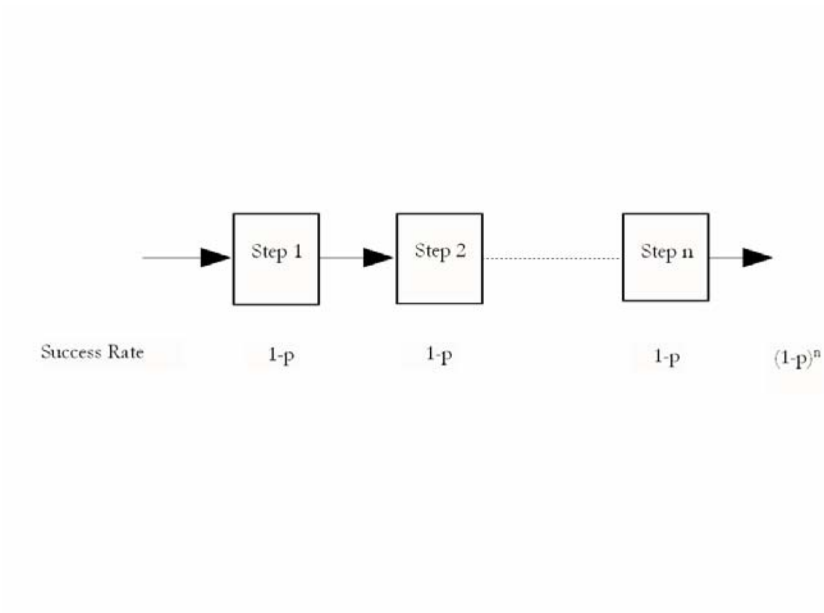

Figure 15.1 A Modern Production Process?

An empirical implication of this third idea would be that the comparative productivity of modern production techniques compared to their handicraft precursors would be much less in low wage economies.

India has seen an extraordinary maintenance in the textile weaving sector, for example, of handlooms. By the 1830s in England handloom weaving of cottons was largely superseded by power looms in factories, even though the wages of handloom workers were only about half those of factory workers.[419] Yet 176 years later the handloom sector in India is still very large, particularly in cottons. Indeed the output of the handloom sector has grown steadily since statistics were first gathered in 1900. In 1997-8, as table 15.3 shows, output of woven cloth from hand-

419 See Bythell, 1969.

looms in India was about 10 times as great as in 1900. In 1997-8 25% of cloth production in India was still from handlooms.

Cloth in India is in fact produced in three ways. The mill sector, consisting of large power loom plants as in the USA, the handloom sector costing of looms in houses and workshops, and the "power loom" sector, consisting of workshops of 1-50 power looms outside the formal regulation of the mill sector. The survival of the handloom industry in India is often attributed to government protection. Since independence the government has levied excise taxes on mill output while keeping the handloom sector tax-free. Thus even in 1997-8 most fabrics paid an excise duty of 10-20%, but handloom cloth was still exempted. However, the informal "power loom" sector has largely avoided paying these excise taxes.[420] So the tax advantages mainly serve to explain why smaller power loom operations could out-compete large mills. They do not explain why handlooms can still compete against untaxed power loom operations. Power looms produce 2.5 times the amount of output per hour as handlooms, and one weaver should be able to operate between 4 and 8 power looms at a time, based on labor requirements in Britain and the USA circa 1900. Day wages per worker in the handloom and power loom sectors are about the same, so this implies that power loom labor costs per meter of cloth should be 5-10% of handloom labor costs. Since capital costs for power looms per meter are estimated to be only about 20% higher than for handlooms interest rates would have to be extraordinarily high before handlooms had any cost advantage. But in practice power looms in India require much more labor even than machine powered looms in England

[420] See Misra (1993), pp. 89-119.

Table 15.3 Cloth Production in India by Sector, 1997-8 (meters^2)

Year	Mill Produc-tion	Decentralized Powerloom	Handloom Production
1900-3	483	0	793
1936-9	3,630	0	1,420
1980-1	4,533	4,802	3,109
1997-8	1,948	20,951	7,603

Sources: Office of the Textile Commissioner, 1997, 1998. Mazumdar, 1984, 7, 36.

in the nineteenth century. Power loom weavers typically supervise only 1.5 looms each.[421] This drastically reduces the labor cost advantages of the power loom. The high levels of staffing of power looms might be explained by the very low wages of the operatives, but Indian wages now are as high or higher than those in England in the 1830s when a more primitive power loom easily swept aside the competition of handlooms. The key issue here is that because of the capital requirements power looms are operated with hired labor, while handlooms are placed in the homes of the workers, and the work is paid for on a piece rate basis.

421 Mazumdar, 1984, 93.

Why the Differences in Labor Quality?

On this last issue there is no satisfactory theory. Economies seem to alternate between relatively energized phases and those of relative somnolence in, to us, a largely random pattern. We saw above that India saw declining income relative to the US and UK for 120 years since 1870. Recently, coinciding with some modest economic reforms that did no more than move the economy partially back to the free market period of the *Raj* of 1857-1947, India began to grow again. But growth in India is actually confined to a selection of states. There are others within the same political framework, such as Bihar and Uttar Pradesh, that have continued to perform very poorly. British income relative to France and Germany declined substantially from 1950 to 1980, but has since returned to equality. Ireland, whose income per person was only about two thirds that of Britain from 1800 to 1980 has since grown to an income per person that is one of the highest in Europe, exceeding that of Britain. New Zealand in the last 20 years has seen significant slippage in its income relative to other OECD countries.

This pattern of alternating periods of energy and somnolence extends back far in history. The Golden Age of the Netherlands in 1550-1650, for example, was followed by 150 years of economic stagnation. English observers visiting Polish farming estates in the 1820s remarked on the low energy of even the free labor, who were stimulated only by the prospect of drink. The only thing that is different is that the magnitude of the swings, the reversals in fortune, seem greater in the post-Malthusian world.

16 Conclusion: Strange New World

Thus there is a great irony in the economic history of the world. In most areas of enquiry – astronomy, archeology, paleontology, biology, history for example – knowledge declines as we move away from our time, our planet, our society. The present and the local is the area of familiarity and certainty. It is mainly in the distant mists that lurk the strange baffling objects: quasars, dwarf human species, hydrogen sulfide fuelled bacteria, mass extinctions, bizarre cultural forms.

But in economic history the distant world of the Malthusian era, however odd it may appear, is a known world: a world that followed established, comprehensible laws and economic principles. Want to know why Englishmen in 1450 were so wealthy? The immediate source was the severe decline in population, to a low of only 2.2 million. This endowed each Englishman with more than 12 acres of farmland, an abundance of resources that spilled ample food onto every table. The deeper source was the plague bacillus, *Yersinia pestis*, combined with the poor hygienic practices of pre-industrial Europe, which allowed large rat populations to subside in close familiarity with people.

In pre-industrial societies living standards are thus predictable from disease and other environmental conditions. Further differences in social energy across societies, which have probably existed for all time, also were muted by the Malthusian constraints, so that they had minimal impacts on living conditions. In economics the known world thus stretches from the original foragers of the African savanna till 1800.

But since the *Industrial Revolution* we have entered a strange new world where economic theory is of little or no use in understanding differences in income across societies, or the future path of income in any society. Wealth and poverty is a matter of differences in local social interactions and social energy that get magnified, not dampened, by the economic system to produce feast or famine. It is a world that the vast deluge of economics journal articles, working papers, and books devoted to ever more technically detailed studies of capital markets, trade flows, tax incidence, sovereign borrowing risk, corruption indices, rule of law, serves more to obscure than to illuminate. For the economic history of the world constructed above is largely innocent of these traditional economics staples. For the great engines of economic life in the sweep of history – demography, technology, and labor efficiency – seem uncoupled from these quotidian economic concerns.

Technical Appendix

In this appendix all the formulas used in the book are derived using simple algebra.

1. The Fundamental Equation of Growth

In all economies, if y is output per person, A the level of efficiency, k capital per person, and z the land per person, then

$$g_y = ag_k + cg_z + g_A \qquad (1)$$

where g_x denotes the growth rate of a variable, a is the share of output paid to capital owners, and c the share paid to land owners.

To show this assume a general relationship between output and the other variables of the form

$$y = AF(k, z) \qquad (2)$$

A now is interpreted as measuring how well the economy translates inputs into output. The exact nature of the function $F(k, z)$ is unspecified, and does not need to be.

A small change in efficiency, ΔA, changes output by $\Delta AF(k, z)$. Thus a 1 percent increase in efficiency increases output by 1 percent. A small change in capital per person, Δk, changes output by $r\Delta k$, where r is the rental payment per unit of capital. This is because in a competitive economy the amount paid to each input equals the amount the last unit used adds to output. Similarly Δz changes output by $s\Delta z$, where s is the rental per unit of land.

Adding up these effects, we can divide small changes in output per person into

$$\Delta y = r\Delta k + s\Delta z + \Delta AF(k, z) \qquad (3)$$

Dividing both sides of (3) by y and rearranging gives

$$\frac{\Delta y}{y} = \frac{rk}{y}\frac{\Delta k}{k} + \frac{sz}{y}\frac{\Delta s}{s} + \frac{\Delta AF(k,z)}{AF(k,z)} \qquad (4)$$

(1) follows from (4).

2. Efficiency Growth Rates

(1) implies that we can measure the rate of efficiency growth as

$$g_A = g_y - ag_k - cg_z$$

Equivalently we can measure efficiency growth as the weighted average rate of the growth of payments to labor, capital and land. That is

$$g_A = ag_r + bg_w + cg_s \qquad (5)$$

To derive this note that the value of the output equals the sum of payments to owners of labor, capital and land. So

$$y = w + rk + sz \qquad (6)$$

(6) implies that, again for small changes,

$$\Delta y = \Delta w + \Delta rk + r\Delta k + \Delta sz + s\Delta z$$

$$\Rightarrow \qquad \Delta y - r\Delta k - s\Delta z = \Delta w + \Delta rk + \Delta sz$$

Dividing everything above by y, and rearranging, gives

$$\frac{\Delta y}{y} - \frac{rk}{y}\frac{\Delta k}{k} - \frac{sz}{y}\frac{\Delta s}{s} = \frac{w}{y}\frac{\Delta w}{w} + \frac{rk}{y}\frac{\Delta k}{k} + \frac{sz}{y}\frac{\Delta s}{s}$$

$$\Rightarrow \qquad g_A = g_y - ag_k - cg_z = ag_r + bg_w + cg_s$$

3. The Fundamental Equation in the Malthusian Economy

Before 1800 we have a special case of equation (1) where in the long run $g_y = g_k = 0$. Also $g_z = -g_N$, where N is the level of population. Thus if population was growing at 1 percent per year, then land per person was falling at this rate. Substituting these values in (1) gives, for the long run,

$$g_A = cg_N$$

Since income per person does not change over the long run in the Malthusian economy, and since to a first approximation wages and the return on capital should be constant, then (5) implies that

$$g_A = cg_s$$

Hence the growth rate of real land rents in the Malthusian world, absent changes in real interest rates, should be the same as the growth rate of population.

4. The Sources of Efficiency Growth

Supposing there are j sectors in an economy, overall efficiency growth rate of the economy can be decomposed into the contribution from each sector through the equation

$$g_A = \sum \theta_j g_{A_j}$$

where θ_j is the value of output of sector *j* relative to the value of all final outputs produced in the economy.

5. Modern Growth

In the modern era, the share of land rents in national incomes for industrialized economies has declined sharply, to typically – percent or less. This implies that for the modern era we can simplify the fundamental equation of growth even further.

$$g_y \approx a g_k + g_A$$

Further, growth in efficiency induces more physical capital investment. The amount of this induced capital accumulation can be estimated from the fact that

$$a = \frac{rk}{y}$$

Since in the modern era *a* has been relatively constant at about 0.25, and the real interest rate *r* has also been relatively constant, by implication

$$g_k \approx g_y$$

Thus

$$g_y \approx \frac{g_A}{(1-a)}$$

Also in the modern era the products ag_r and cg_s are both close to 0, because g_r and c are each close to 0. Thus

$$g_A \approx bg_w$$

Thus almost all the gains from growing efficiency in the modern economy have flown to wage earners. And we can approximate the rate of efficiency growth in the modern era just by looking at the growth of real wages.

6. Generalizations

The above results for the sources of growth in income per capita are derived for an economy with only one output, one type of labor, one type of land, and one type of capital (which is just stored up output). But all these results generalize easily into analogous expressions for an economy with many types of output, labor, capital and land, as the appendix shows. Thus in an economy with i types of output the growth of output becomes

$$g_Y = \sum \theta_i g_{Y_i}$$

where θ_i is the share in the value of output of the commodity or service i. The growth of the labor input becomes

$$g_L = \sum \frac{b_j}{b} g_{L_j}$$

where b_j is the share in the total payments to the factors of production paid to workers of type j. And the growth of the capital stock is similarly

$$g_K = \sum \frac{a_j}{a} g_{K_j} \ .$$

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